Volume 29 Number 4 Decemberr 2011

GEOTECHNICAL NEWS

CANADA • UNITED STATES • MEXICO

Sensing Cable Buried Over a Potential Sinkhole Area

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GEOTECHNICAL NEWS

Volume 29 Number 4 **December 2011**

Publisher **John W. Gadsby**

Managing Editor **Lynn Pugh**

Graphics **George McLachlan**

Editors

Linda Bayer, Phil Bruch, Robert Chapuis, John Dunnicliff, Paolo Gazzarrini, Saeed Otufat-Shamsi, Ward Wilson

Managing Editors and Advertising

BiTech Publishers Ltd.
103 - 11951 Hammersmith Way **NEW**
Richmond, British Columbia
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Tel: 604-277-4250, Fax: 604-277-8125
email:gn@geotechnicalnews.com
web: www.geotechnicalnews.com

Canadian Editorial Office

Canadian Geotechnical Society
Phil Bruch, Editor, CGS News
email: Phil_Bruch@golder.com

United States Editorial Office

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

Computing in Geotechnical Engineering

Saeed Otufat-Shamsi, 4188 Hoskins Road,
North Vancouver, BC V7K 2P5,
Tel: 604-603-5650,
email: Saeed@novotechsoftware.com

Groundwater

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

Instrumentation

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

The Grout Line

Paolo Gazzarrini, 12-2242 Folkestone Way,
West Vancouver, BC, V7S 2X7
Tel: 604-913-1022, Fax: 604-913-0106
email: paolo@paologaz.com

Waste Geotechnics

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

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Membership Information

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

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CGS NEWS

Message from the President

Bryan Watts, President of Canadian Geotechnical Society, 2011-2012.

Like 650 others, I have just returned from the 64th Canadian Geotechnical Conference (CGC) which was co-hosted with the 14th Pan-American Conference on Soil Mechanics and Geotechnical Engineering (PCSMGE) in Toronto from October 2 to 6, 2011. The conference has been a real success thanks to the efforts of the local Organizing Committee, under the leadership of the Chair, **Andrew Drevininkas**. The conference featured not only the customary keynote lectures from the CGS but keynote lectures from our PanAm colleagues. A highlight of the conference was the **Casagrande Lecture** given by our **Dr. Kerry Rowe** from Queen's University who presented his latest work on leakage from lined landfills. **The Hardy Lecture** was given by our **Dr. K.Y. Lo** of the University of Western Ontario and the **Geotechnical Colloquium** by **Dr. Craig Lake** of Dalhousie University. All lectures were well attended.

For those of you interested in the operations of the Canadian Geotechnical Society during the conference, let me describe those briefly. It all starts on the Saturday before the conference when the Executive Committee (EC) reviews the agenda for the CGS Board of Directors Meeting on Sunday. The EC does this to summarize effectively the activities of the past year for the Board and to anticipate questions from the Board. Our Secretary-General, **Dr. Victor Sowa**, prepares the agenda for the Board Meeting. At the Board Meeting we go through this agenda which leads to a review of the audited financial statements for the previous year, an update on the budget for the current year, and the proposed budget for the next year. The results of our Board Meeting are brought forward to the Annual General Meeting (AGM) held at the Wednesday lunch during the conference. This is all dry stuff but essential to the proper governance of a distinguished technical society like the CGS.

One of the highlights of this conference for me was the Legget Dinner held on the last night of the conference. The purpose of this dinner is for the previous **Legget Medal** winners to get better acquainted with the new 2011 **Legget Medal** winner who is **Dr. Liam Finn** from the University of British Columbia. **Dr. Finn** has been one of the leading authorities in geotechnical earthquake engineering since the 1960s. The Legget dinner always has a theme and this year we asked six of the attendees to describe early influences that guided them towards geotechnical engineering. My only regret was that we did not think to record those responses as they were vivid descriptions of geotechnical history.

Attending the Legget dinner were **Dr. Gabriel Auvinet**, ISSMGE Vice-President, North America, from the Instituto de Ingenieria UNAM, and **Dr. Roberto Terzariol**, ISSMGE Vice-President, South America, from the Universidad Nacional de Cordoba in Argentina. Our **Dr. Adams** also attended the dinner with a few kind words. Dr. Terzariol asked if this was the same J.I. Adams who published a technical paper in the 1960s with Dr. Meyerhoff on the uplift capacity of foundations. Dr. Terzariol uses this paper in one of his courses in Argentina and was delighted to speak to Dr. Adams directly. Such is the stature of our Legget Medal winners!!!

At the Board meeting, our past President, Dr. Michel Aubertin, presented his proposal to start a **Mining Geotechnique Committee** which was accepted. This committee will bring together our members who have an interest in this area. **Dr. Richard Bathurst** was unanimously accepted as our incoming President for the 2013-2014. He also tabled a Membership Committee Task Force Report on increasing membership in the CGS. This report contains many good ideas and was accepted by the Board. It is up to the Executive Committee to decide which of these ideas to initiate and when. The proposal from the Regina group for the 2014 conference was accepted. Next year, 2012, the conference is in Winnipeg, followed by Montreal in 2013.

A few of our Board members have completed their mandates this year. We thank them very much for their efforts: **Chris Hawkes, Dwayne Tannant, Marcia MacLellan, Myint Win Bo, Tae C. Kim, Robert P. Chapuis, Didier Perret, Adrian Thompson, Jim Graham,** and **Tim Keegan.** We also thank very much the following retiring Associate Editors of the Canadian Geotechnical Journal: **Tarek Abdoun, David Cruden, Fabrice Emeriault, Hanping Hong, Andrew Whittle, Bruno Bussière**, and **Josée Duchesne**.

In my message to the membership at the AGM, I expressed concern about the lack of a leader for the Geoenvironmental Division. Fortunately **Dr. Myint Win Bo** of DST Consulting Engineers agreed to take on this task. We thank him and ask that each member consider where they want to put their efforts in our society. We encourage younger people to step into key roles going forward.

The excellent reputation of the *Canadian Geotechnical Journal* continues under the Editor of the Journal, Ian Moore. Ian Moore advised the Board of Directors, that after a bit of a rocky

start, the new arrangement with a private not-for-profit publisher has improved. The change from one online system to a new system is better than the old system, and Ian expects that it will be more efficient, and help the Editorial Board improve processing times.

The Cross Canada Lecture Tour (CCLT) is continuing with two annual tours, which are funded through the Canadian Foundation for Geotechnique. The Spring Tour was presented by **Dr. Mark Diederichs**. By the time that this message reaches you, **Mr. Steve Vick** will have completed his Fall Cross Canada Lecture Tour. I hope that everyone enjoyed both Lecture Tours. Our next CGS sponsored conference is the 11th International Symposium on Landslides / 2nd North American Symposium on Landslides to be held in Banff on June 3 to 8, 2012. I hope to see many CGS members there.

Le Message du Président

Comme les 650 autres délégués, j'arrive tout juste de la 64e conférence canadienne de géotechnique (CCG), qui a eu lieu conjointement avec la 14e conférence panaméricaine sur la mécanique des sols et l'ingénierie géotechnique (CPMSIG) à Toronto, du 2 au 6 octobre 2011. La conférence a remporté un franc succès, grâce aux efforts du comité organisateur local, sous la gouverne de son président **Andrew Drevininkas**. L'événement présentait non seulement les conférences d'honneur habituelles de la SCG, mais aussi des conférences d'honneur de nos collèges de la Conférence panaméricaine. La **Conférence Casagrande** a constitué l'un des moments forts de la conférence. Elle a été prononcée par l'un de nos membres de Queen's University, **Kerry Rowe, Ph. D.**, qui a présenté ses travaux les plus récents sur les fuites dans les décharges à revêtement. La **Conférence Hardy** a également été donnée par un de nos membres, **K.Y. Lo, Ph. D.**, de la University of Western Ontario. Enfin, **Craig Lake, Ph. D.**, de Dalhousie University, était le conférencier retenu pour présenter le **Colloque canadien de géotechnique**. Ces conférences ont attiré un public nombreux.

Pour ceux d'entre vous qui s'intéressent aux activités de fonctionnement de la Société canadienne de géotechnique durant la conférence, permettez-moi d'en faire une brève description. Le tout commence le samedi avant la conférence, alors que le Comité exécutif passe en revue l'ordre du jour de la réunion du conseil d'administration de la SCG qui a lieu le dimanche. Le but de cet examen est résumer les activités de l'exercice précédent, pour en faire un exposé efficace au CA et prévoir ses questions. Notre secrétaire général, **Victor Sowa, Ph. D.**, prépare l'ordre du jour pour la réunion du CA. Durant la réunion, nous suivons cet ordre du jour, lequel comprend l'examen des états financiers vérifiés de l'exercice précédent, une mise à jour du budget de l'exercice en cours et le budget proposé pour le prochain exercice. Les résultats de la réunion du CA sont présentés à l'assemblée générale annuelle, qui a lieu durant le dîner au programme du mercredi de la conférence. Il s'agit là de tâches arides, mais qui sont essentielles à la gouvernance convenable d'une société technique distinguée comme la SCG.

Pour moi, l'un des points saillants de cette conférence a été le banquet de remise de la **médaille Legget** qui a lieu le dernier soir de la conférence. Le but de ce banquet est de réunir les récipiendaires précédents de la **médaille Legget** afin qu'ils fassent connaissance avec le nouveau lauréat de la **médaille Legget**. En 2011, elle a été décernée à **Liam Finn, Ph. D**., de la University of British Columbia. Ce dernier est l'une des autorités du domaine de l'ingénierie parasismique depuis les années 1960. Ce banquet a toujours un thème. Cette année, nous avons demandé à six des personnes présentes de décrire les influences qui les ont incitées à suivre la voie de l'ingénierie géotechnique. Mon seul regret est de ne pas avoir songé à enregistrer ces exposés, car ils constituent des descriptions hautes en couleurs de l'histoire de la géotechnique.

Parmi les personnes présentes au banquet Legget se trouvaient **Gabriel Auvinet, Ph. D.**, vice-président de la SIMSG (Amérique du Nord), de l'Instituto de Ingenieria UNAM, et **Roberto Terzariol, Ph. D.**,vice-président de la SIMSG (Amérique du Sud), de la Universidad Nacional de Cordoba en Argentine. L'un de nos membres, **J.I. Adams, Ph. D**., était également présent et a prononcé des propos élogieux. M. Terzariol a demandé s'il s'agissait du même J.I. Adams qui avait publié un article technique durant les années 1960 avec M. Meyerhoff, Ph. D., sur la capacité de soulèvement des fondations. C'était là un article qu'il avait utilisé dans l'un de ses cours en Argentine et il était ravi de pouvoir parler à J.I. Adams en personne. C'est là un fort bel exemple de l'envergure de nos lauréats de la médaille Legget!!!

Lors de la réunion du CA, notre président sortant, Michel Aubertin, Ph. D., a présenté sa proposition de fonder un **Comité sur la géotechnique minière**, qui a été acceptée. Ce comité réunira ceux qui, parmi nos membres, s'intéressent au domaine. **Richard Bathurst, Ph. D**., a été accepté à l'unanimité comme président entrant pour la période 2013-2014. Il a également déposé le rapport du Groupe de travail spécial sur les adhésions, qui vise à augmenter le nombre de membres de la SCG. Ce rapport comprend de nombreuses bonnes idées et a été accepté par le CA. Il revient maintenant au Comité exécutif de décider des idées auxquelles il sera donné suite et à quel moment. La proposition du groupe de Regina d'accueillir la conférence de 2014 a été acceptée. L'an prochain, en 2012, la conférence aura lieu à Winnipeg et, en 2013, à Montréal.

Le mandat de quelques-uns des membres de notre CA a pris fin cette année. Nous souhaitons leur exprimer notre plus vive reconnaissance. Il s'agit de **Chris Hawkes, Dwayne Tannant, Marcia MacLellan, Myint Win Bo, Tae C. Kim, Robert P. Chapuis, Didier Perret, Adrian Thompson, Jim Graham** et **Tim Keegan**. Nous aimerions également remercier les rédacteurs adjoints suivants de la *Revue canadienne de géotechnique,* dont le mandat prend fin : **Tarek Abdoun, David Cruden, Fabrice Emeriault, Hanping Hong, Andrew Whittle, Bruno Bussière** et **Josée Duchesne.**

Dans mon message à l'intention des membres présents à l'AGA, j'ai mentionné ma préoccupation au sujet de l'absence d'un président pour notre Division de l'ingénierie géoenvironnementale. Fort heureusement, **Myint Win Bo, Ph.D**., de DST Consulting Engineers, a accepté d'occuper ce poste. Nous l'en remercions et demandons à tous les membres de réfléchir aux domaines d'activités de notre Société auxquels ils aimeraient consacrer du temps. Nous encourageons les membres plus jeunes à occuper, à l'avenir, des postes clés.

Sous l'égide du rédacteur en chef de la *Revue canadienne de géotechnique*, Ian Moore, l'excellente réputation de cette publication se maintient. Celui-ci a informé le CA que, après des débuts un peu difficiles, le nouvel arrangement avec une maison d'édition privée à but non lucratif s'était amélioré. La transition du système en ligne vers le nouveau système représente une nette amélioration et il s'attend à cela soit plus efficace et aide le comité de rédaction à améliorer les délais de traitement.

Les conférences pancanadiennes se poursuivent, avec deux tournées annuelles subventionnées par la Fondation canadienne de géotechnique. La conférence de la tournée du printemps a été prononcée par **Mark Diederichs, Ph. D.** Au moment où vous lirez ce message, **M. Steve Vick** aura terminé la tournée de l'automne. J'espère que vous avez aimé les deux tournées. La prochaine conférence commanditée par la SCG sera le 11e symposium international sur les glissements de terrain et le 2e symposium nord-américain sur les glissements de terrain. L'événement aura lieu à Banff, du 3 au 8 juin 2012. J'espère y rencontrer de nombreux membres de la SCG.

