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Volume 33 • Number 3 • September 2015

GEOTECHNICAL news

Typical RTS installation on Amsterdam North/South line in 2001

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WIRELESS DATA ACQUISITION for Geotechnical Instruments

DT2011B DATA LOGGER

Monitor a single vibrating wire sensor and thermistor.

DT2055B DATA LOGGER

Monitor up to 10 sensors. Can be any mix of vibrating wire sensors and thermistors.

DT2040 DATA LOGGER

Monitor up to 40 sensors. Can be any mix of vibrating wire sensors and thermistors.

DT4205 DATA LOGGER

Monitor up to 10 channels. Can be any mix of 4-20mA sensors or thermistors.

DIGITAL TILT LOGGER

Low cost, lithium ‘D’ cell powered data logger & tilt meter in a single, compact unit.

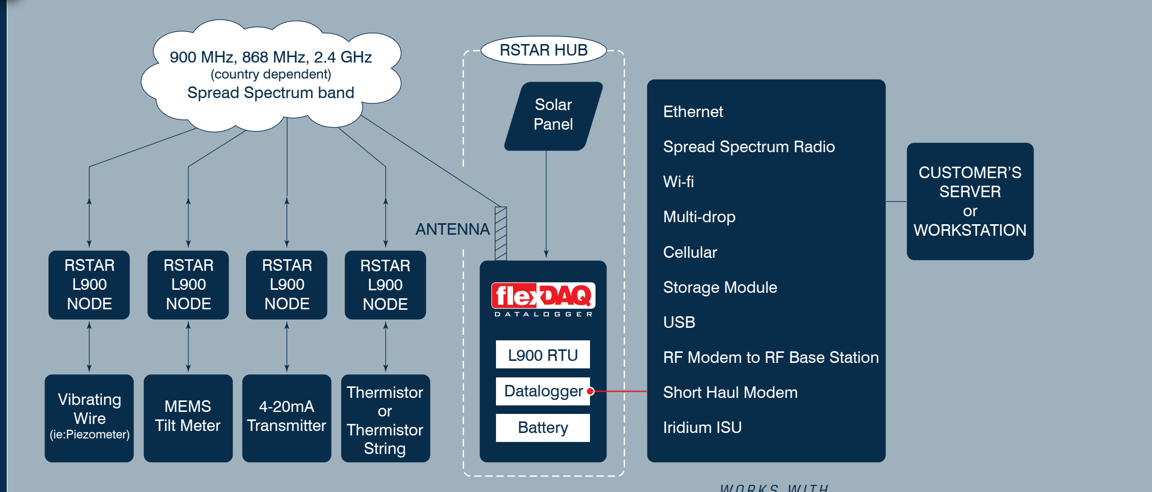
L900 SYSTEM

Wireless technology providing automated data acquisition with minimum per channel cost.

An RSTAR L900 System uses L900 RSTAR Nodes (see left) at the sensor level, deployed in a star topology from an active L900 RSTAR Hub, which consists of an L900 RTU interfaced to a FlexDAQ datalogger. The system is based on the 900 MHz, 868 MHz and 2.4 GHz spread spectrum band (country dependent) with extensive open-country range through use of simple dipole or directional antennae.

DIAGRAM

Typical RSTAR configuration for the RSTAR L900 System.



WORKS WITH GeoViewer REAL-TIME MONITORING

FEATURES

- Excellent Hub-Node range - up to 14 km in open country depending on antenna.
- Ultra-low quiescent power. RSTAR Nodes powered by 1 lithium ‘D’ cell (up to 7 years of life).
- Simple star routing - no mesh overhead.
- Simple network setup: add node serial number to RSTAR Hub list, deploy.
- Based on proven flexDAQ experience and technology - up to 255 L900 Nodes per flexDAQ.
- Multiple telemetry options such as cell, modem, LAN, radio, satellite (see diagram).
- Data accessible at multiple locations via WWW - protected at all stages by encrypted, error-corrected transmission & storage.

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Cover *Typical RTS installation on Amsterdam North/Southline in 2001. (photo courtesy of SolData, all rights reserved)*

Message from the President

Doug VanDine, President of Canadian Geotechnical Society

In my June 2015 Message, I mentioned that there was no commonly accepted definition of the term "geotechnical" in Canada, and that the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) was the only organization that has defined it. I went on to give my opinion as to why this might be the case and asked, but did not answer, the question, "Why should there be a definition?" Following is my answer as to why, along with what I believe there are two prime reasons.

The first reason is that the words and phrases "geotechnical", "'geotechnical engineers", "geotechnical consultants" or something similar do appear in many acts, regulations, bylaws, ordinance, guidelines and/or policies in at least five of the 13 provincial and territorial jurisdictions in Canada. I am sure that each of jurisdictions have different ideas of what qualifications the professionals who practice in the geotechnical field have or should have. I think we would better protect the public, ourselves and our professional reputations if there was a commonly accepted definition in Canada.

The second reason is that since there is no definition or defined qualifications to be a geotechnical professional, pretty much anyone who has any background in civil engineering, geological engineering, mining engineering, petroleum engineering, geology, geophysics or physical geography, and I dare say several other disciplines as well, can all call themselves a "geotechnical professional". Therefore geotechnical practice in Canada is essentially self- regulated, or at best, regulated by peer opinion. Is this the best way to protect the public and our professional reputation?

APEGBC has recently developed a geotechnical engineering competencies and indicators document. It is intended to help new practitioners determine if they have suitable training and experience to practice in the field and to help both APEGBC and practitioners determine if members are carrying out work in the geotechnical engineering field. This document is available on request from *register@apeg.bc.ca.*

Geoscientist Canada, the national organization for most of the provincial/territorial regulatory professional geoscientist bodies, published in 2014 "Competency Profile for Professional Geoscientists at Entry to Practice" *http://geoscientistscanada.ca/wp-content/uploads/2015/07/Competency-Profile-for-Professional-Geoscientistsat-Entry-to-Practice-Combined-Doc.pdf.* This document addressed all geosciences, but separately treats "geoscientists working in the discipline of environmental geoscience" – the discipline closest to the geotechnical field. The purpose of this document was to communicate to governments, employers, students and the general public about the work of geoscientists and to help new practitioners determine if they have suitable training and experience to practice in the field. It was also intended to create stronger links between education and practice, and to assist regulatory bodies in addressing issues such as continuing competence, practice guidelines and disciplinary matters.

The CGS is a technical society and not a regulatory body. In my opinion, the CGS should not get involved in regulating geotechnical practice, but I do believe the CGS has an important role to play in providing input into the definition of "geotechnical" and defining appropriate geotechnical qualifications. I would be pleased to hear from you on this, or any other geotechnical topic. I can be reached at *president@cgs.ca.*

On other matters, GeoQuebec 2015 (the 68th CGS Annual Conference and the 7th Canadian Permafrost Conference) is fast approaching and from early indications, it will be a tremendous success. To **Jean Côté** (CGS), **Sharon Smith** (Canadian National Committee-International Permafrost Association), the local organizing committee, exhibitors, sponsors, presenters, awardees, Executive Committee, and Board of Directors and all attendees, merci beaucoup!

Finally, **Dr. Gordon Fenton** of Dalhousie University will soon be embarking on his Fall 2015 CGS Cross Canada Lecture Tour. The two annual Cross Canada Lecture Tours organized by CGS since 1965, are highly anticipated by Canadian geotechnical professionals across Canada. Thanks to Gordon, and to the 95 lecturers who have proceeded him, for making the huge time commitment

to spread the geotechnical word across Canada.

Until next time.

Provided by Doug VanDine
CGS President – 2015/2016

Message du président

Dans mon message de juin 2015, j'ai mentionné qu'il n'y avait pas de définition couramment acceptée pour le mot « géotechnique » au Canada et que l'Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) était la seule organisation qui avait tenté de définir ce mot. J'ai aussi donné mon avis afin d'expliquer pourquoi il en était ainsi et j'ai posé la question « Pourquoi devrait-il y avoir une définition? », mais je n'y ai pas répondu. Je vous propose ici ma réponse, qui comporte deux principales raisons.

La première raison est que le mot et les expressions « géotechnique », « ingénieurs en géotechnique », « experts-conseils en géotechnique » ou autres termes semblables figurent dans beaucoup de lois, de règlements, de règlements administratifs, d'ordonnances, de directives et/ou de politiques pour au moins cinq des 13 instances provinciales et territoriales au Canada. Je suis certain que chacune de ces instances a des idées différentes sur la nature des qualifications que les professionnels qui exercent leurs activités dans le domaine géotechnique devraient avoir. Je pense que nous protégerions mieux le public, nous-mêmes et nos réputations professionnelles s'il y avait une définition couramment acceptée au Canada.

La deuxième raison est que, puisqu'il n'y a pas de définition ou de qualifications définies pour être un professionnel en géotechnique, à peu près toutes les personnes qui possèdent une formation en génie civil, en génie géologique, en génie minier, en génie pétrolier, en géologie, en géophysique ou en géographie physique, et j'ose dire dans plusieurs autres disciplines également, pourraient se qualifier de « professionnel en géotechnique ». Par conséquent, la pratique de la géotechnique au Canada est essentiellement autoréglementée ou au mieux, réglementée par l'avis des pairs. Est-ce la meilleure façon de protéger le public et notre réputation professionnelle?

Une association professionnelle de la Colombie-Britannique, APEGBC, a récemment produit un document sur les compétences et les indicateurs dans le domaine de l'ingénierie géotechnique. Il vise à aider les nouveaux praticiens à déterminer s'ils ont une formation et une expérience adéquates pour exercer dans le domaine; ce document vise aussi à aider APEGBC et les praticiens à déterminer si les professionnels réalisent des activités dans le domaine de l'ingénierie géotechnique. Ce document est disponible sur demande à *register@apeg.bc.ca*.

Géoscientifiques Canada, l'organisation nationale pour la majorité des organismes de réglementation provinciaux/territoriaux qui gouvernent les géoscientifiques professionnels, a publié en 2014 le document « Profil des compétences initiales nécessaires pour exercer la profession de géoscientifique » *http://geoscientistscanada.ca/wp-content/uploads/2015/07/Competency-Profile-for-Professional-Geoscientistsat-Entry-to-Practice-Combined-Doc.pdf*. Ce document porte sur tout le domaine des géosciences, mais il traite séparément des « géoscientifiques » qui travaillent dans la discipline de la « géoscience environnementale » – la discipline la plus proche du domaine de la géotechnique. L'objectif de ce document était d'informer les gouvernements, les employeurs, les étudiants et le grand public du travail des géoscientifiques et d'aider les nouveaux praticiens à déterminer s'ils possèdent une formation et une expérience adéquates pour exercer dans le domaine. Il avait également pour objectif de créer des liens plus forts entre le secteur de l'éducation et la pratique et aussi aider les organismes de réglementation à traiter des questions telles que la compétence continue, les lignes directrices concernant la pratique et les questions disciplinaires.

La SCG est une société technique et non un organisme de réglementation. Selon moi, la SCG ne devrait pas participer à la réglementation de la pratique de la géotechnique, mais je crois vraiment qu'elle a un rôle important à jouer dans la préparation d'avis sur la définition de « géotechnique » et des qualifications géotechniques appropriées. Je serais ravi de savoir ce que vous pensez de ce sujet ou de tout autre sujet concernant la géotechnique. Il est possible de communiquer avec moi à *president@cgs.ca*.

En ce qui concerne d'autres sujets, GéoQuébec 2015 (la 68e Conférence annuelle de la SCG et la 7e Conférence canadienne sur le pergélisol) approche à grands pas. D'après les premières indications, elle remportera un immense succès. Merci beaucoup à **Jean Côté** (SCG), à **Sharon Smith** (Comité national canadien-Association internationale du pergélisol), au comité organisateur local, aux exposants, aux commanditaires, aux conférenciers, aux lauréats, au comité exécutif, au conseil d'administration et à tous les participants!

Enfin, **M. Gordon Fenton** de l'Université Dalhousie participera prochainement à la tournée de conférences pancanadiennes de la SCG à l'automne de 2015. Les deux tournées de conférences annuelles à travers le Canada organisées par la SCG depuis 1965 sont très attendues par les professionnels canadiens de la géotechnique. Merci à Gordon et aux 95 conférenciers qui l'ont précédé d'avoir pris l'énorme engagement qui permet de promouvoir la géotechnique dans l'ensemble du Canada.

