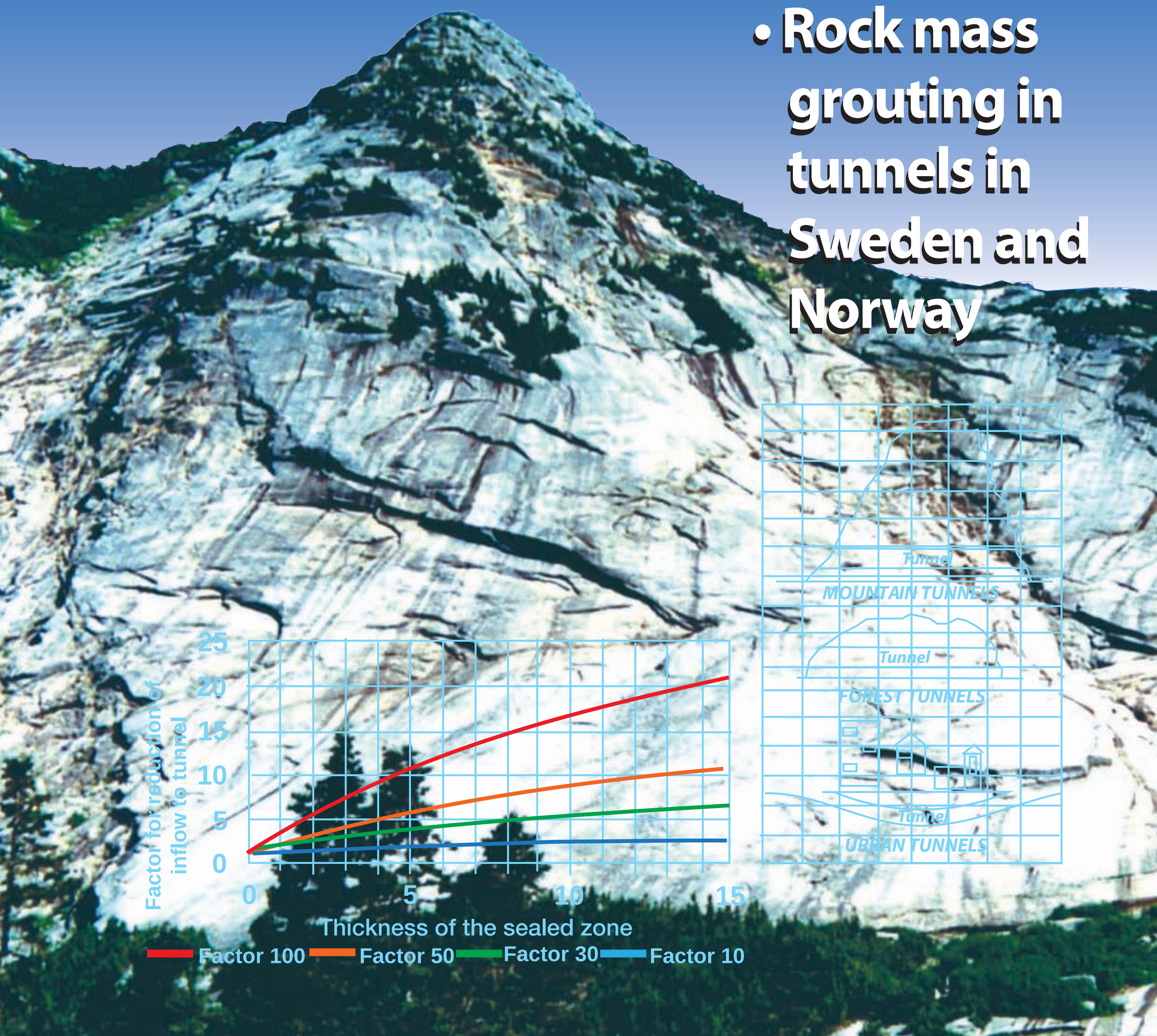
Now online at
www.geotechnicalnews.com

Volume 32 • Number 1 • March 2014

GEOTECHNICAL*news*

• Rock mass grouting in tunnels in Sweden and Norway



innovation

in MEMS Digital Inclinometer Systems

DIGITAL MEMS INCLINOMETER SYSTEM

How the best just got better.

For measuring any lateral movement down in the earth, via inclinometer casing, the Digital MEMS Inclinometer System from RST Instruments Ltd. was the first, and is still the best, Digital MEMS Inclinometer System available.

Over the last 10 years, RST's Inclinometer systems have had the shortest overall length available for a given base length compared to competitive inclinometers. Undaunted, we've forged ahead and improved on our very own industry-leading specifications. With a new minimum negotiable casing radius of 1.93 m, RST's Digital MEMS Inclinometer can still traverse a smaller radius bend than all other inclinometers available in the industry.

OTHER INCLINOMETERS VS. RST

Interference

Interference at connector is visibly inherent in other inclinometers (left) while RST's Digital MEMS Inclinometer (right) can clearly traverse a smaller radius bend (1.93 m) than all other inclinometers.

Minimum Negotiable Casing Radius

Other Inclinometers:
3.12 m

RST Inclinometer:
1.93 m

0.5 m wheelbase probes shown in 70 mm OD inclinometer casing.

RST's newly developed connector is by far the industry leader for the least amount of connector interference.

RST also provides the most robust cable on the market with a breaking strength of 5.90 kN (1325 lbs.) Also, our new, non-slip, swaged cable marks are unmatched in grip strength.

The compact reel system with 50 m cable weighs a very manageable 4.7 kg and can be easily held with one hand. A padded carrying case is included.

MEMS TILT & INCLINATION SERIES

Above, the RST Digital MEMS Inclinometer Probe with industry leading system accuracy of ±2 mm per 25 m, is shown connected to the cable.

The all new Ultra-Rugged Field PC² functions as the data collector which provides a high-level user interface, "at-the-borehole" data analysis and graphical comparison to previous data sets. The new "zoom-in" feature allows you to explore your data in more detail and Bluetooth® and Wi-Fi® connection come standard. Microsoft® Office Mobile is also included.

SYSTEM INCLUDES:

MEMS Digital Inclinometer probe, cable system, reel with battery power, and an Ultra-Rugged Field PC that functions as a wireless readout, analysis, and data storage device. Includes all accessories, as shown at left. Please contact the RST sales team for complete details.

inclinalysis™
digital inclinometer analysis software

RST Inclinalysis™ Software is a powerful companion to the RST Digital MEMS Inclinometer System. It allows the user to quickly and efficiently reduce large volumes of inclinometer data into a variety of formats suitable for analysis and presentation.

VIEW THIS SYSTEM IN ACTION!

YouTube http://youtu.be/1nqpiQUzh4o

LinkedIn http://www.linkedin.com/company/rst-instruments-ltd-

rst INSTRUMENTS

innovation in geotechnical instrumentation

TELEPHONE	604 540 1100	FAX	604 540 1005
TOLL FREE	1 800 665 5599 North America only		
EMAIL	info@rstinstruments.com		
WEBSITE	www.rstinstruments.com		

Certified System ISO 9001

MIG0251C

GEOTECHNICAL NEWS

PUBLISHER John W. Gadsby
MANAGING EDITOR Lynn Pugh

Editors

Linda Bayer
Robert Chapuis
John Dunnicliff
Paolo Gazzarrini
Don Lewycky
Ward Wilson

Managing Editors and Advertising

BiTech Publishers Ltd.
103 - 11951 Hammersmith Way
Richmond, British Columbia
Canada V7A 5H9
tel 604-277-4250 • fax 604-277-8125
email ***gn@geotechnicalnews.com***
web ***www.geotechnicalnews.com***

GEOTECHNICAL NEWS is published quarterly.

Paper subscription rates:
- within North America: $58.00 CDN per year
- overseas: $95.00 US per year through BiTech Publishers Ltd.

Electronic version:
GEOTECHNICAL NEWS is also available in electronic version. For details,visit ***www.geotechnicalnews.com***

Canadian Editorial Office

Canadian Geotechnical Society
Don Lewycky, Editor, CGS News • email: *don.lewycky@edmonton.ca*

Membership Information : Canadian Geotechnical Society
Gibson Group Association Management
Wayne Gibson, 8828 Pigott Road • Richmond, BC V7A 2C4 • tel: 604-277-7527 • email: *cgs@cgs.ca*

United States Editorial Office

Geo-Institute of the American Society of Civil Engineers
Linda R. Bayer, 1801 Alexander Bell Drive, • Reston, VA 20191-4400 • tel: 703-295-6352
fax: 703-295-6351 • email: *lbayer@asce.org*

Editors

Groundwater
Robert P. Chapuis, Dept. CGM, Ecole Polytechnique, PO Box 6079, Sta. CV Montréal, QC, H3T 1J4
tel: 514-340-4711 • fax: 514-340-4477, • email : *robert.chapuis@polymtl.ca*

Instrumentation
John Dunnicliff, Little Leat, Whisselwell, Bovey Tracey, Devon TQ13 9LA, England
tel: +44 1626-832919 • email: *john@dunnicliff.eclipse.co.uk*

The Grout Line
Paolo Gazzarrini, 12-2242 Folkestone Way, West Vancouver, BC, V7S 2X7 • tel: 604-913-1022
fax: 604-913-0106 • email: *paolo@paologaz.com*

Waste Geotechnics
G. Ward Wilson, Professor, Geotechnical and Geoenvironmental • University of Alberta, Dept. of Civil & Environmental Engineering, 3-069 NREF, Edmonton, AB T6G 2W2 • tel: 780-492-2534
fax: 780-492-8198 email: *wwilson2@ualberta.ca*

Printed in Canada


USA, CANADA,
ANYWHERE PROGRESS TUNNELS DEEP...
WE DRY THE GROUND.
MORETRENCH
CANADA

DGSI
DURHAM GEO SLOPE INDICATOR

Call Today To Learn More Call: 1-425-493-6200
Email: solutions@slope.com

COMPLETE OFFERING OF GEOTECHNICAL AND STRUCTURAL INSTRUMENTATION

Digitilt AT Inclinometers

The Digitilt AT Inclinometer System includes a digital probe, control cable marked in feet or meters, a cable gate, a Bluetooth reel, Reader APP for Android based tablet and DigiPro2 Basic software. The AT System now features custom length cables from 100m (300 ft) to 300m (1000 ft).

Track Monitoring

DGSI's track monitoring systems help maintain railroad safety by monitoring settlement and twist. The systems are installed on railroad tracks that cross landslides or washout areas. They are also installed on tracks affected by nearby construction activities either adjacent or beneath the track.

Digitilt Classic Inclinometers

The Digitilt Classic Inclinometer System consist of a control cable marked in feet or meters, a Datamate II readout. DigiPro2 software and a pulley assembly are options to complete a system is designed to measure subsurface deformations in vertical and horizontal boreholes.

Strain Gauges

DGSI's strain gauges are used to monitor strain in concrete and steel structures and can be easily installed in the field. Strain gauges are durable to minimize long-term drift and changes in calibration. DGSI's strain gauge readings are obtained using a vibrating wire readout.

Inclinometer Casing

DGSI's inclinometer casing is considered to be the strongest, most reliable casing available. Offered in three diameters and five coupling styles, all of DGSI's casing features precision grooves and provides superior resistance to twisting and bending.

Joint & Crackmeters

DGSI's 3-D Crackmeter is an economical solution for measuring the movement of cracks and joints in structures. The crackmeter can be either grouted in place or welded to the structure and is read utilizing a depth micrometer.

Piezometers

DGSI's VW piezometers are used to monitor pore-water pressure. They are available in standard configuration as well as push-in, vented, pneumatic and heavy-duty models.

Data Recorders, Loggers

DGSI offers a wide range of data recorders and loggers to monitor geotechnical sensors and instrumentation. DGSI can configure data systems and monitoring programs to customer specifications in order to reduce the time and expense required to deploy data acquisition systems.

Extensometer & Settlement Cells

DGSI's line of extensometers include magnet extensometers, digital tape extensometers, and rod extensometers and are used to monitor settlement. DGSI's Settlement Cells are used to monitor a single point of settlement.

Atlas Web-Based Monitoring

Atlas web-based monitoring software solves the two major problems of data acquisition; the timely processing of data and the distribution of results to others. DGSI can provide system integration of sensors, data logger and web-based monitoring on a 24/7 basis.

Durham Geo Slope Indicator
Tel: **425-493-6200 / 866-916-0541**
Web: **www.slopeindicator.com**

NOVA METRIX

Volume 32 • Number 1 • March 2014

CONTENTS

Cover Art design by Pat Adams

Model GK-405 Vibrating Wire Readout

Model 4900
Geokon Vibrating Wire Load Cell

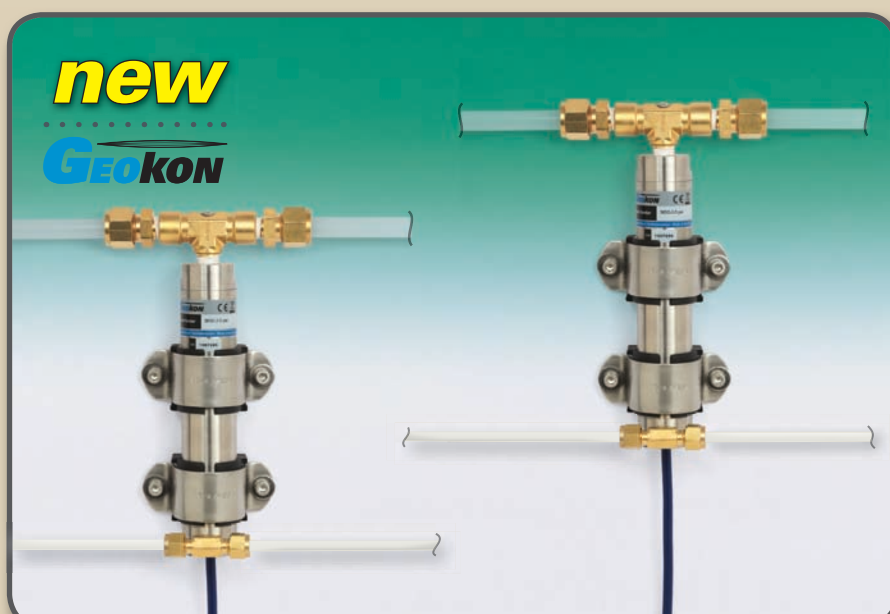
The rugged Model GK-405 can be used with all Geokon vibrating wire sensors, in all kinds of weather conditions:

- Integrated Handheld Field PC
- Bluetooth® communication between Field PC and Dock
- Real-time datalogging
- Two modes of data acquisition
- Data and configuration storage on internal 4 GB Solid State Drive
- Rechargeable Li-ion battery
- Cold weather operation

For more information, please visit:
www.geokon.com/GK-405

35 YEARS OF INNOVATION AND QUALITY
In Geotechnical Instrumentation

Multipoint Settlement Systems



Geokon Model 3650-2 and 4650-2 are Multipoint Settlement Systems comprised of a series of sensitive Semiconductor Pressure Transducers or Vibrating Wire Pressure Transducers connected together with a special Nylon tube filled with de-aired water or, where necessary, de-aired water and anitfreeze. The string of sensors are connected to a common reservior with a large liquid capacity.

Ideal for the measurement of differential settlements in:

- Tunnels
- Bridges
- Excavations
- Floor slabs
- Compensation grouting

For more information, please visit:
www.geokon.com/3650-2

GEOKON *The World Leader in Vibrating Wire Technology™*
1 • 603 • 448 • 1562
info@geokon.com
www.geokon.com

…In Canada
GKM Consultants
1 • 450 • 441 • 5444
info@gkmconsultants.com
www.gkmconsultants.com

Message from the President

Richard J. Bathurst, President of Canadian Geotechnical Society

As you read this article, I and your CGS Executive team will be well into our second year of our two-year terms. The time has gone quickly and along with our very busy Secretary General (**Victor Sowa**), we have been active on a number of fronts.

The first important task in 2014 was to appoint new chairs for our Technical Divisions and Committees, and new Section Directors to replace the outgoing chairs and directors who have completed their three-year terms. As a matter of policy, the Society attempts to limit these persons to a single three-year term and to avoid reappointments. This allows as many CGS members as possible an opportunity to participate in CGS leadership roles. To ensure that this policy is implemented, it is very important that each group develop a succession plan with a designated leader-elect well in advance of each end of term.

I am pleased to announce the new representatives of the Technical Divisions and Sections on the Executive Committee for 2014 are **Myint Win Bo** and **Paul Dittrich**, respectively. The new Division Chairs are **Baolin Wang** (Cold Regions Geotechnology), **Richard Brachman** (Geosynthetics), **Tai Wong** (Groundwater) and **Alex Baumgard** (Soil Mechanics and Foundations). The new Section Directors are **Seán Mac Eoin** (Edmonton), **Harpreet Panesar** (Regina), **Rashid Bashir** (Saskatoon), **Kendall Thiessen** (Winnipeg), **Nicholas Vlachopoulos** (Kingston), **Sarah Poot** (Sudbury),

James Mitchell (Nova Scotia) and **Hany El Naggar** (New Brunswick). I am particularly grateful to Hany El Naggar who has agreed to take the lead in reviving the New Brunswick Section after moving it from Moncton to Fredericton. The new Committee Chairs are **Jinyuan Liu** (Education) and **Kent Bannister** (Professional Practice). Finally, I am pleased to announce that **Murray Grabinsky** is the new chair of the CGS Geotechnical Research Board. Amongst a number of other tasks, this Board is responsible for the selection of the annual CGS Colloquium Speaker. **Scott McDougall** (BGC Engineering) has been selected the **2014 CGS Colloquium Speaker** and will give his talk at the 67th Canadian Geotechnical Conference in Regina this fall.

At the annual CGS Board Meeting held on September 29, 2013, I presented a motion to disband the **Computing Committee**. The consensus of the CGS Board of Directors was that computing methods are now ubiquitous in all technical areas of our geotechnical discipline and thus the need to promote computing methods through a separate committee was no longer required. As a result, the motion was approved unanimously.