From the Society

Canadian Geotechnical Society Awards and Honours 2011

R.F. Legget Award: W. D. Liam Finn

R.M. Quigley Award: R.W.I. Brachman, H.A. McLeod, I.D. Moore, and W.A. Take *"Three-dimensional ground displacements from static pipe bursting in stiff clay"* (Vol.47 (4) pp.439-450)

Honourable Mention: Jian-Hua Yin, Chun-Man Cheng, Md. Kumruzzaman, and Wan-Huan Zhou *"New mixed boundary, true triaxial loading device for testing three-dimensional stress–strain–strength behaviour of geomaterials"* (Vol. 47, (1) pp.1-15)

J. Paul Dittrich, R. Kerry Rowe, Dennis E. Becker, and K.Y. Lo *"Influence of exsolved gases on slope performance at the Sarnia approach cut to the St. Clair Tunnel"* (Vol. 47 (9) pp. 971-984)

G. Geoffrey Meyerhof Award: Ryan Phillips, Principal Consultant, C-CORE, St. John's, Newfoundland

Thomas Roy Award: No Award in 2011

Roger J. E. Brown Award: Not scheduled for 2011

John A. Franklin Award: Peter F. Stacey, President, Stacey Mining Geotechnical Ltd., Vancouver, BC

Geoenvironmental Award: Not scheduled for 2011

Geosynthetics Award: Not scheduled for 2011

Robert N. Farvolden Award (Joint award with IAH-CNC): Robert N. Betcher, Section Head, Groundwater Management Section, Manitoba Water Stewardship, Winnipeg, Manitoba

Graduate Student Paper Award

1st Prize: Fathi Mohamed, *"Bearing Capacity and Settlement Behaviour of Shallow Footings in Unsaturated Sands"* Department of Civil Engineering, University of Ottawa, Advisors; Dr. Sai Vanapalli and Dr. Murat Saatcioglu

2nd Prize: Jeffrey Oke, *"Investigation into Application of Rankine and Coulomb Theory on Forepoles deformation in Conventional Tunnelling Methods,"* Department of Geological Sciences and Geological Engineering, Queen's University; Advisors, Dr. Nicholas Vlachopoulos and Dr. Mark Diederichs

Undergraduate Student Report (Individual)

1st Prize: Candice Williams, *"Design of a Fluorescent Tracer Injection Experiment to Characterize Infiltration Patterns in Whiteman's Creek, Ontario,"* Department of Civil Engineering, University of Waterloo; Advisor, Dr. William K. Annable

2nd Prize: Sarah Klassen, *"The Impacts of Groundwater Trends and Bioengineering on Riverbanks in Winnipeg,"* Department of Civil Engineering, University of Manitoba, Winnipeg; Advisor, Dr. James Blatz

Undergraduate Student Report (Group)

1st Prize: Brad Copping, Sonia Hachey, Sean Legassie, Brandon Love, John Nichols, and Jennifer Pellerin, *"Seismic amplification and resonance effects in Fredericton, New Brunswick: geological origin and geotechnical significance"* Department of Earth Sciences, University of New Brunswick; Advisors, Dr. Karl Butler and Dr. Tom Al

2nd Prize: Jennifer Day, Michaela Kuuskman, and Claire MacCallum, *"Assessment of Railway Embankment Fouling,"* Department of Geological Sciences and Geological Engineering, Queen's University, Kingston; Advisor, Dr. D. Jean Hutchinson

Canadian Foundation for Geotechnique National Graduate Scholarship: Adedeji Dunmola, Carleton University

A.G. Stermac Awards

David M. Cruden, Professor Emeritus, University of Alberta

Brad M. Ellingwood, Chief Geotechnical Engineer, E2K Engineering Ltd.

Heinrich K. Heinz, Managing Director /Geotechnical Engineer, Thurber Engineering Ltd.

David F. Wood, David F. Wood Consulting Ltd.

CGS R.M. Hardy Keynote Address: Kwan Yee Lo, Professor Emeritus, University of Western Ontario.

CGS Keynote Address: Not scheduled for the 2011 Pan-Am-CGS Toronto Conference.

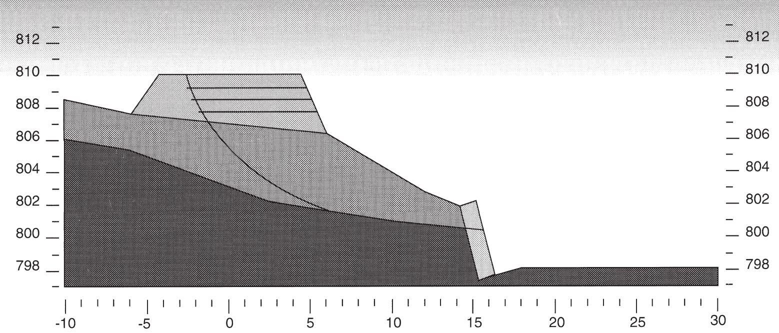
Casagrande Lecture: R. Kerry Rowe, Professor and Vice-Principal (Research) Queens's University.

Canadian Geotechnical Colloquium: Craig Lake, Associate Professor, Dalhousie University

Cross Canada Lecture Tours: Mark Diederichs (Spring 2011), Steven G. Vick (Fall 2011)

Awards from Engineering Institute of Canada (EIC)

La Médaille K.Y. Lo Medal: W. D. Liam Finn, Professor Emeritus, University of British Columbia



Fellowship of the Institute (FEIC): Jean Hutchinson, Professor, Queen's University

Fellowship of the Institute (FEIC): Wayne Savigny, BGC Engineering Inc., Co-founder and Principal

CGS Certificates of Appreciation

The following people were presented with Certificates of Appreciation for their individual valued contributions to the CGS at the conclusion of the 64th Canadian Geotechnical Conference and 14th Pan-American Conference on Soil Mechanics and Geotechnical Engineering.

2011 Retiring Canadian Geotechnical Society Directors

Chris Hawkes: Chair, Rock Mechanics Division
Dwayne Tannant: Section Director, Interior BC Geotechnical Group
Marcia MacLellan: Section Director, Southern Alberta
Myint Win Bo: Section Director, Thunder Bay
Tae C. Kim: Section Director, Southern Ontario
Robert P. Chapuis: Section Director, Western Quebec
Didier Perret: Section Director, Eastern Quebec
Adrian Thompson: Section Director, New Brunswick
Jim Graham: Chair, Heritage Committee
Tim Keegan: Chair, Transportation Geotechnique Committee

2011 - Retiring Associate Editors – Canadian Geotechnical Journal

Tarek Abdoun
David M. Cruden
Fabrice Emeriault
Hanping Hong
Andrew Whittle
Bruno Bussière
Josée Duchesne

2011 CGS-PanAm Conference - Organizing Committee

Chair: Andrew Drevininkas
Co-Chair: Giovanni Cascante
Financial Chair: Harry Oussoren
Technical Chair: Tim Newson
Chair Teaching and Learning Conference: Greg Siemens
Secretary: Paul Dittrich
Member: Jason Lee
Member: Ron Howieson
Member: Lisa Coyne
Member: Robert Ng
Member: Tae C. Kim
Member: Ali Nasseri-Moghaddam
Member: Jordan Lee
Member: Stan Gonsalves
Conference Advisor: R. D. Holtz
Conference Advisor: Sai Vanapalli
Conference Advisor: Suzanne Lacasse
Conference Advisor: Michael Bozozuk

2011 - 5th Canadian Conference on Geotechnique and Natural Hazards Organizing Committee

Dwayne Tannant: Chair
Rick Guthrie: Chair, Technical Program
John Cassidy: Technical Committee Member
John Clague: Technical Committee Member
Steve Evans: Technical Committee Member
Corey Froese: Technical Committee Member
Hamish Weatherly: Technical Committee Member

2011 - 3rd Canadian Young Geotechnical Engineers and Geoscientists Conference Organizing Committee

Kent Bannister: Co-Chair
Kathy Kalenchuk: Co-Chair
Andrew Bidwell: Treasurer and Local Organizing Committee
Ariane Locat: Promotions and Registration
Matt Perras: Technical Program
Maureen Matthew: Technical Program
Michael Van Helden: Member at Large
Neil Kjelland: Member at Large
Nelson Ferreira: Sponsorship
Santiago Paz: Website
Sidantha Weerakone: Chair, Local Organizing Committee
Susan Pfister: Promotions and Registration

Call for Nominations – The Canadian Geotechnical Colloquium, 2013

The Canadian Geotechnical Colloquium is a commissioned work financially supported by the Canadian Foundation for Geotechnique (CFG). It is awarded annually to a member of the Canadian Geotechnical community. The purpose of the Colloquium is to provide information of a particular interest to Canadian geotechnique and to provide encouragement to a younger member of the Society in pursuing studies in the Colloquium's preparation. The Colloquium is presented at the CGS-SCG Annual Conference and must be suitable for publication in the Canadian Geotechnical Journal. It must be prepared in the format established by the Journal; however, the decision to publish in the Journal is exclusively the responsibility of the Journal Editor. The choice of the individual and topic is made by the Society's Selection Committee of the Geotechnical Research Board based on the nominations received. The successful candidate receives an honorarium of $5,000 and a framed certificate.

Each nomination letter must provide an introduction to the candidate and their main accomplishments. It must be accompanied by an abstract of about 2000 words of the proposed lecture, emphasizing the importance of the topic to the Canadian geotechnical community, a brief review of the state-of-the-art on that problem, an outline of the significance of the candidate's contribution, and a curriculum vitae listing the nominee's practical experience relevant to the topic and the nominee's publication record. Information on the nomination criteria can be obtained from Item C-2 of the "Awards and Honours Manual 2010", or the latest edition. To find this Manual, CGS members can log-in at http://cgs.ca/login.php then proceed to Online Member Resources, and find the Awards and Honours Manual.

Nominations should be submitted prior to January 31, 2012 to James Blatz, P.Eng., Department of Civil Engineering, University of Manitoba, Winnipeg, MB R3T 2N2 Canada, blatzja@cc.umanitoba.ca or in care of the CGS Secretariat at cgs@cgs.ca.

Call for Nominations – The Robert N. Farvolden Award for Hydrogeology

Every year, in conjunction with the Canadian National Chapter of the International Association of Hydrogeologists (CNC/IAH), the Canadian Geotechnical Society presents the Robert N. Farvolden Award to an individual or group to recognize excellence in hydrogeology in one or more of the following areas: research and publication, professional practice and education, and service to the professional community or public, either nationally or internationally. Recent winners have been Garth van der Kamp (2005), Emil Frind (2007), Frank Patton (2008), the late Pierre Gélinas (2009), Robert van Everdingen (2010) and Bob Betcher (2011).

For the 2010-2012 Farvolden Awards, because the two organizations are not meeting jointly, the nominations must be received by the CGS Secretary General, Dr. Victor Sowa (vsowacgs@dccnet.com), or by Dr. Grant Ferguson (Grant Ferguson [grant.ferguson@usask.ca]), President of the CNC/IAH, by April 1st of the year of the Award. The 2012 Award will be announced first at the CNC/IAH meeting in Niagara Falls in September and then presented at the meeting of the CGS in Winnipeg in October.

A nomination for the Farvolden Award must describe the contributions of the candidate(s). Each nomination will be considered by the Award Selection Committee. This Committee may reject, without further consideration, any nomination that, in its opinion does not adequately detail the contributions of the candidate(s). The nominee (or nominees in the case of a joint nomination) may be a specialist or a generalist working in academia, or for a government agency or in consulting. The nominee(s) should display a similar integrity, mentorship, or similar unselfish leadership that distinguished Robert N. Farvolden in his career. The nomination should be supported by additional letters of support which must include support from outside the institution to which the nominee(s) belong(s). An appropriate nomination will include a summary of the person's (or persons') academic background, their mentoring and/or teaching credentials, their achievements during their career, and their contributions to Canadian hydrogeology through their leadership and participation. A single nomination submitted by April 1st of the Award year is sufficient to initiate and complete the annual process of selection on the basis of the nominee's excellence in research and publication, or professional practice and education or professional service or some combination of these areas.

The IAH and CGS call on Canadian hydrogeologists to submit nominations for the Farvolden Award to honour those who have displayed the very qualities that Bob Farvolden brought to our profession.

Chris Neville,
Chair, Hydrogeology Division, CGS

Membership Registration for 2012

Visit the Canadian Geotechnical Website at www.cgs.ca to renew your membership.

Membership Benefits include:

- Keep up with local, national and international developments
- Share insights, visions and experience
- Present projects and research to peers
- Record Continued Education Unit (CEU) and Professional Development Activities (PDAs)
- Attend lectures, Cross Canada Lectures, short courses, workshops, seminars and conferences etc. organized locally or nationally at membership rates
- Eligible to participate as Executives in local or national committees and boards
- Meet, socialize and know colleagues with common interests, potential employers or employees
- Develop contacts with colleagues across Canada
- Sponsorship and mentorship initiatives
- Membership fee includes free internet access to all early Canadian Geotechnical Journal plus 12 new issues per year
- Geotechnical News - 4 issues per year
- Website www.cgs.ca, CGS News, CGS e-News

We look forward to your membership renewal or joining as a new member soon. We also ask that all current members to invite a friend or colleague to join the Canadian Geotechnical Society. With your help, we can continue to provide the benefits the society brings to our profession.

Conference Summary: 64th Canadian Geotechnical Conference, 14th PanAmerican Conference on Geotechnical Engineering and Soil Mechanics, and 5th PanAmerican Conference on Teaching and Learning Geotechnical Engineering

The 64th Canadian Geotechnical Conference, 14th PanAmerican Conference on Geotechnical Engineering and Soil Mechanics, and 5th PanAmerican Conference on Teaching and Learning Geotechnical Engineering was held in Toronto from October 2 to 6, 2011. Over 825 conference delegates attended, with over 500 technical proceeding papers and 63 exhibitor booths. The conference was a blend of Canadian and South American conference traditions, with a combination of plenary and concurrent breakout sessions. The conference technical program was set to enhance opportunities for interaction between academics, practitioners, designers, contractors and owners, through a combination of invited speakers for plenary and keynote presentations, specialist technical breakout sessions, poster presentations and exhibits.

On Sunday, preconference workshops on *Meaningful Numerical Modelling in Geotechnical Engineering, The Use of Geophysics for Geotechnical Projects: Benefits and Potential Pitfalls, Advanced Features for Slope Stability Analysis, Geosynthetics in Landfill and other Barrier Systems and FLAC Modelling for Soils* were presented.