À la prochaine.

Del la part de Doug Vandine
Président – 2015/2016

From the Society

Upcoming Conferences and Seminars

68th Canadian Geotechnical Conference
7th Canadian Permafrost Conference
September 20 – 23, 2015
Québec City, Québec

The **Eastern Quebec Section** of the Canadian Geotechnical Society and the **Canadian National Committee for the International Permafrost Association (CNC-IPA)**, invite you to **GéoQuébec 2015**, for the joint 68th Canadian Geotechnical and 7th Canadian Permafrost Conference. The conference will be held from September 20 - 23, 2015 in the Convention Centre in Québec City, Québec. It will cover a wide range of topics, including speciality sessions that are of local and national relevance to the fields of geo-engineering, permafrost and engineering geology. In addition to the technical program and plenary sessions, the conference will include a complement of workshops, short courses, technical excursions and local tours.

The official languages for the conference will be English and French. The Convention Centre is located in the historic downtown area of Québec City, a UNESCO World Heritage Site, facing onto Québec's Parliament Hill. Old Québec City, which is the cradle of French civilization in North America, is best explored on foot and September is the best time of the year with a typically warm, dry weather and the maple trees just beginning to take on their colourful fall foliage.

The conference theme **Challenges from North to South**, reflects the diverse and complex challenges that the geotechnical, cold regions engineering and permafrost communities will need to address in order to support sustainable economic development.

For more information regarding sessions, topics and the technical program, please visit the web site *www.geoquebec2015.ca* or contact **Jean Côté** (Conference Co-Chair - geotechnical) at *jean.cote@geoquebec2015.ca* or **Michel Allard** (Conference co-Chair - permafrost at *michel.allard@geoquebec2015.ca*. For geotechnical contributions, please contact **Didier Perret** (Technical Program co-Chair) at *comtec_geot@geoquebec2015.ca* and for permafrost and cold region engineering contributions, **Richard Fortier** (Technical Program co-Chair) at *comtec_perg@geoquebec2015.ca*.

68e conférence canadienne de géotechnique
7ième conférence canadienne sur le pergélisol
20 - 23 septembre 2015, Québec, Québec, Canada,

La Société canadienne de géotechnique (SCG), la Section régionale de l'Est-du-Québec de la Société canadienne de géotechnique et le Comité national canadien de l'Association internationale du pergélisol (CNC-AIP) vous invitent à participer à GéoQuébec 2015; il s'agit de la 68e conférence canadienne de géotechnique et de la 2e conférence conjointe SCG/CNC-AIP sur le pergélisol. Cet événement se déroulera au Centre des congrès à Québec (Québec), Canada, du 20 au 23 septembre 2015. Le thème de GéoQuébec 2015 – Des défis du Nord au Sud - reflète la diversité des défis complexes auxquels font face les spécialistes en géotechnique, en géotechnique des régions froides et en pergélisol pour assurer le développement durable des communautés canadiennes. Les langues officielles de la conférence sont le français et l'anglais. Le Centre des congrès se trouve à quelques pas du quartier historique de la ville de Québec, un joyau du patrimoine mondial de l'UNESCO, et fait face à la colline parlementaire de Québec. Le mois de septembre à Québec est le meilleur moment de l'année, avec une température clémente et des érables qui se parent de leur feuillage coloré.

Le Comité local d'organisation de la conférence invite les membres des communautés canadiennes et internationales en géotechnique, en géotechnique des régions froides et en pergélisol à contribuer à la conférence en soumettant les résultats de leurs travaux et découvertes dans ces domaines. La conférence couvrira un large spectre de thèmes incluant des séances spéciales d'intérêt local et national dans les domaines de spécialisation de la géo-ingénierie, du pergélisol et du génie géologique. En plus du programme technique et des séances plénières, la conférence comprendra des ateliers, des cours intensifs, des excursions techniques et des visites guidées.

Pour plus d'information sur les sessions, les sujets et le programme technique, visitez le site web *www.geoquebec2015.ca* ou contacter **Jean Côté**, Coprésident de la conférence (géotechnique) *jean.cote@geoquebec2015.ca*, **Michel Allard**, Coprésident de la conférence (pergélisol) *michel.allard@geoquebec2015.ca*. Pour les contributions en géotechnique, **Didier Perret**, Coprésident du programme technique *comtec_geot@geoquebec2015.ca*. Pour les contributions en géotechnique des régions froides et sur le pergélisol, **Richard Fortier**, Coprésident du programme technique *comtec_perg@geoquebec2015.ca*.

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

Call for Abstracts

The **Vancouver Geotechnical Society** and the **Canadian Geotechnical Society** invite you to the 69th Canadian Geotechnical Conference. The conference will be held from October 2 to 5, 2016 in Vancouver, British Columbia, Canada. It will cover a wide range of topics, including specialty sessions that are of local and national relevance to the disciplines of geotechnical and geo-environmental engineering.

In addition to the technical program and plenary sessions, the conference will include a complement of short courses, technical tours, local excursions and entertaining social activities.

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

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

The theme of the Conference is **"History and Innovation"**, which will recognize the historical achievements and lessons learned over time while highlighting innovation in geotechnical engineering research and practice. The Local Organizing Committee for the conference invites members from the Canadian and international communities to contribute papers and case studies dealing with historical design and construction practices or innovative analysis, techniques and solutions.

Authors are invited to submit their abstracts with a maximum of 400 words through the conference web site; *www.geovancouver2016.com*, which will be launched late September 2015.

The abstracts should generally fall within the following topics, but sessions will be added for groups of abstracts which share a common theme but are not listed below:

- Fundamentals

  Engineering Geology, Geomorphology, Soil Mechanics, Rock Mechanics, Physical and Numerical Modelling.
- Case Histories

  Site Characterization and Design of Tailings Dams, Slope Stability Analysis, Failure Analysis, Highway Improvement Projects, Seismic Design Aspects.
- Geohazards

  Climate Change, Floods, Landslides, Earthquakes, Tsunamis.
- Problematic Soils

  Soft and Compressible Soils, Expansive and Collapsible Soils, Loose and Liquefiable Soils, Residual Soils, Ground Improvement Methods, Geosynthetics.
- Infrastructure

  Bridges, Highways, Embankments, Dams, Pipelines, Tunnels, Shoreline Engineering, Harbours.
- Site Characterization

  Advanced Laboratory Testing, In Situ Testing, Instrumentation and Monitoring, GIS and Remote Sensing, Geophysical Methods.
- Foundation Design

  Spread Footings, Rafts, Driven Piles, Helical Piles, Caisson Piles, Retaining Walls, Soil Structure Interaction.
- Energy Resources

  Hydroelectric, Liquefied Natural Gas, Wind, Forestry, Mining, Tailings, Oil Sands.
- Design Codes

  NBCC 2015, CHBDC 2014.
- Groundwater & Hydrogeology

  Groundwater hydraulics, River Mechanics, Physical and Numerical Modelling.

- Cold Regions Engineering

  Ice Behaviour, Geocryology, Permafrost Degradation, Periglacial Processes.
- Geo-Environmental Engineering

  Landfills, Contaminated Soils, Contaminated Groundwater, Remediation.
- Education & Professional Practice

  Training and CV, Professional development, Communications, Contracts, Legal Aspects, Project Management.

The abstracts can be written in English or French. The deadline for abstract submission is January 29, 2016. Authors whose abstracts are accepted by the conference's Technical Subcommittee will be notified by February 26, 2016 and invited to submit full papers. The submitted papers, which can be in either English or French, will be reviewed prior to final acceptance and inclusion in the conference proceedings. At least one author of an accepted paper must register for the conference for its inclusion in the proceedings. Please address any questions to the Conference co-chairs: **Mustapha Zergoun** at *mzergoun@thurber.ca* or **Andrea Lougheed** at *alougheed@thurber.ca.*

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

Appel aux résumés

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

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

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

Le comité d'organisation de la conférence invite les membres des communautés canadienne et internationale à contribuer par des articles et des études de cas historiques, portant sur la conception, la construction ou l'analyse à partir de techniques et de solutions novatrices.

Les auteurs sont invités à soumettre des résumés de 400 mots au plus en utilisant le site de la conférence; *www.geovancouver2016.com* qui sera lancé à la fin septembre 2015. Les résumés devraient normalement se rattacher à l'un des thèmes suivants, qui pourront cependant être modifiés en fonction des résumés reçus.

- Aspects fondamentaux

  Géologie de l'ingénieur, géomorphologie, mécanique des sols, mécanique des roches, modélisation physique et numérique.
- Historique de cas

  Caractérisation et conception des digues de parcs à résidus miniers, stabilité des pentes, analyse à la rupture, projets d'autoroutes, aspects sismiques.
- Risques naturels

  Changements climatiques, inondations, glissements de terrain, séismes et tsunamis.
- Sols problématiques

  Sols mous et compressibles, sols susceptibles aux affaissements, sols gonflants, sols lâches et susceptibles à la liquéfaction, techniques d'amélioration des sols, géosynthétiques.
- Infrastructures

  Ponts, autoroutes, barrages en terre, pipelines, tunnels, génie côtier, ports.
- Charactérisation des sites

  Essais avancés en laboratoire, mesures in situ, instrumentation, Systèmes d'information (SIG) et télédétection, Méthodes Géophysiques
- Calcul de fondations

  Semelles, pieux battus, pieux à hélices, caissons, murs de soutènement, interactions sol-structure.
- Ressources énergétiques

  Hydroélecité, gas naturel liquéfié, éoliennes, génie forestier, génie minier, résidus miniers, sable bitumineux.
- Codes nationaux

  Code national du bâtiment 2015, Code canadien des ponts et chaussées 2014.
- Eaux souterraines et Hydrologie

  Hydraulique des eaux souterraines, mécanique des

rivières, modélisation physique et numérique.

- Génie des régions froides

  Comportement de la glace, géocryologie, dégradation du pergélisol, processus périglaciaires.

- Géotechnique environmentale

  Dépotoirs, sols et eaux souterraines contaminés, restauration.

- Education et activités professionnelles

  Formation et CV, développement professionnel, communications, contrats, aspects légaux, administration de projets.

Les résumés peuvent être rédigés en français ou en anglais. La date limite pour soumettre un résumé est le 29 janvier 2016. Une invitation pour la soumission d'articles sera envoyée avant le 26 février 2016 aux auteurs dont les résumés auront été acceptés par le sous-comité du programme technique. Les articles soumis, en français ou en anglais, seront révisés avant leur acceptation pour publication sur clé USB dans les comptes rendus de la conférence. Au moins un des auteurs d'un article accepté doit s'inscrire à la conférence pour la publication de cet article. Vous pouvez acheminer toutes questions aux coprésidents de la conférence: **Mustapha Zergoun** à mzergoun@thurber.ca ou **Andrea Lougheed** à alougheed@thurber.ca.

Members in the News

Canadian Academy of Engineering (CAE) Honorary CAE Fellowship Recipient - Dr. Norbert Morgenstern

Kim Sturgess, Norbert Morgenstern.

Dr. Norbert Morgenstern has consistently produced internationally award-winning research that has shaped the civil engineering field, specifically in dam design, slope stability studies and major natural resource development. He has been invited to contribute his expertise by research institutions, multinational companies and governments in over 30 different countries on six continents. He has given a significant number of keynote addresses at major international conferences and symposia, and has had 330 manuscripts published in technical journals, conference proceedings and books – an impressive and rare feat for many scholars. An inspiring educator for over 50 years, Dr. Morgenstern has transformed geotechnical engineering as it is taught and practiced in Canada and abroad.

Through his leadership and reputation as an international authority on geotechnical engineering, he established one of the leading geotechnical schools in North America, attracting top specialists and talented graduate students from around the world. This award was in recognition of his exceptional contributions and outstanding productivity in education, research and consulting that have profoundly influenced geotechnical engineering practice worldwide, and in recognition of his service to the civil engineering community in Canada and internationally through numerous committees and task forces that have assisted government and professional societies at all levels. Dr. Morgenstern was presented his Honorary Fellowship on June 18 in Calgary by Kim Sturgess, CAE past president.