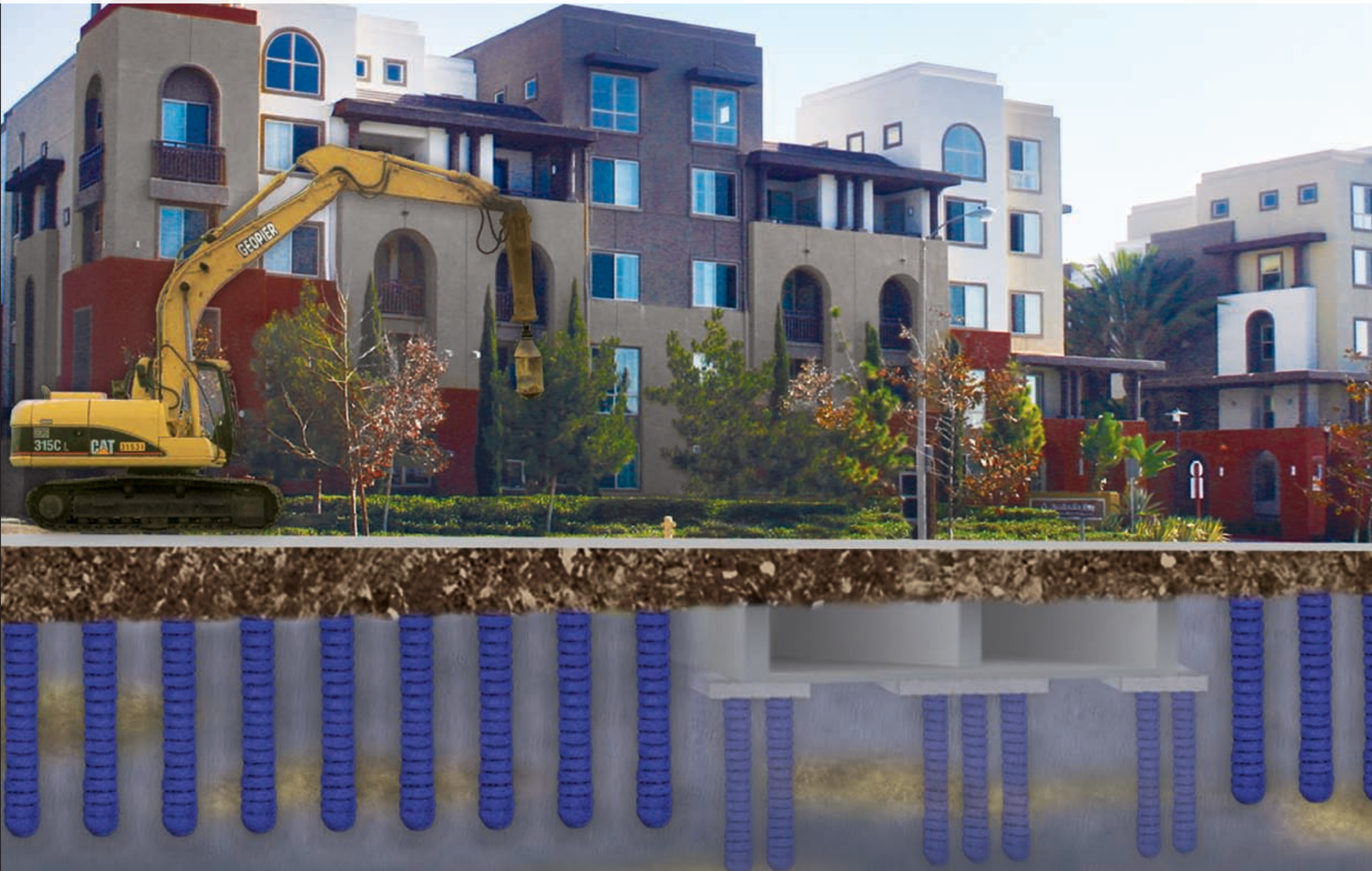
An agreement on the award rules for the **Schuster Medal** was recently finalized between the CGS and the Association of Environmental & Engineering Geologists (AEG). This medal is named in honour of Dr. Robert Schuster who is an internationally recognized expert in the area of landslides with a career spanning 60 years including many years with the USGS. The medal is given to members of the CGS and AEG who have made outstanding contributions to geohazards research in North America. The award rules stipulate that the award will be given in alternate years to a CGS member and an AEG member. I am delighted to see this award formalized because it reflects the collegiality and common interests of engineering geologists on both sides of the border.

In other award-related news, I am delighted to report that two of our CGS members (**Gordon Ward Wilson** and **Régis Bouchard**) were elected **Fellows of the Engineering Institute of Canada (EIC)**. No more than 20 EIC members from all 11 constituent Societies of the EIC are granted this distinction each year. Congratulations to them both.

I'm also is pleased to announce that our agreement with **BiTech Publishers** has been renewed for another three years. In addition to publishing Geotechnical News, BiTech also distributes our **Canadian Foundation Engineering Manual (CFEM).** Read-

GEOPIER IS GROUND IMPROVEMENT.™

Work with engineers worldwide to solve your ground improvement challenges.



THE GEOPIER GP3 SYSTEM: CONTROLLING SETTLEMENT

WE HELP YOU FIX BAD GROUND.

For more information call 800-371-7470,
e-mail info@geopier.com or visit geopier.com.

Tensar® | GEOPIER® FOUNDATIONS

Plans for a 150,000 square foot apartment complex in Irvine, CA featured a common "wrap" style structure, with 4-story apartments surrounding a 4.5-story parking garage. The site was underlain by 20 to 25 feet of soft to medium stiff lean clay with groundwater encountered at depths of 8 to 10 feet. The clay was underlain by stiff clay and dense sand to a depth of 50 feet. Reconciling the settlement tolerances between the apartments and the parking structure presented a unique design challenge. The GP3® system was an ideal solution, meeting the specified settlement tolerance for 1" total foundation settlement and ½ inch differential between the parking structure and the apartments. By reducing total settlements and accelerating time rate of settlement for all structures, GP3 eliminated the need for a 6-9 month surcharge.

ers may recall that the French version of the fourth edition of the CFEM was launched at the time of the last annual conference in Montreal. **Lynn Pugh** at BiTech reported that 146 copies were sold almost immediately.

Angela Küpper (VP Technical) and I are currently preparing a survey that will give all CGS members an opportunity to give us their opinions and preferences on the scope and format of a fifth edition of the CFEM. We hope to hear from CGS members in academia (including students), consulting, industry and government, in an attempt to ensure that the next version of the CFEM satisfies as many members from these sometimes diverse sectors as possible. Our objective is to decide on both these issues at the next annual fall meeting of the CGS in Regina.

The 50-year anniversary of our **Canadian Geotechnical Journal** was an important milestone celebrated in Montreal last September. The success of the journal has resulted in a tremendous increase in workload for the Editor, Professor **Ian Moore**. I was as relieved as Ian was to hear that Canadian Science Publishing has recently appointed a second (international) editor, Professor **Daichao Sheng**, to share the work load with Ian. This will ensure that manuscript submissions continue to be adjudicated in a timely manner.

A very important transition at CGS headquarters is now being planned for the beginning of January 2015. Our current Secretary General (Victor Sowa) will be stepping down after what will then be eight years of dedicated and outstanding service to our Society. I have appointed our President-elect (**Doug VanDine**) to chair a search committee to find the next Secretary General. A call for applicants was emailed to all members in January and it is also repeated in this issue of **Geotechnical News**. Applications are due by April 30, 2014. Serious candidates are free to contact me if they would like clarification on any details of the duties of the Secretary General and the call for applicants. Concurrent with this search will be an internal review by the CGS Executive of the organizational structure and day-to-day responsibilities of the Secretary General and our CGS administrative providers (**Gibson Group Management Inc - Wayne Gibson** and **Lisa McJunkin**). This periodic re-evaluation of administrative procedures and responsibilities is a normal and prudent procedure for any professional society, particularly whenever there is a change of such a key position as the Secretary General.

In closing, I wish all CGS members the best as we move toward the summer months and I look forward to reporting on further activities of your Society in the June issue of Geotechnical News.

Provided by Richard Bathurst – President

Message du président

Lorsque vous lirez ce message, le Comité exécutif de la SCG et moi-même aurons entamé la deuxième année de notre mandat de deux ans. Le temps a passé à la vitesse de l'éclair. À l'instar de notre secrétaire général fort occupé (**Victor Sowa**), nous sommes allés de l'avant avec de nombreux dossiers.

La première tâche importante de l'année 2014 a été de nommer les nouveaux présidents des comités et divisions techniques, ainsi que les nouveaux directeurs de sections, pour remplacer ceux qui terminent leur mandat de trois ans. La Société a pour politique de tenter de limiter le poste de ces personnes à un unique mandat de trois ans et d'éviter de reconduire les mandats. Cela permet au plus grand nombre possible de membres de la SCG d'avoir la possibilité d'assumer des rôles de direction au sein de la Société. Pour veiller à la bonne mise en œuvre de cette politique, il est très important que chaque groupe élabore un plan de relève qui nomme un dirigeant désigné bien avant la fin de chaque mandat.

Je suis heureux d'annoncer que, pour l'année 2014, les nouveaux représentants des divisions et des sections techniques du Comité exécutif sont **Myint Win Bo** et **Paul Dittrich**, respectivement. Les nouveaux présidents de divisions sont **Baolin Wang** (Géotechnique des régions froides),

Richard Brachman (Géosynthétique), **Tai Wong** (Eaux souterraines) et **Alex Baumgard** (Mécanique des sols et fondations). Les nouveaux directeurs de section sont **Seán Mac Eoin** (Edmonton), **Harpreet Panesar** (Regina), **Rashid Bashir** (Saskatoon), **Kendall Thiessen** (Winnipeg), **Nicholas Vlachopoulos** (Kingston), **Sarah Poot** (Sudbury), **James Mitchell** (Nouvelle-Écosse) et **Hany El Naggar** (Nouveau-Brunswick). Je remercie tout particulièrement Hany El Naggar d'avoir accepté de faire revivre la section du Nouveau-Brunswick, après l'avoir déménagée de Moncton à Fredericton. Les nouveaux présidents de comités sont **Jinyuan Liu** (Éducation) et **Kent Bannister** (Pratiques professionnelles). Enfin, j'ai le plaisir d'annoncer que **Murray Grabinsky** est le nouveau président du Conseil de recherche en géotechnique de la SCG. Au nombre des tâches de ce conseil figure la responsabilité de choisir le conférencier du colloque annuel de la SCG. Le conférencier retenu pour le **Colloque 2014 de la SCG** est **Scott McDougall** (de BGC Engineering). Il présentera sa conférence à Regina, lors de la 67e conférence canadienne de géotechnique, qui aura lieu à l'automne.

Lors de réunion annuelle du conseil d'administration de la SCG du 28 septembre 2013, j'ai présenté une résolution proposant de dissoudre le **Comité de l'informatique**. Le CA a convenu que les méthodes informatiques étaient désormais omniprésentes dans l'ensemble des secteurs techniques de notre discipline et que le besoin de les promouvoir en leur consacrant un comité distinct était donc révolu. Par conséquent, la résolution a été approuvée à l'unanimité.

La SCF et l'Association of Environmental & Engineering Geologists (AEG) ont récemment convenu des règles d'attribution de la **Médaille Schuster.** La médaille a été nommée en l'honneur de Robert Schuster, Ph. D., un spécialiste des glissements de terrain de réputation internationale et dont la carrière a duré 60 ans, dont plusieurs années à l'USGS. La médaille est décernée à des membres de la SCG et de l'AEG qui ont apporté des contributions exceptionnelles à la recherche sur les géorisques en Amérique du Nord. Les règles d'attribution stipulent que la médaille sera décernée chaque année, en alternance entre un membre de la SCG et un membre de la l'AEG. Je suis enchanté de l'officialisation de cette distinction, parce qu'elle reflète la collégialité et les intérêts communs des ingénieurs en géologie des deux côtés de la frontière.

Toujours dans le domaine des distinctions, je suis ravi d'annoncer que deux des membres de la SCG (**Gordon Ward Wilson** et **Régis Bouchard**) ont été nommés **fellows de l'Institut canadien des ingénieurs (ICI)**. L'ICI confère cet honneur annuel à tout au plus 20 membres de ses 11 sociétés membres. Félicitations à tous les deux.

Je suis également heureux d'annoncer que notre entente avec **BiTech Publishers** a été renouvelée pour trois autres années. En plus de publier le magazine **Geotechnical News**, BiTech distribue également nos manuels, **le Canadian Foundation Engineering Manual (CFEM)** et le **Manuel canadien d'ingénierie des fondations (MCIF)**. Les lecteurs du présent message se rappelleront peut-être que la version française de la quatrième édition du CFEM, le MCIF, a été lancée durant notre dernière conférence annuelle, à Montréal. **Lynn Pugh**, de chez BiTech, a signalé avoir vendu 146 exemplaires presque sur le champ.

Angela Küpper (vice-présidente technique) et moi-même sommes en train de préparer un sondage qui donnera aux membres de la SCG l'occasion de nous faire part de leurs opinions et de leurs préférences sur l'ampleur et le format d'une cinquième édition de ces manuels. Nous espérons que les membres de la SCG qui travaillent en milieu universitaire (y compris les étudiants), ainsi que dans les domaines de l'expertise-conseil, de l'industrie et du gouvernement nous répondent, afin de nous assurer que la prochaine édition satisfait le plus grand nombre possible des membres appartenant à ces secteurs assez différents. Notre objectif est de prendre une décision sur ces deux questions lors de la prochaine réunion automnale de la SCG à Regina.

Le 50e anniversaire de notre **Revue canadienne de géotechnique** a constitué un jalon important que nous avons célébré à Montréal en septembre dernier. La réussite de la revue a entraîné une énorme augmentation de la charge de travail de notre rédacteur en chef, le professeur **Ian Moore**. Lorsque j'ai appris que Canadian Science Publishing avait récemment nommé un deuxième rédacteur en chef (international), le professeur **Daichao Sheng**, pour partager le travail avec Ian, mon soulagement n'a eu d'égal que le sien. Cela garantira que les soumissions de manuscrits continueront à être traitées dans des délais opportuns.

Nous sommes en train de planifier une très importante transition au sein du siège social de la SCG, pour le début de janvier 2015. Notre présent secrétaire général (Victor Sowa) terminera ses fonctions après une période qui correspondra alors à huit années de service dévoué et exceptionnel à notre Société. J'ai nommé notre président désigné (**Doug VanDine**) à la présidence du comité responsable de trouver le prochain secrétaire général. En janvier, un appel de candidatures a été envoyé par courriel à tous les membres. Il est également diffusé dans ce numéro de **Geotechnical News**. La date d'échéance de présentation des candidatures est le 30 avril 2014. Les candidats sérieux peuvent communiquer avec moi s'ils désirent des précisions sur les tâches du poste de secrétaire général ou sur l'appel de candidatures. Parallèlement à cette recherche, le Comité exécutif de la SCG réalisera un examen interne de la structure organisationnelle et des responsabilités quotidiennes du secrétaire général et des fournisseurs de services administratifs (**Wayne Gibson** et **Lisa McJunkin, du Gibson Group Management Inc**.). Cette réévaluation périodique des procédures et responsabilités administratives est une procédure normale et prudente pour toute société professionnelle, particulièrement lors de changements à un poste aussi important que celui de secrétaire général.

Pour terminer, j'adresse mes meilleurs vœux aux membres de la SCG, à qui j'aurai le plaisir de rendre compte des autres activités de notre société dans le numéro de juin de Geotechnical News.

Del la part de Richard Bathurst - président

From the Society

Call for Applicants for Position of Secretary General, Canadian Geotechnical Society

The Canadian Geotechnical Society (CGS) is beginning a search for a new Secretary General who will undertake the position on or about **January 1, 2015.**

The CGS Secretary General is a paid part-time position. The Secretary General is responsible and accountable for the effective and efficient management of the Society's affairs in accordance with written policies, guidelines and instructions issued by the Board of Directors or the President. The Secretary General reports to the President.

The Secretary General should be someone who:

a. is a professional engineer or professional geoscientist who works, or has worked, in the field of geotechnique in Canada

b. is an active member of CGS and knows the CGS well

c. is in a position to work part-time for the CGS (nominally 15 to 20 hours per week)

d. can work from a home office or can arrange logistical support from a supporting company or university, and

e. is at ease working with computers and computer technology.

The duties and responsibilities, and desirable attributes of the Secretary General are summarized in the CGS Administration Manual, Appendix 28 *http://members.cgs.ca/memberIndex.php*, Online Member Services, CGS Manuals, *Administration Manual 2012* (PDF Format)

The anticipated schedule for appointing the new Secretary General is as follows.

1. January 31 2014: call for applicants
2. April 30, 2014: applications due
3. May 2014: identification of short list of candidates
4. June 2014: interviewing candidates
5. June/July 2014: recommendation to Executive Committee and approval by Board of Directors
6. September/October 2014: announcement of new Secretary General at the 2014 Canadian Geotechnical Conference in Regina
7. January 1, 2015; new Secretary General takes up appointment.

Applicants should contact the Chair of the Selection Committee, **Doug VanDine**, CGS President Elect (*vandine@islandnet.com*) and enclose a short resume focused on the position. Interested individuals must respond no later than **April 30, 2014**.

Provided by Richard Bathurst – President

Demandes de candidatures au poste de secrétaire général de la Société canadienne de géotechnique

La Société canadienne de géotechnique (SCG) recherche un candidat pour pourvoir au poste de secrétaire général vers le **1er janvier 2015**.

Le poste de secrétaire général de la SCG est un emploi à temps partiel rémunéré. Le secrétaire général est responsable et redevable de la gestion efficace et efficiente des affaires de la Société, conformément aux politiques, lignes directrices et instructions transmises par écrit de la part du conseil d'administration ou du président. Il relève du président.

Un secrétaire général devrait avoir les compétences suivantes :

a. être ingénieur ou géoscientifique travaillant ou ayant travaillé dans le domaine de la géotechnique au Canada;
b. être un membre actif de la SCG et bien connaître cette Société;
c. être en mesure de travailler à temps partiel pour la SCG (théoriquement, de 15 à 20 heures par semaine);
d. pouvoir travailler à domicile ou prendre des arrangements pour obtenir du soutien logistique au sein d'une entreprise ou d'une université;
e. avoir de la facilité à travailler avec des ordinateurs et des technologies informatiques.

Les tâches, les responsabilités, ainsi que les compétences souhaitables du secrétaire général sont résumées dans l'annexe 28 du Manuel d'administration de la SCG, à *http://members.cgs.ca/memberIndex.php*, à la page des services aux membres, rubrique des manuels de la SCG, document intitulé *Administration Manual 2012* (en PDF).

Voici le calendrier prévu pour les différentes étapes de l'entrée en fonction du nouveau secrétaire général :

1. 31 janvier 2014 : Demande de candidatures
2. 30 avril 2014 : Date d'échéance des candidatures
3. Mai 2014 : Établissement d'une présélection de candidats
4. Juin 2014 : Entrevues avec les candidats
5. Juin-juillet 2014 : Recommandation du Comité exécutif et approbation du conseil d'administration
6. Septembre-octobre 2014 : Annonce du nom du nouveau secrétaire général lors de la conférence canadienne de géotechnique de 2014, à Regina
7. 1er janvier 2015 : Entrée en fonction du nouveau secrétaire général

Les personnes souhaitant poser leur candidature devraient communiquer avec le président du Comité de sélection, **Doug VanDine**, qui est également le président désigné de la SGC (*vandine@islandnet.com*) et lui envoyer un court curriculum vitæ mettant bien en évidence leurs compétences pour le poste. Les personnes intéressées devraient se manifester d'ici le **30 avril 2014**.

Del la part de Richard Bathurst - président

Call for Nominations for CGS Awards

Nominations for CGS Awards may be submitted to The Canadian Geotechnical Society Secretariat, (8828 Pigott Road, Richmond, BC, V7A 2C4, Canada; Fax: (604) 277-7529, e-mail: *cgs@cgs.ca*, by not later than **June 1, except where noted**.