Plenary session presentations consisted of the Casagrande Lecture by Kerry Rowe on *Short and long-term leakage through composite liners* and the R.M. Hardy Address by K.Y. Lo on *The effects of deep excavation in soils and rock on adjacent structures*. The CGS Colloquium was presented by Craig Lake on *Assessing geo-environmental performance of cement-based containment systems* and the CGS Graduate Student Paper was presented by Fathi Mohamed on *Bearing capacity and settlement behaviour of shallow footings in unsaturated sands*. Six keynote and theme lectures were also presented by Carlos Santamarina, José Amundaray, Gabriel Auvinet, Márcio Almeida, John McCartney and Andy Take.

The primary CGS Award, the 2011 R.F. Legget Medal was presented to Dr. Liam Finn of UBC at the luncheon on Tuesday. Later that evening at the awards gala, the remainder of the awards and honours were presented.

At the Monday luncheon, the 75th Anniversary of the ISSMGE was celebrated with presentations on the *Past, Present and Future of ISSME in North and South America* by Norbert Morgenstern, Gabriel Auvinet, Roberto Terzariol, Franco Francisca, and Sandra Garcia.

The social program offered wonderful combinations of food, drink and entertainment, starting at the Sunday evening icebreaker, through the Awards Gala, to the local colour night at the Royal Ontario Museum.

At the Closing Ceremonies, Conference Chair Andrew Drevininkas passed the conference bell and banner to the committee for the CGS 2012 conference, which will be held in Winnipeg.

We would like to express thanks to the organizing committee on behalf of all of the attendees for an entertaining, informative and successful conference. We are also extremely grateful for the generous support of our sponsors and exhibitors, as without their support this conference would not have been possible. Special thanks to our platinum sponsors: AMEC, BGC Engineering, Coffey Geotechnics, ConeTec, EBS Engineering & Construction, Geopac, Geo-Slope International, Golder Associates, MEG Consulting, Rapid Impact Piers, Reinforced Earth Company, Stantec, and Worley Parsons.

2011 Legget Medal Award

Introduction for 2011 Legget Medal Recipient: Professor Emeritus Dr. W.D.Liam Finn

Introduction by: Adrian Wightman, BGC Engineering Inc.

Adrian Wightman

Mr. President, honoured guests, mesdames et messieurs, damas y caballeros, ladies and gentlemen. It is my privilege to introduce the R.F. Legget medal recipient for 2011.

This year's Legget medalist was born in Ireland and after distinguishing himself throughout his primary and secondary education he graduated with a first class honours degree in civil engineering from the National University of Ireland, at the age of 21. He promptly earned a Fulbright Scholarship to the University of Washington in Seattle. In Seattle he fell in love with soil mechanics, along with skiing, tennis, and, fast cars. He earned his M.Sc. in swelling soils at 24, and his Ph.D in civil engineering and mathematics with his thesis on boundary value problems in soil mechanics, at age 27. It was one of those fast cars that shortly afterwards brought him to Vancouver as an assistant professor at UBC in 1961.

The year 1964, was a turning point in our medalist's career. The Alaska earthquake in March and the Niigata earthquake in June opened up a need for research into liquefaction and soil response to earthquake shaking. He landed in the thick of this at UC Berkeley when he arrived as visiting professor in July 1964, to teach soil plasticity but left as a fresh convert to the new discipline of geotechnical earthquake engineering. In that same year he was appointed full professor and head of the civil engineering department at UBC. In the mid to late 1960s, having obtained NSERC funding for cyclic triaxial, simple shear, and shaking table equipment he gathered in a diverse group of like-minded faculty and established some of the first graduate courses in soil dynamics in the world, and helped propel UBC to the forefront of geotechnical earthquake engineering research in Canada, and around the world. In 1970 he became the youngest Dean of Applied Science in Canada at the age of 37.

I well remember one evening in 1978, at a meeting of the Vancouver branch of the CGS listening to a remarkable lucid explanation of the Martin-Finn-Seed model of pore pressure generation during earthquake shaking, and having one of those rare light bulb moments…. That's how it works!

Of course I am speaking about Prof. Emeritus W. D. Liam Finn. Liam is proud of the fact that UBC was one of the first laboratories to install a fully automated shaking table that could model soil response and liquefaction – several years ahead of UC Berkeley. This helped attracted students from Japan starting a long period of contact and research cooperation that lasted well into the 1990s, earning Liam a citation from the Japanese government and honourary membership of the Japanese Geotechnical Society in 1999. And so it was that following his UBC retirement in 1998 Liam spent the next 6 years in Japan where he held the post of Anabuki Professor of Foundation Geodynamics at Kagawa University. During that period he continued to be active internationally, giving the Mallet Milne Lecture on Earthquake Engineering in London, England (the first geotechnical engineer to be invited), the First Ishihara Lecture at the 11th international conference on Soil Dynamics and Earthquake Engineering, and a Keynote lecture at the 13th world conferencing on Earthquake Engineering in Vancouver. He is also the recipient of the R.M. Quigley Award from the CGS. The G. Geoffrey Meyerhoff award from the CGS, and is this year's recipient of the K.Y. Lo Medal from the Engineering Institute of Canada.

Liam tells me that of his many technical achievements he is particularly proud of the Martin-Finn-Seed model for non-linear effective stress analysis, and also of the Lagrangian formulation for large displacement used in the Program TARA-FL for modelling postliquefaction displacements of soils.

Liam has remained very active since his return to UBC in 2005. He is involved in a program for seismic retrofit of BC's schools, a risk management plan for the government of BC, the Canadian seismic research network, and the NRC's Standing Committee on Earthquake Design- the group which writes the seismic provisions of the Canadian building code, to name a few. Over the years he has mentored over 40 graduate and post-doctoral students and has published some 400 technical papers, and been the keynote speaker at countless conferences and seminars. In short, Liam has had a profound impact on our profession and the Canadian Geotechnical Society.

Liam tells me that he still likes exploring the unknown in geotechnical engineering and analysis - and these days he enjoys the pursuit without having to worry about the result. Liam plans to pursue this while-ever he enjoys it, and is relying on his friends to tell him when to stop.

I think I am allowed to say that Liam's nomination came from the hearts of all the geotechnical faculty at UBC, past and present, several of whom are here today, so ladies and gentlemen please join me in acknowledging our most worthy recipient of the R.F. Legget medal for 2011, Professor Emeritus W.D. Liam Finn.

W. D. Liam Finn's 2011 Legget Medal Award Acceptance Speech

W.D. Liam Finn

Mr. President, Geotechnical Colleagues and Friends!

I am deeply honoured to have been selected by the Canadian Geotechnical Society (CGS) to receive their most prestigious award, the R.F. Legget Medal and I am very grateful to the society for their consideration. My thanks are also due to the selection committee and my nominees for thinking that I might be a worthy candidate for consideration.

This is a very happy occasion for me and it is enhanced by the presence of my wife, Tomris, whose affection, care and understanding have been mainstays of my professional and private life. I just learned at this meeting that my nominees were all my geotechnical colleagues at the University of British Columbia. I was deeply touched by that. The appreciation of one's peers is deeply satisfying to a professional engineer. Finally I must thank Adrian Wightman of BGC Engineering, Vancouver, for his introduction, especially for how he presented it. By the end of his presentation I began to like the guy he was talking about. As a lifelong analyst, I know very well how idealization improves a model!!

The CGS asked me to give a historical overview of geotechnical engineering and say a few words about the future. Let me assure you that I do not intend to deliver a historical lecture between the main course of this lunch and the dessert. But I will make a few observations about my own more restricted field, Geotechnical Earthquake Engineering.

I was fortunate to be a visiting professor at Berkeley in 1964 when the Alaska and Niigata earthquakes occurred. The damage caused by liquefaction was a dominant characteristic of each earthquake. Professor Seed and his graduate students (now Professor Emeritus I. M. Idriss of UC Davis and the late Professor Ken Lee of UCLA) were studying these events and seeking ways to evaluate liquefaction potential and analyze the seismic response of the ground. I quickly realized the opportunities of working in a field about which little was known and switched my research efforts from applications of plasticity theory in Soil Mechanics to what was then called Soil Dynamics and later matured into Geotechnical Earthquake Engineering (GEE). I returned to UBC in 1966 and managed to get NSERC to fund a soil dynamics laboratory including the first geotechnical shake table to have full control over the input motions. The table incorporated an MTS controller and MTS devoted an issue of their trade magazine to the UBC installation. Geotechnical earthquake engineering was on its way in Canada.

In 1966 two papers appeared that advanced the role of dynamic analysis: a paper by Anil Chopra of Berkeley on dams and a paper on slopes by me. Both papers showed the power of finite elements in the analysis of earth structures. My paper led to an invitation to visit the Soviet Union in 1967 to assist in the dynamic analysis of the analysis of the largest rock fill dam in the world planned for Soviet Georgia.

In the years up to 1973, the Berkeley group laid the foundations of geotechnical earthquake engineering and raised the capability of practicing engineers to do dynamic analysis of earth structures by the development of the programs SHAKE, QUAD4 and FLUSH. These programs were all based on the brilliant insight of equivalent linear analysis. On the laboratory front great progress was made in understanding the parameters that controlled liquefaction potential but a gradual shift was underway towards evaluating liquefaction potential using in-situ testing because of the difficulty of retrieving representative samples of sand. This initial period of development culminated in the analysis of the failure of the Lower San Fernando Dam under shaking from the 1971 San Fernando earthquake. The analysis of this dam exposed some limitations in the existing total stress methods of analysis and set the stage for the development of effective stress dynamic analysis.

In 1975 the Martin-Finn–Seed (M-F-S) porewater pressure generation model was developed that made effective stress dynamic analysis possible. This model was incorporated in the UBC programs DESRA 1-D (1975) and Tara-2D (1980). Later versions of these programs are still in use today and the M-F-S model is also available in FLAC. By 1988 the attitude towards treating liquefaction was changing from removing the liquefaction threat to dams by expensive ground improvement to controlling the consequences to ensure an acceptable performance level. It was first applied to the remediation of Sardis Dam in Mississippi where performance criterion was to limit crest settlement to 1.7m. To allow the large displacement analysis of the untreated dam in order to understand the potential failure mechanism, TARA was modified to a Lagrangian formulation – the basis also of the FLAC program. This was the advent of formal performance based design in Geotechnical Earthquake Engineering.

FLAC has had a powerful influence on engineering practice by facilitating nonlinear as well as effective stress dynamic analysis. It provides a standard, well maintained platform for a variety of constitutive models with effective pre- and post-processing capabilities and has a very detailed operating manual. It has replaced the many individual programs developed by academics which generally required the intervention of the developer to apply them in practice by a single widely accepted computational platform.

Now a few brief words about the future. A major event looms in the immediate future - a reassessment by the profession under the guidance of the US National Research Council (NRC) of the assessment of liquefaction potential and the estimation of residual strength. Such reviews have been held at roughly 10 year intervals since 1985. The NRC review was initiated to resolve the uncertainty in the profession caused by the recent controversy surrounding the different procedures for liquefaction assessment by the leading research institutions in the field, UC Davis and UC Berkeley. The proposed NRC workshop will hear from both of these proponents as well as studying all other relevant evidence and in cooperation with leading researchers and practitioners will formulate a state of the art report which hopefully will be widely accepted in practice.

Soil-structure interaction (SSI) is becoming an important issue for designers, especially for tall buildings with several levels of basements. The questions they typically ask are: what shall I use for input motions? where shall I input the motions? how can I model the interaction at the base and on the basement walls? Thirty years of research on SSI research has done little to reduce the uncertainties associated with these problems. The design of basement walls is itself a contentious issue. Some codes require that wall pressure for design using the Mononobe-Okabe approach should use peak ground acceleration. Many structural engineers feel that using a PGA based on 2% exceedance in 50 years is overkill because of the outstanding behaviour of basement walls during earthquakes. Fundamental centrifuge studies are now being conducted in California and analytical studies in British Columbia to resolve the issue. Preliminary results from both studies suggest that 0.55- 0.65PGA may be all that is required.

The future is still full of challenges but engineers have much better analytical and experimental tools to deal with these challenges. Practice will continue to evolve in the constant struggle to provide clients with robust, cost effective solutions to their problems. Geotechnical engineering after 50 years is still an exciting field and a worthy profession for daring, inquiring minds.

Canadian Foundation for Geotechnique

The Canadian Foundation for Geotechnique (the Foundation) was established in 1970 as a registered charitable organization that operates at arm's length from the Canadian Geotechnical Society (CGS). Its mission is to recognize and foster excellence in geotechnique in Canada. Specifically, the Foundation funds the CGS student awards and prizes, the CGS Colloquium, travel for the Cross Canada Lecture Tours, and the Foundation's own National Graduate Scholarship. In total the Foundation requires approximately $35,000 every year to fund these endeavours.

At the very successful, joint CGS/Pan Am Conference in Toronto in October 2011, we were asked, "Where does the Foundation gets its funding?"

Since 2000, the Cross Canada Lecture Tours have been supported entirely by corporate sponsorship. Over this period of time there have been 22 very generous companies who have helped with the sponsorship.

The remainder of the Foundation's annual funding comes from 1) individual donations, primarily from CGS members and 2) the interest it earns on its investments.

The principal from which the interest is derived has been accumulated over the years, initially from the profits of the 6th International Conference on Soil Mechanics and Foundation Engineering, which was held in Montreal in 1965, and latterly from interest-free loans from the CGS, and both interest free loans and donations from the CGS local sections, some of which originate as profits from various CGS conferences.

But by far the most important source of funding for the annual awards, prizes and the Foundation's National Graduate Scholarship is donations from individual CGS members. Each time you renew your CGS membership on-line, you are reminded to donate something to the Canadian Foundation for Geotechnique. If you aren't already a regular donor, we would encourage you to you join the CGS members that made donations last year. Donations can also be made directly to the Foundation by completing a donation form that can be downloaded from our website at www.cfg-fcg.ca.

The donations do not need to be large … "many hands make light work".

Over the years the Foundation has had a number of significant donations from individuals. The Foundation recognizes those individuals who have donated a cumulative amount of more than $25,000 as *Legacy Donors*. Donations can take the form of cash, securities or bequests. Contributions can be made by an individual or by a group to honour an individual. Contributions can be targeted to a specific initiative or for unspecified purposes. This past year we initiated a similar *Legacy Corporate Sponsor* program. Both the Legacy Donors and Legacy Corporate Sponsors are honoured annually at the Canadian Geotechnical Conference. The amount of the donation is never disclosed.

So, for the individual who asked the question … that's the short answer. We hope it gives everyone cause to pause and donate to the Foundation when joining the CGS for the first time, or when renewing one's membership.