Canadian Foundation for Geotechnique News

Cross Canada Lecture Tour

Twice a year, the Canadian Foundation for Geotechnique (CFG) funds the Cross Canada Lecture Tour. The tour is sponsored each time by the generous donations of corporate sponsors from within our membership. The spring CCLT was sponsored by **KGS Group, Tetra Tech EBA, Geo-Slope International**, and **Thurber Engineering.**

The Canadian Geotechnical Society Spring Cross Canada Lecture Tour May 4 – 14, 2015

The spring CCLT was graciously performed by **Dr. Nicholas Sitar**

Dr. Nicholas Sitar.

from the University of California at Berkeley. Dr. Sitar, Ph.D., P.Eng., is the Edward G. Cahill and John R. Cahill Professor of Civil and Environmental Engineering at the University of California at Berkeley. He received his B.A.Sc. in Geological Engineering from the University of Windsor in 1973, his M.S. in Hydrogeology in 1975 and his Ph.D. in Geotechnical Engineering in 1979, both from Stanford University. He taught in the Geological Engineering Program at UBC from 1979 to 1981, then joined the faculty in Geotechnical Engineering at UC Berkeley in 1981. Most recently he served as the Director of the University of California Earthquake Engineering Research Center from 2002 to 2008.

Dr. Sitar's professional and research interests include engineering geology, geotechnical earthquake engineering, rock mechanics, groundwater modeling, groundwater remediation and the application of numerical and stochastic methods to engineering analysis. He is the author and co-author of over 170 publications in geotechnical engineering, engineering geology, groundwater and groundwater remediation. His particular interests in geotechnical earthquake engineering include seismic slope stability, seismic response of retaining structures and mechanically stabilized walls, and the performance of improved ground. In engineering geology he has concentrated on the influence of the depositional environment on the properties of coarse sediments, debris flow initiation, and modeling of jointed rock masses.

The intensive schedule of 13 lectures in two weeks included 7 locations in Eastern Canada in the first week and 6 lectures in Western Canada in the following week, as shown below.

Dr. Sitar made available three different topics to the local organizing committee for each venue where he presented. The three topics that were available are listed below.

Monday May 4	Halifax (lunch), Fredericton (dinner)
Tuesday May 5	Montreal (dinner)
Wednesday May 6	Quebec (dinner)
Thursday May 7	Ottawa (lunch) Toronto (dinner)
Friday May 8	Kingston (lunch)
Monday May 11	Winnipeg (lunch)
Tuesday May 12	Edmonton (lunch), Calgary (dinner)
Wednesday May 13	Victoria (lunch)
Thursday May 1`4	Prince George (lunch)
Wednesday May 14	Vancouver (dinner)

Seismic Earth Pressures on Retaining Walls and Basements

Methods for evaluating the seismically induced lateral earth pressures gradually evolved from the seminal Japanese work performed in the 1920's. The resulting design procedures suggest large dynamic loads during strong ground motion. However field evidence from recent major earthquakes fails to show significant problems with the performance of retaining structures designed for static earth pressures only. Similarly, the results of extensive centrifuge experiments indicate that seismically induced lateral earth pressures at high PGA are significantly less than those estimated using the most current design methods based on the Mononobe-Okabe assumptions. The presentation will focus on latest results from centrifuge model studies, recent observations in large earthquakes, and their implications for a rational seismic design of retaining structures and basement walls.

Influence of Fabric on Engineering Properties of Coarse Sediments

Lightly consolidated and/or weakly cemented coarse sediments: silts, sands, and gravels of various origins are found in many depositional environments. For example, steep slopes in the marine terraces along the Pacific Coast, bluffs in glacial sediments along the Great Lakes, and the Athabasca Tar Sands, all share similar characteristics of being able to stand in steep slopes, and in being difficult to sample and test in conventional tests.. This presentation will first address some of the factors controlling the engineering properties of these materials, concentrating on the role of fabric and cementation. Then the results of geotechnical investigations of the stability of slopes in weakly and moderately consolidated/ cemented sands and gravels will be presented. Examples of similar behavior in a range of different geologic deposits will be discussed.

On the Importance of Kinematics in the Analysis of (Large) Landslides

The most convenient methods of slope stability analysis rely on limit equilibrium solutions which assume a pre-determined slide plane geometry and rigid body deformation. However, many, particularly very large landslides are composed of many individual blocks that may be toppling, rolling or otherwise moving downslope in a manner inconsistent with the above assumptions. Example results of discrete body deformation modeling will be used to show that in such cases the traditional limit equilibrium methods would lead to erroneous and possible very unconservative conclusions.

Provided by Kevin Biggar
Canadian Foundation for Geotechnique

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. 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, **Suzanne Powell, P.Eng.**, at *spowell@thurber.ca*

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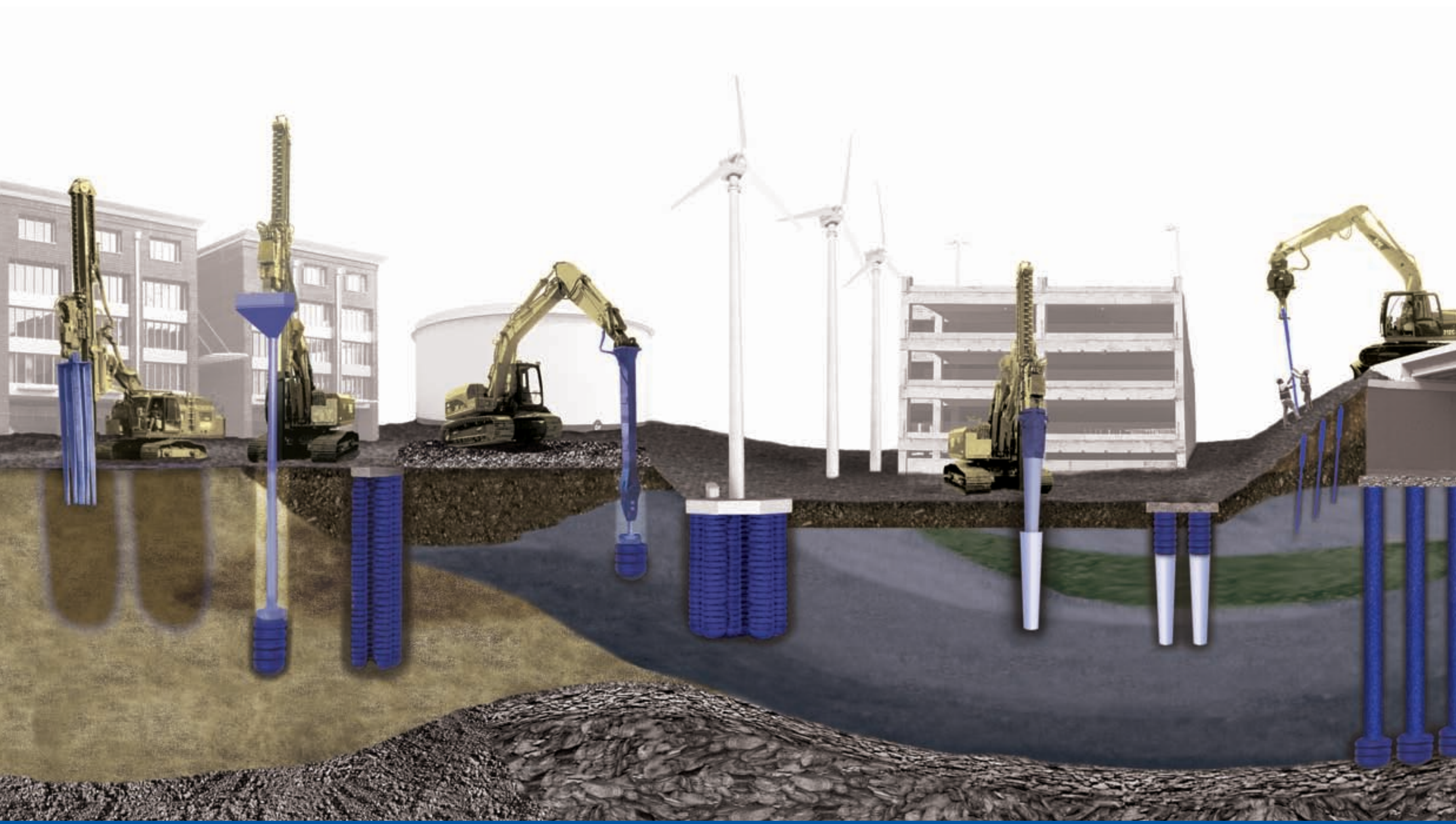

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Introduction by John Dunnicliff, Editor

This is the 83rd episode of GIN.
Just one article this time.

Decommissioning and removal of instrumentation

The article by David Cook and Thijs Claus describes decommissioning and removal of instrumentation after 13 years of monitoring at a large tunneling project in the center of Amsterdam. This is a subject that I'd rarely thought about, despite helping with many monitoring specifications, and the article woke me up to the importance of including this in the planning process and in specifications.

International Courses on Geotechnical and Structural Monitoring in Italy

This year's course attracted 84 registrants from 23 different countries, together with more than 20 exhibitors. The little town in Tuscany again closed off the main street for our street party on the first evening, and as you'll see in this photo, our wines (red, white and spumante) had labels with the name of our course. How about that?

Vino rosso, bianco, spumante.

Planning for the next course in June 2016 is well underway, and we're looking for improvements and innovation. Some new speakers will be invited. To increase the interaction among us all, we plan to invite selected exhibitors to make brief presentations about new trends in contact and remote monitoring, and about data acquisition and management. We also plan to invite selected registrants to make brief presentations about case histories and lessons learned. For updates, see www.geotechnicalmonitoring.com.

After the 2015 course we had an exciting field trip to the Poggio Baldi landslide (*www.landslidemonitoring.com*), where ten companies made demonstrations of their equipment. We're exploring the possibility of another field trip combined with the 2016 course.

Rugby, tradition and pomp

The rugby world cup will be played here in England during September and October (*www.rugbyworldcup.com*). Yes, USA will be competing, but not Canada. New Zealand are the cup-holders - how many of you have watched the fabulous haka, a traditional ancestral war cry of the Māori people of New Zealand, which the national rugby team performs before international matches? If not, watch the beginning of the 2011 final on youtube. Search for "best haka ever". What a great way to establish fear in the minds of opponents!

As I write this, the cup trophy is on a tour of UK. Last week it was in Dartmoor National Park, where I live. So, being a rabid fan, I went to see, and as it turned out, also to touch. It arrived on a display table in the back of a Landrover! I didn't know anything about the formalities of the event, and I learned that the location was selected for a formal handover from the jurisdiction of one mayor to another, hence the tradition and pomp. In the photo, from the right: Mayor of Plymouth; Mayor of Exeter (love the regalia!); flunky with mace (who is obligated to accompany the mayor of Exeter on formal occasions – love the mace, the hat and the sunglasses – no sun was visible!); Chairman of local district council; no idea (but someone said that he was a security guard, responsible for preventing me from stealing the trophy).

Tradition, pomp and the Webb-Ellis trophy.

As a very Americanized Englishman (having lived across the pond for 30 years), I found all this fascinating and amusing. How about having a ceremony like this, or a haka, at the beginning of the World Series?

Closure

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

Gan bei! (dry the cup). China.

Lessons learned during removal of instrumentation after 13 years of monitoring at a large urban tunnelling project

David K Cook and Thijs Claus

Background

In Amsterdam, one of Europe's biggest settlement monitoring contracts, the monitoring of the Noord/Zuidlijn (North/Southline) Metro line, has ended. Installation commenced in 2000 and removal completed in 2013. Following completion of 3.8 km of twin-bore metro tunnels, three large cut and cover stations and construction under the historic Amsterdam Central Station, project-related settlement and consequent risks had passed. After a period of close-out monitoring, the instrumentation was decommissioned and removed. Figure 1 shows a typical robotic total station for monitoring any deformation of buildings during tunnelling beneath the roadway.