The nomination letter must include:

- reasons why the individual merits the award relative to the nomination criteria
- any other pertinent information on the nominee
- C.V. of the nominee

Letters from other Canadian Geotechnical Society members supporting the nomination add strength to the nomination.

Nominators are recommended to review the full award details before preparing nominations for the Awards listed below. The Awards details can be obtained from the Society's Awards and Honours Manual, (Sections B-1 to B-12 inclusive), which is available to CGS members in the CGS Members Section of the CGS Website. CGS members can log-in at *http://cgs.ca/login.php*, then proceed to Online Member Resources, find CGS Manuals and proceed to the Awards and Honours Manual. Information can also be obtained from Division Chairs, Section Directors, and the Secretariat.

Funding for the Society's awards is provided by generous support from the independent charitable body, **The Canadian Foundation for Geotechnique.**

Members are invited and encouraged to submit nominations for the following CGS Awards:

R.F. Legget Medal - the highest CGS honour

Awarded to an individual for outstanding life-long contributions to geotechnique.

R.M. Quigley Award

Awarded to an individual or individuals for the best paper published in the Canadian Geotechnical Journal within the preceding year in which the prize is awarded. Nominations are made by the Associate Editors of the Canadian Geotechnical Journal.

G. Geoffrey Meyerhof Award

Awarded to an individual for outstanding and exceptional contributions to the art and science of foundation engineering.

Thomas Roy Award

This award is presented to honour an outstanding contribution to the field of Engineering Geology in Canada.

Roger J.E. Brown Award

The award is presented to an individual, preferably Canadian, for publishing the best paper on permafrost science or engineering in:

- Canadian Geotechnical Journal, or
- Canadian Journal of Earth Sciences, or
- Proceedings of National or International Permafrost Conferences, or
- to honour an individual for their excellence in the field of permafrost.

Awarded every second year, it will be awarded in 2014.

John A. Franklin Award

This award recognizes an individual or individuals, who have made an outstanding technical contribution in the fields of rock mechanics or rock engineering in Canada and or internationally. Awarded every second year, it will **not** be awarded in 2014.

Geosynthetics Award

This award was presented for the first time in the 2000 to recognize an individual or individuals who have made an outstanding technical contribution to the use of geosynthetics in Canada and/or internationally. Awarded every second year, it will be awarded in 2014.

Geoenvironmental Award

This award was presented for the first time in 2000 to recognize an individual or individuals who have made an outstanding technical contribution to the practice of multidisciplinary geoenvironmental engineering in Canada and/or internationally. Awarded every second year, it will be awarded in 2014.

Robert N. Farvolden Award

Following some years as the Hydrogeology Division Award, the Robert N. Farvolden Award was presented for the first time in 2002. The Groundwater Division selects the winner of the award, which recognizes outstanding contributions to groundwater science and engineering in Canada. The Awards Committee of the Groundwater Division commonly asks for input from the International Association of Hydrogeologists, Canadian National Committee, (IAH-CNC).

CGS Graduate Student Award

For the best paper authored or co-authored and presented by a geotechnical graduate student at an accredited Canadian University. The winning paper each year is presented by the student at the annual Canadian Geotechnical Conference. All submissions and accompanying documentation must be received by the Chair of the Student Awards Sub-Committee **on or before May 21** of the competition year. The contact information for the Chair is **Sumi Siddiqua**, School of Engineering, University of British Columbia, Okanagan Campus, EME 4257 - 3333 University Way, 1137 Alumni Avenue, Kelowna, BC, VIV 1V7, Tel: 250-807-9863, *sumi.siddiqua@ubc.ca*

CGS Undergraduate Student Awards

There are two undergraduate student awards that endeavour to increase student awareness of the Society and their involvement in it.

a. **The Undergraduate Student Report, Individual Submission Award** was established In 1987 with the main purpose of recognizing and rewarding excellence in the preparation of a geotechnical report by an individual full time undergraduate student in an accredited engineering program or a geoscience program in a Canadian University.

b. **The Undergraduate Student Report, Group Submission Award** was added in 1990 to recognize and reward excellence of a report prepared by one or more undergraduate students in an accredited engineering program or a geoscience program in a Canadian University.

All submissions and accompanying documentation must be received by the Chair of the Student Awards Sub-Committee **on or before May 21** of the competition year. The contact information for the Chair is **Sumi Siddiqua**, School of Engineering, University of British Columbia, Okanagan Campus, EME 4257 – 3333, University Way1137 Alumni Avenue, Kelowna, BC, VIV 1V7, Tel: 250-807-9863, *sumi.siddiqua@ubc.ca*

A.G. Stermac Awards for Service to the Canadian Geotechnical Society

Before 1999, these awards were known as the CGS Service Plaques. A.G. Stermac Awards are presented to members of the Society who have contributed specific or special, worthy and significant service(s) to the Society. All submissions must reach the Society's Secretariat not later than **June 1**.

Provided by Victor Sowa - Secretary General

Call for Nominations for Awards Engineering Institute of Canada (EIC)

Canadian Geotechnical Society (CGS) members are invited to submit nominations for EIC Awards to the Society Secretariat (cgs@cgs.ca) or the Secretary General (vsowacgs@dccnet.com), **no later than July 15, 2014**. All members of the Society are eligible for the awards, prizes and honours from the **Engineering Institute of Canada**. EIC Policies dictate that all candidates nominated by CGS members for EIC awards, must be members of the CGS.

Nominators are required to provide nomination documents consisting of the following four items:

1. A completed EIC Nomination Form that can be obtained from the EIC Website,
2. The nomination letter,
3. The candidate's Curriculum Vitae, (short form preferred) and
4. Supporting letters from colleagues who are preferably Fellows of the EIC (FEIC).

Nominators are recommended to review the full awards details and criteria prior to preparing nominations for the Awards listed below. More information on the procedures, details and schedule for EIC honours and awards can be found in Sections D-1, D-2 and D-3 of the Canadian Geotechnical Society's Awards and Honours Manual. This information is available to CGS members in the CGS Members Section of the CGS Website. CGS members can log-in at *http://cgs.ca/login.php*, then proceed to Online Member Resources, find CGS Manuals, then proceed to the Awards and Honours Manual. Continue in the Manual to Sections D1, D2 and D3 for detailed information. This information includes a list of past Award Medal members and also Past FEIC members. The past FEIC members are listed both chronologically and also for convenience, alphabetically.

The CGS Executive Committee reviews all nominations submitted by members, as well as other possible candidates. The nominations are forwarded to the Honours and Awards Committee of EIC for consideration. All constituent societies of EIC participate in this program.

Members of CGS are eligible for the following EIC honours and awards:

- The **Sir John Kennedy Medal** is the most senior award of the Institute. This medal is awarded in recognition of outstanding merit in the engineering profession, or of noteworthy contributions to the science of engineering or to the benefit of the Institute.
- The **Julian C. Smith Medal**, established in 1939 by a group of senior members of the Institute to perpetuate the name of a Past President of the Institute. The medal is awarded for "achievement in the development of Canada".
- The **John B. Stirling Medal** was established in 1987 through the generosity of E.G.M. Cape and Company Ltd. to honour a former President of the Company who was President of the Institute in 1952. It is awarded "in recognition of leadership and distinguished service at the national level within the Institute and/or its Member Societies".
- **The Canadian Pacific Railway Engineering Medal** was established in 1988. The medal is presented "in recognition of leadership and service over many years at the regional, branch, section or equivalent levels, within the Institute or its Member Societies".

- The **K.Y. Lo Medal** was created in 1998 and is awarded "to a member of the EIC who has made significant engineering contributions at the international level. Such contributions may include:
  - promotion of Canadian expertise overseas;
  - training of foreign engineers;
  - significant service to international engineering organizations;
  - advancement of engineering technology recognized internationally".
- **Fellowship of EIC (FEIC)**. A member of CGS, of at least 45 years of age, can become a Fellow of the Institute on the grounds of excellence in engineering practice and exceptional contributions to the well being of the profession and to the good of the Society.
- **Honorary Membership**. The Council of the EIC may elect to award an Honorary Membership in the Institute to non-members who are not engineers, but who have achieved distinction through service to the profession of engineering.

Provided by Victor Sowa - Secretary General

Appels de nomination pour les prix de l'Institut canadien des ingénieurs (ICI)

Les membres de la Société canadienne de géotechnique (SCG) sont invités à soumettre des nominations aux prix et médailles de l'ICI au Secrétariat de la société (cgs@cgs.ca) ou à son secrétaire général (vsowacgs@dccnet.com) **d'ici le 15 juillet 2014 au plus tard**. Les membres de la SCG sont admissibles aux prix, médailles et distinctions **de l'Institut canadien des ingénieurs.** Selon les politiques de l'ICI, tous les candidats mis en nomination par des membres de la SCG à des prix de l'ICI doivent être membres de la SCG.

Les personnes qui soumettent des nominations doivent fournir les quatre documents suivants:

1. un formulaire de l'ICI dûment rempli, qu'il est possible d'obtenir du site Web de l'ICI;
2. une lettre de nomination;
3. le curriculum vitæ du candidat (abrégé, de préférence);
4. au moins deux lettres de recommandation (mais pas plus de trois) de la part de collègues, dont au moins une d'un fellow de l'ICI.

Avant de préparer un dossier, il est recommandé aux personnes qui font une nomination de lire les détails et les critères relatifs aux prix énumérés plus loin dans le texte. Pour plus de renseignements sur la procédure, les détails et le calendrier des prix et distinctions de l'ICI, consultez les sections D-1, D-2 et D-3 du manuel de la SCG sur les prix et distinctions (Awards and Honours Manual). Ces renseignements sont fournis aux membres de la SCG dans la section du site Web qui leur est réservée. Pour y accéder, il faut ouvrir une session à *http://www.cgs.ca/login.php?lang=fr*, consulter les ressources en ligne à l'intention des membres, trouver les manuels de la SCG, ouvrir le manuel sur les prix et les distinctions et passer aux sections D1, D2 et D3, qui présentent des renseignements détaillés, dont une liste des membres ayant déjà remporté une médaille ou qui sont déjà fellows de l'ICI. La liste des fellows est présentée en ordre chronologique et, pour des raisons pratiques, en ordre alphabétique.

Le Comité exécutif de la SCG examinera toutes les nominations soumises par les membres, de même que celles d'autres candidats possibles. Les nominations qu'il sélectionnera seront ensuite acheminées au comité des prix et des médailles de l'ICI, pour examen. Toutes les sociétés membres de l'ICI participent à ce programme.

Les membres de la SCG sont admissibles aux prix et distinctions de l'ICI énumérés ci-dessous:

- La **Médaille Sir John Kennedy** est la plus ancienne distinction de l'Institut. Elle est décernée en reconnaissance de mérites exceptionnels ou de contributions dignes de mention dans le domaine de l'ingénierie ou au bénéfice de l'Institut.
- La **Médaille Julian C. Smith** a été établie en 1939 par un groupe de membres émérites de l'Institut, afin de perpétuer la mémoire d'un ancien président de l'ICI. Elle est décernée en reconnaissance d'une "contribution au développement du Canada".
- La **Médaille John B. Stirling** a été établie en 1987, grâce à la générosité de la société E.G.M. Cape and Company Ltd., pour honorer un ancien président qui était à la tête de l'Institut en 1952. Elle est décernée "en reconnaissance des qualités de chef et des services émérites rendus à l'Institut et/ou à ses sociétés membres à l'échelle nationale".
- La **Médaille Canadian Pacific Railway Engineering** a été établie en 1988. Elle est décernée "en reconnaissance de plusieurs années de leadership et de services dans les régions, les chapitres ou des niveaux équivalents, au sein de l'Institut ou de ses sociétés membres".
- La **Médaille K.Y. Lo** a été créée en 1998 et est décernée à "un membre de l'ICI qui a apporté d'importantes contributions à l'ingénierie au niveau international. Au nombre de telles contributions peuvent figurer:
  - la promotion de l'expertise canadienne outre-mer;
  - la formation d'ingénieurs étrangers;
  - d'importants services rendus à des organismes d'ingénierie internationaux;
  - l'avancement d'une technologie d'ingénierie reconnue sur la scène internationale".

Fellowships de l'ICI. Un membre de la SCG âgé d'au moins 45 ans peut devenir fellow de l'Institut en raison de son excellence en matière de pratiques d'ingénierie et du caractère exceptionnel de ses contributions à l'avancement de la profession et de la société.

Membre honoraire. Le Conseil de l'ICI peut nommer des membres honoraires de l'Institut. Il s'agit de non-membres qui ne sont pas ingénieurs mais qui se méritent cette distinction en raison de services rendus à la profession de l'ingénierie.

De la part de Victor Sowa - secrétaire général

Canadian Foundation for Geotechnique 2014 National Graduate Scholarship

Dr. Dennis Becker, President of the Canadian Foundation for Geotechnique (La foundation canadienne de géotechnique), is pleased to announce the call for nominations for the 7th annual *Canadian Foundation for Geotechnique National Graduate Scholarship.*

The scholarship, valued at $5,000, was established by the Canadian Foundation for Geotechnique in 2007, on the occasion of the 60th Canadian Geotechnical Conference in Ottawa. The 2014 scholarship will be presented at the Canadian Geotechnical Conference, in Regina, SK this fall.

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 2014 Scholarship will be accepted by the Canadian Geotechnical Society's Scholarship 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, 2014**. 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

Upcoming Conferences and Seminars

2014 Canadian Geotechnical Conference
September 28 - October 2, 2014, Regina, Saskatchewan

The Canadian Geotechnical Society (CGS) invites you to its 67th annual conference at the Delta Hotel in Regina, Saskatchewan. **GeoRegina 2014** will be held from Sunday, September 28 to Wednesday, October 1, 2014.

The theme for **GeoRegina 2014**, *Engineering for the Extremes*, will highlight current trends in geotechnical engineering by addressing increasingly complex problems under more extreme operating conditions. The technical program will offer opportunities for delegates to explore various examples ranging from environment damage to rehabilitation of failing infrastructure. In keeping with CGS practice, challenging and informative workshops, seminars and tours will be offered in conjunction with the conference.

For more information on **GeoRegina 2014**, including delegate pricing and sponsorship/trade show opportunities, please visit the conference website at *www.georegina2014.ca.*

Geotechnical Society of Edmonton
Two Day Symposium
April 3 - 4, 2014, Edmonton, Alberta

The Geotechnical Society of Edmonton is pleased to present a two day symposium entitled *Landslides – Assessment, Characterization and Risk*. The symposium will feature a combination of previously presented keynote lectures, as well as several new papers given by eleven prominent speakers, including last year's Terzaghi Oration by Dr. Suzanne Lacasse. Confirmed presenters in addition to Dr. Suzanne Lacasse include Drs. Derek Comforth, Norbert Morgenstern, Derek Martin, Doug Stead, Serge Leroueil, Scott Anderson, David Cruden, Scott Burns, Delwyn Fredlund and Richard Goodman.

This symposium represents a unique opportunity where all of these world renowned speakers and practitioners will be brought together at one time. In attending this one symposium, attendees will be able enjoy a number of significant keynote lectures that would otherwise have required them to travel to several conferences held around the world. Interest in this symposium is anticipated to be high and seating is limited. You are encouraged to register as soon as possible to ensure that you will not miss out on this unique opportunity.

For more information or to register, go to *www.geotechnical.ca*

6th Canadian Geohazards Conference
June 15 - 18, 2014
Queen's University
Kingston, Ontario

The 6th Canadian Geohazards Conference GeoHazards 6 will be held at Queen's University, Kingston Ontario from June 15 - 18, 2014. Keynote speakers include John Clague (Simon Fraser University), Jacques Locat (Université, Laval), Mike Porter (BGC Engineering), Peter Jordan (BC Forest Service), Rupert Wedgewood (Parks Canada) and Pete Quinn.

A technical program of over 50 oral and poster presentations is expected. Look for details about the keynote speakers, short courses and workshops at *www.geohazards6.ca.* Delegate registration is now open - early pricing ends on April 30.

For more information please visit *www.geohazards6.ca.*

International Discrete Fracture Network Engineering Conference
October 19 - 22, 2014
Vancouver, British Columbia

DFNE 2014 *www.dfne2014.ca* will be the inaugural international meeting of engineers and geoscientists who use discrete fracture network engineering in the characterization of rock masses and solutions of engineering problems. This new and rapidly expanding area of engineering has wide applications, including underground and surface mining, underground nuclear waste disposal, petroleum geomechanics, civil engineering and natural hazards.

With keynote lectures provided by Bill Dershowitz (Golder Associates FracMan Group), Loren Lorig (Itasca International) and Bruce Meyer (Meyer & Associates), three days of technical presentations, and numerous short courses preceding the conference, it promises to be an excellent forum on state-of-the-art practice in Discrete Fracture Network Engineering.

Members in the News

2014 EIC Awards

The following CGS members were recently recognized for their contributions and received these awards from the **Engineering Institute of Canada (EIC).**

Dr. Ward Wilson – Fellow, Engineering Institute of Canada

Ward Wilson

Dr. Wilson graduated in civil engineering from the University of Manitoba and completed his Master's degree and PhD at the University of Saskatchewan. He is currently a Professor in the Department of Civil & Environmental Engineering at the University of Alberta and brings over 25 years of industrial experience to his practice in advanced mine waste management and unsaturated soil mechanics for numerous sites worldwide.

He has served as a specialist consultant to several large international mining companies such as the well-known Acid Rock Drainage Risk Review recently completed by Rio Tinto. In addition, Dr. Wilson recently served as the lead author responsible for the chapter on Prevention and Mitigation in the Global Acid Rock Drainage Guide. He is currently the Principal Investigator of the Oil Sands Tailing Research Facility, where he leads innovative research programs to support and enhance the Alberta oil sands industry's ability to manage and mitigate environmental risks associated with oil sands tailings.

Dr. Ward Wilson – Fellow, l'Institut canadien des ingénieurs (ICI)

Dr. Ward Wilson a gradué en génie civil de l'Université de Manitoba et a complété une maîtrise et un doctorat de l'Université de la Saskatchewan. Il est présentement professeur au département de génie civil et de génie environnemental de l'Université de l'Alberta où il partage son expérience industrielle de plus de 25 ans en gestion des résidus miniers et en mécanique des sols non saturés sur de nombreux sites à travers le monde.

Il a agi à titre de consultant spécialiste dans plusieurs grandes compagnies minières internationales telles que Rio Tinto pour laquelle il a collaboré au panel bien connu Acid Rock Drainage Risk Review. De plus, le Dr. Wilson a récemment été l'auteur principal du chapitre Prevention and Mitigation dans le Global Acid Rock Drainage Guide. Il est présentement le chercheur principal du centre de recherche Oil Sands Tailing Research Facility, où il dirige des programmes de recherche novateurs pour supporter et améliorer la capacité de l'industrie pétrolière de l'Alberta à gérer et réduire les risques environnementaux associés aux résidus de sables bitumineux.