Upcoming Conferences

Visit the CGS website (www.cgs.ca) for information on a variety of local, regional, national and international conferences.

65th Canadian Geotechnical Conference - GeoManitoba 2012 - Call for Abstracts

The Canadian Geotechnical Society (CGS) and the Manitoba Section of the Canadian Geotechnical Society invite you to the 65th Canadian Geotechnical Conference. The Conference will be held at the Fairmont Hotel located in downtown Winnipeg, Manitoba, Canada from **September 30 October 3, 2012.** The "GeoManitoba 2012 Building On The Past" conference reflects the heritage of geotechnical engineering in Canada and how our past will help us going forward in new research, developments and advancements in geotechnical engineering. It also reflects the ever increasing need to restore or upgrade our country's aging infrastructure. The official languages for the conference will be English and French.

Described as the "cultural cradle of the nation" by one of Canada's national newspapers, Winnipeg has a long tradition of developing its arts community, supporting countless galleries, museums, theatres, dance companies and music organizations. Winnipeg also has one of the highest number of restaurants per capita of any city in North America. The Fairmont hotel is located within walking distance of the historic Exchange district and the Forks Market, along with several museums and galleries. Winnipeg's downtown has been experiencing a rejuvenation in recent years with construction of MTS Centre (the home of our newly returned Winnipeg Jets), The Museum for Human Rights which is presently under construction, and Manitoba Hydro Place (which has won several international awards for its innovative design). Please join us to enjoy Winnipeg's rich culture and experience friendly Manitoba hospitality firsthand!

The organizing committee of the conference invites members of the Canadian and International communities to contribute recent research developments and advancements of geotechnical engineering, cold regions engineering, geo-environmental engineering and hydrogeology. The conference will cover a wide range of topics, including special sessions that are of local and national relevance to the fields of geo-engineering. In addition to the technical program and plenary sessions, the conference will include a complement of local tours, workshops and short courses.

Authors are invited to submit abstracts of a maximum **400 words** through the conference web site (www.CGS2012.ca). The abstract can be written either in English or French. The deadline for abstract submission is **January 27, 2012.** Invitations for submission of full papers will be sent to authors whose abstracts are accepted by the conference's Technical Committee **by February 27, 2012.** The submitted papers will be reviewed prior to final acceptance for inclusion in the conference proceedings, which will be also available on CD-ROM. At least one author of an accepted paper must register for the conference.

Abstracts should generally fall within the following topics, but sessions will be added for groups of abstracts with common themes not listed below:

Case studies, case histories and papers related to revitalization of aging infrastructure are actively solicited. Papers featuring innovative analysis techniques and solutions, as well as research (recent and/or future trends), are strongly encouraged.

Fundamentals
Engineering geology
Foundation Engineering
Geoenvironmental
Landslides / Slope Stability / Slope Engineering
Reliability-Based / Limit States Design
Risk Assessment
Rock Mechanics
Soil Mechanics
Seepage / Groundwater
Cold Regions Geotechnology
Soil Stabilization

Geotechnical
Revitalization of Aging Infrastructure
Reliability-based / limit states foundation design
Geohazards
Retaining walls / MSE walls
Brownfields and Redevelopment
Mine Site Remediation
Design of Earth Dams
Design of Clay Liners
Marine Geotechniques
Non-textbook Soils/Waste Soils
Harbour and Shoreline Geotechniques

Hydrogeology
Aquifer Sustainability
Mine Waters
Source Water Protection
Coastal Aquifers
Paleogroundwaters
Water Supply Protection
GUDI Assessment and Protection

Cross-Disciplinary
Geoenvironmental Sustainability
Instrumentation

Questions regarding sessions, topics and technical program should be directed to the Technical Committee contacts given below:

For General Inquiries
Gil Robinson
Dyregrov Robinson Inc.
Conference Chair
email: gilrobinson@mymts.net

For Technical Questions
Kent Bannister
Manitoba Hydro
Program Chair
email: kbannister@hydro.mb.ca

Editor

Phil Bruch, P.Eng.
Principal, Senior Geotechnical Engineer
Golder Associates Ltd.
1721 – 8th Street East
Saskatoon, SK S7H 0T4
Tel.: 306-665-7989,
Fax: 306-665-3342,
email: Phil_Bruch@golder.com.

G-I News

King Becomes 16th G-I President

Philip G. King, P.E., D.GE, F.ASCE became the 16th Geo-Institute president on Saturday, October 1, 2011. His term began immediately and ends following the G-I 2012 Fall Board of Governors meeting. King was pleased to welcome Craig H. Benson, Ph.D., P.E., D.GE, F.ASCE as the new vice-president and William M. Camp, III, P.E., D.GE, M.ASCE as the new treasurer. Larry Jedele, P.E., D.GE, M.ASCE will serve through 2012 as the past-president. For information: *www.geoinstitute.org*

Registration is Open

Geo-Congress 2012
"State of the Art and Practice in Geotechnical Engineering"
March 25-29, 2012
Oakland Marriott City Center
Oakland, CA,
www.geocongress2012.org

Time and money are things geo-professionals need to use wisely. So, at Geo-Congress 2012, we've amassed some of the best geotechnical experts on dozens of "hot" topics and have added new sessions to appeal to practitioners, educators, students and just about anyone in the geo-profession. Hundreds of hours of education in one location for under $900. That's less than one standard seminar! We also listened closely to the geo-professional community and have added new programs and events to the exciting agenda.

- 16 State of the Art sessions presented by leading educators
- 17 State of the Practice sessions by renowned practitioners and educators
- A 1.5-hour geo-professional business session designed to add value to clients and Society.

Register by January 20, 2012 for your chance to win a $200 Starbucks gift card.

Exhibit space and sponsorships are still available. For information: *www.geocongress2012.org*.

Expand Your Company's Outreach

Need an economical marketing tool to publicize your business? Want to mingle with top students at the annual G-I Congress? Then, become a Geo-Institute Organizational Member and receive all the benefits listed below. Download an application at: *http://content.geoinstitute.org/files/pdf/Organizationalbrochure.2freemos.pdf*

$2.73/day provides your organization with:

- Prominent exposure at G-I Congresses, specialty conferences, and tradeshows.
- An annual reduced-fee-admission (half of member price) to any national G-I event or specialty conference.
- One free month of advertising (listing) on the G-I home page.
- One free listing as the OM of the month in a monthly G-I eUpdate newsletter.
- Exclusive preference for conference exhibit space at G-I events.
- A link on the G-I Web site page to your organization's Web site.
- A dedicated page of all Organizational Members in each issue of *Geo-Strata* magazine.
- A special Organizational Member section for corporate news, promo, etc. in each issue of *Geo-Strata* magazine.
- A listing in the G-I Organizational Membership brochure.
- Five complimentary copies of each issue of *Geo-Strata* magazine.
- Reproducible G-I logos for use on letterhead and business cards.
- "Organizational Member" wall plaque.
- The opportunity to serve on the Organizational Member Council.

Member Needed for New Diversity Program

The newly-approved Diversity Committee needs your leadership and ideas. Here's your chance to make a difference to the profession and the G-I. The Diversity Committee is responsible for developing a robust diversity program within the G-I that will provide leadership and raise awareness in all matters of diversity and inclusion within the geotechnical engineering community. As a committee member, you can proactively partner with other Geo-Institute committees, the ASCE Committee on Diversity and with other affiliated organizations. For information or to volunteer: *lschulz@asce.org*

DiLoreto Becomes ASCE's President-elect

Congratulations to Gregory E. DiLoreto, P.E., P.L.S., F.ASCE, who members elected as the Society's President-elect for 2012. DiLoreto is the chief executive officer of the Tualatin Valley Water District serving Portland, Oregon's western metro area. DiLoreto, whose deep involvement in the Society spans more than 30 years, will work alongside 2012 President Andrew W. Herrmann, P.E., SECB, F.ASCE, and succeed to the presidency in 2013. He assumed his new role

Gregory E. DiLoreto

during ASCE's annual business meeting in October in Memphis, TN.

Help Civil Engineers Hit by Natural Disasters

Over the last several months, our nation has witnessed a series of natural disasters of historic magnitude, ranging from severe flooding to F5 tornadoes. Unfortunately, these extreme events have taken their toll on ASCE/G-I members and their families who live and work in the affected areas. In Alabama, for example, the student community was seriously impacted, causing some student members to lose their home and possessions.

To demonstrate support for these members, ASCE has established a relief fund for these people and will match your contributions up to a total of $10,000. For information: Nancy Berson at *nberson@asce.org*. or *www.asce.org/Headlines/ASCE-Natural-Disaster-Relief-Fund-Established;-Donations-Matched-Up-to-$10,000-Total/*

Past Presidents Committee to Recommend Award Nominees

The Geo-Institute Board of Governors recently approved formation of a Past President's Committee that will be tasked with identifying nominees for the ASCE OPAL awards, as well as the numerous other Geo-Institute and ASCE awards. The committee will be comprised of the immediate past three Geo-Institute presidents.

US /Russia Geotechnical Engineering Workshop 2012

A 2012 U.S./Russia Geotechnical Engineering Workshop held in conjunction with Geo-Congress 2012 (March 25-29 in Oakland CA) is planned. The purpose of the "Current Geotechnical Practice in Russia and the USA Workshop" is to bring together leading U.S. and Russian geotechnical engineering practitioners, researchers, and educators to develop specific plans for research and educational collaborations. The broad theme will allow for identification of geotechnical research and education priorities and for fostering relations to promote effective collaborations between the participants about these priorities. Workshop participants will each share their state of the practice in geotechnical engineering

Get Your Monthly G-I eUpdate News

ASCE/G-I members: If you have not been receiving your Geo-Institute monthly eUpdate newsletter, and you are certain it is not getting caught in your spam filter, contact ASCE Customer Service at 800-548-2723 to verify that your eUpdate e-mail preference box is active.

Geotechnical Professional Development Corner

WEBINARS

All webinars below are co-sponsored by the Geo-Institute.

Use of Geosynthetics for Waterproofing Critical Hydraulic Structures
Tuesday, January 10, 2012 / 11:30-1
https://secure.asce.org/ASCEWebsite/Webinar/ListWebinarDetail.aspx?ProdId=120429305

Load and Resistance Factor Design (LRFD) for Geotechnical Engineering Features: Micropile Foundations
Thursday, January 12, 2012 / 12-1:30 pm (ET)
https://secure.asce.org/ASCEWebsite/Webinar/ListWebinarDetail.aspx?ProdId=120429457

Load and Resistance Factor Design (LRFD) for Geotechnical Engineering Features: Drilled Shaft Foundations
Monday, January 23, 2012 / 12-1:30 pm (ET)
https://secure.asce.org/ASCEWebsite/Webinar/ListWebinarDetail.aspx?ProdId=120429999

Geosynthetic Reinforced Mechanically Stabilized Earth Walls
Wednesday, January 25, 2012 / 11:30-1 pm (ET)
https://secure.asce.org/ASCEWebsite/Webinar/ListWebinarDetail.aspx?ProdId=120430133

Estimating of Unsaturated Soil Properties for Shear Strength and Volume Change Applications- NEW
Tuesday, January 31, 2012 / 12-1:30 pm (ET)
https://secure.asce.org/ASCEWebsite/Webinar/ListWebinarDetail.aspx?ProdId=120430407

Best Practices in Subsurface Investigations and Soil and Rock Testing
Friday, February 3, 2012 / 12-1:30 pm (ET)
https://secure.asce.org/ASCEWebsite/Webinar/ListWebinarDetail.aspx?ProdId=120457983

An Overview of Geosynthetics and Their Major Applications
Wednesday, February 8, 2012 / 12-1:30 pm (ET)
https://secure.asce.org/ASCEWebsite/Webinar/ListWebinarDetail.aspx?ProdId=120431601

(LRFD) For Geotechnical Engineering Features: Earth Retaining Structures- Cut Walls
Tuesday, February 28, 2012 / 12-1:30 pm (ET)
https://secure.asce.org/ASCEWebsite/Webinar/ListWebinarDetail.aspx?ProdId=120457983

Free Access to 25 Award-Winning Engineering Management Papers

2011 marks the 25th anniversary of the *Journal of Management in Engineering's* recognition of the years' best papers. To celebrate the Journal's significant contributions to the engineering profession, ASCE is providing free access to the Journal's award-winning articles which represent the "best of the best" from industry experts and consultants on diverse management and leadership issues. For information: *www.asce.org/JME-25years*.

Members in the News

G-I Members Elected ASCE Region Governors

Congratulations to the newest G-I members who were recently elected as ASCE Region Governors for 2011-2014. Being a Region Governor is a challenging position in which one serves on Standing Committees; provides leadership at Council meetings and workshops for Section and Branch leaders and Younger Member Forums; and attends meetings of Councils, Sections, Branches, student organizations, technical and professional groups and Younger Members. In addition, the Governors plan, organize, direct, manage, and carry out events to engage and serve members in their Region.

Region 4: **Grant K. Autry, P.E., P.L.S., LEED AP, M.ASCE**, who will share responsibilities with Lamont W. Curtis, P.E., DEE, F.ASCE.

Autry has been the regional manager for Alliance Consulting Engineers, Inc. in South Carolina since May 2011. Some of his former positions include director of business development for Southside Constructors, Inc. (2010-2011); vice president /regional director for Stewart Engineering, Inc. (2008-2010); and principal/office manager for Terracon Consultants, Inc. (2002-2008). His volunteer roles are numerous and include the past president for the North Carolina Section and the Eastern Branch, North Carolina Section; past Section Representative Eastern Branch, North Carolina Section; past Delegate to Region 6 Council; and chair of North Carolina Infrastructure Report Card.

Region 8: **Thomas G. Krzewinski, P.E., D.GE, F.ASCE**, who will share responsibilities with Heidi A. Dexheimer, P.E., M.ASCE

Krzewinski has been with Golder Associates Inc. in Anchorage, AK since 2002. His former companies in Duluth, MN include American Engineering Testing (1991-2002); GME Consultants (1989-1991); Twin City Testing (1987-1989) and Dames & Moore in Anchorage and Seattle (1973-1987). His volunteer roles were numerous and include past president of the Alaska Section of ASCE; past president Duluth Section of ASCE; the 2010 Recipient of ASCE's Can Am Award and in 2009 was ASCE's candidate for Alaska Engineer of the Year.