Third parties

Although most third-party stakeholders understood that the ongoing risk of settlement was low and that the financial cost of keeping an automated network of robotic total stations (RTS) and associated prisms was large, there

Figure 1. Typical RTS installation – (Photograph courtesy of SolData; all rights reserved).

were objections to removal of the system. These generally came from occupants of buildings adjacent to the cut and cover stations. After 13 years of continuous monitoring they were accustomed to the security provided by the system. This was especially so for the inhabitants adjacent to one station where a number of construction incidents had occurred that resulted in very severe localised settlements. In the initial stages of close-out monitoring removal of the systems was discussed with these groups. By addressing their concerns the stakeholders were then convinced the monitoring system was no longer required.

General - removal of a monitoring system

Removal was the final element of the contract awarded to Soldata-Grontmij JV (SG) (by Dienst Metro (DM), who procured the Metro line for the Municipality of Amsterdam (MoA) who had installed, maintained and operated the monitoring system. The main components to be removed were:

- 74 RTS including computers, support brackets, wiring and power boxes.
- Over 6000 prisms.
- Communication infrastructure, including Wi-Fi, 3G modems, brackets, wiring and aerials.
- Combined in-place inclinometer/ extensometers, piezometers and associated infrastructure, such as access chambers; ducts, cabling, data loggers & instruments.
- Power supplies.

A number of these elements were to be removed from the exterior of historic buildings such as Amsterdam Central Station, Beurs van Berlage (the old stock exchange) and De Munt Toren. To ensure that there were no building damage issues or planning problems, the removal had to be undertaken in an agreed fashion. Guidance in the contract was that after removal the contractor was responsible for making good the underlying materials.

Given this requirement DM and SG agreed on a removal strategy dictated by:

- Duration: A shorter time span for removal was more cost-effective for SG. This required DM to streamline permissions from various departments within MoA, building occupants and other stakeholders and communicate those plans in a timely fashion to occupants and building owners.
- Quality: Fast tracking was permitted providing only that quality was not compromised. SG trialled a number of removal/making good methods to various materials before work commenced. The successful methods were implemented and a rigorously documented system put in place. Each element to be removed was photographed both before and after removal.

Removal of monitoring equipment

Robotic total stations and monitoring prisms

The main component was the support bracket removal. During removal a number of issues were encountered.

Accessibility: Not all prisms and instruments were located on readily accessible places. This meant that sometimes the trade-off was made to not maintain or remove certain prisms.

Making good: After removal holes (diameter 8 mm) remained. The contractor was obliged to making this good. DM specified a number of requirements for this filling:-

- Aesthetically pleasing, e.g. flush with surface and matching colours of surrounding material.
- Ability to fix to a number of substrata.
- Not sensitive to differences in temperature (i.e. low alpha coefficient).
- Life expectancy similar to the surrounding materials.

Generally the material to which RTS brackets and prisms were attached consisted of brick, (from relatively new to very old), mortar joints and natural stone. Two main filler types were considered:

- 2-part epoxy based mortars
- Cement based mortars

After careful consideration and trials of both materials, epoxy mortar was the preferred option. Both could fulfil the requirements, but the ability to fix to all sub-strata and the consistent aesthetic quality of the epoxy mortar dictated.

Fixing to substrata was more difficult with cement based mortars because of the time lag between making the mortar and filling the small hole. This time could be large due to the scattered holes over the facades of the building and the busy streets of Amsterdam; that led to multiple position changes for cherry picker access.

Furthermore, the materials have different permeability. Dry stone drew moisture from a standard cement based filling, rendering it useless. It was necessary to either pre-wet the stone or treat with a hydrophobic agent.

Only in very specific instances, such as Amsterdam Central Station, was a mortar-based filler used. In these instances the authenticity of filler material prevailed above other requirements. At Central Station the costs for removing a single prism and making good tripled compared to elsewhere on the project. This increase in cost was mainly driven by hiring specialised personal and ensure all batches of mortar matched the respective facades.

Subsurface equipment

Subsurface monitoring installations consisted of boreholes used for:

- Deep datums.
- Combined in-place inclinometer/ extensometers.
- Piezometers.
- Cable ducts and manholes.

22 deep datums, located beyond the North/Southline zone of influence were installed to allow rigorous level control during the construction works. These were of ongoing value to the MoA and incorporated within their existing networks. No removal was therefore required of these items.

Other subsurface monitoring equipment consisted of a number of boreholes (up to 80 metres deep) adjacent to either the station boxes or tunnels. A number of issues arose whilst removing them:

- It was not practicable to remove the entire depth of a borehole, so with agreement from MoA boreholes were only removed over the top 1 metre. This depth included all chambers, ducts, cabling and extensometer heads.
- In-place inclinometers within the boreholes needed to be removed before removal of the other borehole elements. This proved difficult in a number of cases because friction had built up between the wheels of the inclinometers and the casings. This was caused by a number of reasons such as soil, corrosion and borehole deterioration. Special care was taken to try and remove the inclinometer assemblies completely but this was not achieved in all cases. Some chains broke after too much force was applied. It was found that the main reasons were the age and deterioration of the boreholes and the inclinometer chains. If friction builds up over the large lengths of the chain, there is little chance of removing the chain without complete excavation. In a small number of cases the inclinometer chain broke and a number of sensors could not be removed. An environmental impact assessment was undertaken determined that the instruments could be left (providing they were sealed) in the borehole. This environmental impact assessment was undertaken by SG after instruction by DM. It was determined that no hazardous chemicals of toxic heavy metals were present in the inclinometers that could pollute the soil or groundwater.
- A borehole spanning multiple soil layers can causes leaks between the impermeable layers. Later this may become an issue if boreholes deteriorate further. The consequence could be unwanted flow of water between soil layers, the inability to lower the hydraulic head when needed and possible damage to infrastructure. To avoid these potential problems the boreholes were filled with activated calcium bentonite. This was poured into the borehole and expanded when in contact with water. This expansion process took approximately 40 minutes. Using volume checks between boreholes and expanding clay it was confirmed that a seal had been achieved.

Disposal of monitoring equipment

The equipment to be disposed fell into two categories, that with monetary value and that with only scrap value. Each batch for sale required offers from a minimum of three independent parties – this was a Municipality requirement to avoid fraudulent practices.

Robotic total stations (RTS)

The modern RTS were popular saleable items. These were sold to third parties in a number of batches. Some of the older instruments, which were no longer supported by the manufacturer, had no commercial value and donating these instruments to non-profit organisations such as schools or charities was examined, but proved not to be a viable option.

All sales were carefully documented to verify the traceability of the instruments. This was performed with the manufacturer. One key component of the successful sale was that the instruments have been fully maintained, on a regular basis, during their use in the project and full service histories were available.

Other monitoring equipment

Equipment with no monetary value was sent to recycling plants. Considerable effort by both SG and DM was expended on documenting each element of the monitoring system, such as location, how removed and eventual disposal method.

Lessons learned - designing a monitoring system with removal in mind

A system is usually designed to monitor specific entities or parts of structures. During installation consideration of final removals is generally not given any priority. Location of monitoring equipment is as important for removal as for maintenance purposes.

- Consider maintenance options for equipment. Does it need maintenance, and if yes at what frequency?
- Consider product life span, will it need to be replaced during the project lifetime?
- Consider equipment fixing to the substrate, does it need to be permanent?

Over the duration of the contract changes occurred in the urban environment and also in applicable safety legislation. Certain elements could not be removed in a similar fashion to that used for installation and additional measures were required.

Some elements could not be removed. For example, at locations such as back facades of buildings, where access could only be achieved with the help of the residents, not all residents were willing to assist. Prisms were installed in difficult to reach locations within very narrow streets (no cherry picker/scissor lift access possible). These were installed up to 13 years before their removal under less rigorous health and safety requirements. If a prism could not be removed using normal methods a risk assessment was performed to determine whether or not leaving the prisms in place could lead to a future liability. In a number of cases these consisted of prisms located above pavements (sidewalks) where a falling prism could potentially hurt pedestrians below. A number of special measures were undertaken to remove these prisms. These included use of certified abseilers who accessed from the top of a building.

Projects with a lifespan such as North/Southline (13 years) should consider that circumstances change. This does not mean every possible option should be considered, but budgets may be stretched in ways which could not have been foreseen at the time of contract award. At the time of installation it was anticipated that the monitoring would be in place for a period of approximately 6 years. In practice it was in place for over double that time.

It is customary to produce as-built drawings and for large monitoring projects these are important for programmed removal. A complex monitoring system with a large number of parts (in total the GIS accounted for 21,998 individual measuring points and the monitoring database consisted of 208 million readings) cannot be fully removed without proper documentation and this needs to be produced over the monitoring period.

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Tailings management simulation and technology evaluation

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Introduction

Tailings management is an inherent component of any water-based mining process. In the oil sands mining industry, tailings management has evolved from simple fluid storage in a single external impoundment to multistage, mechanical and chemical dewatering processes and storage in several in-pit and external impoundments. The industry is currently focusing on transforming their fluid fine tailings (FFT) and waste materials into deposits that can be incorporated into closure landforms and subsequently reclaimed. There are three stages of dewatering that tailings may go through before they meet their end reclamation targets (Boswell and Sobkowicz 2010). The first stage (Stage 1) involves mechanical or natural classification of the tailings stream. Mechanical separators such as hydrocyclones may be used to separate a tailings slurry stream into a low density, fine grained overflow and a coarse, dense underflow. Tailings may also undergo natural segregation/dewatering when they are discharged sub-aerially. In this case, a coarse beach deposit and a low density, fine grained slurry run off are formed. The beach run off collects within the impoundment and gradually settles with time. The second stage (Stage 2) of dewatering includes the various

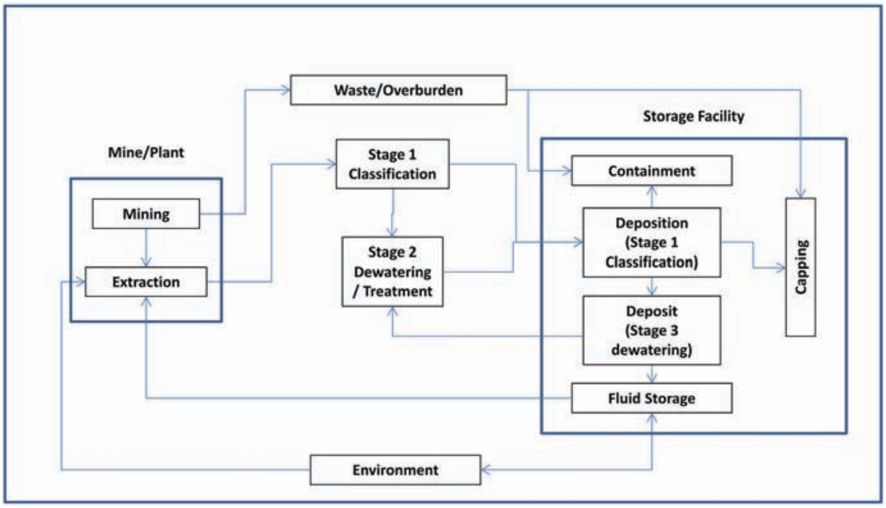

Figure 1. TMSim conceptual mine and tailings system.

mechanical, chemical and electrical methods described in Sobkowicz and Morgenstern (2009). These technologies will typically dewater the tailings streams to near, but still wet of their liquid limit. Upon deposition, the tailings deposits will typically have strengths of a few hundred pascals (Boswell and Sobkowicz 2010). The final stage of dewatering following deposition (Stage 3) includes time dependent and environmental dewatering processes. Stage 3 dewatering includes sedimentation/consolidation processes and environmental dewatering processes such as freeze/thaw, desiccation and evapotranspiration dewatering.

The management of tailings also includes the construction and operation of tailings storage facilities (i.e. impoundments). These may be constructed from the tailings or from other mine wastes. The construction of the impoundments must be coordinated with the deposition and storage requirements of the tailings and associated process water to ensure sufficient storage capacity and freeboard are available. The required capacity of the impoundment is a function of the tailings dewatering processes (described above), the interaction with the environment (i.e. seepage, precipitation, evaporation) and process water demands from the extraction process.

Mine operators manage their tailings through the implementation of a tailings management system (TMS) that incorporates all aspects of the tailings dewatering and their associated storage facilities.