Régis Bouchard – Fellow, Engineering Institute of Canada

Régis Bouchard is a pioneer in the development of in situ geotechnical characterization techniques and high quality sampling and was Techmat's leader for 25 years. He was the first to

Régis Bouchard

offer piezocone testing in the province of Quebec. He developed and adapted various sophisticated tools, such as a self-boring permeameter, the large diameter Laval sampler for sands and the use of a geocamera in boreholes.

He is the author and co-author of numerous scientific papers dealing with the mechanical behaviour of sensitive clays and compacted clay for liners, the behavior of embankment dams and the design of sewage ponds. He was also heavily involved with various industrial research chairs, including those from Université Laval and Université de Sherbrooke, where he made himself very accessible to researchers and students.

Régis Bouchard is highly recognized, not only in Quebec where he has worked for major clients such as Hydro-Quebec and the Ministry of Transportation, but also elsewhere in Canada, California and Taiwan.

Régis Bouchard – Fellow, l'Institut canadien des ingénieurs (ICI)

Régis Bouchard est un pionner du développement de méthodes d'investigation géotechnique in situ et d'échantillonnage de haute qualité et a été le dirigeant de Techmat durant

25 ans. Il a été le premier à offrir au Québec les sondages au piézocône. Il a développé et adapté divers outils sophistiqués, notamment le perméamètre autoforeur, l'échantillonneur Laval de grand diamètre pour les sables, et les géocaméras en trous de forage.

Il est l'auteur et le co-auteur de plusieurs articles sur le comportement mécanique des argiles sensibles, les membranes d'argiles compactées, le comportement des barrages en remblais, et la conception des étangs d'épuration. M. Bouchard s'est impliqué au sein de différentes chaires de recherches industrielles, dont celles de l'Université Laval et de l'Université de Sherbrooke, dans lesquelles il a contribué activement avec les chercheurs et les étudiants.

Régis Bouchard est reconnu non seulement au Québec, où il a œuvré pour des clients majeurs tels Hydro-Québec et le Ministère des Transports, mais aussi au Canada en général, en Californie et à Taiwan.

2013 EIC Awards

The following CGS members were recognized for their contributions and received the following awards from the Engineering Institute of Canada (EIC) in 2013. These awards were intended to be featured in a 2013 issue of Geotechnical News, but this was not possible. The CGS apologizes to the award winners for the delay.

Dr. Peter K. Kaiser - John B. Stirling Medal

Dr. Peter K. Kaiser was been awarded the **John B. Stirling Meda**l *in recognition of leadership and distinguished service at the national level within the Institute and/or its Member Societies*.

Dr. Peter Kaiser has had an enormous influence on the state of the art in rock engineering as applied to underground excavations, including mines and tunnels. Working on the frontiers of rock engineering issues, in the deepest and most difficult rock conditions, Peter's research findings have made it possible to design and successfully construct excavations in complex geological settings, in deep underground mines in Canada and around the world.

Since his arrival at Laurentian University, in 1989, Peter has founded four separate and equally successful research groups, all of which continue to thrive. Peter has worked very closely with the mining and tunnelling industries to ensure that important research findings are applied in industry and that the people he trains have first class knowledge and hands-on experience.

Peter Kaiser was previously the recipient of distinguished awards from the CGS, CIM, the EIC and the Canadian Academy of Engineers in recognition of his incredible research productivity, and his influence on Canadian mining industry in the development of Canada, her natural resources and her highly trained personnel.

Dr. Ian D. Moore - Julian C. Smith Medal

Dr. Ian D. Moore has been awarded the **Julian C. Smith Medal** for *achievement in the development of Canada.*

Dr. Ian Moore, one the world's foremost researchers in the field of buried infrastructure, was recognized for his extraordinary leadership and contributions to service at the national and local levels, including the Canadian Geotechnical Society, (CGS).

As a joint Editor of the Fourth edition of the Canadian Foundation Engineering Manual (2006), Ian led a CGS team who updated the Manual that is extensively used by geotechnical professionals across Canada and internationally. As Editor of the Canadian Geotechnical Journal, Ian has overseen its growth in international prestige and importance as a journal with its emphasis on high calibre articles of practical importance.

As founding chair of the Kingston Section of the CGS between 2006 and 2010, Ian led development of a vibrant new section, engaging local experts from industry, academia, government, and the graduate student community at Queen's and RMC. In addition, as the founding Executive Director of the Geo-Engineering Centre at Queen's-RMC, Ian has led the development of one of North America's largest and internationally respected teams of geo-engineering scholars.

Dr. Iain G. Bruce - Fellowship of the Engineering Institute of Canada (FEIC)

Dr. Iain G. Bruce was awarded a **Fellowship of the Engineering Institute of Canada (FEIC)** *in recognition of excellence in engineering practice and exceptional contributions to the well being of the profession and to the good of the Society*.

Dr. Iain Bruce founded Bruce Geotechnical Consultants in 1989 and co-founded BGC Engineering Inc. in 1990. Under his guidance, BGC Engineering grew from a small specialist consultancy to a multidiscipline organization of over 300 people in 20 years. Iain's engineering expertise is in dealing with mine wastes and mine tailings dams. He has undertaken many projects not only in Canada, but also on four continents. In addition, he currently serves on Geotechnical Review Boards for over a half dozen national and international mining companies. Iain also contributed to preparing the Mining Association of Canada (MAC) guideline on Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities, 2002.

Iain contributed to the well-being of the geotechnical profession as an executive member and then Chair of the Vancouver Geotechnical Section in 1989; and as a member of the Organizing Committee for the Vancouver Geotechnical Society's Spring Symposiums in 1987 and 1989. He also served as a guest lecturer for the Civil Graduate Program at UBC for several years.

Dr. Denis LeBoeuf - Fellowship of the Engineering Institute of Canada (FEIC)

Dr. Denis LeBoeuf was awarded a **Fellowship of the Engineering Institute of Canada (FEIC)** *in recognition of excellence in engineering practice and exceptional contributions to the well being of the profession and to the good of the society.*

Dr. Denis LeBoeuf is Professor of Civil Engineering and Graduate Program Director at the Department of Civil Engineering and Water Resources, Université Laval.

Professor LeBoeuf is a well recognized technical specialist and is involved in research projects dealing with soil dynamics, foundation engineering, earth dams engineering, dynamic soil-structure interaction and geotechnical earthquake engineering.

His current research on earthquake resistance is funded by NSERC (National Science and Engineering Research Council) and FQRNT (Fond Québécois de Recherche en Nature et Technologie), Hydro-Québec and the Ministère des transports du Québec.

He also has a very active consulting engineering practice and has worked as a geotechnical specialist on many projects for Hydro-Québec, Ministère des transports du Québec, SNC-Lavalin, Iron Ore Co. of Canada, Techman Engineering (Calgary, Alberta), RSW Inc.(Montréal) and the "Société d'ingénierie Cartier" (Montréal).

Professor LeBoeuf has also contributed generously of his time to technical societies such as the Canadian Geotechnical Society and others.

Dr. Robert J. Fannin - Fellowship of the Engineering Institute of Canada (FEIC)

Dr. Robert J. Fannin was awarded a **Fellowship of the Engineering Institute of Canada (FEIC)** *in recognition of excellence in engineering practice and exceptional contributions to the well being of the profession and to the good of the society.*

Dr. Fannin has compiled a body of experimental findings and related field observations that have contributed significantly to the state-of-the-art in geotechnical engineering as it relates to landslide risk management, designing with geosynthetics and seepage-induced erosion in earth dams. His contributions to developments in each of these areas of engineering practice have received international recognition, garnered a number of awards for outstanding scholarship, and led to several distinguished visiting fellowships.

Dr. Fannin brings all of these experiences to his university teaching, and also to short courses for practising professionals, in a commitment to engineering education and life-long learning that has won him several awards for teaching excellence.

In parallel with his teaching and research contributions, Jonathan Fannin has contributed significantly to the advance of the profession through volunteer commitments in conference organization, professional associations and as an Associate Editor of the Canadian Geotechnical Journal.

Provided by Victor Sowa - Secretary General

Heritage Committee

History of Local Chapters of the Canadian Geotechnical Society

The Heritage Committee believes that the history of the local chapters of the Canadian Geotechnical Society to be valuable part of the Society and its members. The CGS Heritage Committee would like to assemble if at all possible, a collection of historical summaries of all the chapters. As an example, the CGS Heritage Committee is pleased to provide a second history of one of our prominent local chapters. This month, the focus is on the history of the **Geotechnical Society of Edmonton**. Hopefully these stories will encourage other local chapters of the CGS to gather their archives and write their own history.

If you have any questions or have other historical information that you wish to share or know of any opportunities to acquire material that is at risk of being lost, please contact the Chair of the CGS Heritage Committee, **Dr. Mustapha Zergoun**, at *mustapha.zergoun@metrovancouver.org*.

A Brief History of the Geotechnical Society of Edmonton

The Geotechnical Society of Edmonton (GSE) was registered as an independent Society on February 5, 1969 and is affiliated with the Canadian Geotechnical Society (CGS). Signatories on the incorporation documents of the Society were **Murray Harris, P.Eng., Stan Thomson, P.Eng, B. Alexander, P.Eng., Ron Innes, T.E. Berg, P.Geol** and **E.C. Luck, P.Eng**. The GSE is one of the oldest geotechnical groups in Canada and has an average membership of approximately 190.

The GSE was initially formed to bring professionals and non-professionals together so they could share their geotechnical experiences and ideas with one another. Membership to the GSE is extended to those individuals in private consulting, government, industry, students or anyone else who has an interest in geotechnical and geoenvironmental issues. Approximately once every four weeks from September to May, feature speakers address the membership body to discuss new developments and challenging projects in geotechnical and geoenvironmental engineering on both the local and global scales. The annual roster of meetings also typically includes two distinguished Cross-Canada Lectures supported by the Canadian Foundation for Géotechnique, a charitable organization independent of the CGS and of which the GSE has been an ongoing financial supporter. The season culminates with the Annual General Meeting which includes a business dinner meeting, the election of a new Executive and a presentation by a distinguished speaker.

Held at various venues in Edmonton, including the University of Alberta and the Northern Alberta Institute of Technology, the meetings provide members an opportunity to network and to enjoy a meal together, followed by presentations by local practitioners or visitors. The presentations span a wide range of geotechnical and geo-environmental topics, as well as related issues such as professional practice, risk, legal issues and new technologies and construction techniques.

Since 1995, the GSE has also sponsored an annual spring symposium or seminar on various geotechnical and geo-environmental related themes. These events typically attract 80 to 130 registrants.

In 1982, the GSE introduced its highest award, the Geotechnical Service Award. Stan Thomson, one of the founding fathers of the Society was the first recipient of this award and the award was subsequently renamed in 1999 as the **Stan Thomson Geotechnical Society of Edmonton Award**. This award recognizes a particular individual's contribution to the development and growth of the GSE and to geotechnical or geoenvironmental engineering in the Edmonton area. The award consists of a commerative plaque and a lifetime membership to the Society.

In 1985, the GSE introduced the GSE Graduate Student Award, In 1999 the award was renamed **N.R. Morgenstern Student Award.** The award is given to the graduate student who submits the best paper as selected by the professors in the Geotechnical Division of the Department of Civil and Environmental Engineering at the University of Alberta. Along with a $1500 monetary award and a certificate, the award winners are invited to present their paper to the general membership at a wine and cheese reception, held in the early fall. The wine and cheese meeting is the September meeting where the N.R. Morgenstern Graduate Student Award winner from the previous spring gives a presentation to the group. A poster session by other graduate students is also held at the reception, to allow the representatives from industry to meet and discuss current research projects with the students.

In 2003, the Civil Engineering Department at the University of Alberta held the first of what was to become an annual competition for it's graduate students, challenging them to put the theory they were learning into practice. They were required to design and predict the failure strengths of model reinforced retaining walls that they had to construct on the day of the competition, with no opportunity to undertake trial tests. In 2004, the format of the competition was expanded, with guest judges from various local geotechnical consultants. The guest judges evaluate the various designs for innovation and give small prizes to the students supplied by various local firms, along with a cash prize for first place provided by the Geotechnical Society of Edmonton and one or more corporate sponsors.

By 2005, the competition was expanded to allow the participation

of students from NAIT. In addition, this year saw the first appearance of a trophy for the first place student team. The trophy was designed by **Mr. Paul Boos** and was financially supported by his firm, Reinforced Earth Company.

The trophy mimics the appearance of a reinforced wall with a roadway running across the top. The cruciform wall panels typically associated with a Reinforced Earth wall are modeled by brass plates which are inscribed with the names of the winning students. The trophy is kept on display at the Civil Engineering Department at the University of Alberta between competitions. In recognition of his long term service to the University of Alberta and to the local geotechnical community, both the competition and the trophy were named after **Dr. Don Scott** in 2005.

The GSE has hosted five annual CGS's annual conferences, including the ones in 1962, 1974, 1985, 1998 and most recently in 2008. The GSE has also hosted a number of specialty conferences, including the 1994 First International Conference of Environmental Engineering with the ISSMFE, the 2001 Assessment and Remediation of Contaminated Sites in Arctic and Climates (ARCSACC) and in 2003, the 3rd Canadian Conference on Geotechnical Engineering and Natural Hazards.

Submitted by Dr. Mustapha Zergou
Chair of CGS Heritage Committee

Directors, Committee Chairs, Secretariat, 2014
Directeurs, Présidents du Comité, Secrétariat, 2014

(Additional information for the various positions shown below is located on the CGS website at **www.cgs.ca**)

BOARD OF DIRECTORS - EXECUTIVE COMMITTEE	
President, Président	Richard J. Bathurst, P.Eng., *bathurst-r@rmc.ca*
Vice President Technical/ Vice Président Technique	Angela Küpper, P.Eng., *akupper@bgcengineering.ca*
Vice President Financial/Vice Président aux Finances	Dharma Wijewickreme, P.Eng., *dharmaw@civil.ubc.ca*
Vice President Communications/Vice Président aux Communications	Catherine N. Mulligan, P.Eng., *catherine.mulligan@concordia.ca*
Technical Divisions Representative	Myint Win Bo, P.Eng., *P.Geo., mwindo@dstgroup.com*
Section Representative	Paul Dittrich, P.Eng., *paul_dittrich@golder.com*

DIVISION CHAIRS/PRÉSIDENTS DES DIVISIONS	
Cold Regions Geotechnology/Géotechnologie des régions froides	Baolin Wang, P. Eng., *bwang@nrcan.gc.ca*
Engineering Geology/Géologie de l'ingénieur	Doug Stead, P.Eng., *dstead@sfu.ca*
Geoenvironmental/Géologie de l'environnement	Myint Win Bo, P.Eng., P.Geo., *mwinbo@dstgroup.com*
Geosynthetics/Géosynthétiques	Richard W.I. Brachman, P.Eng., *brachman@civil.queensu.ca*
Groundwater/Eaux souterraines	Tai Wong, P.Eng., *tai.wong@sait.ca*
Rock Mechanics/Mécanique des roches	Jim Hazzard, P.Eng., *jhazzard@itascacg.com*
Soil Mechanics and Foundations/Mécanique des sols et des fondations	Alex Baumgard, P.Eng., P.Geo., *abaumgard@bgcengineering.ca*
SECTION DIRECTORS/DIRECTEURS DES SECTIONS	
Vancouver Geotechnical Society	Jason Pellett, P.Eng., GIT, *jpellett@eba.ca*
Vancouver Island Geotechnical Group	J. Suzanne Powell, EIT., *spowell@thurber.ca*
Prince George Geotechnical Group	Eric Mohlmann, P.Eng., *e.mohlmann@geonorth.ca*
Interior BC Geotechnical Group	Sumi Siddiqua, MIT., *sumi.siddiqua@ubc.ca*
Geotechnical Society of Edmonton	Seán Mac Eoin, P.Eng., *sean.maceoin@aecom.com*
Calgary Geotechnical Group	Frank Magdich, P.Eng., *frank@oakenviro.com*
Regina Geotechnical Group	Harpreet Panesar, P.Eng., *harpreet.panesar@gov.sk.ca*
Saskatoon Geotechnical Group	Rashid Bashir, P.Eng., *rashid_bashir@golder.com*
Winnipeg Section	Kendall Thiessen, P.Eng., *kthiessen@winnipeg.ca*
Ottawa Geotechnical Group	Mamadou Fall, P.Eng., *mfall@genie.uottawa.ca*
Thunder Bay	Eltayeb Mohamedelhassan, P.Eng., *eltayeb@lakeheadu.ca*
Kingston Group	Nicholas Vlachopoulos, P.Eng., *vlachopoulos-n@rmc.ca*
Toronto Group	Paul Dittrich, P.Eng., *paul_dittrich@golder.com*
London Group	Mrinmoy Kanungo, P.Eng., *mkanungo@golder.com*
Sudbury Group	Sarah E.M. Poot, P.Eng., *spoot@golder.com*
Ouest du Québec/Western Quebec - Montreal	Annick Bigras, ing., *bigras.annick@hydro.qc.ca*
Est du Québec/Eastern Quebec - Quebec City	Jean Côté, ing., *jean.cote@gci.ulaval.ca*
Nova Scotia Chapter	James S. Mitchell, P.Eng., *james.mitchell@stantec.com*

New Brunswick Chapter	Hany El Nagger, P.Eng., *hany-elnaggar@unb.ca*
Newfoundland Chapter	Janet Williams, P.Eng., *janet.williams@lvm.ca*
EX OFFICIO MEMBERS OF CGS BOARD OF DIRECTORS	
President-Elect/Président-Elu	Doug VanDine, P.Eng., P. Geo., *vandine@islandnet.com*
Chair, Geotechnical Research Board/Président, Conseil de la recherche en géotechnique	Murray W. Grabinsky, *murray.grabinsky@utoronto.ca*
Editor Canadian Geotechnical Journal/Le directeur de la rédaction de la Revue canadienne de géotechnique	Ian Moore, P.Eng., *moore@civil.queensu.ca*
Editor, CGS News in Geotechnical News/Le directeur de la rédaction des Nouvelles de la SCG	Don Lewycky, P.Eng., *don.lewycky@edmonton.ca*
Representative of CSCE on CGS Board	Reg Andres, P.Eng., *randres@rvanderson.com*
CHAIRS OF STANDING COMMITTEES/LES PRÉSIDENTS DES COMITÉS PERMANENTS	
Education Committee/Le comité sur l'éducation	Jinyuan Liu, P.Eng., *jinyuan.liu@ryerson.ca*
Heritage Committee/Le comité Héritage	Mustapha Zergoun, P.Eng., *mustapha.zergoun@metrovancouver.org*
Landslides Committee/Le comité sur les glissements de terrain	Michael Porter, P.Eng., *mporter@bgcengineering.ca*
Transportation Geotechniques Committee/Le comité sur la géotechnique des transports	Roger Skirrow, P.Eng., *roger.skirrow@gov.ab.ca*
Professional Practice/Le comité sur la pratique professionnelle	Kent Bannister, P.Eng., *kbannister@trekgeotechnical.ca*
Mining Geotechnique Committee/Comité technique sur la géotechnique miniére	Michel Aubertin, ing., *michel.aubertin@polymtl.ca*
REPRESENTATIVES ON OTHER ORGANIZATIONS	
Representative to EIC Council	Richard J. Bathurst, P.Eng., *bathurst-r@rmc.ca*
Representative to CSCE Board	Catherine N. Mulligan, P.Eng., *catherine.mulligan@concordia.ca*
SECRETARIAT	
Secretary General/Secrétaire Général	Victor A. Sowa, P.Eng., P.Geo., *vsowacgs@dccnet.com*
Administrator/Administrateur	Wayne Gibson, P.Eng., *cgs@cgs.ca*

Editor

Don Lewycky, P.Eng.
Director of Engineering Services,
City of Edmonton
11004 – 190 Street NW
Edmonton, AB T5S 0G9
Tel.: 780-496-6773
Fax: 780-944-7653
Email: don.lewycky@edmonton.ca

Introduction by John Dunnicliff, Editor

This is the seventy-seventh episode of GIN. Only one article this time.