Chuaqui, Bruce, and Ansari Form GeoSupport Inc.

Marcelo Chuaqui, **Donald Bruce, Ph.D., D.GE and Nadir Ansari , P.E.,** recently launched GeoSupport Inc., which supports their combined focus on the specialty geotechnical construction industry. The firm provides technical support and value-added service with the development of comprehensive grouting related programs; Quality Assurance and Quality Control program development and execution; and on-site supervision. This group has contributed to major drilling, grouting and deep mixing projects in Canada and the U.S.

Chuaqui, president of GeoSupport Inc., has worked in the ground improvement and specialty geotechnical construction fields and enjoys technical and logistical challenges.

Bruce is president of Geosystems, L.P and specializes in geotechnical construction processes, particularly anchoring, drilling, grouting, deep mining and cut offs with almost 40 years experience in the industry.

Ansari is president of Isherwood Associates, a consulting firm specializing in geostructural engineering. He has been involved in the introduction of in-situ soil reinforcing techniques to southern Ontario which include soil-nailed, micropiled and ground-improved walls. Ansari has an extensive background in analysis, review, design, field inspection and monitoring of over 800 earth retention structures on sites in Canada, the U.S. and Mexico.

Erbland Joins S&ME as Senior Engineer

Philip J. Erbland, P.E., joined S&ME's Geotechnical Engineering Department as a senior engineer. He has more than 17 years of professional

Philip J. Erbland

geotechnical engineering experience, including an extensive background in the industrial, marine and federal markets. His work spans the public and private sectors in the U.S. and the Caribbean.

Erbland, a graduate of the Florida Institute of Technology, holds a bachelor's degree in ocean engineering and a master's degree in engineering with emphasis in geotechnical engineering. He is a member of ASCE serving on the Ports and Harbors Committee of the Coasts, Oceans, Ports & Rivers Institute (COPRI); the Florida Engineering Society and the American Society of Highway Engineers. Reach him at the firm's Tampa office at *perbland@smeinc.com*.

Perlow Shares Experiences

Mike Perlow, Jr., P.E. of Engineering Knowledge Management, Inc. published and presented "Helical Pile Acceptance Criteria, Design Guidelines and Load Test Verification" at the GeoFrontiers 2011 conference in Dallas, as well as "Settlement Based Helical Pile Design" at the Helical Foundations and Tieback Seminar in Dallas. He also presented his paper, "Risk Assessment Model for Municipal, Transportation, and Energy Infrastructure in Karst

Areas" at the 25th Central Pennsylvania Geotechnical Conference in Hershey, PA. Perlow was an adjunct lecturer in 2009 for the Civil Engineering Department at Lehigh University in Bethlehem, PA, as well as a visiting research engineer in 2010. He is active in the Lehigh Valley Section of ASCE including the 2011 Lehigh Valley Regional Infrastructure Planning and Investment Project.

Organizational Member News

- The Organizational Member Council (OMC) needs your leadership skills for one position on its Council. If you are an employee of a G-I Organizational Member firm and would like to join us, contact Chairman Kord Wissmann at 704.799.3185.
- The OM session "Demonstrating the Value Geoprofessionals Provide to Projects" will be held on Monday, March 26, 2012 from 10 am – 11:30 am as part of the 2012 Geo-Congress in Oakland, CA.
- OMs receive a 5% discount for advertising in *Geo-Strata* magazine. Contact your advertising representative to receive your discount.
- Become the 2012 Corporate Volunteer Award winner, to be presented at the Geo-Congress 2012 in Oakland, CA. You should have received the Award Submission Package by mail, or you can access the information on the Organizational Member page of the Geo-Institute website at *www.geoinstitute.org*. The submittal deadline is January 15, 2012.
- Maximize your membership. As an OM, you can send us news for publication in the OM News section of each *Geo-Strata* issue. Do not send sales-oriented copy. Send to *geo-strata@asce.org*.

G-I Upcoming Conferences

Geo-Congress 2012
State-of-the-Art and Practice in Geo-Engineering
March 25-29, 2012
Oakland Marriott City Center
Oakland, CA
www.geocongress2012.org

Geo-Congress 2013
March 3-6, 2013
Town & Country Resort
San Diego, CA
Visit *www.geoinstitute.org/events.html* for other upcoming events.

Editor

Linda R. Bayer, IOM, Manager
Geo-Institute of ASCE
1801 Alexander Bell Drive
Reston, VA 20190-4400
Tel: 703-295-6162
Fax: 703-295-6351
email:lbayer@asce.org

Geotechnical Instrumentation NEWS

Geotechnical Instrumentation News

John Dunnicliff

Introduction

This is the sixty-eighth episode of GIN. Two articles, a report on the recent FMGM and a book review this time.

The Once-every-four-years Gathering of our Clan

The 8th International Symposium on Field Measurements in GeoMechanics (FMGM) in Berlin, Germany, is now done and dusted. Here's a report by Ton Peters, a colleague from The Netherlands. There were some very useful practical papers, including many on recently developed remote methods for measuring deformation, including:

- Terrestrial interferometric synthetic aperture radar (TInSAR, GBInSAR)
- Satellite interferometric synthetic aperture radar (SInSAR, including DInSAR and PSInSAR)
- Robotic Total Stations (RTS or ATS: Automatic Total Stations, or AMTS: Automated Motorized Total Stations)
- Terrestrial Laser Scanning (TLS)
- Airborne Laser Scanning (ALS or Aerial LIDAR)
- Digital photogrammetry
- Digital image correlation

I'm planing to provide an overview of each of these and other remote methods for measuring deformation in one or more later GIN—a one-page overview of each and a concluding article with a comparative analysis of the various techniques.

As indicated by Ton Peters in his report, a hard copy of the symposium proceedings will be available from early December 2011:

- Publisher: TU Braunschweig
- Editors: J. Gattermann and B. Bruns
- ISBN: 3-927610-87-9
- For further information: igb@tu-bs.de

If you're a serious member of our intrumentation clan, I encourage you order a copy.

The 2015 FMGM will be in Australia, and 2019 FMGM may be in Brazil.

Evaluating Practices for Installation of Vibrating Wire Piezometers

In past GINs we've had several articles in support of the fully-grouted method for installation of vibrating wire piezometers. Garrett Bayrd of Shannon and Wilson, Seattle, has faced reluctance by decision-makers to adopt this method, despite all the evidence in GIN and elsewhere. He has therefore undertaken a test program to evaluate the necessity of a variety of installation procedures, and to check the accuracy and response times of vibrating wire piezometers installed in different materials. His intent was to see if simpler installations could function as well as more complicated ones. In addition to reporting on his test methods and results, he includes an overview of previous publications about the fully-grouted method, including two that were presented at FMGM in Germany in September. His conclusions add more ammunition for us when we advocate use of the fully-grouted method.

Case History Describing a Distributed Fiber-Optic Monitoring System

Past GINs have also included two articles on the distributed fiber-optic system (Inaudi and Glisic, September 2007; Bennett, December 2008). Bill Shefchik of Burns & McDonnell, Kansas City and his colleagues provide a case history describing use of the method for providing early warning of sinkhole formation over deep caverns created by salt mining. There were several papers on measurement with fiber-optic sensors at FMGM in Berlin—emphasizing my suggestion that you might want to have a copy of the proceedings.

Monitoring Underground Construction—A Practice Guide

There is a new and excellent "practice guide", focused on monitoring underground construction but, in my view, relevant to all other types of geotechnical construction for which monitoring may be of value. See the book review later in this GIN.

The Next Continuing Education Course in Florida

This is now scheduled for April 7-9, 2013 at Cocoa Beach. Details of this year's course are on http://conferences.dce.ufl.edu/geotech. The 2013 course will follow the same general format but with significant updating, including remote methods for measuring deformation. Information will be posted on the same website in late summer next year.

Closure

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

Na zdorovlia! (To your health! - Ukraine). Thanks to Bohdan Czmola for this.

Report on the Symposium on Field Measurements in GeoMechanics (FMGM 2011)

Berlin, Germany, 12-15 September 2011

Ton Peters

The symposium was held at the famous Humboldt University in the city centre of Berlin. The set-up of booths from the exhibitors within the conference rooms created an informal atmosphere with many possibilities of interaction. A total of approximately 280 registrants and 20 exhibitors made the symposium a great success. It was an inspiring event, for which I thank and honor the German organizing team, with Jörg Gattermann as its leader.

A hard copy of the symposium proceedings with among others the contribution of the authors mentioned in this report will be available from early December 2011:

- Publisher: TU Braunschweig
- Editors: J. Gattermann and B. Bruns
- ISBN: 3-927610-87-9
- For further information: igb@tu-bs.de

Young Engineers Forum

This is a novelty in the history of FMGM, introduced by the German organization, and it worked very well. It was a contest for young engineers (under age 35) to present their work to an international jury, consisting of Elmo Dibiagio, Pedricto Filho and Ton Peters, and to have a chance to win one of the three money prices. Because of the high quality of the papers and the good presentations it was a difficult task for the jury to select the winners.

The first price was awarded to Paolo Mazzanti (Italy) for his outstanding work on Terrestrial InSAR monitoring. Mazzanti applied this new measurement technology to predicting landslides and made some specific observations that need further research. Based on these observations the Fukuzono method of predicting failure was adapted. The jury found this a thorough scientific paper, with a high practical use for the FMGM community and it was very well presented.

Second and third were Jan Sommer (Germany) and Kazuo Sakai (Japan). Sommer showed the set-up and results of a fascinating experiment on a full-scale model of a new foundation type for offshore wind turbines. Based on a monitoring program and finite element analyses Sakai explained the behavior of the rock mass and concrete lining during shaft sinking by the short step method. Both gave good presentations of their work.

The three prize winners are shown in Figure 1.

Figure 1. Prize winners, from left to right: Sakai, Sommer and Mazzanti. (Photo courtesy of the FMGM organization).

Figure 2. Visualizing convergence displacement of a tunnel. (Picture courtesy of Nexco East and Konoike Construction).

Highlights

As could be seen from the high number of participating companies and the many outstanding presentations, the geotechnical monitoring industry has grown in size and quality since the previous FMGM in Boston, USA four years ago,. Also the industry has matured. There are both manufacturers of instrumentation and software who proved a few specialized products, and also a large number of manufacturers capable of supplying a wide range of instruments. A listing of these many companies, together with products and web addresses, is given by John Dunnicliff in the symposium proceedings. Another sector of companies provides the full service of installing, monitoring, presenting data and maintaining.

An absolute eye-opener was the idea of on-site visualization of measurements as shown by Shinichi Akutagawa (Japan). A case was presented where the forces in a strut and movement of the walls of an excavation were visualized directly in the building excavation. The system consists of a small programmable datalogger with LED illumination (blue-green-orange-red) connected close to the sensors and displaying the safety level of forces in the struts or movement of the retaining walls. Workers, supervisors, engineers, staff and also the public can immediately see when safety levels are exceeded so that a response can be initiated. Figure 2 shows a different case of the same system in a tunnel, visualizing convergence displacement.

How to create a smart levee? This was a typical Dutch question raised by Victor Hopman (The Netherlands). Many river deltas in the world are of great economic value. However, in general these areas are susceptible to flooding because of the low level of the land. In The Netherlands, with over 50% of the land below sea level, protection against flooding is in the form of 17,000 km of artificial levees and flood defense structures such as storm surge barriers. In the Netherlands, relevant research in the past few years has been concentrated on full-scale field experiments on levees, mainly related to the so-called IJkdijk project (www.ijkdijk.eu). At a special test site in Groningen on one large levee, the slope stability failure mechanism has been investigated thoroughly by a wide range of sensors. Four smaller levees have been subject to backward seepage erosion (piping), again monitored by a large suite of sensors.

Tunneling and underground construction are a major challenge in urban areas, with the potential risk of failure and influence on the surroundings to the project. Many papers during the symposium dealt with this subject. Martin Beth (France) gave an overview and his reflections at the use of monitoring to meet the requirements of controlling these risks during excavation. New technologies were discussed showing their strengths, weaknesses and usability in an urban environment.

Testing of a large fiber-optic strain-rosette embedded in a landslide area was discussed by Johannes Wöllner (Austria). Landslides are unavoidable natural processes in alpine regions, often associated with economic and social disasters. Therefore large efforts have been made to investigate the causes and mechanisms of landslides, using accurate monitoring techniques. For this purpose a new measurement system, an embedded strain-rosette was developed, consisting of three long-gauge fiber-optic sensors. Long-term deformations as well as rapid deformations were investigated at the test site Gradenbach.

The fully-grouted method for installation of piezometers in boreholes was discussed often. Iván Contreras (USA) and Lucia Simeonia (Italy) presented papers on the practical and scientific aspects of that method, indicating its major benefits. A new discussion could be the influence of casing and backfilling of the borehole of an inclinometer installation for vertical probe inclinometer measurements, as started by Michael Alber (Germany). The laboratory tests conducted have proved that that even in hard rock conditions the best suited backfilling materials should have a low shear strength. It could be demonstrated that under these laboratory circumstances sand seemed the best filling material reflecting the initial displacements. However I have to comment that sand is a filling material that is difficult to use in practice. The problem is how to fill the whole borehole properly with sand at a certain density, and in practice in the field this is verging on the impossible.

The Rasnik Optical-Electronic Alignment System has been developed for monitoring the alignment of detectors at particle physics experiments at CERN (Conseil Européen pour la Recherche Nucléaire), Switzerland. Rob van der Salm (The Netherlands) explained this high-precision instrument for monitoring displacements in three directions. It consists of a back-illuminated coded mask, a lens and a pixel image sensor. An image of the mask is projected on to the sensor by means of the lens. If one of the three components is displaced in a direction perpendicular to the optical axis, then the image on the sensor shifts proportionally, to be registered by the readout system of the image sensor. A displacement in the direction of the optical axis results in a change of the image scale, and can also be measured.

FMGM 2015

Looking back on a very successful symposium in Berlin I am excited by the prospect of the next one in four years. The options for the organization and city of the next FMGM symposium were discussed, and offers were made by Australia to organize it in Sydney and from Brazil to organize it in their country. Helmut Bock concluded the discussion in stating that it will be in Australia in four years. After that Brazil is considered a favorable option in eight years, but that will have to be decided in Australia.
See you all in Sydney.