As discussed in Sobkowicz (2012) and Sobkowicz and Morgenstern (2009), there are numerous technologies that may potentially transform the fluid tailings streams into geotechnically stable deposits. Additionally, tailings management plans are constantly evolving as mining and closure plans change with the economic and regulatory environment as well as stakeholder perceptions. Therefore, technology providers and the end users (mine operators and regulators) can have a tremendous task trying to understand and evaluate how these technologies fit within mine plans, what the implications of adopting a new technology are and where and how resources should be invested to further enhance a technology.

To address the ongoing need to evaluate tailings management technologies and processes, a dynamic systems model TMSim was developed (Beier et al. 2012, Beier 2015). The TMSim model provides a quantitative tool that aides in the evaluation of tailings management technologies and provides guidance to mine operators on the strengths and limits of such technologies.

TMSim model

The TMSim simulation tool was developed using an object orientated, systems dynamic modeling software (GoldSim) as the "simulation engine" that was then coupled with Excel

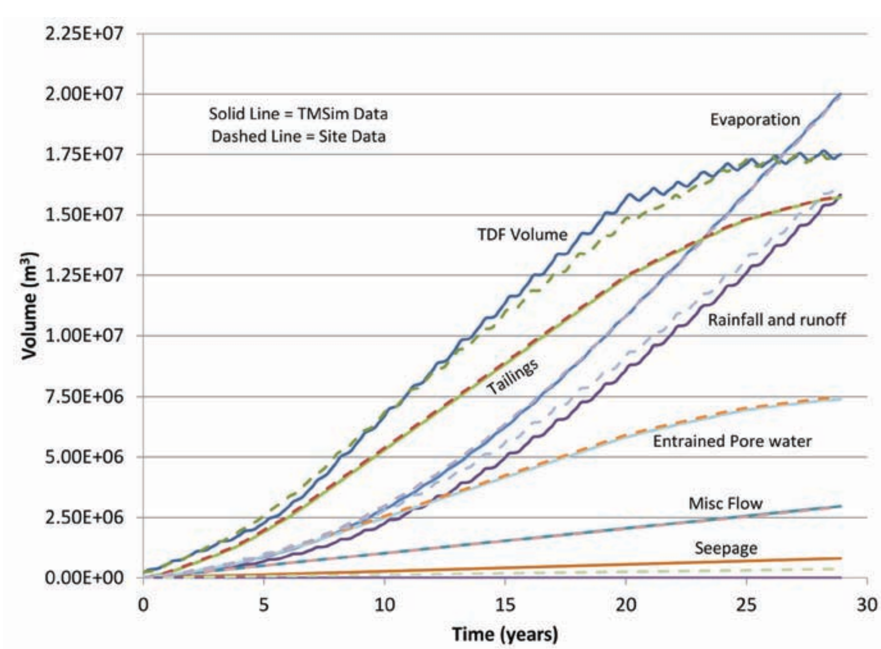

Figure 2. Validation of TMSim volume data with a base metal mine site data set.

VBA (Visual Basic for Applications) macros and FSConsol. Based on a conceptual systems model of a tailings system (Figure 1) the TMSim model tracks the stocks (accumulation of mass) and flows of mass (solids [mineral including both fine and coarse], water and chemicals) throughout the system. The conceptual model incorporates mine plan data, extraction process, various stages of dewatering (including Stage 1 classification, Stage 2 pre-deposition dewatering and Stage 3 post-deposition dewatering) and an impoundment material balance including tailings, process water, construction material and capping materials. A suite of sub-models were used to represent these individual components in the TMSim model environment. Critical processes (such as consolidation rates, Stage 2 dewatering, seepage, etc.) within each component will dictate mass transfer between the sub-models. A spreadsheet is used for the data entry/interface for all model inputs such as site properties, tailings properties, mining and extraction rates, environmental data and pertinent management decision variables (i.e. constraints on the system).

The user has the option to utilize built-in functions and sub-models or to implement their own models (i.e. user defined models, UDF). The UDFs can be simple or complex numerical models, depending on the level of detail available and objective of the modeling. The decision logic required to allow switching between dewatering technologies and deposition points must also be provided by the user.

TMSim was developed using a top-down systems modeling approach, keeping the "big picture" in focus. Each of the individual sub-system models can be constructed from process-based, empirical or even qualitative formulations based on tentative relationships between parameters. The challenge to the modeler is then to apply the appropriate level of detail that will result in a suitable engineering simulation that will satisfy the objective of the model process.

To assess the management strategies or to evaluate a particular technology, the TMSim model provides the following performance measures as output:

- Available storage volume (in-pit, impoundment, construction material).
- Required impoundment storage volume (for both solids and water).
- Available recycle water volume and quality.
- Strength gain trajectories within the deposit.
- Seepage rate to the environment and its quality.
- Sensitivity/flexibility of disposal option.
- Impacts on extraction.
- Interim model results such as flow rates and solids/fines content that can be used as input for transport analysis (pipeline/pump).

Base metal mine scenario

For the initial validation of the TMSim model, a base metal mine tailings plan was modeled. The data used in the validation was taken from an engineering feasibility study. The complexity and scale of the proposed tailings management plan was deemed suitable for the development and validation stages of the simulation model structure and components. The TMS for the base metal mine operation includes thickeners to dewater the non-plastic, sandy-silt tailings to ensure the tailings are non-segregating upon deposition. The tailings are then deposited sub-aqueously and stored under a water cap. Overburden is utilized to construct a tailings impoundment structure that is subsequently lined with a geomembrane.

A sample of the output from the TMSim model is provided in Figure 2 and includes the required total storage volume and tailings volume with time. The solid lines represent the TMSim model data, and the dashed lines represent the mine site data sets. As can be seen from the figure, at the end of mine life, the mass balance for the model reflects the mine site data set sufficiently. The modeled total volume in the tailings disposal facility (TDF) deviated from the mine data set by up to +/-5% over the life of the mine. Upon inspection of the data and the TMSim model, the difference can be attributed to how the area and stage volume/height were calculated in TMSim versus the feasibility study and not due to loss of mass in the TMSim model.

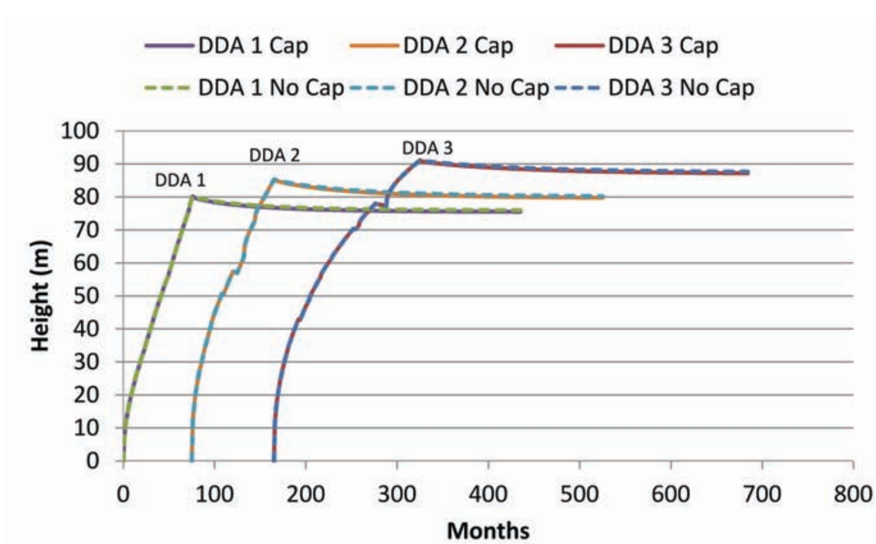

Figure 3. Total height of the CFF tailings deposits.

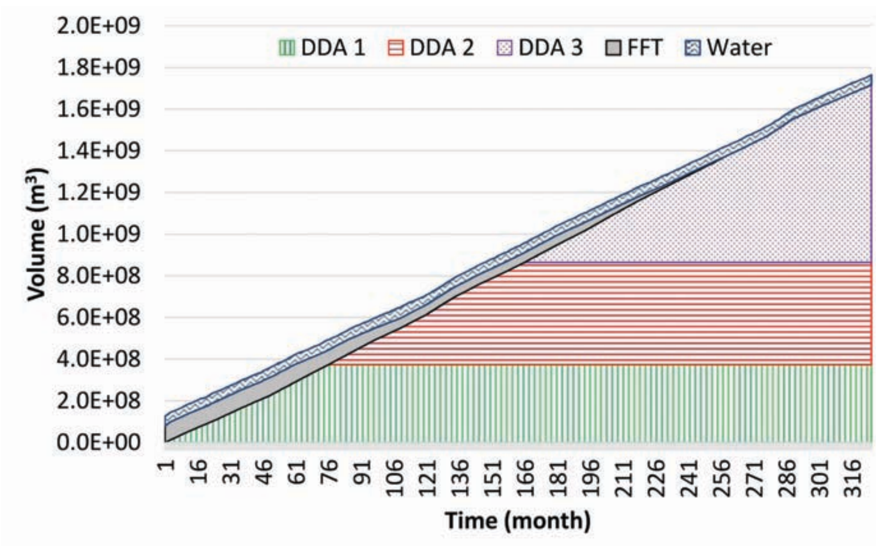

Figure 4. Volume of the CFF tailings deposits, process water and FFT requiring storage on site.

Oil sands mine scenario

The base metal mine scenario demonstrated that TMSim could reasonably simulate a mine and tailings plan for a simple case. These preliminary simulations provided an analogue for an external oil sands tailings facility with deposition of FFT or thickened tailings with dyke construction using coarse tailings and/or overburden. However, fine tuning of the initial model was required to reflect the management scheme and material flows at oil sands operations (e.g. multiple depositional impoundments both in- and out-of-pit).

The TMSim model was expanded to demonstrate the application of the model for an oil sands mine. The Syncrude Aurora North mine plan, as presented in a Directive 074 tailings management plan (Synrcude 2012), was modeled using TMSim. The tailings management technology implemented was composite tailings (CT), a method of blending fine grained fluid tailings with coarse grained cyclone underflow. All data utilized in the simulation were collected from publicly available sources of information. A mass balance was completed to ensure the calculated mass in the various tailings deposits agreed with expected results from the Syncrude plan. The TMSim results were within 2% of the Syncrude plan; therefore, the model mine plan assumptions and UDFs incorporated into TMSim were considered acceptable (Beier 2015).

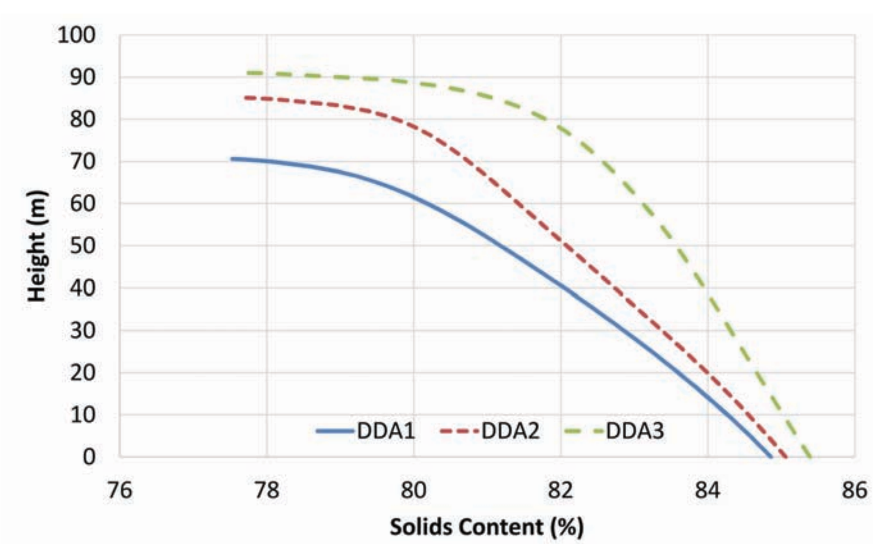

Figure 5. Gravimetric solids content profiles of CFF tailings in each DDA immediately after filling.