Do you want GIN to continue? Despite arm twisting, you're being backward in coming forward. The first step is a 200- to 300-word abstract. The ball is in your court.

Reason for only one—it's the same old story—despite arm twisting, you're being backward in coming forward. Guidelines for articles are on www.geotechnicalnews.com/instrumentation_news.php—see the link "How to submit articles to John Dunnicliff for GIN". The first step is a 200- to 300-word abstract. **Do you want GIN to continue? The ball is in your court.**

A newer, better way to measure tunnel deformations

The article by Chris Fagan and Charles Daugherty is one of those nuts-and-boltsy contributions that tell us about a better way to do something. I like such straightforward articles!

International Course on Geotechnical and Structural Monitoring

Plans for the course in Italy in June are almost complete. Details are on *www.geotechnicalmonitoring.com.*

After many years of courses in USA, most recently in Florida, I've taken a fresh look at what I think these courses should include. In addition to the monitoring methods that we've been using for many years, this course includes innovative remote monitoring methods such as total stations, satellite and terrestrial radar, Lidar and GPS - my Italian colleagues are experts at these modern methods. The course schedule (lecturers and topics) is on the website—The Course/Schedule. Additional information is on page 35.

Come and join us in the 10th century castle! (I got it wrong in December GIN, and jumped ahead three centuries!). The wine is good, too!

Closure

Please send contributions to this column, or an abstract of an article for GIN, to me as an e-mail attachment in MSWord, to john@dunnicliff.eclipse.co.uk, or by mail: Little Leat, Whisselwell, Bovey Tracey, Devon TQ13 9LA, England. Tel. +44-1626-832919.

Op uw gezondheid! (Flemish: Dutch speakers)

The Laser-Distometer: a newer, better way to measure tunnel deformations

Chris Fagan and Charlie Daugherty

The conventional method

The conventional method of measuring deformation between two points, typically in a tunnel or excavated cavern, has been to use a tape extensometer. The tape extensometer is stretched between two eye-bolts over the space where the measurement is being taken, the tape is tensioned correctly using the on-board tension sensor, and the distance shown on the tape is recorded (Figure 1). Deformation is measured by comparing subsequent readings over time.

Figure 1. Stretched tape extensometer.

When used correctly, tape extensometers will achieve accurate deformation measurements, at sub-millimeter precision. However, in practice, the manufacturer-claimed precision is difficult to achieve when monitoring deformation in a tunnel or cavern that is under active construction. This can be problematic, because the most critical time to monitor deformation is while construction is active, for instance, when a tunnel heading is advanced, or when a cavern is excavated.

It is difficult to measure deformation using a tape extensometer during active construction for the following reasons:

- During measurements the link between eye-bolts creates a physical barrier. This can cause costly delays, as equipment that can pass by is restricted.
- Measurements are often rushed because of pressure from surrounding workers delayed by the physical barrier.
- A second person is sometimes required, often assisting on a ladder, to hook the second end of the tape to the eye-bolt, which increases monitoring costs.
- Eye-bolts protrude from the monitored surface, and are easily damaged or bent by construction activity.
- The tape extensometer can be cumbersome to transport.
- Ambitious construction schedules and time constraints on workers means that an often time consuming and disruptive measurement process is easily overlooked.

Introduction of the laser-distometer alternative

These difficulties inherent in monitoring with a tape extensometer mean that readings may be skipped or rushed just when data collection is most needed. An alternative method of measuring deformation is to use a laser-distometer and targets. The laser-distometer is placed into a cradle at one point (Figure 2), the laser beam is reflected from a target at the second point, and captured again by the laser-distometer. The distance is then calculated within the instrument by recording the interval of time between sending and receiving the laser pulse.

Figure 2. Laser-distometer in cradle.

The authors have not found hard evidence of laser-distometers being specified or permitted for tunnel deformation monitoring before late 2006. At that time instrumentation specifications for New York City Transit's 7 Line Subway Extension were modified by the designer, the Parsons Brinckerhoff Team, to include the following statement, "In tunnels driven by TBM, Contractor may consider the use of laser measuring devices in lieu of tape extensometer convergence bolts in order to begin measurements as close as possible to the back of the tunneling machine. Such devices shall be able to achieve an accuracy of 1/16-inch or better across a space of 20-feet. Spot markers and reflective targets shall be provided to ensure that readings can be repeated at the same monitoring points as the tunnel progresses." This specification was published in January 2007 in time for the bidding of tunnel construction, but the construction contractor who won the job did not choose the laser-distometer option.

The laser-distometer measurement alternative had not been offered in the specifications for the Metropolitan Transportation Authority's East Side Access Project, for which the start of design had preceded the 7 Line Subway Extension's design by several years. However, when the time came to excavate the project's connecting tunnels and enlarge the cavern beneath Grand Central Terminal in 2007, it was obvious that up-to-then standard methods of deformation monitoring faced some great hurdles. Discussions were begun with the construction contractor and an agreement reached that led to a contract modification calling for any tape extensometer measurements of tunnel and cavern deformation to be replaced by laser-distometer measurements.

The laser-distometer in practice

A portable cradle for the distometer should be fabricated, and attached to an anchor bolt at the first point with a swiveling head (Figure 3). The reflective target at the second point should be small (approx. 2-inch diameter) and mounted with its face perpendicular to the direction of the laser beam from the first point. The laser-distometer uses electronic distance measurement technology, which is commonly used in the surveying industry, however it had not necessarily been tried and tested in this application.

Figure 3. Laser-distometer reading.

Project specifications will generally specify use of the tape extensometer, yet the laser-distometer offers many advantages over the former method. Some of these are:

- No physical barrier is created when taking readings.
- Reduced setup and reading time.
- Only one person is required and no direct access to the second target is necessary.
- The laser-distometer is small, lightweight and can be easily transported in a pocket.
- The likelihood of a greater number of measurements being recorded is higher, due to a simpler data collection process.
- A lesser "nuisance" factor while taking readings may result in the collection of better quality data.

Laser-distometers with millimeter accuracy are widely available, and in most cases are considerably less expensive than tape extensometers. The advantages of the laser-distometer over the tape extensometer are obvious to these authors and to others, but hard data makes for a more compelling case.

From 2007 to 2012, more than 8,000 laser-distometer readings were collected at the East Side Access Project between 310 tunnel and cavern deformation point pairs. Readings in the tunnels were collected immediately behind the tunnel boring machines between targets installed on virgin rock, and readings in the caverns were recorded immediately following excavation by drill and blast.

The data collected were analyzed to validate the suitability of the laser-distometer as a replacement for the tape extensometer. To evaluate the suitability, all erroneous data (anchor bolt damaged or destroyed) was removed from the dataset, and all point pairs indicating trending data (deformation is occurring) were removed. This left a "stable" dataset of more than 6,000 readings between 245 deformation point pairs (Figure 4). The intent of reducing the complete dataset to a "stable" dataset is to analyze the laser-distometer as a measurement tool, rather than analyze the actual deformation that may have occurred.

Results of the program and conclusions

The scatter in the stable dataset plotted as a histogram is an excellent approximation of the normal distribution. Therefore, by calculating the mean and standard deviation of the stable dataset, it follows that 93.1% of readings fall within the three millimeter manufacturer specification of instrument precision.

In reality, random errors are introduced into the measurement process by the operator. Assuming that random errors by the operator introduce an additional one-millimeter of error into the readings, it follows that 96.3% of readings fall within the instrument specifications, and if two millimeters of random error are introduced, then 99.8% of readings fall within the instrument specifications.

The most significant random error to be mindful of is "pointing" error, whereby the laser beam is reflected from different points on the second target during successive readings. Other random errors may be introduced into the readings when the laser-distometer is not snugly fitted into the cradle, or when excessive dust within the tunnel causes refraction of the laser beam.

The laser-distometer has met the requirements for deformation monitoring at the East Side Access Project, and has proven to be a viable alternative to the tape extensometer. Under ideal conditions, it is possible that the tape extensometer may yield deformation readings of higher precision, however this comes at a considerably higher cost, both in material and labor. Where project-specified limits of movement allow for the substitution of a laser-distometer for the tape extensometer, the option should be seriously considered.

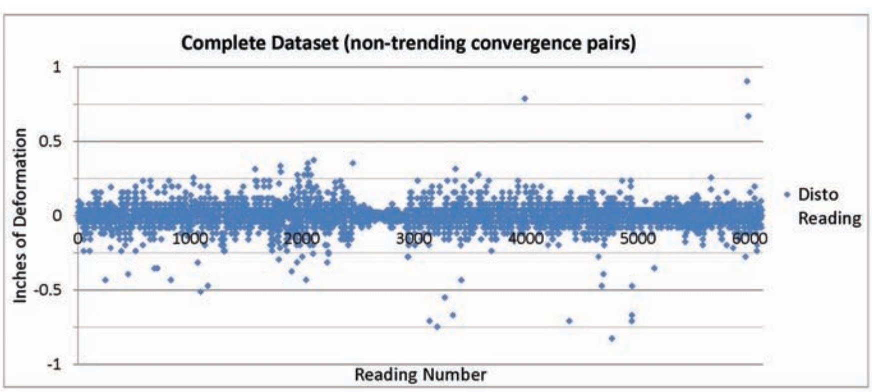


Figure 4. Laser- distometer dataset.

Chris Fagan

Geocomp Engineering, 139 Fulton Street, Suite 917, New York, NY 10038.

Tel: 646-831-8941.
email: cfagan@geocomp.com.

Charlie Daugherty

Parsons Brinckerhoff, One Penn Plaza, New York, NY 10119.

Tel: 212-465-5451,
email: daugherty@pbworld.com.

Commercial sources:

Leica Geosystems – laser-distance meters http://www.leica-geosystems.com/en/Which-DISTO-is-the-right-one_102657.htm

Leica Disto A3 (used for monitoring at East Side Access described in this article) http://www.leicadisto.co.uk/products/disto_a3.html

Trimble – laser-distance meter http://www.trimble.com/construction-tools/qm95-quick-measure.aspx?dtID=features

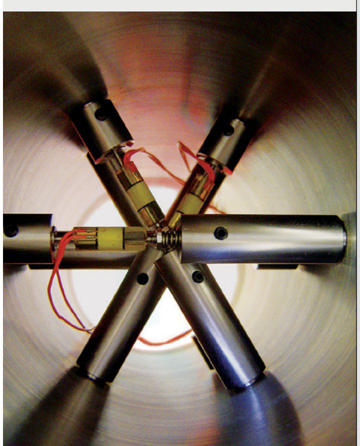
Tape Extensometer

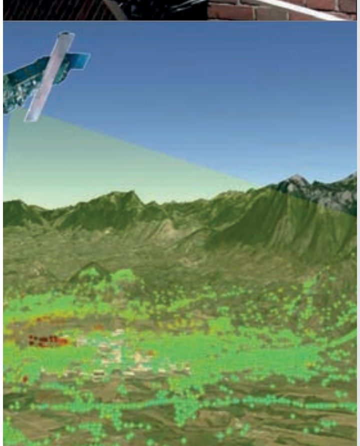
Slope Indicator - http://www.slopeindicator.com/instruments/ext-tape.html

Geokon - http://www.geokon.com/tape extensometers/

ITMSoil - http://usa.itmsoil.com/pages/digital+tape+extensometer

RST - http://www.rstinstruments.com/Tape%20Extensometer.html





International Course on

Geotechnical and Structural Monitoring

June 4-6, 2014

"Castle of Poppi", Tuscany (Italy)

Course Director: **John Dunnicliff**, Consulting Engineer

Organizer: **Paolo Mazzanti**, NHAZCA S.r.l.

NEW COURSE: This annual course in Italy replaces the long-standing series of continuing education courses in Florida. The format will be similar to the Florida courses, but with the addition of **substantial content on remote methods for monitoring deformation**.

COURSE EMPHASIS: **is on why and how to monitor field performance.** The course will include planning monitoring programs, hardware and software, recent developments such as web-based and wireless monitoring, remote methods for monitoring deformation, offshore monitoring, case histories, and lessons learned. Online sources will be included, together with an open forum for questions and discussion.

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**.

OBJECTIVE: to learn the who, why and how of successful geotechnical and structural monitoring while networking and sharing best practices with others in the geotechnical and structural monitoring community.

INSTRUCTION: **provided by leaders of the geotechnical and structural monitoring community**, representing users, manufacturers, designers and people of academia from Italy, England, Australia, France, Germany, Norway, Switzerland and USA.

WHERE: the 3-day course will be held in Poppi (Tuscany, Italy), in the main room of a 13th century castle (www.castellodipoppi.com). Poppi is in the countryside of Tuscany, near the city of Florence. **Dedicated transportation to Poppi from Florence main train station and city airport will be available**.

www.geotechnicalmonitoring.com

Tailings and Mine Waste '13 Conference Returns to the Canadian Rocky Mountains

Nicholas Beier, Vivian Giang and Ward Wilson


Conference participants at the banquet reception.


A retired RCMP officer greets conference attendees at the ice breaker (Photo courtesy of Jen Stogowski Photography).

Between November 3 and 6, 2013, over 385 mine waste managers, engineers, regulators and researchers gathered at the Banff Springs Hotel in Banff, Alberta, for the 17th International Conference on Tailings and Mine Waste. The University of Alberta Geotechnical Centre and Oil Sands Tailings Research Facility (OSTRF) hosted the conference, which provided attendees an opportunity to discuss the latest developments in tailings and mine waste management.

The University of Alberta is one of three hosting universities for this conference, which began in 1978 at Colorado State University. Participants from Canada, the USA and abroad presented new ideas and made professional contacts with others who have mutual interests and goals. Exhibitors were also present at the conference to showcase their technologies and services.

This year, two keynote presentations were made by Dr. Angela Küpper and Dr. Michel Aubertin. Dr. Küpper presented a de-licensing framework for oil sands tailings dams. The framework is based on a performance and risk-based approach and aims to take oil sands tailings dams to a stage at which they are considered solid mine waste structures and not dams. Dr. Aubertin spoke on "Mine Waste Management @ RIME" and presented the work that had led to the establishment of the Research Institute on Mines and the Environment (RIME UQAT-Polytechnique) in April 2013.

Special to this year's conference was an unprecedented industry presentation session by member companies of Canada's Oil Sands Innovation Alliance Tailings Environment Priority Area (COSIA Tailings EPA). As of 2011, over 850 million cubic meters of mature fine tailings are being stored in massive tailings ponds that are viewed as a significant environmental risk. This moderated panel presentation provided the most recent developments in oil sands tailings and management and how industry is responding to these major challenges.

With 18 sessions over three days, the presentations covered an array of topics related to the engineering and management of tailings and mine waste, including case histories; the design, operation and disposal of mine waste; geotechnical considerations; mine waste/tailings modeling; liners, covers and barriers for waste control; acid mine drainage; reclamation and remediation of mine impacted sites; oil sands issues; surface water and groundwater management and geochemistry; and policies, procedures and public safety. The conference proceedings are composed of 64 technical papers, and presentations are available for download (see *www.ostrf.com/seminars*). Videos of select presentations are also available for viewing on the website.

The OSTRF would like to thank ConeTec, BGC Engineering, DuPont, O'Kane Consultants Inc., WorleyParsons, COSIA, OSRIN, Norwest Corporation, MWH Global and Robertson GeoConsultants Inc. for their invaluable sponsorship of the conference. The next Tailings and Mine Waste Conference will be held in Keystone, Colorado, October 4-8, 2014.

Heroic engineering feat honoured on Canada's new $10 polymer bill

On November 7, 2013, the Bank of Canada released the last of its new polymer bank notes in a series of events across the country. The events commemorated National Railway Day, which marks the hammering of the last spike that completed Canada's first transcontinental railroad on November 7, 1885. This significant work united Canada as a country and began a new chapter in building the nation. Fittingly, the new $10 bill features a train traversing through Canada's iconic Rocky Mountains in tribute to this heroic engineering feat.

Dr. Michael Hendry of the University of Alberta Geotechnical Centre unveiled the $10 bill at the Bank of Canada's Prairies regional event. Tyler Vreeling and Benjamin Oswald of Back42 created a special sculpture made of railway spikes to present the $10 polymer bill. To view photos of the event, visit *www.carrl.ca/news.*

"For Canada to continue to grow and prosper, it is critical that the railway transportation system evolve to become more innovative, more efficient and more resilient to our harsh and changing environment," said Hendry in his speech. Hendry is involved in two of Canada's leading rail research programs: he is the Associate Director of the Canadian Rail Research Laboratory (CaRRL) and a research theme lead for the Railway Ground Hazard Research Program (RGHRP).

CaRRL and the RGHRP facilitate innovative research for the transport sector and create opportunities for the development of skilled workers and researchers for Canada's railway industry. For more information about the research being conducted through the CaRRL and RGHRP programs, visit *www.carrl.ca.*

New Golder Associates scholarship at the University of Alberta encourages research in mine closure

Les Sawatsky, Elena Zabolotnii and Ward Wilson.

On November 5, 2013, the University of Alberta Geotechnical Centre announced the establishment of the Golder Associates Mine Closure Graduate Scholarship. Golder Associates Principal and Director of Engineering Les Sawatsky presented the inaugural award to Elena Zabolotnii at the Tailings and Mine Waste Conference banquet. "I am honoured to receive this scholarship. The support Golder Associates is providing to young engineers to pursue further education is a true hallmark of an industry leader," said Zabolotnii as she accepted the award.

Speaking for Golder Associates, Les Sawatsky described the origin of the award, namely the very successful International Mine Closure Conference held at Lake Louise in 2011 that generated a large profit due to excellent endorsement by 600 attendees and generous donations by the oil sands industry and suppliers. Les says that Golder Associates is delighted to promote sustainable mine closure by sponsoring this award on behalf of the industry that supported Mine Closure 2011.

Golder Associates Ltd. donated $86,000 to create the scholarship, which will be given annually to an outstanding student pursuing graduate research in the field of geotechnical engineering specializing in mine closure.