Ton Peters, Manager Urban Engineering, Deltares, PO box 177 2600 MH Delft, The Netherlands, email: ton.peters@deltares.nl

Evaluating Practices for Installation of Vibrating Wire Piezometers

Garrett Bayrd

Introduction

The fully-grouted method of vibrating wire piezometer installation has gained wide acceptance. This method calls for installing vibrating wire piezometers (VWPs) directly in bentonite-cement grout. The non-fully-grouted method calls for installation in sand packs, with bentonite above the sand pack, and grout above the bentonite. In my field experience, project managers have instructed me to install VWPs in canvas bags full of sand and then grout the boring. I have also had field experiences where clients still have reluctance to the fully-grouted method, and call for sand packs and bentonite. In addition, manufacturers recommend saturating the filter stone, and some recommend inverting the VWP tip.

I undertook this research to evaluate the necessity of a variety of installation procedures, and check the accuracy and response times of VWPs installed in different mediums. My intent with this study was to see if simpler installations could function as well as more complicated ones.

Previous Research, Publications and Practice

Diaphragm piezometers (both VWPs and pneumatic piezometers) have been in use for many decades. Early installations of these piezometers mimicked the installation procedure for standpipe piezometers, or Casagrande piezometers, using sand and bentonite. Research during the late 1960s presented and supported the hypothesis that VWPs could be installed directly into a bentonite-cement grout mixture. Further research performed by Mikkelsen (2002) and Contreras et al (2008) have supported the hypothesis that installations of VWPs into grout function without error. Mikkelsen (2002) provides grout strength and permeability information for several mixes of grout, and advocates for installations of VWPs directly into a bentonite-cement grout mix. Contreras et al (2008) provide a theoretical model for the ability of a VWP to function in grout, test grout permeability, and perform field tests of these installations. This research was then followed by a discussion by Dunnicliff (2008), which supported these conclusions with case histories of successful fully-grouted VWP installations around the world. Webber (2009) supports the use of the fully-grouted method. Additional information was presented at the September 2011 Symposium on Field Measurements in GeoMechanics in Berlin, Germany by Contreras et al (2011), and Simeoni et al (2011). Note that I read these two papers after completing my tests and a draft of this article, and that there is general agreement among us. Contreras et al (2011) provide field and laboratory examples of functional VWPs that are installed directly into grout. They also provide data from a laboratory test (of a VWP installed in grout and tested in a triaxial compression test chamber) similar to the tests that I will discuss in this article. Their laboratory test of a VWP has results that agree with those presented here. Simeoni et al (2011) provide even more examples of successful field installations of fully-grouted VWPs, and examine pressure responses through sections of grout. I seek to expand on their work by testing the accuracy and response time of VWPs in various installation methods (not just grout) in the laboratory.

Test Methods

I wanted to test both the accuracy (instrument output versus the known pressure applied to the bottom of the test chamber), and the response times (how long it took for the instrument to record the change in applied pressure) of various VWP installations.

In order to test different installation methods, I salvaged an unused triaxial compression test chamber. The interior of the chamber was approximately 5.5 inches in diameter and 11 inches high. For each test, I installed one VWP into the chamber, varying the installation method and surrounding material. The VWP sensors were installed in various materials typically used for backfill when installing a VWP in a boring. Water pressure was applied from the bottom of the chamber directly on to the surrounding material, a distance of 4 to 7 inches from the diaphragm of the VWP. Therefore, the water pressure had to propagate through 4 to 7 inches of the surrounding material before it reached the piezometer diaphragm. In order to model field conditions, I attempted to saturate all surrounding materials by introducing de-aired water into the bottom of the test chamber and allowing air to escape out of the top, until water was flowing out of the top of the chamber. Then I capped the top of the chamber and began applying pressure and recording data. This method resulted in incomplete saturation of the grout and clay. I suspect that the incomplete saturation may have resulted in slower response times.

Table 1. Tests of VWP Installation Methods

Test Number	Surrounding Material	Diaphragm Tip Direction	Pre-Saturated (test a) or Not (test b)	Using a Protective Canvas Bag or Not
1 (a and b)	Water	Up	Both tests performed	No
2	Water	Down	No, Intentionally capturing air	No
3	Sand	Up	No	No
4	Sand	Up	No	Yes
5	Grout	Up	Yes	Yes
6	Grout	Up	Yes	No
7 (a and b)	Grout	Down	Both tests performed	No
8	Clay	Up	No	No

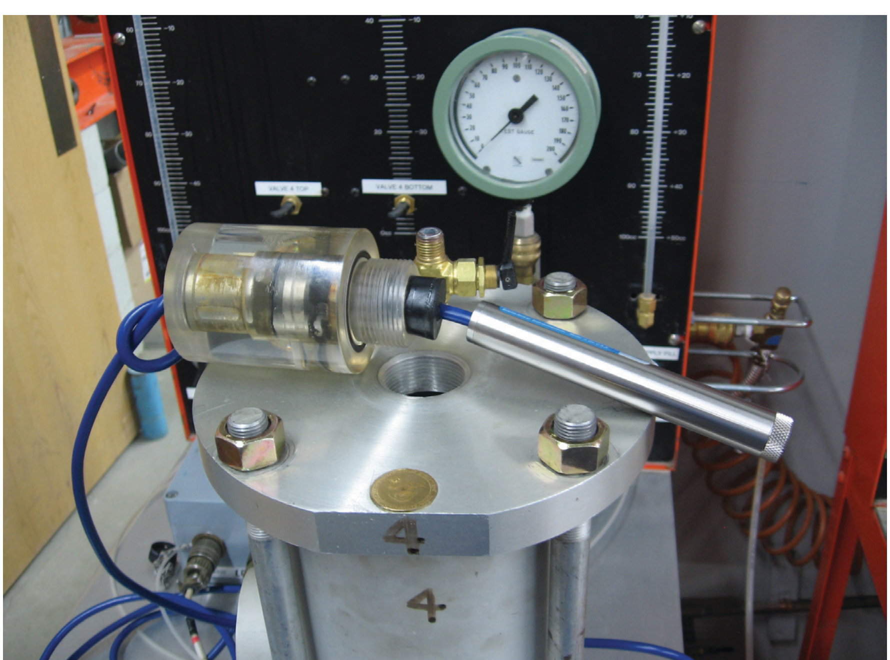


Figure 1. Test setup.

To setup the tests, the VWP was suspended in the triaxial test chamber, and the surrounding material was placed around it. For sand, water and clay, I had the triaxial chamber connected with the top and bottom plate, and poured the surrounding material through the hole in the top. For grout, I created a false bottom with mastic tape and a plate approximately 1 inch above the bottom of the cylinder. The VWP was suspended in the cylinder over this false bottom, and grout was poured in and allowed to cure. Two Geokon model 4500 VWP sensors were used, with pressure maximums of 250kPa, both of which were periodically tested for accuracy by submerging them in the triaxial test chamber filled with water, applying pressure into the chamber, and observing the pressure recorded by the VWPs. I tested to see if varying the installation methods and surrounding material affected the response times, or ultimate accuracy of the instrument. Each installation method was tested twice, once with each VWP.

Methods of installation for the VWP tests are presented in Table 1:

The sand I used in the testing was Colorado silica sand. The grout mix was 1 gallon water to 3 lb cement to approximately 1 lb bentonite grout. To mix the grout, water and cement were added and mixed first in a 5 gallon bucket, and then bentonite was added and mixed in. I used the Mikkelsen and Contreras et al method of grout mixing, adding bentonite until a consistency was reached in which the grout formed craters when dripped. New batches were mixed for each separate test, and the grout was allowed to cure for 48 hours. The bentonite chips were 3/8 inch chips, hydrated for approximately a week.

Figure 1 shows the typical setup before the VWP is installed. The background is the triaxial compression test frame that was used to apply pressure to the chamber. I connected the VWP to a datalogger, which recorded the VWP data every 5 seconds. I compared data from the VWP to the pressure applied by the triaxial compression test frame.

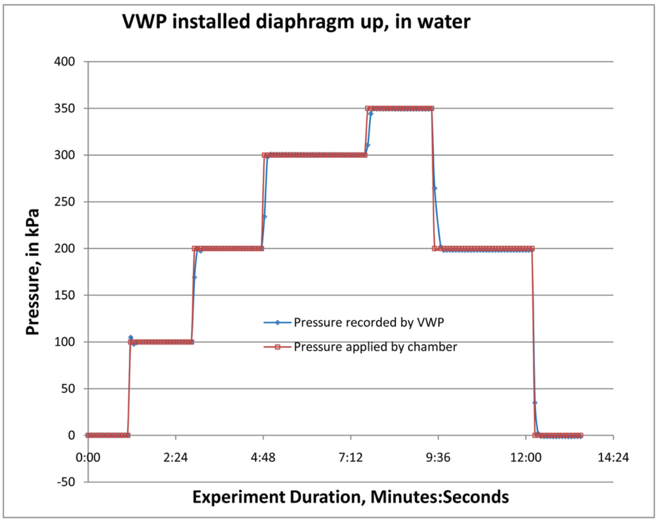


Figure 2. VWP installation diaphragm up, in water, without a canvas bag.

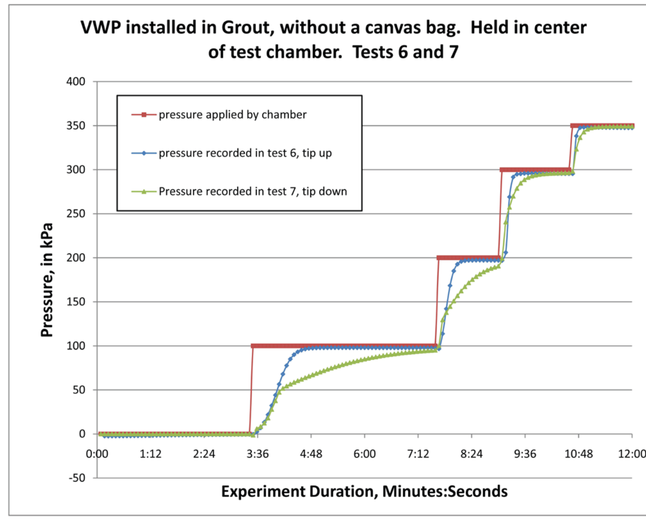


Figure 3. VWP installed diaphragm up and down, in grout, without a canvas bag.

Applied pressure to the test chamber was recorded manually and was incrementally adjusted to test the response time of the VWP to the differing pressures applied at the base of the chamber.

Test Results

With all of the installation methods in sand or water, the VWP responded within less than 20 seconds to changes in pressure, and reliably recorded pressure, with maximum errors of 3kPa and a standard deviation less than 0.1 kPa. Figure 2 shows the comparison between the applied pressure measured by the triaxial compression test chamber and that recorded by the VWP for test 1 a.

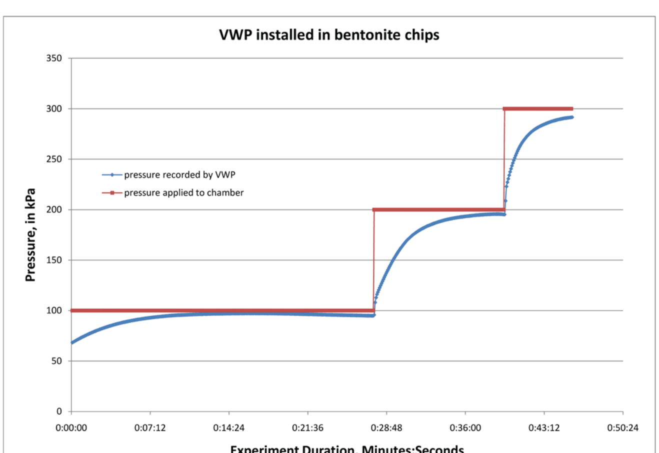


Figure 4. VWP installed diaphragm up, in bentonite clay, without a canvas bag.

This response time and accuracy was typical for tests 1 (a and b) through 5. It is also important to note, that for one test, I intentionally captured as much air as I could with the in the chamber of the VWP between the filter stone and the diaphragm, and it functioned with similar response times to those in Figure 2. It is also important to note that the VWP installed in a canvas bag in grout had response times closer to a VWP installed in sand than a VWP installed in grout without a bag. However, the long axis of the bag was almost as tall as the cylinder, which minimized the distance the water pressure had to travel, a situation we wouldn't see in the field.

Figure 3 is the graph of response times for test 6 and 7.

As shown in Figure 3, there is a larger delay between the pressure applied by the frame and the pressure measured by the VWP for the instruments installed in grout. I suspect that this is due to the incomplete saturation of the grout. If air was present in the grout, it would compress and dissolve into solution when pressure was added, which would delay the VWP from responding to the effects of the pressure added to the chamber. This hypothesis is supported by the fact that the incremental pressure steps from 100 to 200 kPa has a shorter response time compared with the intervals from 0 to 100 kPa, potentially because the air is already partially compressed and dissolved. In addition, it was observed that more water had to be added to increase the pressure from 0 to 100 kPa in the grout than from 100 to 200 kPa. In general, as the testing sequence progressed from water to sand to grout to clay, I observed that progressively more water was required to increase the pressure in the chamber. Assuming that the VWP would be installed below the water table in the field, I would expect to eventually have complete saturation in the backfill material. As such, this lengthened response time may be a factor of the laboratory testing, and not a factor in field installations. This is supported by the fact that the VWP installed tip down (which may have captured additional air) had a larger (but still only 120 second) response time to the increase in pressure.

I tested the difference between installing the VWP diaphragm up and diaphragm down in grout in tests 6 and 7. These tests had very similar results. The VWP installed diaphragm down took twice as long to respond to increases in pressure. However, the length of time it took to get accurate readings when pressure was immediately changed from 0 to 100 kPa was only 120 seconds for the VWP installed tip down and 60 seconds for the VWP installed tip up.

Installing VWPs in bentonite chips is not recommended by the manufacturers, but I tested the results of such an installation out of scientific curiosity. As discussed by Dunnicliff (1988, 1993, page 161), using bentonite chips as backfill can adversely affect pressures recorded by VWPs, both by absorbing water from the formation and therefore recording a falsely low pore water pressure, and alternatively by expanding and pressing on the surrounding ground and therefore recording a falsely high pore water pressure. Figure 4 is a graph of the response times of a VWP installed directly in saturated bentonite chips compared with the pressure applied by the triaxial compression test frame. I see an even greater response time between incremental pressure changes, and an almost asymptotic approach to the true value applied by the frame. Again, this may due to incomplete saturation of the bentonite chips. As they approach the 100 or 200 kPa level, they VWPs approach the pressure levels applied by the frame, but do not reach them (reaching 97 and 195 kPa, respectively). It's possible that, given enough time, the VWP would reach the pressure reading applied by the frame, but I didn't have enough time to test this process.