Novel tailings dewatering technology evaluation

To demonstrate the utility of the TMSim model, a novel bench scale tailings dewatering technology, cross flow filtration (CFF), was evaluated. CFF is a pressure-driven filtration process that can be used for dewatering slurries of fine particles and can offer improvements over conventional filtration. Details on the CFF process for tailings dewatering can be found in Beier et al. 2008, Ifill et al. 2010 and Zhang 2010. CFF offers an opportunity to deposit tailings without inducing segregation of the fines from sand, thus preventing further accumulation of FFT. It also provides immediate recycle of process water to the extraction plant. This reduces the energy costs required for heating process water, resulting in reduction in Green House Gases associated with the extraction process.

The CFF process can be implemented in an oil sands mine to dewater extraction tailings or coarse tailings prior to deposition, thus negating the formation and subsequent build up of FFT. For typical extraction tailings at ~55% gravimetric solids content (Cw), approximately 50% of the water must be removed to bring Cw to at least 70-75% to prevent segregation (Beier and Sego 2008). Upon dewatering to 70% or greater Cw, the CFF-tailings could then be deposited as stacks within the mined out pit. Sufficient overburden material should be available to provide in pit containment dykes for the CFF tailings.

The TMSim model was utilized to assess a CFF technology scenario applied to the same Syncrude Aurora North mine plan as the CT technology (Beier et al. 2014). Several simulations were completed to assess the CFF dewatering model and mine plan assumptions. In each scenario, up to three in-pit dedicated disposal areas (DDA) were used to contain the CFF dewatered tailings. A sample of various performance measures from one of the TMSim runs are included in Figures 3, 4 and 5.

The TMSim simulations demonstrated the CFF dewatering process could provide an opportunity to deposit high density tailings stacks requiring minimal containment. Up to two-thirds of the yearly process water demand could also be satisfied by immediate recycle from the CFF process. Additionally, if FFT spiking is incorporated, the existing legacy inventory can be consumed and stored in the pore space of the CFF tailings.

Conclusions

A simulation model, TMSim, was developed which offers a quantitative tool to aide in the evaluation of tailings management technologies and provide guidance to mine developers on strengths and limitations of such technologies. TMSim provides a virtual modeling environment that incorporates the major components of a mine system including the mine plan, various stages of dewatering and an impoundment material balance. Validation of the model with base metal and oil sands mine data sets demonstrated TMSim's ability to simulate tailings management systems and technologies for a range of mining applications.

The process of compiling the necessary input data required by the TMSim model provided significant insight into the CFF process. The TMSim simulations presented above provide a baseline for further refinement and sensitivity analyses of the technology and depositional scenarios. As research and development progresses on the CFF process, the model can be refined, providing an improved understanding of the impact of the CFF technology to a mine and tailings plan.

The TMSim model was established to be an effective, quantitative tool that can be used in the evaluation of technologies for mining operations. The model can simulate a tailings system over time, demonstrate various outcomes by alternating management practices and conduct sensitivity analyses. Essentially, the simulation model is a "what-if" tool to experiment with various operating strategies or design alternatives to support technology assessment and scenario analysis.

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Paolo Gazzarrini

Overture

40th episode of the Grout Line and 10th anniversary! So? HAPPY B-DAY Grout Line!

And what is the best way to celebrate if not with a dedicated article and a piece of creative writing? The former, is an article from Jim Warner, Grouting Consultant, Mariposa (CA) (warner@sti.net), and the latter, a poem, written by Michael J. Byle, D.GE, F. ASCE, National Discipline Lead, Civil/Geotechnical Engineering (Michael.Byle@tetratech.com) - Tetra Tech, Inc, Langhorne, PA- USA. Not only an Engineer, but also a poet. Congratulations Mike and thanks! Along with Jim, the original instigator of the Grout Line as you can read below, Mike is a frequent contributor to this department.

In addition to these two contributions, last but not least, this edition concludes with a review of the annual "Grouting Fundamentals & Current Practice" short course by Scott Kieffer, Head of Institute & Professor of Engineering Geology- Graz University of Technology- Austria (kieffer@tugraz.at), course director.

40th Episode

Jim Warner

It all started in January 2005, at the ASCE Geo-Frontiers Conference in Austin, Texas. The benefits of grouters from different backgrounds sharing experiences, was the subject of lively discussion in the exhibit booth of Bi-Tec Publishers. The International Conference on Grouting occurred only once, every 10 years; so how could grouting industry participants from around the world share their experiences in a more timely manner? Perhaps, an informal section in an industry publication? The idea of The Grout Line was kicked around, but….. more importantly, Paolo Gazzarrini agreed to head the effort, with Lynn Pugh of BiTech, agreeing to publish it.

Ten years, and forty episodes later, what has happened since it began?

The many facets of pressure grouting have continued to develop, and be better understood, not only by those of us in the industry, but even more importantly, by engineers and others who can benefit by our offerings. We have all become a little smarter!

Significant improvements in available materials and admixtures have occurred, and the resulting benefits for mix design, discussed. The article "How Many Components in a Grout Mix" by Marcelo Chaqui, in the March, 2006 Grout Line provided much to discuss, in this regard.

The enormous advances and improvements in instrumentation technology have benefitted us greatly. With help of the frequent discussions in The Grout Line, we can now safely perform work in formations, and around structures, that was not conceivable, even a short ten years ago.

Real time computer monitoring, which at the time was in its infancy, has become routine on all important projects, and many smaller ones, as well. The subject has been thoroughly discussed and debated in The Grout Line, with an especially comprehensive article by 33 different authors, "A Monitoring Ruckus", appearing in the June 2012 issue. Included was the current state of practice, as well as the somewhat controversial issue of who should receive and own, the original computer input files.

And the most contentious issue continues, what is the optimum way to grout rock? Amenability; GIN; Aperture Controlled; Apparent Lugeon, which is best? The various offerings (and sometimes strong opinions) appearing in The Grout Line have provided us with much food for thought, and even more significantly, the ability to better understand the mechanisms involved. Though controversial, this is good!!!..... we are all a little smarter, as a result!

Unlike in earlier times, grouting is now more often viewed as the science it is; not as some form of black magic which only the gifted promoters could perform. The Grout Line has been instrumental in spreading the word.

The Colorado School of Mines week long Short Course on Grouting continues to educate our industry. This is the only exhaustive training available in the grouting industry, and in its 36th year this past June, had 115 registrants from 12 different countries, on five different continents. The Grout Line has regularly supported and reported on its progress.

But.... what has not changed? Paolo is still begging for articles, news, and other material of interest to grouters. So let us continue to supply him with our ideas, opinions, and experiences. For with such open discussion, (even contrary opinion), we can better understand and improve the work we do. This is noble, and will benefit not just grouters, but all mankind!

I use this special episode to share with you the complete list of articles published in these ten years. And of course thanks to all the authors who have helped me in keeping alive this department of our very interesting, competitive and quite often, argumentative industry.
THANKS to everybody!

Ode to Grout

Michael Byle

Oh that grout, that marvelous goo;
You'd be surprised at the things it can do.
You can pat it and poke it and splash it like mud;
But there are many more things you can do with this crud.
You can glue up your dirt and make it real strong.
You can plug up those holes that have been leaking so long.
You can cause it to gel, or just let it flow;
There is almost no limit to the places it'll go.

What else you may ask can we do with this stuff?
I can tell you much more 'til you cry "Enough!"
You can pour it, or jet it, or pump it you know;
With packers, and sleeve ports, or in open hole.
You can make it so thick that it really won't flow,
But compacts the ground if you pump it real slow.
With special ingredients that make up this goo;
There is almost no limit to the things it'll do.

When you have fine fractures or soil to fill,
Chemical grouting may just fit the bill.
Some grouts are so thin that like water they flow.
Others much thicker, expand as they go.
You can mix them and blend them for all that they're worth,
And then perform magic under the earth.
Fixing cracked pipes, or sealing a leak
There's almost no limit to grouting's mystique.

There's more, much more to this marvelous goo.
It can do most anything you want it to.
For construction that's new or fixing what's old,
There's nothing much better than this liquid gold.
Whether fixing your piles, or sealing your dam,
Grouting can do it as slick as canned Spam.
Creating a curtain or fixing a wall,
Grouting can do it in no time at all.

No matter the problem, no matter the cause,
Think about grouting to mend any flaws.
For this little treatise I'd like to point out,
That this only applies to underground grout.
While grouting above, we likely can do,
We have to leave something for those builders to do.
Think about grouting when ideas are few;
Because there is almost no limit to what this goo can do.

Episode	Date	Author/s	Topic
1	Jun-05	Jim Warner	Pressure grouting
2	Sep-05	John Dunnicliff	Listen To The Driller
3	Dec-05	Paolo Gazzarrini and others	Jet Grouting- North Vancouver
4	Mar-06	Marcelo Chaqui Paolo Gazzarrini Kew Waver	How many components in a Grout Mix? Discussion Listen To The Driller discussion
5	Jun-06	Gomez-Robison–Cadden Giovanni Dugnani John Dunnicliff	Compaction Grouting Listen to the Driller. Comment Listen to the Driller. Comment
6	Sep-06	Dick Berry Jim Warner	Permeation Grouting How many components in a Grout Mix? Discussion
7	Dec-06	Giovanni Dugnani Donald Bruce	How many components in a Grout Mix- Discussion ASCE- GI -Glossary of Grouting Terminology
8	Mar-07	Robinson-Matheson-Gomez Donald Bruce John Dunnicliff	Testing Polyurethane Grout Equal Rights for Grouters Poem
9	Jun-07	Giovanni Lombardi	GIN Again Misunderstood
10	Sep-07	Shuttle-Bonin	GIN Distilled
11	Mar-08	Vanderpool and other Paolo Gazzarrini	LMG vs Comp Grouting CSM Grouting Course
12	Jun-08	Giovanni Lombardi Shuttle-Bonin	Misunderstanding of GIN Confirmed An Alternative Viewpoint on GIN
13	Sep-08	Spagnoli	Theoretical Evaluation of Liquefaction Mitigation Through Jet Grouting
14	Dec-08	Jim Warner	History of GI Committee on Grouting
15	Mar-09	Burke-Spagnoli	Comments
16	Jun-09	Peter Town	Epoxy Resin Injection
17	Sep-09	Mohammed El Tani	Grout-Time (GIN dispute)
18	Dec-09	George Burke	Quality Control Consideration for JG
19	Mar-10	Sam Bandimere	Contracting Means and Methods
20	Jun-10	Theresa Rappenport	4th Grouting Int Conference
21	Sep-10	Paolo Gazzarrini	CSM Grouting Course
22	Dec-10	Paolo Gazzarrini	Compaction Grouting Consensus Guide
23	Mar-11	Sam Bandimere	30 years of Grouting
24	Jun-11	Donald Bruce	Rock Grouting for Dams and the Need to fight regressive thinking
25	Sep-11	Giovanni Lombardi	Some Consideration on the GIN Grouting Method
26	Dec-11	Jim Warner Donald Bruce Mike Byle	In remembrance of Clive Houlsby Discussion Rock Grouting Managing Risk for Grouting in Karst
	Mar-12		No article
27	Jun-12	From DFI magazine Jim Warner and others	4th Grouting Int Conference A Monitoring Ruckus

Episode	Date	Author/s	Topic
28	Sep-12	Stuart Littlejohn Scott Kieffer and others	Errata Corrige CSM Grouting Course 2012
29	Dec-12	Paolo Gazzarrini	ISM and Use of Real Time Monitoring for micropile/ anchors testing and stressing
30	Mar-13	Brook Brosi and Clay Rathbun	Use of dyed cement grout in foundation grouting
31	Jun-13	Donald Bruce	Refusal and closure in rock grouting; Let's get it right!
32	Sep-13	Mohamed El Tani	Grouting Emancipation
33	Dec-13	Paolo Gazzarrini	A Christmas Fairy Tale of Rock Grouting in a Dam
34	Mar-14	Evind Grov and others	Rock Mass grouting in Sweden and Norway. A matter of cultural differences or factual causes?
35	Jun-14	Paolo Gazzarrini Sam Bandimere	Jet Grouting book review A Grouting Industry Review
36	Sep-14	Jim Nickerson and others	Lake Mead- Intake Tunnel No. 3- Pre-excavation grouting challenges using a high pressure slurry TBM
37	Dec-14	Marco Ziller, Maurizio Siepi	A challenging jet grouting project for the construction of the railway tunnel in Stans (Austria)
38	Mar-15	Kathleen Bensko Paolo Gazzarrini	US Army Corps of Engineer Grouting Technology Manual presentation Some considerations about the jet grouting reflow/spoil and its management
39	Jun-15	Jim Warner	Grouting in Structures

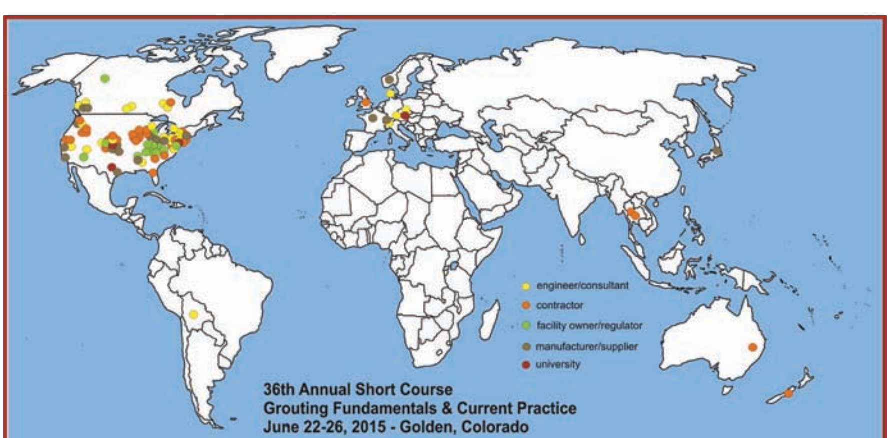
As promised, I conclude with, a quick overview of the Annual Short Course "Grouting Fundamentals and Current Practice" from Scott Kieffer.