Dewatering a large excavation with well points Consequences of a poor assessment of split spoon samples

Robert P. Chapuis

During my career first as a consultant, and then as a professor, I have had the privilege to be an expert in several cases. This is the third legacy case that I have presented in Geotechnical News. Over the past few years, I have asked for authorization to publish scientific issues on selected old (over 20 years) but still interesting cases. Having no authorization to publish is unfortunate for professional knowledge. The owners and their current legal counsels have given authorization, but with the request that all names and legal issues be kept confidential. In addition, no photographs can be published, which would enable identification of a site or person. The actual year cannot be given.

Context

This case is about a large excavation which was planned to be dewatered using a wellpoint system, in order to ensure stable working conditions at its base. Wellpoints are small diameter shallow wells of about 2 inch (51 mm) diameter, with short screens, 50 to 90 cm long. They are driven vertically and jetted, using high–pressure water, into pervious or semi–pervious soils. The hole around the wellpoint is filled with filter sand to catch all seepage in successive layers, and convey all water to the screen. Wellpoints are closely spaced (0.6 to 3 m) along the edge of an excavation. Each group of 50 to 80 wellpoints is connected to a header main and pumped by a high–efficiency vacuum dewatering pump. In practice, due to head losses in the ground, screen, pipes, connections, and flow rate limitations within the vacuum pump, the drawdown achieved by a row of wellpoints is limited to 5 m.

Consider an excavation that must reach a depth of 14 m below the water table. A first series of wellpoints would be driven from the bottom of a first excavation levelled just above the water table. After having excavated the first 5 m of soil and having lowered the water table by 5 m (to have a dry bottom), a second series would be installed 5 m deeper. Finally, a third series would be installed at a depth of 10 m to carry on the dewatering and complete the excavation down to 14 m, before building a reinforced concrete raft or shallow foundations. A wellpoint system means that the excavation sides are made of soil sloping at an angle usually between 1.2H/1V and 2H/1V. Therefore, the excavation occupies a large surface, which is acceptable only in open fields, not in already heavily constructed sites.

Till investigation

The site of this case history is far from any developed areas. The natural ground was roughly horizontal and covered with a moist organic layer 0.4 to 0.9 m thick. The investigation included several boreholes, which used diamond drilling and a flush–joint casing, with lateral or upwards clean water jets as washing fluid for the cored sediments. A split spoon was used to take soil samples at intervals of 1.5 m (5 feet). Split spoons are known to provide class–4 soil samples in any geotechnical classification, but not intact samples as sometimes found in geological papers. The contactor had to excavate 4.5 m deep in a very thick grey till layer (silty sand and gravel, no plasticity) with a few thin and yellowish sand–and–gravel layers.

The call–for–tender documents included the full geotechnical report, with borehole logs, sample grain size distributions and a cross–section of the area to be excavated, obtained using interpolation between boreholes. The contractor was requested to provide a stable excavation with a dry and solid bottom. The geotechnical report issued warnings for the need to control the surface water, and to control seepage in the sand–and–gravel layers, which could be achieved, for example, with a wellpoint system.

Field work and observations

The contractor removed and put aside the organic top layer, and then drained the site surface with peripheral ditches and sump pumps. Next, high–pressure jetting was used to install a few hundred wellpoints along the edge of the planned excavation. The vacuum dewatering system then started pumping. During the first few hours, the flowrate decreased from about 200 L/min (40 gpm) to only a few L/min, and stayed low over the following weeks. The excavation easily progressed in the till, which contained only a few boulders. The excavated slopes were stable and only little water was seeping from the till upper portion, which had been altered (in past centuries) and given some secondary porosity by frost action (fissures) and biological action (roots and burrows).

Only one sand–and–gravel layer was found which was clearly visible as a sinuous yellow seam within a grey till. The yellow ribbon-like layer was in a horizontal plane about 2 m below the top of the till layer. The ribbon was 2–3 m wide and 30 cm thick in its middle. The sand–and–gravel thickness decreased toward the ribbon edges. When plotted on a map, this unique sand–and–gravel seam was located between the boreholes, which could not have detected it. The boreholes had detected a few thin yellowish sand–and–gravel layers, but only one was found in the excavation. This single layer conveyed little water, which was easily controlled.

The owner and the contractor thought that a lot of time and money had been spent on the wellpoint system, whereas such a system was not required for this excavation. At this time, I was hired as an external expert, to examine the data and to try to uncover what happened.

I visited the site, took soil samples and photographed the yellow ribbon-like layer. This was a puzzling case. To better document the case, I asked to see the handwritten field reports by the drilling inspector. The engineer had a copy at the construction site. The field reports were very detailed, and provided very useful information.The drilling reports described the casing progression, as well as the washing and sampling operations. All split-spoon samples had a high recovery. At all times, the upper portion of the sample, 7 to 12 cm high, was a yellowish sand–and–gravel, whereas its lower portion was a grey till. The upper and lower portions of the sample were kept and analyzed separately. Each sand–and–gravel sample appeared as a thin aquifer layer within an aquitard till. Because the ground surface was nearly horizontal, and samples were taken at similar depths in each borehole, all yellowish sand–and–gravel layers were found at similar elevations in all boreholes. The engineer thought that there could be continuous thin aquifer layers, as shown by interpolation dotted lines in the cross–section of the geotechnical report. The presence of aquifer layers was also the reason why the engineer believed that there was a risk of significant water inflow into the excavation, and a need to control the water by using a wellpoint system.

All needed information was there. I announced that it was time to explain what had happened. Our small group including employees of the owner, engineer and contractor, returned to the excavation. There, I took a grey till sample of about one kilogram, and put it in a plastic bag. Then I brought the sample to the outlet of the wellpoint system, where a little clear water was discharging into a ditch connected to surface water. I used the clean water to wash the till in the plastic bag, letting the fines escape from the bag. To everyone's surprise, the grey till turned into a yellow sand–and–gravel. Everybody suddenly realized what had happened. What had been interpreted as a thin aquifer layer was simply the result of locally and partially washing the till during the drilling operations, before taking a split–spoon sample.

Conclusion

As a technical expert, and as usual, I was not involved in the out–of–court settlement. All parties had understood the situation, and they did not need me anymore for legal and financial considerations. However, because the case never went public, many professionals were kept unaware of this problem and its simple cause from soil washing. This negative aspect of the confidentiality rules works against the Professional Order's and the Corporation's mandate to protect the public, and is unfortunate for the engineering profession.

However, this case was useful for my research. It revealed, for example, that damage and erosion due to drilling operations must be taken into account. It also motivated further research on hydraulic short-circuits along the well casings (Chapuis and Sabourin 1989; Chesnaux et al. 2006) and their influence during slug tests (Chapuis 2001) and pumping tests (Chapuis and Chenaf 1998).

References

Chapuis, R.P. 2001. Extracting piezometric level and hydraulic conductivity from tests in driven flush–joint casings. Geotechnical Testing Journal, 24(2): 209–219.

Chapuis, RP, and Chenaf, D. 1998. Detecting a hydraulic short–circuit along a monitoring well with the recovery curve of a pumping test in a confined aquifer: method and example. Canadian Geotechnical Journal, 35(5): 790–800.

Chesnaux, R., Chapuis, RP, and Molson, J.W. 2006. A new method to characterize hydraulic short–circuits in defective borehole seals. Ground Water, 44(5): 676–681.

Chapuis, R.P. and Sabourin, L. 1989. Effects of installation of piezometers and wells on ground water characteristics and measurements. Canadian Geotechnical Journal, 26(4): 604–613.

Paolo Gazzarrini

Overture

34th episode of the Grout Line and, as usual for this time of the year, a reminder, for those of you who are interested in the 35th (one edition more than the Grout Line, but with annual frequency) Grouting Fundamentals & Current Practice to be held at the Colorado School of Mines from June 16 to June 20, 2014.

The figure above summarizes who should attend and for more information about the complete schedule and instructors, please visit the web site *http://csmspace/events/grouting*. Notice the unique half day field demonstration of grouting techniques and grouting products.

In addition to the above reminder, for this edition of the Grout line, I have a Nordic (Swedish-Norwegian) grouting article, mainly for grouting in rock in tunnels. In the proceeding of the 7th Nordic Grouting Symposium organized by BeFo (Stiftelsen Bergteknisk Forskning or- in English- Rock Engineering Research Foundation- *www.befoonline.org*) held in Gothenburg (Sweden) on November 13, 2013, I found the following article that can be of some interest to North American grouters.

I have authorization to re-publish the article from BeFo and I would like to thank Eva Friedman, from BeFo, in helping me to make this happen.

The authors are Eivind Grøv - Chief Scientist SINTEF and Professor II University of Science and Technology in Trondheim (NTNU), Norway, *eivind.grov@sintef.no*,
Johan Funehag- Assistant Professor, Chalmers University of Technology; Gothenburg; Sweden, *Johan.Funehag@chalmers.se*, and
Thomas Janson- PhD rock mechanics, Tyréns, Gothenburg, Sweden *Thomas.Janson@tyrens.se*

Rock mass grouting in Sweden and Norway A matter of cultural differences or factual causes?

Eivind Grøv, Johan Funehag, Thomas Janson

Introduction

Rock mass grouting has become an important aspect in tunneling and underground excavation, particularly whilst executing such work in urban areas with a highly developed surface infrastructure and also in areas which due to various reasons are sensitive to fluctuations in ground water levels. The public focus on tunneling work has increased during the last decades, not only project cost and schedules are scrutinized carefully, but also the consequences caused by ground water lowering on the surroundings such as flora and fauna, building settlements etc.

There is a difference in philosophy around in the tunneling industry; some scholars prefer high pressure grouting whilst others prefer lower pressure. One school using high pressure one can say that the design is in a simplified way a similar process as when determining the minimum stress component by doing hydraulic fracturing of the rock mass, thus creating a new crack in virgin material, or by jacking existing ones. By high pressure means here such as 100 bars or more and by low means static water pressure plus a compensation of 1-10 bars. Is there any explicit description on what pressure is the correct to be applied in any given circumstances; Can it be that several different techniques, such as different pressures can be applied giving the same predetermined outcome? Would it be a matter of functional requirements as a result of the grouting efforts? Or is it simply governed by a number of other aspects that are culturally based?

The primary objective is to make the tunnel tight enough for its purpose. In addition this article will include two more objectives to have in mind when planning and executing rock mass grouting; namely that grouting is all about water control - not water proofing, with the focus on prevention rather than cure suggesting pre-excavation grouting being preferred to post-grouting. This paper discusses the differences between the grouting strategies in Sweden and Norway aiming at concluding whether these are fundamentals of cultural differences, contractual practices, and construction methods or have any other factual causes.

Background

Grouting pressure in Sweden - development

From the early 1900s until the 1970s a comprehensive expansion of dams and hydroelectric power projects was carried out in Sweden. In these projects, sealing of the rock mass was normally done by cement grouting. The results of the grouting was controlled by Lugeon measurements in control hole that would achieve a certain tightness, normally 0.1 to 0.3 Lugeon.Traditionally for these grouting works, grouting was performed with low pressure, i.e. 5-15 Bar in overpressure, and a long grouting time (Vattenfall, 1968). In connection with the urban tunnel expansions in the 1970s and 80's, with low rock overburden and requirements of the groundwater levels, rules of thumb was developed and experience based knowledge for grouting techniques. A common rule of thumb was that the overpressure would be about half the rock cover but with a maximum of 20 bars in overpressure.

During the 90's, the development of theoretical consideration started of the applied pressure and its cases to the bedrock and grouting effect. Different criteria for how large pressures should be applied were presented and some conclusions were that is all depended on the stress situation and rock quality. Further, field tests were made using higher pressures in some tunnels in Sweden. The experiences showed that this was not beneficial to the sealing effect. A criterion that was developed for the maximum allowed grouting pressure, Δp, to avoid a global "jacking" or uplift, ie:

$$\Delta p = 3\rho_{rock} g d_{rock} - 2\rho_{water}$$

Where ρ_{rock} is the density of rock, g is earth acceleration, d_{rock} is the depth of the overburden rock mass and p_{water} is the ground water pressure. Typically for a tunnel in granite (ρ=2650 kg/m^3) at 100 m depth and a ground water pressure of 80 meters the maximum overpressure is around 60 bars. There is another rule of thumb saying that the maximum overpressure is 3 times the vertical stress. With the same parameters as above gives a maximum overpressure of some 80 bars. Research studies started in the 2000s to show how the fractures behave during high pressures. Issues which were highlighted in the surrounding rock and fractures were the deformations, blocking of the grout spreading, stiffness changes and follows a progressive process. The recommendation was to control the pressure in real time, ie not to a fixed pressure criterion.

In Sweden today, the determination of the pressure is usually based on the traditional rules of thumb and sometimes on the criteria to avoid "jacking'', ie, the pressure varies substantially depending on the own experience. With current research on grouting, the focus is on the grout spread and the development follows the environmental principles such as not overdoing material consumption if one can handle a situation with less material applied.

Table 1.Typical grout pressure applied for Swedish infrastructure tunnels in urban areas

Rock cover	Max grout pressure in holes
0 – 5m	5-15 bar
5 – 15m	15-25bar
15 – 50 m	25-35bar

Grouting pressure in Norway - development

The use of high pressure grouting has shown to be effective in good rock mass conditions and in situations with rather impervious rock. It also requires knowledge of the minimum in-situ stress component, as this is considered an upper boundary of the grout pressure to avoid uncontrolled hydraulic jacking or splitting of the rock mass. The use of grouting pressure reaching as high as 100 bar has become quite common in conjunction with Ordinary Portland Cement (OPC). By utilizing micro fine cement (MC fulfilling Blaine size of not greater than 650 m²/kg) a more moderate grout pressure of 50 to 70 bars above actual water head may be applied. It requires that strict compliance to the stop criteria is executed throughout the work. In extreme cases hydraulic fracturing can be applied to improve the effectiveness of the grouting, which implies that the grouting is actually exceeding the minimum in-situ stress component. However, in poor rock mass conditions caution must be undertaken to avoid a too high grout pressure, which could cause a lengthy and consuming grout effort, and impose harm to the tunnel surroundings as injecting grout material into neighboring houses and road/railway bases in the close vicinity of the tunnel work. Today the typical specifications on grouting pressure in infrastructure tunnels requires as follows:

Table 2. Typical grout pressure applied for Norwegian infrastructure tunnels in urban areas

Rock cover	Max grout pressure in holes in roof & walls	Max grout pressure in invert holes
0 – 5m	20bar	30bar
5 – 15m	40bar	60bar
>15m	100bar	100bar

From this, one can see that already with a rock cover of only 15 m or more the pressure can be as high as 100 bars. It must be stated that there is no scientific appreciation of the acceptance of such high grout pressures, or the risks associated with it. As a comparison; at the end of the large hydroelectric power development in Norway, a typical grouting pressure in unlined headrace tunnels would be the internal water pressure plus 10 bar compensation. Though, the purpose of the grouting was to decrease the permeability to avoid water leakage

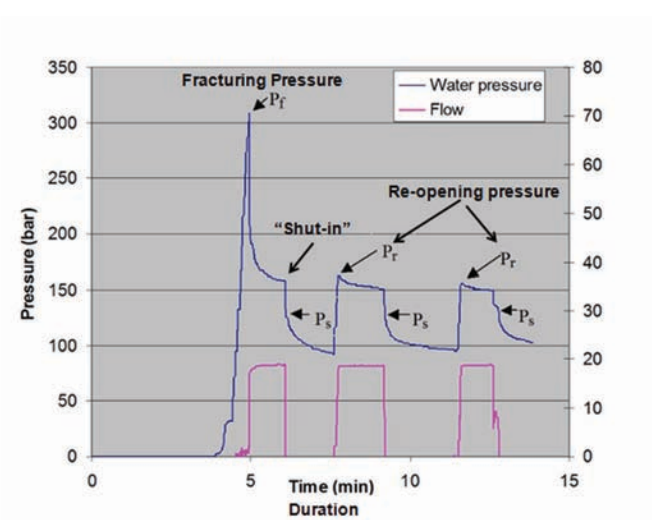


Figure 1. The principles of hydraulic splitting tests.

out from the water tunnels. Despite specific differences in the actual execution of rock mass grouting and stress measurements the principles are in general the same. An example on the typical execution of stress measurement with hydraulic splitting is shown in (Figure 1), where the closing pressure (P_S)represents the minimum stress component

In Norway, typical grout principles are presented in drawings attached to the tender and contract documents including trigger values for grout on demand. Further such drawings or specifications will include maximum inflow rates and the clients/contractor would agree on how to perform the works when it comes to execution. The contract provides specification to material as this is a remeasurement item. A typical trend in Norway over the last decades is an increased number of grout holes being employed for road and rail way tunnels in urban areas, or sections with strict requirements. In some cases as many as between 60 and 70 holes have been applied for such cross sections. Another trend that has been observed in Norwegian tunnelling over the last 5-10 years is that the introduction of micro-cement has not reached the popularity as would have been expected, rather it seems as the application of ordinary portland cement maintains to be the dominating cement type to be used. This might be attributed to the additional material cost of micro fine cement which is probably 3-5 times higher than OPC and the fact that owners do not materialise the savings in reduced time and quantities, improved setting control and grout stability being associated with microfine cement for grouting.

Even though the use of ordinary portland cement as the main grout mean implies a large quantity of cement to be used, in many cases the consumption of grout reaches several tens of tons and even more, occassions on above 100 tons have been experienced in single grout rounds before the planned sealing criteria is achieved. This is far more than would be required to establish a impermeable zone of rock surrouding the tunnel. And the time of performing such grouting is becoming extremly long when such high quantitites of cement is applied, this again leads in fact to an increased cost for the grouting works.

Norwegian grouting strategies compared to that applied in Sweden

Both (Garshol, 2002 & 2003) and (Grøv, 2008a) provide a description of Norwegian grouting practice, following the arrow. To the list below a second numbering is complemented to address the concept of the Swedish way, following the circle and italic fonts. The most important elements are shown in the table on pages 44 & 45.

The grouting procedure of two Scandinavian tunnels; the Bærum tunnel and Nygård tunnel, two forest tunnels, are compared in Table 3 (page 45). The Bærum tunnel consisted of cambrosilurian sedimentary slate, lime and sandstone with intrusive dikes. The Nygård tunnel mainly consists of gneiss, granitic gneiss with some amphibolite dykes. Further details on fracture degree and characteristic are not available on an overall perspective.