Field Considerations

I attempted to re-create as many of the field conditions as I was able to in a laboratory setting. To do this, I mimicked the installation methods for the surrounding material by dropping chips and sand around the instrument, and pouring grout around it. I attempted to re-create accurate distances between the instrument and applied pressure. However, my investigation varied from field techniques in several ways, which are important to note. First, the grout I poured was not cured under pressure, as grout in the field would be. Grout in the field would feel the effects of the column of grout above it. Second, my VWPs were allowed unlimited water. I didn't and couldn't re-create the effects of installing a VWP into a low-permeability unit, which might restrict the amount of water the VWP receives. Inverting the tip is recommended by some manufacturers to retain water in the tip. This may allow the VWP to function better in a low-permeability soil situation. I was not able to test low-permeability settings in the laboratory.

Recommendations

My results suggest that a VWP will function well in a variety of installation methods, including: diaphragm up, diaphragm down, in water, sand, and in grout - with a canvas bag full of sand or without. In fact, I had difficulty getting the VWPs to fail. In laboratory tests, I found that the canvas bags of sand, inverting the tip, or pre-saturating the filter stone or VWP were not necessary procedures for the VWP to function properly. Based on my test results, the absence of these procedures made no difference to the accuracy of the VWP or the response times. It could be argued that the canvas bags of sand assist with the protection of the VWP during installations, but I have no reason to believe that this is the case. Manufacturers recommend saturating the filter stone, and some recommend inverting the VWP tip. As I was unable to mimic an installation in low-permeability soil in the lab, my results don't contradict these recommendations. In some cases, the use of the sand-filled bags can make the installation process more difficult and time consuming, but inverting the tip and saturating the filter stone are easy steps to take. This research supports the capability of a VWP to function properly when installed by the fully-grouted method,

Acknowledgments

I would like to thank Shannon and Wilson, Inc., for the grant that made this research possible. I'd like to thank the staff of the Shannon and Wilson soils laboratory, primarily Joe Laprade and Aaron Van Derslice, for help with the triaxial compression tests, and use of their equipment. I'd also like to thank Rob Clark, whose technical experience and assistance was crucial to the success of this research.

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Garrett Bayrd, Geologist, Shannon and Wilson, Inc. 400 North 34th Street, Seattle, WA 98103,
email: gbb@shanwil.com

Salt Cavern Monitoring System for Early Warning of Sinkhole Formation

Bill Shefchik
Reynold Tomes
Riccardo Belli

Introduction

The city of Hutchinson is located in Reno County, Kansas. Hutchinson is on the route of the trans-continental, high-speed mainline of one of the nation's largest railroads. The railway passes near a former salt mine well field, where mining was carried out in the early part of the twentieth century. The salt mining was performed at depths of over 400 feet by drilling wells through the shale bedrock into the thick underground salt beds, and then pumping fresh water into the salt, dissolving the salt to be brought back to the surface as brine, for processing and sale. This solution mining process resulted in the presence of multiple, large underground voids and caverns, which have been reported to be up to 300 feet tall and over 100 feet in diameter. In places, the shale roof rock over some of these old mine voids has collapsed, forming crater-like sinkholes that can be over 100 feet in diameter and 50 feet deep at the surface. The collapse and sinkhole formation can occur very rapidly, over a period of hours to days. Figure 1 is a photograph of a sinkhole that opened up virtually overnight at this site in 2005, by collapse of a salt cavern that was last mined in 1929. The potential rapid formation of sinkholes by collapse of old mine caverns clearly represents an issue for ground stability and a non-negligible safety risk for surface infrastructure, including the railway.

Monitoring Solution

An area on the site containing old, potentially unstable salt caverns adjacent to sensitive surface infrastructure was identified with the aim of establishing an effective monitoring system in order to provide early stage detection, continuous monitoring, and automatic telemetry. Arrangements were made for alerting via cell phone and email, in case of ground deformation (strain) that may be the early signs of sinkhole formation.

The distributed fiber-optic (FO) monitoring system (Inaudi and Glisic, 2007) was selected in large part because it provides thousands of monitored points using a single fiber-optic sensing cable, all measured at the same time, in a single scan. This is well-suited to defining a monitored perimeter where the exact location of where a sinkhole might form is not known precisely. In addition, this monitoring system was selected because of the ease of installation by burial in a shallow trench.

In a geotechnical project like this, the selection of the sensing cable represents a key aspect, and at the same time, a big challenge: the sensing cable needs to be capable of withstanding hostile environmental conditions, such as wide temperature variations and burial in the ground, as well as being resistant to burrowing rodents. At the same time the cable needs to be sensitive enough to provide early and reliable displacement detection of settlement of approximately 10 mm in magnitude, according to soil type and characteristics. It must also be capable of optimizing the transfer of forces from the ground to the fiber, even through the various cable protective layers, which in this case includes a steel ribbon wrapping to resist gnawing by rodents.

The sensing cable is directly buried at a depth of approximately 1.4 meters, (4 ft), over a potential sinkhole area above and around salt caverns over a path with a total length of over 4 km, (13,000 ft) – see Figure 2.

After digging the trench, the silty soil was mechanically compacted, and the sensing cable laid on the compacted soft ground before the trench was backfilled. The sensing cable was installed in several segments in order to provide easier handling during installation, and

Figure 1. Sinkhole formed rapidly in 2005, at Old Brine Well at the Hutchinson site.

Figure 2. Trench preparation.

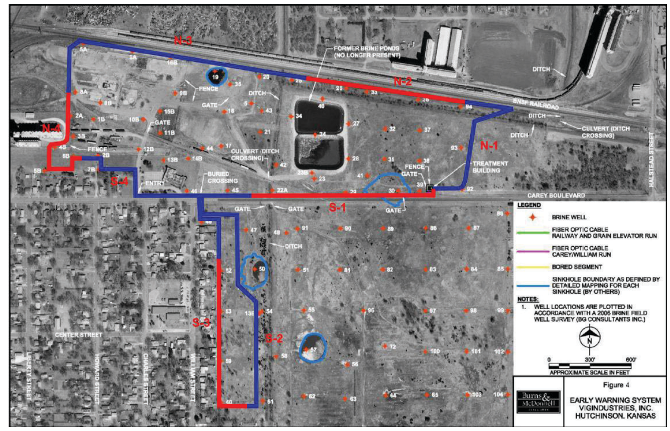

Figure 3. Sensing cable layout.

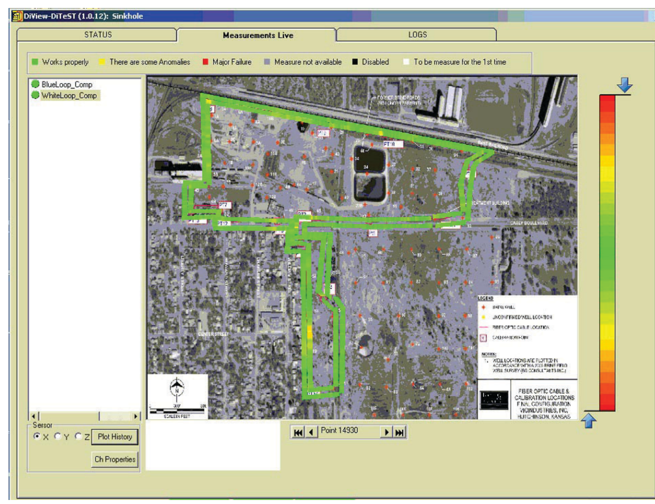

Figure 4. Software for sinkhole project: Direct, real-time readout of ground strain along the cable.

to adapt to the site by running the cable through several short, horizontally bored segments beneath a large drainage ditch, multiple road crossings, and other obstacles at the surface. All cable segments were later linked together, to form a single sensing loop, by fiber-optic fusion splicing. The splices between segments, as well as some extra lengths of non-buried cable, are stored in dedicated, above-ground junction boxes, that can be accessed for maintenance as well as for re-routing segments of cable in case a break were to be caused by the formation of a sinkhole.

The final layout of the FO cable is shown in Figure 3, the different colours, with labels, are used to identify the different cable sections spliced together.

After finishing the cable installation and completing all the necessary quality/functionality tests on the sensing cable itself such as sensor integrity test by mean of visual fault locator, sensor attenuation test by means of OTDR measurements, Optical Time Domain Reflectometry, quality of the FO splices, the system was ready for commissioning and final handover. The system commissioning mainly consisted of:

- Sensor parameterization to optimize system performances in terms of strain resolution. In this phase using the FO system managing software it is possible to set the length of the sensor, the spatial resolution, the measurement time and a series of instrument parameters that influence the final system performance in terms of strain resolution and accuracy.
- Establishment and surveying of a coordinate system to relate lengths along the cable to specific marked locations on the ground: a key aspect in a distributed monitoring project is an established coordinate system that will allow the precise position of an alarm triggered by ground strain to be shown on a computerized map. At a point where ground strain is detected by the cable, the software reports the exact location along the cable, in meters of distance from the end of the cable, (essentially at location of the computer). Luminous high-visibility signs were posted at the site along the cable route, indicating lengths from the end of the cable, so that responders in the field can quickly and accurately proceed to whatever location the alarm indicates. The coordinate system also allows the definition of several specific alarms zones, according to the client's requirements, which will be automatically handled by the software.
- System functionality check: simulation of ground settlement by artificial imposition of external force. Tests were run in the field, along temporarily un-buried segments of

Figure 5. Site pull test.

the cable, by displacing the cable in simulation of ground strain or by putting the cable in tension, to gauge and record the response of the system.

Software

The final step for achieving a fully automatic surveillance system is the Distributed Data Management and Analysis Software, designed for data storage, processing, representation, and analysis, as well as for the control of single or multiple reading units.

The main functions of the software are automatic data acquisition, map and graphical visualization of the real-time strain data along the entire cable length, and triggering of warnings of significant ground displacement on the display, as shown in Figure 4. The software stores all information related to a sensor in a single data-base structure. Multiple users can access the software simultaneously from different PCs (locally or remotely over a modem or LAN).

The algorithm that supports the software is particularly robust against false alarms caused by outlier values or noisy measurements. Moreover it allows the whole system, reading unit, and distributed temperature sensing cable, to be insensitive to environmental influences and variations. Seasonal variations in temperature can be screened out, so that they do not impact the validity and reliability of the measurements.

Besides all these capabilities, the software is specifically developed to send alerts in case ground deformation exceeds a designated threshold level. In this project, if a threshold is exceeded, an alert is triggered by both e-mail and text message to a selected list of recipients who will respond to the received warning by proceeding to the site to assess whether a sinkhole may be forming, and then take corrective action. The recipients include key project management, the client's consultant, and local first responders, in this case the Hutchinson Fire Department. In case the warning is not acknowledged the software automatically sends a reminder to the same recipients.

The software structure offers a certain level of self-diagnostic capability, and provides data and information to the users in an easy and fully understandable format.

Site Pulling Tests

In order to assess system capabilities in terms of ground deformation detection and alert triggering, some site pulling tests were carried out. These tests are aimed to evaluate and confirm the performances of the whole final system intended as sensor, reading unit and data management software working together. The idea was to apply an external force to segments of the cable in portions of the trench that had not yet been backfilled, in order to induce strain and simulate the symptoms of ground deformation.

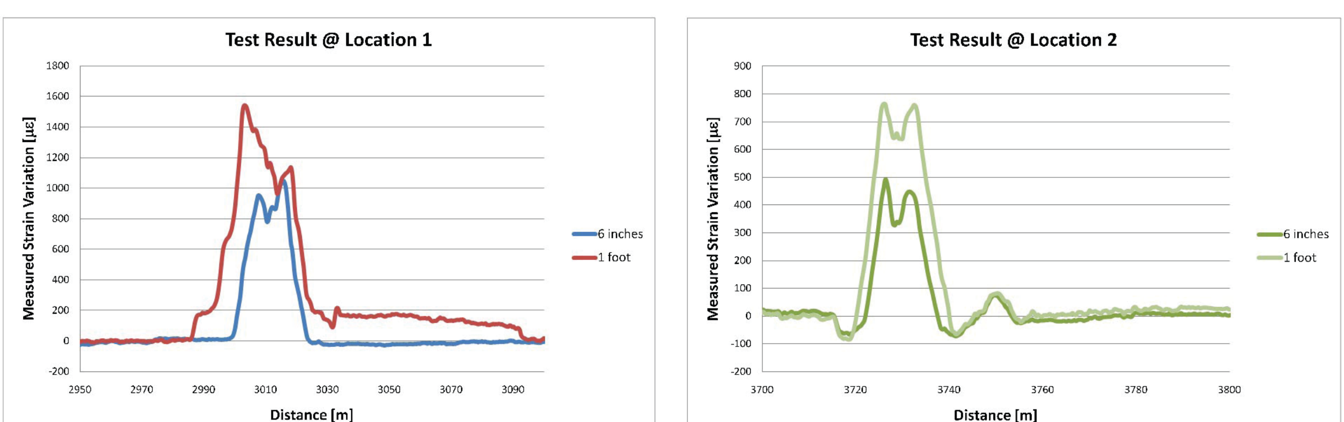

Figure 6 a & b. Examples of results of the on-site pulling tests.

For one test, a vertical force was applied on a cable section by raising the cable to different heights above the floor of the trench in order to simulate a highly localized ground deformation event – see Figure 5.

Different forces were applied to the cable during the test, to simulate different levels of ground displacement, with cable displacements of 15 cm, (6 in.), 30 cm, (1 ft), 61 cm (2 ft), and 1.2 m. The test was repeated at several different locations to evaluate the capability of the system for reliably determining the exact location of ground strain events. The system proved capable of sub-meter accuracy, at multiple test locations along the 4 km-long cable. All the tests demonstrated the proper functioning of the system, both in terms of ground deformation detection and alert triggering with exact locations.

The recorded results and graphs showed how the different amounts of deformation of the cable can influence the strain distribution along the sensing cable. The data showed a coherent behaviour of the system at all of the test locations – see Figures 6a and 6b.