36th Annual Short Course "Grouting Fundamentals & Current Practice" Review

The 36th annual short course on Grouting Fundamentals & Current Practice was held from June 22-26, 2015 at the Colorado School of Mines in Golden, CO. With 115 delegates from five continents, the breadth and depth of grouting experience at the course was exceptional, and discussions with the course faculty were both insightful and engaging. The traditional half-day field demonstration included 16 manufacturers, suppliers and contractors, and as always was a course highlight. The demonstration included overburden drilling techniques, high-shear mixing, anchor installation and testing, compaction and permeation grouting, use of borehole packers, hydraulic fracturing, computer monitoring, penetration of ultrafine cements and colloidal silica, use of borehole televiewers, and slab jacking with chemical grouts.

The Grouting Fundamentals & Current Practice short course is world renowned and has been an esteemed source of information and knowledge for generations of grouters. The 37th course installment will be held from June 13-17, 2016, again at the Colorado School of Mines.

In closing, some comments from me. It was, in my opinion, the best course in my 6 years of participation.



Very open and active discussions with a fantastic demonstration of interest as evidenced in the picture below; during the field afternoon, with the "real" demonstration grouting, and despite a tornado watch with a very strong and windy thunderstorm, still a number of interested people resisted until 7 pm for the final compaction grouting test. This was really a demonstration of dedication and interest!

As usual, I make the same request, asking you to send me your grouting comments or grouting stories or case histories. My coordinates remain:

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

Ciao! Cheers!

Jonathan Fannin, Editor

Professor of Civil Engineering, University of British Columbia

Jonathan Fannin

Writing in this column for the GN June 2015 issue, I reported on the material properties of a geotextile, noting that inherent differences between the manufacturing processes of a woven and a nonwoven geotextile impart differences to the opening size distribution of the fabric and, by association, differences to the capacity for flow of water across the plane of the fabric. Likewise, there is a difference in tensile strength and stiffness that results from the manufacturing process.

The use of a geotextile in filtration applications is predicated on it having adequate strength to ensure no adverse damage throughout the process of installation (termed 'construction survivability') and that it can also endure, thereafter, the working environment of the application (termed 'durability'). Upon selecting a suitably strong and durable geotextile, the requirement for soil-geotextile filtration compatibility is contingent on there being no unacceptable erosion as a consequence of soil loss through the geotextile while, at the same time, providing for unimpeded flow of water from the soil through the geotextile.

It is widely-accepted practice to select a candidate geotextile for routine construction works with reference to (i) criteria for strength and durability, given the anticipated method of construction service environment, (ii) an empirical rule governing base soil retention, and (iii) an empirical rule governing base soil permeability. Typically, the approach has been found conservative, and yields a geotextile filter for which the margin of safety is believed acceptable. However, the exact nature of that margin of safety is not quantified – therefore, in applications that are deemed critical or severe, the state-of-practice is first to identify a candidate geotextile on the basis of the reported values for

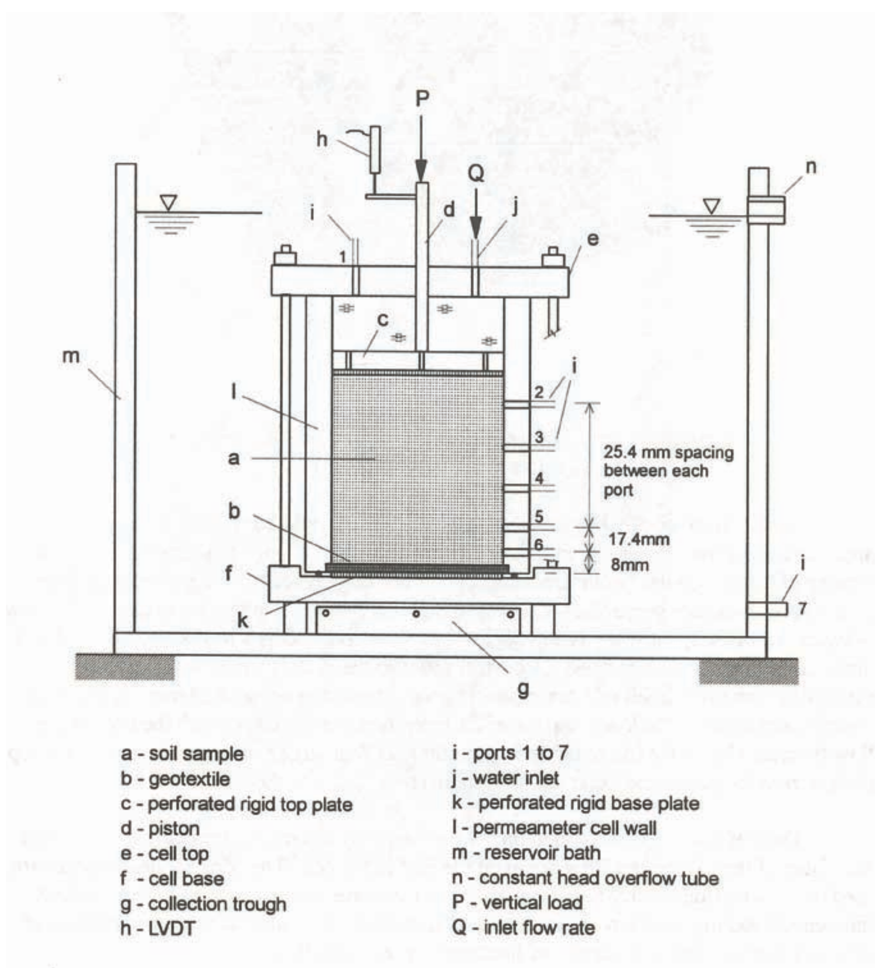


Figure 1. Configuration of the gradient ratio test.

its strength, opening size and permittivity from index testing, and then to evaluate its suitability from laboratory compatibility testing. In this article, I review the origins and some notable developments in North America that have informed current practice in the evaluation of soil-geotextile compatibility.

The early work of the US Army Corps of Engineers (Calhoun, 1972) on filtration compatibility included laboratory permeameter testing to investigate factors governing soil retention and permeability. More specifically, the laboratory filtration tests examined the ability to retain silty base soils. Two permeameters were used, a relatively small one that accommodated a specimen 127 mm in diameter and large one with a diameter of 292 mm. Each was fitted with a series of manometer ports on the rigid-wall of the permeameter, at a vertical center-to-center spacing of 25 mm above the geotextile. The smaller permeameter was used to evaluate clogging phenomena. Following placement of the geotextile, de-aired water was introduced and the soil then placed underwater using a tremie-type device, with care taken to minimize segregation of the grains. Unidirectional flow was applied in a downward direction, with the hydraulic gradient controlled by means of a constant head reservoir. Interpretation of the results included the reporting of a ratio of two values of hydraulic gradient, termed a 'clogging ratio' given by i_{57}/i_{37} (with reference to Fig. 1) The value i_{57} is measured across the lower 25 mm of soil plus the geotextile, and the value i_{37} is measured across the lowermost 75 mm of soil plus the geotextile. A ratio greater than 1 was considered indicative of clogging (Calhoun, 1972). Subsequent work, using the same permeameter and arrangement of manometer ports (USACE, 1977), led to the clogging ratio being replaced by a 'gradient ratio' (GR) that was determined with reference to i_{57} measured across the lower 25 mm of soil plus the geotextile, and i_{35} measured across the adjacent soil a distance 25 mm to 75 mm above the geotextile, yielding:

$GR = i_{sg}/i_s$

where:

i_{sg} = hydraulic gradient across the soil-geotextile composite zone

i_s = hydraulic gradient in the soil

In principle, ideal compatibility exists for a gradient ratio = 1 (see Fig. 2). A value greater than 3 was considered indicative of 'excessive clogging', and served to quantify the compatibility of the soil and geotextile.

Haliburton and Wood (1982) used a permeameter similar to that of Calhoun (1972) to evaluate the comparative performance of two nonwoven and four woven geotextiles. A sand, and a gap-graded silt-sand (5 % to 80 % silt content), were used in testing. The soil was reconstituted by a dry tremied-placement technique, and then slowly back-flooded from below with tap water. This represents a minor variation to the method of specimen reconstitution that was used by Calhoun (1972) and it appears to have exerted a strong influence on the subsequent standardization of the test in 1992 (as ASTM D 5101). The experimental findings were used to support the quantifying of excessive clogging by a gradient ratio value of 3 (from UASCE, 1977), for which Lafleur et al. (2002) subsequently proposed an upper limit of 2 for blinding and lower limit of 0.5 for piping.

The ASTM recommended specimen reconstitution technique involves placement of the soil specimen of diameter 100 mm and length 100 mm above the geotextile in a dry and

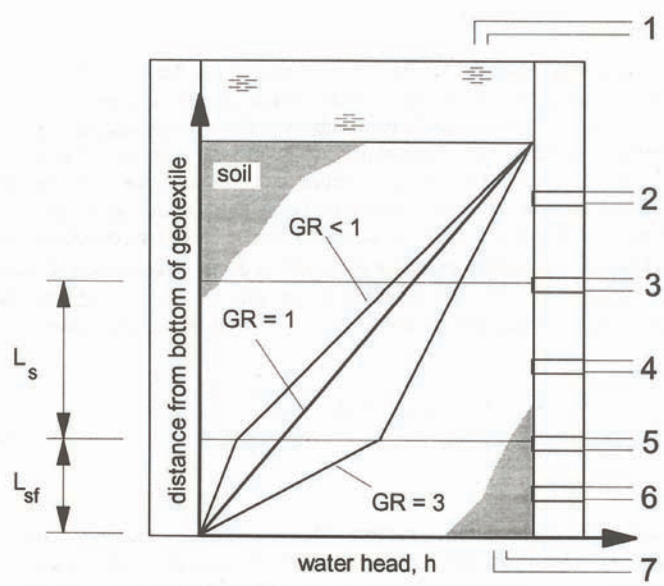


Figure 2. Schematic illustration of the gradient ratio.