Methodology

To be able to compare different tunnels and applied grouting pressures distinctions must be made on characteristics of tunnels, grouting technique, equipment and somewhat the grouting materials used. If the main purpose is in all cases to have control of the

Norwegian grouting strategies	Same or not in Sweden
The contractual arrangements should promote risk sharing and co-operation between all parties for day-to-day decision making and provide for fair reimbursement of grouting efforts.	Contracts is a possible step for risk management.
Both the Owner and Contractor deploy skilled personnel on site to monitor and follow-up the grouting works to refine the grouting strategy as necessary on an iterative basis in response to accumulated experience.	An observational approach has been adopted for grouting for several years.
Groundwater inflow is controlled by pre-grouting the rock mass ahead of the face.	Same.
Unless the strategy is to conduct continuous, systematic grouting due to known adverse conditions, at least 4 probe holes are maintained ahead of the face to give advance information on hydrogeological conditions.	Pre-grouting is a standard way always adopted in normal infrastructural tunnels. No owner up to today wants to take risk of testing another way accept in research.
Grouting is carried out ahead of the face through a 360º fan of grout holes, usually no more than 25 m in length to limit the scope for drillhole deviation and un-grouted 'windows'.	Same.
Grouting intensity is varied by adjusting the number of grout holes in the fan and hence the spacing of the grout holes at the next planned overlapping packer position. The spacing is dependent on previous experience of performance, complexity of the hydrogeological conditions and the groundwater inflow rate criteria.	Seldom varied. It means often 3-4 m spacing and a packer mounted 1 m inside the borehole.
The aim is to achieve the required result in one round of grouting.	Same.
Control holes are drilled in the pre-grouted mass to gauge the success of the pre-grouting exercise.	Sometimes.
If seepage from the control holes indicates that the required inflow criteria are unlikely to be achieved, then the rock mass is treated by another round of grouting.	Sometimes.
The tunnel face is not progressed until it is determined that the required inflow criteria are likely to be achieved.	Possibly a follow up in a measuring weir after the project is done. After that a post-grouting campaign can be used.
Groundwater inflow criteria are usually given as rates of inflow measured over a distance which is meaningful to the potential far-field effects on the surrounding environment. Typical inflow criteria are usually expressed in L/min/length of probe hole or control hole arrays and L/min/100 m of tunnel length.	The inflow criteria per 100 m of tunnel length is a measure adopted for the tunnel project. The stipulations from the environmental courts is only is maximum drawdown and possibly a total flow out from tunnel.
A typical 'toolbox' of grout types may include: ▫ polyurethane grout for dealing with high inflows from probe holes or grout holes (Northcroft, 2006), ▫ OPC grout for infilling wide discontinuities, ▫ micro-cement grout injected under high pressure (typically at least 50 bar above the ambient groundwater pressure) to fill typical discontinuities and fine cracks, and ▫ colloidal silica grout to be used in the finest of fissures (Northcroft 2006; Bahadur et al., 2007).	A predetermined "Toolbox" of grouts for Sweden. Not well established, from project to project. Often depending on the experiences of the building leader at site. Quite common is that the design is changed from the original documents to a design decided on site.

Norwegian grouting strategies	Same or not in Sweden
Emphasis is on the injection of a limited number of stable, micro-cement grout mixes with a water:cement ratio ranging between 0.5 and 0.9 and containing additives to increase penetration and control stability, workability and gel time. The grout is mixed by a high-speed colloidal mixer.	Stable grouts, a water:cement ratio ranging between 0.8 and 1.0, are commonly being used today in Sweden.
Adequate and relevant use of 'stop criteria' in terms of the amount injected as well as the grouting pressure applied in order to optimise grouting efficiency and prevent the spread of 'wild' grout.	The stop criteria based on pressure is common. Limiting volume per borehole is always used. The time criteria have been used in shorter trial sections in some few tunnels so far. The testing is adapted for an eventual use in the progress of the tunnel. So far it seems promising.
Adaptations of the grouting pattern, grout mixes and injection procedures are carried out by a skilled grouting crew to best suit the conditions that are being encountered on a shift-by-shift basis.	A predetermined pattern based on prognosis are used and followed.
The adaptations are made in a systematic manner and remain loyal to the agreed grouting strategy and stop criteria. Therefore, the agreed strategy and criteria need to anticipate and accommodate a wide range of conditions at the outset. The strategy and criteria are then actively refined with due responsiveness to the actual experience being gained on site.	Similar in Sweden.
Records are maintained of the drilling and grouting details, engineering geological characteristics of the rock mass and groundwater inflows from probe holes, control holes and the excavated tunnel in order to provide a sound basis for subsequent decision making.	Same in Sweden.
Pre-grouting is preferred rather than post-grouting.	Same in Sweden.

Table 3. Comparison of two grouting procedures adopted in Norway (Bærum tunnel) and Sweden (Nygård tunnel).

	Bærum tunnel	**Nygård tunnel**
Excavation year	2010 Completion	2008 Completion
Tunnel cross-section	approx. 100sqm	approx. 125sqm
Circumference	approx. 42m	approx. 20 - 50 m
Rock quality	Shale, schist and limestone, mixed with volcanic intrusions	"normally Swedish rock", i.e. gneiss of granitic composition, RQD between 75 – 90, 2 joint sets plus irregular joints and a number of small weakness zones
Number of holes	63 holes in the crown + 10 holes in the face, giving a total of 73 holes	50 holes in the crown and zero in the face
Hole spacing at start	0.67 metres	1.5 m in the roof and 2.0 in the walls and bottom
Cover length	23.5 metres	24 meters
Overlap between fans	approx. 8 metres	6 meters
Stipulated inflow criterion	4 litre/minute and 100 metres	2 - 5 litre/minute and 100 metres

water yields a synthesis of what has been accomplished regarding the "tightness" of tunnels.

The geology may affect significantly the performance and results of a grouting scheme, therefore a brief overview of the Norwegian and Swedish geological conditions will be provided.

Norway and Sweden forms part of a Precambrian shield and are considered typical 'Hard Rock' environment with respect to tunnelling. In Norway, approximately two thirds of the country is covered by Precambrian rocks (older than 545 million years), and for Sweden the figure is some 9/10. The most common rock type of these old rocks is the gneiss, other rock types from this era are granite, gabbro and quartzite. The oldest rocks is found in the north east part in Sweden where the rocks are 2,6 billion years or older, whilst in Norway the oldest rock is found along the west coast. The younger rocks that are formed by an over thrust where older sediments are metamorphosed and now overlaying the Precambrian rocks. This mountain ridge is called the Caledonian mountains and found in hilly areas in west of Sweden and covering almost one third of Norway, particularly in Mid-Norway. The rock types are mostly shale, gneiss and schist with varying degree of metamorphose. In the outer rim of the mountain in Sweden the Precambrian rocks are found but with a high degree of metamorphose. The youngest rocks found are sedimentary rocks, with almost no metamorphose, has an age younger than 500 million year. These are found in southern parts of Sweden, the island Öland and Gotland around the Lake Vättern and Siljan. The rock types are mainly shale and limestone. A similar province is found in the Oslo region but with an extra touch of magmatic intrusive which make the Oslo region a rather complicated geological province both with respect to the number of types of rocks and to large deformation zones due to the intrusions.

The Precambrian shield as whole is heavily fractured due to the long period of geological and tectonic events. The rock mass is also severely cut by various types and generations of discontinuities, from cracks and joints to zones containing totally disintegrated material. It is common that at least three main fracture sets are found when mapping and not seldom even four and up to totally crushed material can be found. Through a stretch of some 100 meters it is common to find at least a few larger fracture zones, sometimes with clay fillings making the progress of a tunnel difficult, both mechanically and hydrogeologically. One positive thing is though that, at present, the province is tectonically stable for all practical aspects related to tunnelling work.

The rock mass is consequently a very typical jointed aquifer where water occurs along the most permeable discontinuities and with a high ground water level tunnelling works are normally taking place in saturated conditions with the risk of disturbing the ground water balance imposing consequential damages.

Characteristics of tunnels

To compare different grouting concepts with focus on pressure one has to have in mind that there are different groundwater pressures acting in the rock. When grouting towards a high groundwater pressure one must apply a high total grouting pressure. The total pressure, P_t (the one set on the pump) is then the sum of the overpressure, ΔP and the ground water pressure, P_w. Besides the ground water pressure the rock stresses are essential.

The overall principle for any type of underground project should be based on the environmental consideration like the best available technology and minimize resources in every step of building process. This can be narrowed down to use the most environmental friendly grout and use as little as possible but still seals the tunnel. To summarize the chain of events using high pressure is something like this; with opening of fractures, if it happens, increase the amount of grout and increases the time to reach a stop pressure. Time is one of the most costly ingredients in grouting works in Sweden which coincides well with the conditions in Norway. From this point of view the "problem" lies in much spent resources. The more evident factors could be that grout enters the surface with pollution effects as a consequence or a heave of the ground with uplift of building or infrastructure as a risk. Both the vertical and horizontal stress governs if the fractures will open and potentially cause a stress problem in the tunnel or not. If both stresses are high, one can apply

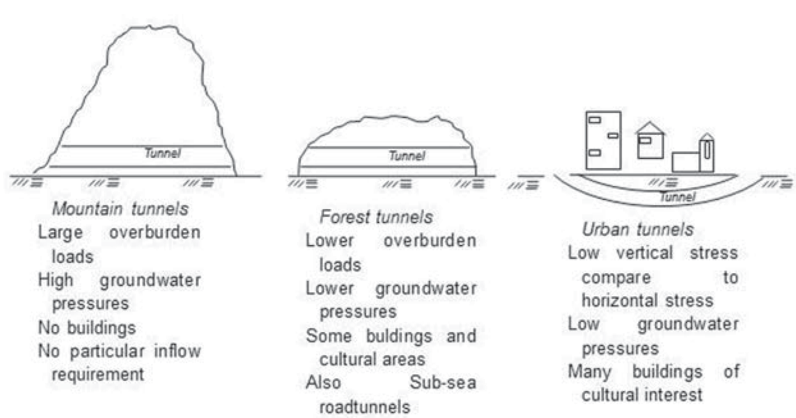


Figure 2. Schematic drawing of the three main types of tunnels.

high grout pressure without the risk that any opening of fractures occurs, the opposite also applies. With a high vertical stress and low horizontal stress, perpendicular fractures towards the tunnel will have higher potential of opening up. A categorization of tunnels is made to compare the applied ground water pressures, see Figure 2.

Mountain tunnels. Often a high vertical stress confining any horizontal fracture planes but opens fracture sets vertical to the tunnel drift. The horizontal stress can be lower than the vertical one which opens up fractures parallel to the tunnel. High overburden of rock minimizes the risk for spreading of grout to the surface. *Forest tunnels and sub-sea tunnels*. Drainage of wet areas is often a risk. Lower in-situ rock stresses increases the risk of opening the fractures during grouting producing a larger spread of grout. Risk for grout to enter the wet areas or streams.

Urban tunnels. Have low vertical stresses in-situ and often relatively high horizontal stresses. The low vertical stress produces the risk of uplifting. The high in-situ horizontal stress confines parallel fractures with the tunnel with obvious risk for spreading grout to the surface. Strict demands on water ingress.

The targeted ingress to tunnels will govern the grouting procedure. A strict demand requires often a more thorough design on grouting, where not so strict demands requires often only a drill pattern with a the type of grout and a borehole layout. Below follows a list of how the targets can be set.

Commonly used figures in Norwegian tunnels for typical Limit Residual Inflow Rate (LRIR):

- 2 – 10 liters/minute/100m of tunnel length – Urban tunnels in sensitive areas
- 10 – 30 liters/minute/100m of tunnel length– Subsea/Forest tunnels
- > 30 liters/minute/100m of tunnel length– Mountain tunnels with no specific requirements

The same differentiating for Swedish tunnels would look like:

- 0.5-2 liters/minute/ 100m of tunnel length- Urban tunnels
- 2-10 liters/minute/ 100m of tunnel length- Forest tunnels
- About 10 liters/minute/ 100m of tunnel length- Mountain tunnels. NB! not common for Swedish tunnels

From the comparison we can see that the stipulations on water ingress in tunnels vary quite a bit across the border between Norway and Sweden. This can be due to the historic experiences described earlier where focus in Sweden has been on grouting research whilst in Norway the empirical approach has governed. And the research in itself can attract discussions and focus to the projects with more demands and requirements as a consequence.

These LRIR-values are determined based on investigating the sensitivity of surface structures and habitats (biotypes) on ground water lowering. The LRIR value may vary from one section of a tunnel to the next, pending on the sensitivity of identified structures or habitats on the surface above the tunnel. It must be noted that LRIR is not the key element in rock mass grouting whilst tunneling the key issue is how sensitive surface structures and habitats are to ground water lowering. The LRIR-value is just a way to indirectly measure such sensitivity through an assessed impact on the ground water in conjunction with the inflow rate to the tunnel. A possible scenario would be that that no impact occurs on surface even in situations with an increased inflow to the tunnel, and in such case the LRIR must be revised.

In urban tunnels with a low specified LRIR a systematically pre-grouting regime should be applied to secure a desired result. As a rule of thumb in Norway:

- 2 – 15 liters/minute/100m => systematic pre-grouting
- > 15 liters/minute/100m => pre-grouting initiated by measured water inflow in probe holes

In Sweden are all urban tunnels done with systematic pre-grouting and the requirements are < 10 liters/minute/100m.

A summary of pressure and stipulated ingress of water into tunnel from different tunnels in Sweden and Norway is found in the tables below (table 4, table 5 and table 6) below. The summary below is divided as much as possible to the three types of characteristics of the tunnel. The focus is on the grout pressures and the stipulated ingress requirements. The values in table below are “mainly”, i.e. some sections in the present project could have other values.

Table 4. Mountain Tunnels

Project	Depth (m)	Final pressure (MPa)	Stipulated ingress
Äspö, TASS, Sweden	450	10	1 l/min/100 m
Äspö TASP, Sweden	420	8	25 l/min/100 m
Namntall, Sweden	100	5.5	12 l/min/100 m
Bragernes, Norway	100	9	8-30 l/min/100 m
Lunner, Norway	130	5	4-20 l/min/100 m

Table 5. Forest Tunnels			
Project	**Depth (m)**	**Final pressure (MPa)**	**Stipulated ingress**
Törnskogstunneln, Sweden	35	2.5	3 l/min/100 m
Kattleberg, Sweden	50	3	8 l/min/100 m
Björnböle, Sweden	60	5	7 l/min/100 m
Nygårdstunneln, Sweden	60	3	5 l/min/100 m
Baneheia, Norwegian	40	8	1.7 l/min/100 m
Bærum tunnel. Norway	Vary	10	2 l/min/100 m

Table 6. Urban Tunnels			
Project	**Depth (m)**	**Final pressure (MPa)**	**Stipulated ingress**
Götatunneln; Sweden	40	3.5	0.7 l/min/100 m
Arbetstunnel Citybanan, Sweden	35	2.5	7 l/min/100 m
Norra Länken, Sweden	30	3.5	4.5 l/min/100 m
Lundbytunneln, Sweden	15	2.5	2.5 l/min/100 m
Tåsentunneln, Norway	15	3.5	13 l/min/100 m
Svartdaltunne, Norway	10	2	<5 l/min/100 m
Storhaugtunneln, Norway	15	5	1.6 1/min/100 m

Contractual differences and experiences

Underground project is generally related to uncertainties, which a large extent due to uncertainties in the geological and hydrogeological conditions. Especially grouting, it is difficult to predict how the work should be carried out to a certain result will achieved. This involves difficulties in the preparation of tender documents and provides a reasonable distribution of risks (Brantberger, 2009).

Water inflow and related pre-grouting works required to avoid settlements and ground water draw down in the vicinity of the tunnel is heavily influencing the project cost and schedule. Ignoring this fact and leaving these issues as contractor risk and design responsibility compensating water inflow control as Lump Sum is the ultimate way to cause program delay and post project claims and disputes.

The regulation of the grouting works, in Sweden, is normally done for the amounts of the different steps in the grouting process such as number of drilling holes, number of probing, establishment the equipment, cement take and so on. The time of the grouting is normally not regulated. Since grouting time is not regulated and the grouting work affects other tunneling jobs, the grouting process will become a time critical part of the tunneling works.

The project owner needs to be directly involved in control of water inflow and costs associated with the efforts to achieve the specified LRIR and also draw on the experiences of the contractor and the consultant. The only way this can be secured is by employing resources with relevant experience with Project Specifications for pre-grouting and install a cooperation enabling decision taking at the tunnel face. The PS shall define inflow requirements for the different sections in the tunnel. Drilling and grouting equipment capacities and minimum performance requirements shall be defined in the PS as well as intended material to be applied.

The two main differences between Sweden and Norway regarding the contracts are:

- Reimbursement by the amount of pumped cement, normal in Sweden
- Reimbursement by the hour and the amount of pumped cement, normal in Norway (Brantberger, 2009)

Trials have been conducted in Sweden to get grouting contracts being paid by the hour. One successful test was for a 100 m long tunnel stretch in Törnskog tunnel. The contract was of type partnering contract where the savings in doing a better solution compared to the standard method could be shared by the contractor and the client.
The test was implanted with recent research on grouting and became a success (Brantberger, 2009). Another trial that was abandoned at the desktop was where the efficient grouting time was introduced. The contractor should only get reimburse for the predetermined time per borehole spent on grouting, not including borehole filling

and the time spent on grouting after the stipulated time. Not even unfilled boreholes should be reimbursed for. The risks were too high and it was never conducted.

The most efficient way for the engineer and owner according to Scandinavian experience is to secure control with performance and cost related to pre-grouting is to obtain qualified estimates in the Bill of Quantity at the tender stage and to re-measure all grouting related activities during tunnelling excavation. Such conditions need to be reflected in the construction contract. A guideline for compensation units would be as follows:

- Probe drilling ahead of tunnel face – re-measured and reimbursed by drill meter
- Drilling for grouting – re-measured and reimbursed by drill meter
- Grout packers - re-measured and reimbursed by piece
- Grout materials – re-measured and reimbursed by kg for all materials
- Grouting time – re-measured and reimbursed by hours used for grouting

To compensate for actual consumption of time and materials for grouting may sound risky for many project owners. However, specifying minimum capacities on machinery and by setting minimum contractual production rates the owner has tools making him capable to control volume and cost of pre-grouting works. Experience from Norwegian view is as follows:

- Design before contract, details to be decided during the tunneling progress
- The amount of cement governs the sealing effect
- Opening of fractures is seen as a risk but could improve the grouting works
- Experience from Swedish point of view is:
- Design before contract, not always
- The amount of boreholes and type of grout governs the sealing effect
- Opening of fractures often seen as negative and as a risk

Discussion and conclusions

Sealing effect and tight enough?

The penetration length is directly proportional to the applied pressure, the fracture aperture and inversely proportional to the viscosity and yield strength. A doubled pressure will increase the penetration length to the double. In Figure 3 below the penetration length is calculated using the equations in (Gustafson and Stille, 2005) where the grouting time is incorporated to determine the penetration length. In the example the over pressures are 4 and 8 MPa respectively, the yield stress are 3 Pa and viscosity= 0.025 mPas. The fracture aperture is set to 120 µm.

For infinite time the final penetration for a pressure of 4 and 8 MPa are 80 and 160 m, respectively. For 30 minutes of grouting the difference is 9 and 18 m, respectively. We can see that the penetration length is long and fast for the first 3 minutes and after that gradually slows down.

Both the tightness (transmissivity) and the extent (thickness) of the sealed zone influence the ingress to a tunnel. For instance, a very tight sealed zone with a low extent is comparable with a large zone with less "tightness".

From the figure below (Figure 4) one can see that the reduction of ingress to the tunnel is strongly correlated to the thickness of the sealed zone for sealing factors of 50 or more. This means that if the grouting can be done, assuring that the transmissivity of the rock mass is lowered by at least a factor of 50, the thickness of the sealed zone can be used for prognosis of the ingress. The thickness can be interpreted to a grout spread, large grout spread mean a larger thickness of the sealed zone.

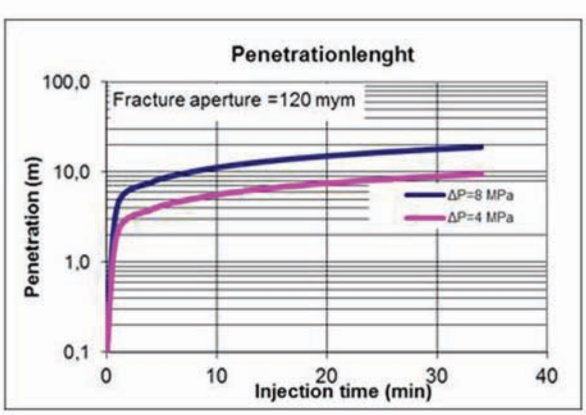


Figure 3. A diagram showing the difference in penetration length using an overpressure of 4 and 8 MPa in a fracture aperture of 120 µm.

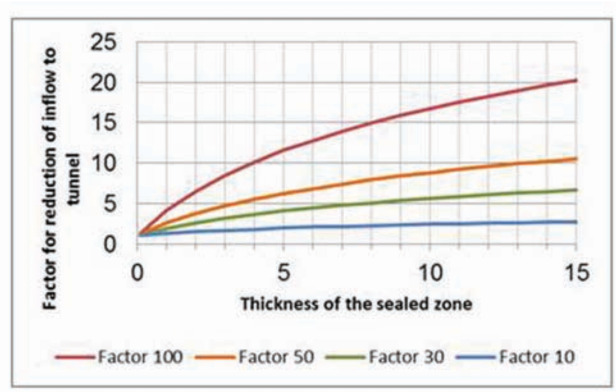


Figure 4. A diagram showing the reduction of inflow to the tunnel correlated to the sealing factor and the thickness of the sealed zone. The tightness or how permeable the sealed zone is described by the sealing factor. For a sealing factor of 100 mean that the sealed zone has 100 times lower transmissivity than the surrounding rock.

For tunnels with high inflows and very strict demands (< 2 l/min), say urban tunnels a tight grouting fan (high sealing factor) together with thick sealed zone is required (see Figure 4 above). Achieving both these requirements are though resource demanding.

Summarizing the above; water ingress to a tunnel can be reduced by either penetrating grout deep into the rock mass, hence using a large grouting pressure to produce a thick sealed zone or by applying lower grout pressure but with a tight grouting fan (high sealing factor). One can say that the ingress by only elaborating round the thickness of the sealed zone is limited but for some tunnels adequate enough.

From this point of view it looks like the Norwegian style is to produce a large thick zone and the Swedish way is to get a high sealing factor and that the Swedish approach is much more based on theoretical background than the Norwegian which is a typical empirical approach with high confident in using experience based grouting.

In recent years, tunnel inflow rates as low as 2 L/min/100 m have been specified and achieved in Norway (Grøv, 2008b) and (Tattersall et al, 2009). Data for land-based tunnels have been summarized in Figure 5 below. It shows the groundwater inflow rates achieved by pre-grouting and the average grout takes plotted against the average head of water for different tunnel segments. Correlation lines which show trends in theoretical inflow rates for uniform un-grouted rock masses with different hydraulic conductivities are shown on the plots for comparative purposes. These have been calculated from an equation for deep, un-grouted tunnels given in (Dalmalm, 2004) for a typical 10 m diameter tunnel (79 m2 cross-sectional face area). For example, a uniform rock mass with a hydraulic conductivity of 5 x 10-8 m/s could be expected to yield an average groundwater inflow of about 25 L/min/100 m at 100 m depth. However, it should be noted that the hydraulic conductivity in the grouted zone needs to be much less than the surrounding rock mass in order to give an apparent overall effective conductivity of 5 x 10-8 m/s if the surrounding rock mass has a much higher hydraulic conductivity. For example, the data points for the Bragernes tunnel between Ch1820 and Ch2500 shown in Figure 2 imply that the natural hydraulic conductivity of the rock mass is much higher than 5 x 10-8 m/s and that the hydraulic conductivity achieved in the grouted zone must be much lower. The grout take of 1911 kg/m length of tunnel shown in Table 1 for Ch2050-2500 confirms that relatively intensive grouting efforts were necessary to reduce the inflow rate in this section of the tunnel.

The groundwater inflow limit targets for land-based tunnels are shown in chapter 3.1 above, whilst for sub-sea tunnels in Norway, the typical groundwater inflow rate target is 30 L/min/100 m. Figure 5 is a collection of different cases being gathered where experience data has been provided. The calculated rock mass permeability is shown with diagonal lines, whilst achieved inflow rate is plotted against water head and consequential grout take is shown with various symbols (see key underneath the figure). Cases where the measured groundwater inflow rate exceeded the inflow rate target are highlighted in green. For both land-based tunnels and sub-sea tunnels there are no data where the inflow rate specified or achieved is greater than 50 L/min/100 m (the upper limit of the graphical plots shown in Figure 5). For land-based tunnels, about 50% of the inflow rates achieved are less than 15 L/min/100 m and in all cases but one the inflow rates are less than 30 L/min/100 m. It can be concluded based on Figure 5 that the grout take is difficult to assess based on even factual parameters as water head and inflow rate. The historical case of Romeriksporten is well known (Beitnes, 2002) and does not provide an example of what is now normally achieved. The case provided much incentive for the development of the better grouting strategies that now form Norwegian state-of-practice.

In the case of sub-sea tunnels, there are some examples where the overall inflow rates exceeded 30 L/min/100 m, but these tunnels were completed between 26 and 13 years ago when grouting practice was much less developed and groundwater inflow rates may not have been as strictly enforced as they are today. The more modern sub-sea tunnels all show inflow rates equal to or less than 30 L/min/100 m. Even in the basaltic rocks of the Nordic region which are commonly highly permeable, (Grøv & Nilsen,

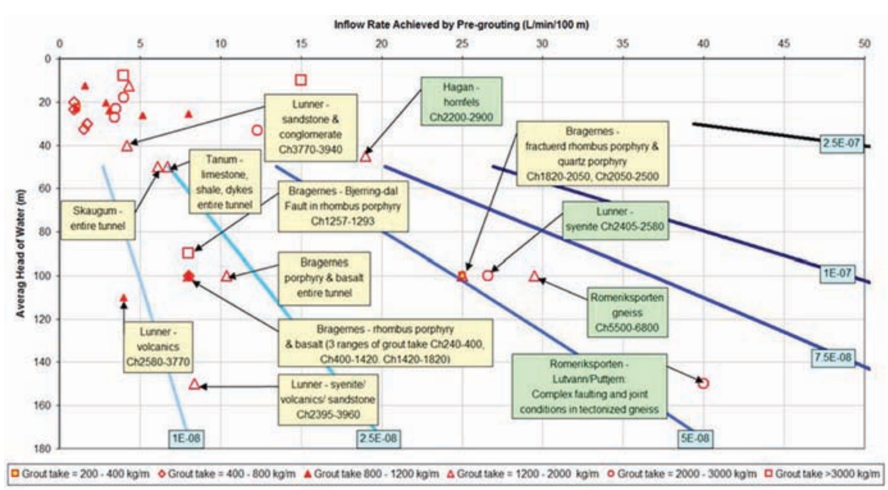


Figure 5. Norwegian Examples of Inflow Rate Achieved and Grout Take for Pre-grouted Land-based Tunnels.

2007) report that overall inflow rates of less than 10 L/min/100 m have been achieved with the application of good pre-grouting practice. The many instances of high grout volumes that were required to achieve the relatively low inflow rates indicate the existence of high initial hydraulic conductivities.

Differences in grouting philosophies

In short it is possible to draw some distinct differences between the practices in Sweden and Norway and in the following we propose that:

1. The Swedish approach is to a large extent theoretically based.
2. The Norwegian approach is to a large extent empirical based.
3. The Norwegian approach was developed during extensive tunneling for hydroelectric power development in a context where the practical aspects governed the grouting and then it moved to urban tunnels.
4. The Swedish approach has been directly applied in urban tunneling and lots of experience on extreme tight requirements from the underground storage of radioactive waste has been included.
5. The Swedish approach applies predefined grout classes, however not always directly related and adapted to the actual rock mass conditions.
6. The Norwegian approach is based on close cooperation at the tunnel face and customizing the works according to the encountered conditions.
7. The Norwegian approach is synonymous with high pressure grouting.
8. The Swedish approach applies low to moderate grout pressure.
9. The Swedish approach uses contract type based on the amount pumped.
10. The Norwegian approach is based on full reimbursement according to actual consumption.

The questions raised in the introduction were: Is there any explicit description on what pressure is the correct to be applied in any given circumstances; Can it be that several different techniques, such as different pressures can be applied giving the same predetermined outcome? Would it be a matter of functional requirements as a result of the grouting efforts? Or is it simply governed by a number of other aspects that are culturally based?

The paper addresses various aspects related to Swedish and Norwegian rock mass grouting aspects and concludes that there are certain points of distinction. The causes on why grouting has developed in various directions in these two closely neighboring countries are difficult to answer; maybe it is a cultural difference but for sure there is a difference in tunnel development in the two countries. Still the observant reader would have identified conformities; such as the drive towards using stable grouts, increased number of grout holes and the reliance on cement based grout design. And finally; we might agree that the result of the sealing is not getting better or worse using high pressures with data shown in this paper.

References

Brantberger, M. (2009). Förfrågningsunderlag för injekteringsarbeten i en utförandeentreprenad.BeFo rapport 92. Stockholm 2009.

Beitnes, A. (2002). Lessons to be learned from long railway tunnels. Water Control in Norwegian Tunnelling, Publication No. 12, Norwegian Tunnelling Society, pp 51-57.

Dalmalm T, 2004. Choice of grouting method for jointed hard rock based on sealing time predictions. Ph.D. thesis, Royal Institute of Technology, Stockholm

Garshol, K (2002). Modern grouting techniques. Water Control in Norwegian Tunnelling, Publication No. 12, Norwegian Tunnelling Society, pp 81-88. <http://www.tunnel.no>.

Garshol, K (2003). Pre-excavation Grouting in Rock Tunneling. www.ugc.basf.com

Grøv, E. (2008a). Water control in Norwegian tunnelling. Proceedings of South American Tunnelling Congress 2008, Brazilian Tunnelling Committee – CBT, Sao Paulo, Brazil.

Grøv, E. (2008b). Control of seepage in rock tunnels. ITA/AITES Training Course Tunnel Engineering 2008, Agra, India.

Grøv, E., Nilsen, B. (2007). Sub sea tunnel projects in hard rock environment in Scandinavia. Chinese Journal of Engineering and Rock Mechanics. Vol. 26 no. 3.

Gustafson, G., Stille, H. (2005) Stop criteria for cement grouting. Felsbau 23, pp 62-68, Verlag Gluckauf, Essen.

Tattersall, J. W., Grøv, E. (2009) Rock Mass Groutability – Application of Norwegian Experience to Hong Kong. Hong Kong Tunnelling Conference 2009

Vattenfall (1968). Anvisningar för utförande av cementinjektering i berg. Statens Vattenfalsverk 1968

Eivind Grøv
Chief scientist Professor SINTEF/ NTNU Trondheim, Norway

Johan Funehag
Assistant Professor, Chalmers University of Technology; Gothenburg; Sweden

Thomas Janson
PhD Rock mechanics, Tyréns, Gothenburg, Sweden

I hope you found this article interesting, as I did, and if you have some comments or grouting stories or case histories, send them to me at: *Paolo Gazzarrini, paolo@paologaz.com , paologaz@shaw.ca or paolo@groutline.com.*

Ciao! Cheers!

Between March 1988 and March 2001, several editors (Bob Holtz, Shobha Bhatia and Jean Lafleur) contributed to the Geosynthetics Department of Geotechncial News.

Starting with the June 2014 issue of GN, we are pleased to welcome Jonathan Fannin as our newest editor of Geosynthetics.

Jonathan Fannin

Jonathan Fannin obtained a B.Sc. (Civil Engineering, 1983) from the Queen's University of Belfast, and a D. Phil. (Geotechnical Engineering, 1983-86) from the University of Oxford for studies on geosynthetics for soil stabilisation. Thereafter, he joined the Norwegian Geotechnical Institute, Foundation Engineering Section. He moved to the University of British Columbia, joining the faculty in 1989, and attaining promotion to Full Professor in 2001.

His professional service has included Chair of the Canadian Geotechnical Society (CGS) Geosynthetics Division, Board Member of the North American Geosynthetics Society, Associate Editor of the Canadian Geotechnical Journal and contributor to the recently published 4th edition of the Canadian Foundation Engineering Manual.

Jonathan Fannin.

Jonathan has been recognised for his teaching excellence with Killam Awards from the University of British Columbia (1998 and 2004), and the President's Teaching Award of the Association of Professional Engineers and Geoscientists of British Columbia (2008). He has been recognised for his research contributions with a Canadian Geotechnical Society Quigley Award for the best paper in the Canadian Geotechnical Journal (1996), as a recipient of the International Geosynthetics Society Award for contributions of laboratory and field research to engineering practice (1998), as a U.K. Royal Academy of Engineering Distinguished Visiting Fellow (2008), by a Geosynthetics Award of the Canadian Geotechnical Society (2012) and, more recently, as a Fellow of the Engineering Institute of Canada (2013). Jonathan has been engaged in university-industry research partnerships on geosynthetics for 30 years, and has sought to disseminate that knowledge through teaching his graduate course on designing with geosynthetics at the University of British Columbia for 25 years, along with many specialist short courses in North and South America, Europe, Africa and Australasia.

When not thinking about geosynthetics, Jonathan chooses to ski-tour in the mountains of Canada, surf-kayak the west coast of Vancouver Island or complete the occasional sprint-triathlon… over time, he has come to recognise the end of a good day is marked by a Guinness, a single-malt whiskey and the company of friends.

Top 20 geo-news in 2013 posted in the Geoengineer.org news center!

The Geoengineer.org News Center is updated daily with the latest on construction projects, natural disasters or failures, and other interesting geo-industry news, written by our geotechnical engineering editors. You can see the latest Breaking News online at *http://www.geoengineer.org/news-center/news*.

Here is a list of the Top 20 most popular news of 2013:

1. Rockridge Geotechnical Inc. launches new corporate website powered by Geoengineer.org (17,268 views by January 2014)
2. Professor Janbu passed away on January 4th at the age of 91 (14,850 views by January 2014)
3. Propose a new SPT/ CPT correlation and win a free copy of NovoSPT software! (14,054 views by January 2014)
4. Announcing the Geoworld technical forums: Connecting you with geoprofessionals who answer your technical questions! (13,800 views by January 2014)
5. University of Michigan Geotechnical Faculty launches Advanced Geotechnical Field and Laboratory Testing Course (9,886 views by January 2014)
6. Founder & CEO of Geocomp Corporation provided pivotal expert witness testimony in the long-standing Hurricane Katrina litigation (7,159 views by January 2014)
7. Grand Dam on the Blue Nile River continues to cause tension between Ethiopia and Egypt (6,680 views by January 2014)
8. Five key considerations when selecting mini excavators (6,595 views by January 2014)
9. Cost to build levee project in Louisiana increases from $887 million to $12.9 billion (6,575 views by January 2014)
10. Introducing NovoTech Geotechnical Software (6,474 views by January 2014)
11. Mudslide in Everett, Washington impacts and derails a passing freight train (6,164 views by January 2014)
12. Huge landslide at the Kennecott Copper Bingham Canyon Mine. Mine slope monitoring paid off (5,958 views by January 2014)
13. ISSMGE's Case Histories Journal releases new issue: Issue #3, Vol. 2 (5,758 views by January 2014)
14. Levees yield in Missouri, Germany and the Czech republic; flooding continues; thousands displaced (5,628 views by January 2014)
15. The New, Extended GeoMap is here to bring you the latest news, conferences and projects worldwide! (5,404 views by January 2014)
16. The information age in Geotechnics is here: US Tunnel Boring Machines tweet and people listen! (5,387 views by January 2014)
17. New Video Highlights Research on the In-Situ Assessment of the Seismic Properties of Municipal Solid Waste (5.037 views by January 2014)
18. Tunnel cave-in at Gold and Copper Mine in Indonesia; Two killed, 27 missing (4,478 views by January 2014)
19. GeoWorld surpasses 3,000 membership landmark! (3,994 views by January 2014)
20. Geoengineer.org launches new ISSMGE.org website and introduces Web Services! (3,688 views by January 2014)

Geoengineer.org's interactive software database gaining momentum!

The **first interactive geo-software database** launched in October 2013 by Geoengineer.org has been populated with **over 400 listings of free and commercial software providers**. All software companies, and individuals can list their software in the database for free. You can learn more and sign up at: *http://www.geoengineer.org/software/home*

Marietta Zarogiannopoulou

Marketing Director
marketing@geoengineer.org
http://Geoengineer.org
http://myGeoWorld.info

Arthur (Art) Willmott Worth

Arthur (Art) Willmott Worth, 79, passed away after his brave battle with pancreatic cancer on January 17, 2014, at Mount Sinai Hospital, Montreal, Quebec. Art surely will be missed by many, but in particular the railroad community where he worked for over five decades. Art's passion for the industry was unwavering. He loved talking about all aspects of railroads with whomever would listen. After a long and dedicated career with CN Railway that spanned over 42 years, Art did not slow down.

After his retirement from CN in 1999, he was a track standards consultant for CANAC (now Savage Industries/ CANAC), Advanced Rail Management Corp, SNC Lavalin and many others. Art continued his work with several organizations, including AREMA, AAR and the Heavy Haul Association, serving in many different

leadership roles on several committees. He loved what he did and dedicated his life to his work.

To honor Art's life, his family has set up a new fund to further Canadian rail research. In lieu of flowers, please donate to the "WORTH MEMORIAL FUND" of the Canadian Rail Research Laboratory (CaRRL) at the University of Alberta to support the projects described on *www.carrl.ca*. To donate online, use the giving form available at *www.giving.ualberta.ca* indicating that your donation is in memory of Arthur Worth or send your cheque similarly inscribed to:

The Worth Memorial Fund
c/o Dept. of Civil and Environmental Engineering
University of Alberta
Markin/CNRL Natural Resources Engineering Facility
9105-116th Street
Edmonton, Alberta, Canada
T6G 2W2

Wheel Rail Seminars will also honor Art's life at the upcoming WRI '14 Conference May 5-8, 2014, in Henderson, NV. Those who would like to share thoughts and memories of Art, which will be compiled and posted at the Conference, can visit the following link using the following user name and password:

Website: *https://www.kanefetterly.qc.ca/cnd/home_en.php?cnd=13643*

User Name: *brandon@wheel-rail-seminars.com*
Password: *fuukye*