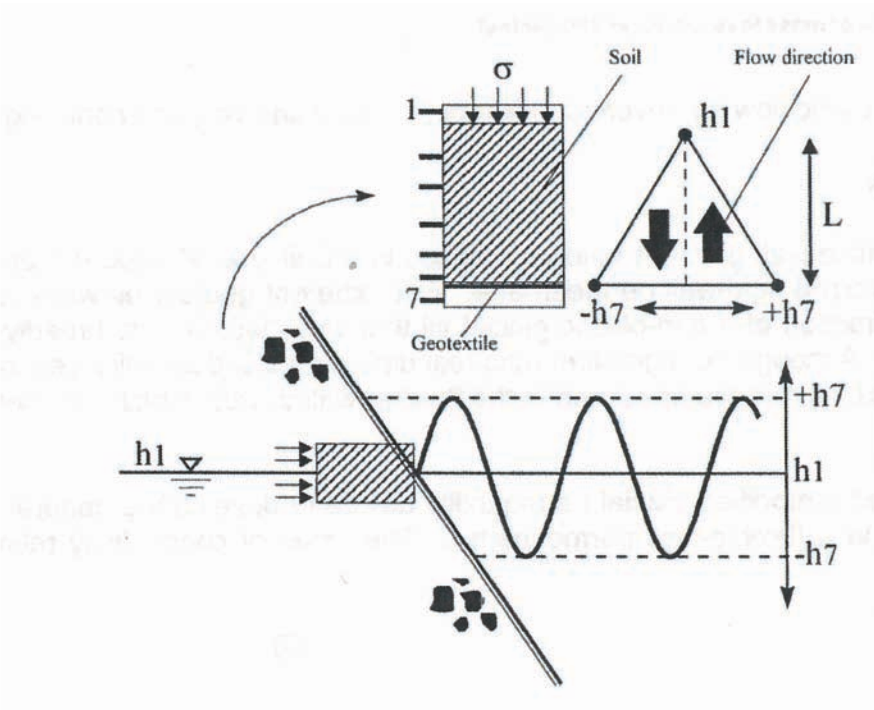


Figure 3. Principle of the cyclic gradient ratio test.

loose condition, flushing the specimen with carbon dioxide in order to expel oxygen and other gases in the permeameter, and then slowly filling the specimen with water (50mm/hr). The specimen should be kept in a no-flow condition overnight to ensure complete saturation.

In principle, the ASTM D 5101 gradient ratio test device (shown with an additional top loading assembly in Fig. 1) provides an attractive method for assessing soil-geotextile compatibility because the candidate geotextile is tested against the soil to be protected, water is permeated through the system, and any potential for clogging or piping is evaluated directly. Interpretation of the gradient ratio test is based on measurements of head loss that occur in the soil and across a 25 mm thick zone adjacent to the geotextile (GR_{25}). Fannin et al. (1994a) introduced an additional port 8 mm above the geotextile (see Fig. 1), in order to gain a more sensitive measure of head loss in the soil-geotextile 'bridging zone' that was termed the modified gradient ratio (GR_8). The benefit of adopting such an additional measurement close to the geotextile is now well-recognized (see for example, Austin et al., 1997; Palmeira et al., 2005).

Reproducibility of the test is very dependent on achieving full saturation of the reconstituted soil specimen. Fannin et al. (1994a and 1994b) established an alternative means to reconstitute homogeneous saturated specimens, by means of water pluviation for uniformly graded soil and by slurry deposition for broadly graded soil. The specimen is leveled by siphoning and, if appropriate, densified by light tapping with a soft hammer. Preliminary testing identified the need for adding a commercial liquid algaecide to inhibit biological growth, a finding that was further confirmed by Fischer et al. (1999).

A conceptual illustration of the approach to modeling cyclic flow in a laboratory element test is illustrated in Fig 3. Hameiri and Fannin (2002) describe a modified gradient ratio test device that was configured to impose cyclic flow using head control, while maintaining the ability to apply axial load and collect soil passing through the geotextile. Fannin and Srikongsri (2007) report data using the same device that show mass loss is sensitive to confining stress and the period of flow reversal, both of which are believed to exert a significant influence on the ability of a bridging network to develop in the base soil adjacent to the geotextile. Extending the database of results to include combinations of 9 different geotextiles and 6 cohesionless soils (with $0.6 \le O_{95}/D_{85} \le 2.8$), Srikongsri and Fannin (2009) examined factors controlling soil retention by means of multi-stage tests, based on the observed relation between O_{95}/D_{85} and rate of mass loss (g/m^2 per 100 cycles). No combination of uniformly graded soil ($C_U < 2$) and nonwoven geotextile yielded a mass loss for $O_{95}/D_{85} \le 2.25$. Similarly, no combination of uniformly graded soil ($C_U < 2$) and woven geotextile yielded a mass loss for $O_{95}/D_{85} \le 2$, however a significant loss was encountered for $2.5 < O_{95}/D_{85}$. In all cases the onset of soil loss occurred at retention ratios significantly greater than the empirical rule of $O_{95}/D_{85} \le 0.5$ that has been advocated for design (Holtz et al., 1997). Likewise, by inspection, it can be inferred that the onset of soil loss occurred at retention ratios greater than $O_{90}/D_{90} \le 0.5$ to 1 that has also been advocated for design (Schiereck, 2003). Accordingly, the empirical design rules for soil retention in reversing flow appear very conservative.

Harney and Holtz (2001) report details for a flexible-wall gradient ratio test device that Bailey et al. (2005) then used to compare with results obtained using the standardized rigid-wall permeameter. Five different geotextiles were examined in testing, in combination with the 2mm-minus fraction of a non-plastic glacial till that was classified as broadly-graded, gravelly, silty sand, and each test was repeated.

Although both gradient ratio test devices yielded a similar response, the ability to test at high effective stress assured saturation of the specimen in the flexible-wall device, which was believed to reduce the time required to complete the test.

Williams and Abouzakhm (1989) had earlier used a modified triaxial permeability device to develop the general concept of the Hydraulic Conductivity Ratio (HCR) test in a flexible-wall permeameter. The value of conductivity ratio is now defined by:

$HCR = k_{sg}/k_{sgo}$

where:

k_{sg} = hydraulic conductivity of the soil-geotextile system at any time during the test

k_{sgo} = initial hydraulic conductivity of the soil-geotextile system at the beginning of the test

The test device allows for back-pressure saturation and consolidation of the test specimen, prior to imposing seepage. In common with the gradient ratio test device, the geotextile is placed at the base of the soil specimen. Downward seepage flow establishes a value of k_{sgo}, and k_{sg} is then measured over a time period sufficient for approximately 5 pore volume exchanges. The methodology has been standardized as a performance test, and is intended for soil with a hydraulic conductivity less than or equal to 5 x 10^{-2} cm/s (ASTM D5567).

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Errors in geotechnical engineering - Case history 1

extract from Suit is a Four letter Word

(Hugh Nasmith, 1986)

Hugh Nasmith has put together an excellent book on litigation which is easy to read, covers the litigation scene thoroughly, has subtle humour, and most important of all, is umderstandable. He remarks in the opening paragraphs that experienced geotechnical engineers will find nothing new in the book except comfort that their situation is not unique. This is true but experienced engineers should read it anyway. (From a review by William A. Trow).

An incorrectly located borehole is probably one of the more common errors in geotechnical engineering.

In most cases the error goes undetected since site preparation will destroy the evidence of the actual location of the borehole, and for most purposes a wrongly located borehole is not critical unless it actually happens to be on the wrong property. The following account describes a case where a wrongly located borehole was the basis of a complex dispute though in this case it appears that the losses suffered by the plaintiff arose from other causes than the consultant's error.

The client was an industrial firm which employed a firm of architects to design and supervise the construction of a building to house heavy machinery. The foundation investigation was carried out by a firm of geotechnical engineers who were familiar with local practice and conditions.

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The subsurface investigation was conducted in two stages. In the first stage the general site conditions were identified and it was recognized that the heavy machinery loads would have to be carried on end-bearing piles driven through soft clay to a very hard bedrock. From local experience it was known that the bedrock surface was very irregular and that difficulty in seating piles on steeply sloping surfaces was often encountered.

In the second stage a further drilling program was carried out to explore in more detail the area to be occupied by the building itself. Unfortunately three borings were plotted approximately fifty feet from their actual locations.

The drilling information from the two programs and reference to the geotechnical report was included on the bid documents along with a disclaimer which stated “This information is presented for the foundation subcontractor. He shall satisfy himself as to prevailing conditions, and no extras will be allowed should conditions differ from those indicated.”

The contract for the building was let to a local general contractor who called for proposals for the installation of end-bearing piles as shown on the bid drawings. Contrary to the recommendation of the local geotechnical engineer the client insisted that the contract for piles be on a lump sum basis.

Proposals were received from several contractors. The successful piling contractor had not worked in this area previously and proposed an alternative to the type of pile shown in the bid documents. Acceptance of the alternative required structural analysis and some modifications of the piling system to achieve the same results as the system shown in the bid documents.

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During the negotiations prior to the award of the contract the piling contractor carried out some drilling at his own expense and confirmed that bedrock slopes steeper than 45 degrees would be encountered. After the contract was signed but before any work had started a further revision to the pile system was proposed by the piling contractor and was accepted on the condition that there would be no change in the lump sum price for the piles.

The piling contractor was required by the terms of the contract to employ the geotechnical firm to provide inspection services. The geotechnical firm was thus fortunate to have an inspector on the site to obtain firsthand knowledge of the pile driving records. However, the piling contractor withheld payment for the inspection service and the geotechnical firm was never paid for this work.

Shortly after the first few piles had been installed the technician who was inspecting the work identified the error in borehole location and correctly surmised the cause of the error. The technician first advised the contractor on site of the error and then advised his employers the geotechnical engineering firm.

The piling contractor immediately entered a claim for extra piling although at this stage the total amount of piling which would be required was still unknown. Work was suspended briefly but the contractor agreed to continue and complete the work prior to the resolution of the dispute.

Negotiation of the claim and threat of litigation continued for almost three years and was finally settled less than half an hour before the claim was to be heard in court. By this time all of the facts of the case had been explored and the only uncertainty remaining was how the judge would interpret the facts. The negotiated settlement involved a payment to the piling contractor of approximately 15% of the amount claimed as an extra.

The key question in the dispute was whether or not the contractor had actually suffered a loss as a result of the error in location of the boreholes. The dollar value of the contractor's claim was based on the number of feet of piling actually installed minus the number of feet of piling which he claimed to have estimated in making his bed, multiplied by the per foot allowance in the contract for piles added or deleted.

Although it might appear that he number of feet of piles actually installed would be easily and accurately determined even this figure was in dispute. The bid documents envisaged piling being installed from the bottom of the excavation to the basement of the building. The contractor actually installed piles from the original ground surface and cut them off when the basement was excavated. This amount of excavated and discarded piling actually exceeded the amount of the claim. The question thus arose as to whether the contractor originally envisaged installing piles from the surface or from the bottom of the excavation.

Although an obvious and embarrassing error had occurred the geotechnical engineer did not automatically accept the claim that the contractor had suffered a loss as a consequence of the error.

The contractor's case was weakened by the fact that he never documented the method by which he had arrived at the lump sum price for pile installation.

Since the geotechnical engineer had firsthand detailed knowledge of the length of each pile installed he was abler to make a detailed comparison between the length of piles installed and what would reasonable be estimated using boreholes plotted in both their correct and their incorrect locations. Various methods were used including drawing contours; assuming each borehole was representative of a proportional area; or simply averaging the borehole lengths and multiplying by the number of piles on the assumption that the boreholes statistically represented the topography of the bedrock.

The most detailed evaluation gave an estimate of total pile length which was closer to the actual amount when using the boreholes plotted in the wrong location than with the correctly located boreholes. The drilling program was never intended to accurately determine the footage of piling required and in fact was inadequate to achieve this result. This was the reason that the geotechnical engineer was opposed to the use of a lump sum piling contract.

It appears that the piling contractor suffered a loss as a consequence of putting in a low lump sum bid in a situation where he was not familiar with the local conditions and where he experienced a great deal of difficulty in installing the piles using his preferred methods. The appearance of the error gave him a fortuitous opportunity to attempt to recoup some of his losses.

It was never tested in court whether or not the disclaimer would limit the owner and architect's liability although the piling contractor entered a claim only against the general contractor and the geotechnical consultant. The general topic of disclaimers is discussed in Chapter 12.

This case illustrated the fact that claims for errors and omissions are sometimes used as a matter of standard business practice. In this case although an obvious and embarrassing error had occurred the geotechnical engineer did not automatically accept the claim that the contractor had suffered a loss as a consequence of the error.