Challenges Encountered and Overcome, and Lessons Learned

Some of the biggest challenges in the development of an FO distributed project can be field issues during installation of the sensing cable. Despite the overall relative ease of the installation by conventional trenching and horizontal boring, inconveniences that can occur over such a wide area, with a 4 km perimeter, must be considered, including the need to divert around buried obstacles; to modify the cable path to avoid third party properties; and to cross beneath roads and surface water drainage features using lined, horizontal borings. These issues can usually be overcome because FO sensing cables are relatively easy to handle, when installed by trained personnel, and, if necessary the cable can be cut and spliced to facilitate the installation. The capability to splice provided the opportunity to install the cable in several sections, greatly simplifying the field modifications needed to install the cable and bypass or overcome obstacles. A challenge that had to be met and overcome on the Hutchinson project was the presence of a particular type of rodent (pocket gopher) that, in their feeding habit of burrowing through the ground to eat plant roots, were found to be damaging the cable. Although the cable was being installed inside a woven fiberglass sleeve to deter such rodents, damage was still being done. Fortunately the damage was discovered by continuous and scrupulous quality checking that was on-going during installation. A new, more robust, armored cable was quickly designed, tested, and produced at the factory. The new cable was required to not only be rodent-proof, but to still be sufficiently flexible to serve the detection sensitivity specifications of the project. The first prototypes from the factory included a precisely wrapped, flexible steel ribbon-armored layer, plus a larger cable diameter designed to exceed the effective jaw spread of the rodents. Prototypes of the new cable were tested under laboratory conditions for suitability of its mechanical and optical characteristics before the subsequent full production run, which then produced all of the cable needed for the project. The re-designed cable has overcome the rodent issue.

Conclusions

Monitoring of the ground for the earliest possible warning of incipient or actual formation of a sinkhole due to collapse of underground mine caverns involves challenges that are uniquely addressed by a fiber-optic system. Since sinkhole formation resulting from mine cavern collapse can occur very rapidly, and possibly with little or no prior warning, a monitoring system that can run virtually continuously is essential if an effective, earliest possible warning is to be provided. For the project discussed in this article, the caverns are widespread across a significant area, are near significant infrastructure (including rail), and will lead to sensitive ground strain variation if their collapse is imminent. A distributed FO system offers significant advantages compared to any other possible monitoring approach in addressing all of these factors, and is very well suited to this complex task.

The entire system was developed to provide fully automatic and self diagnostic capabilities, no operator required; to dispatch alerts via telemetry through both email and cell phone sms; and to provide for remote control of the system to increase troubleshooting effectiveness and system maintenance. The ultimate value of the system is its ability to allow a rapid and effective response and intervention to the consequences of potential rapid sinkhole formation due to collapse of a cavern.

Reference

D.Inaudi, B.Glisic "Distributed Fiber-optic Sensors: Novel Tools for the Monitoring of Large Structures" GIN September 2007, pp 31-35. www.geotechnicalnews.com/pdf/GeoTechNews/2007/GIN_sept_2007.pdf

Bill Shefchik, Burns & McDonnell, 9400 Ward Parkway, Kansas City, MO 64114 USA, email: bshefch@burnsmcd.com

Reynold Tomes, Burns & McDonnell, 9400 Ward Parkway, Kansas City, MO 64114 USA, email: rtomes@burnsmcd.com

Riccardo Belli, SMARTEC SA, Roctest Group, Via Pobiette 11, 6928 Manno – Switzerland, Tel: +41 91 610 18 00, email: riccardo.belli@smartec.ch

Book Review

Monitoring Underground Construction. A Practice Guide. British Tunnelling Society.

Review by John Dunnicliff

The guide has been prepared this year by the British Tunnelling Society subcommittee for monitoring underground construction. Committee members consist of engineers in privately owned consulting firms, in construction contractors and in public agencies, with peer reviewers from similar organizations.

It is intended for clients, project managers, designers and construction contractors, and "may also be relevant to other parties such as insurers and adjacent infrastructure owners who have interests in underground construction work". Very sensibly: "The guide is not intended to be prescriptive in terms of detail design, which is recognised to change relatively rapidly with advancing technology." Hardware and software are not covered. Watch this space!

The guide has the following chapters:

Objectives of Monitoring

This has a crisp listing of why we monitor underground construction, including design verification, QA, risk and liability allocation and asset protection. The listing can be useful for geotechnical designers when they try to convince their project managers and owners that monitoring can have substantial technical and economic value. In this context, readers of GIN should also become familiar with Allen Marr's article in December 2009 GIN, "Reasons for Monitoring Performance with Geotechnical Instrumentation." (www.geotechnicalnews.com/instrumentation_news.php). Marr makes the following powerful statement: "In general, a common feature of these technical reasons is that monitoring programs save money".

Principles for Planning Effective Monitoring Systems

This chapter begins: "It is essential that the objectives of a monitoring system are clearly understood early in the life of a project. This chapter addresses the main actions which are necessary to discharge the obligations to the client."

Designing Effective Monitoring Systems

The principal target audience for this chapter is those who specify and design monitoring systems. The chapter covers the distribution of monitoring; accuracy, precision and range; monitoring frequency; baseline measurements; redundancy; maintenance; data processing, interpretation and review, presentation and archiving; and requirements for responses to monitoring.

Operation and Management

The chapter makes recommendations for roles and responsibilities of the various parties involved with monitoring, including trigger levels (also known as response values and hazard warning levels) and contingency plans.

Appendices

Appendices include:

- Valuable practical check-lists for design of monitoring systems, required outputs, maintainability, operation and management.
- Common monitoring problems experienced on previous projects, with likely root causes. Fascinating reading!

Summary Opinion of Reviewer

In my view this is an extremely practical and valuable publication. The text is direct and crisp, the layout clear and readable. Because this is a British publication, and because this review is primarily for a North American audience, a fair question is, "Is it relevant to the North American underground construction community?" Yes, yes, yes. In fact, much the content is relevant to all other types of geotechnical construction for which monitoring may be of value. As Ralph Peck wrote in 1983:

> *The legitimate uses of instrumentation are so many, and the questions that instrumentation and observation can answer so vital, that we should not risk discrediting their value by using them inappropriately or unnecessarily.*

Over the years I've seen many misuses of instrumentation and monitoring, and Peck's words are so very true today. This guide, if used wisely by those who have a stake in monitoring, should go a long way towards ensuring that monitoring is used appropriately and necessarily.

But don't go—I have something else to say that's not so complimentary. Regular readers of GIN will know my focus on trying to ensure that in order to maximize the quality of monitoring data, monitoring and instrumentation should not be subjected to the low-bid process (often by principal/general contractors requiring potential subcontractors to cut their charges to the bone). In June 2011 GIN (same website as for Allen Marr's article above) there is an article with the title "Who should be responsible for monitoring and instrumentation during construction?" The answer is: **The people who have the greatest interest in the data.** Or put another way, who has the motivation to do these nit-picking tasks with enough care? This can rarely be achieved by cutting charges to the bone. As indicated above, the guide has a chapter on operation and management, and the chapter on principles for planning refers to "the need to establish … a competent team", but the vital topic of recommending contractual arrangements isn't there. In my experience, failure to deal with this issue wisely is the most common "root cause for monitoring problems experienced on previous projects". I find this omission very disappointing.

Reference for the Guide

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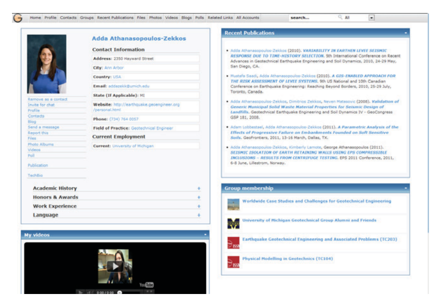

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WASTE GEO Technics

China's Initiative for Fundamental Research on Geoenvironmental Hazards of Municipal Solid Waste Landfills and Sustainable Technology

Tony L.T. Zhan, Y.M. Chen, G.W. Wilson, V. Giang, D.G. Fredlund

On July 10, 2000, a fast moving slope failure of municipal solid waste was triggered at the Payatas Landfill, Quezon City, Philippines. The massive wasteslide buried over 330 people, killing at least 278 people. The following is an eyewitness account of the devastating effects from the event as reported by Merry, Kavazanjian and Fritz (2005).

"At approximately 4:30 a.m. MLT, a large noise was heard throughout the area. Many men who were either already awake or who were awakened by the noise began to gather and discuss what the sound was and whether or not it was safe to go to work that day.

"After considerable discussion, it was decided that the storms that had produced torrential rains for the past ten days had subsided and that it was a day that they should work. As a group, they traveled down the steps to cross the creek. Suddenly, they heard a very loud noise and when they looked up, they saw the landfill coming at them very fast. Many turned to run away but the steps were narrow and became clogged with people.

"Mr. Cabahutan says that he was one of the last in line to go to work and so when they turned around to run, he and his son were near the front of the line. Nevertheless, the waste overcame and buried them. Fortunately, they were quickly rescued. He tells that the slide was followed by a small explosion and fire, although Mr. Cabahutan did not know what caused the explosion.

"At this point in the interview, Mr. Cabahutan was visually shaken and had difficulty continuing…. He explained that 100 bodies of men and children were later recovered at [the steps]" (p. 104).

North Americans rarely, if ever, perceive municipal landfills to have the massive scale of potential hazard described above. However, many regions of the world with extremely dense and growing urban populations along with limited infrastructure must develop a different paradigm for the management of municipal solid waste. China is rapidly becoming a world leader in addressing the need for new directions and fundamental research in sustainable municipal solid waste technologies.

In 2010, China generated 245 million tonnes of municipal solid wastes (MSW), becoming the world's largest MSW generator. MSW generation keeps increasing at an annual rate of about 7%, and China's current accumulative quantity of MSW is over six billion tonnes. Citizens in nearly 400 cities in China face the prospect of wastes surrounding their city. At present, 90.5% of the collected MSW in China are disposed of in landfills, and there are over 800 registered landfills and thousands of unregistered waste dumps. Landfilling will remain the dominant disposal method in the foreseeable future. However, Chinese municipalities face additional challenges of geoenvironmental hazards emerging from the current landfill technology, which threaten the safety and quality of life of the people living in the cities.

To develop sustainable landfill technology, the Ministry of Science and Technology of China has dedicated 35 million RMB (approximately $5.4 million USD) toward fundamental research on the geoenvironmental hazards of MSW landfills. This major research program is a joint undertaking by eight of China's leading universities and scientific institutions, including Zhejiang University, Tongji University, Tsinghua University, Hohai University, Chinese Academy of Sciences, China Institute of Water Resources and Hydropower Research, HKUST Fok Ying Tung Graduate School and BGI Engineering Consultant Ltd. The interdisciplinary research program involves geotechnical engineering, environmental engineering, groundwater engineering, engineering mechanics, and disaster prevention and mitigation engineering. The Principal Investigator of the program is Dr. Yunmin Chen from the MOE Key Laboratory of Soft Soils and Geoenvironmental Engineering at Zhejiang University. Details of the program and research topics will be presented in this paper.

Geoenvironmental Hazards of MSW Landfills and Root Causes

A MSW landfill, being a component of a municipality, is generally located close to the city. Improper management of landfills usually results in three kinds of geoenvironmental hazards to the city (see Figure 1):

(1) *Massive landfill slides or debris flow.* With limited land for waste disposal, many Chinese cities are piling MSW to greater and greater heights. Many landfills in China have already reached piling heights of 60 m and may exceed heights of 100 m in the near future. A landfill failure similar to the Payatas wasteslide (see Figure 2) may bury the surrounding area and cause heavy casualties. A landfill failure is usually accompanied with leachate spill, resulting in the contamination of ground surface. The slope failure at the Xiaping Landfill in Shenzhen, China, resulted in 60,000 tonnes of leachate spill which travelled a distance of over 10 km.

(2) *Soil and groundwater contamination* caused by leachate leakage and diffusion. Devoid or defective landfill barriers will result in the escape of leachate into the underground environment. Field monitoring at the Beitiantang Landfill in Beijing indicated that the groundwater contamination at the landfill has extended to an area of several square kilometers and a depth of 30 m. The remediation of underground contamination is expensive and time-consuming.

(3) *Air pollution, fires or explosions* caused by landfill gas. Landfill gas consists predominantly of methane (CH_4) and carbon dioxide (CO_2), both of which are greenhouse gases. The emission of landfill gas will produce odours and air pollution in the surrounding regions. Methane is highly explosive and may lead to fires and explosion hazards. It is estimated that the annual generation of landfill gas in China is 13 billion m^3 and accounts for 5.8% of the nation's total greenhouse gas emission.

The intractable hazards of MSW landfills are rooted in the biochemical degradation behaviour of the MSW with organic matter. Following waste placement, the landfill becomes a form of biochemical reactor in which the wastes together with moisture react to generate leachate, gases, heat and contaminants, resulting in the deterioration of material properties and deformation of the waste pile. All of these processes contribute to the development of the above-mentioned geoenvironmental hazards. The biochemical process of MSW is very complex, and it generally takes 30-50 years to stabilize. When compared with the MSW generated in North America, Chinese MSW contains much more organic content (40-50%) and water content (40-60% by wet mass), and hence its biochemical behavior is much more significant (Zhan et al., 2011). One tonne of Chinese MSW can generate 0.2-0.3 tonnes of leachate with high mass loading (e.g., Chemical Oxygen Demand (COD): 40,000-80,000 mg/L) and 100-150 m^3 of gas. The degradation-induced compression of MSW is up to 30% of the waste thickness. The strong biochemical behavior of MSW tends to result in high gas pressure, a high leachate mound, high contaminant loading and large deformation of the landfill, which may trigger various geoenvironmental hazards. Figure 3 shows the blowout of a gas-leachate mixture to a height of 5 m when a borehole was drilled at a landfill (Chen et al., 2010). The field investigation for the failure of the Payatas Landfill indicated that pore pressure increase due to landfill gas – pore water interaction in saturated or near saturated waste played a significant role in triggering the slide (Kavazanjian and Merry, 2005).

Sustainable Landfill Technology

Current landfill technology passively controls environmental impacts by designing landfills like dry tombs. Controlled landfills are usually equipped with a bottom barrier, leachate collection and drainage systems, cover system, gas collection system and ex-situ leachate and gas treatment facilities. Under these conditions, the landfill suffers from heavy hazard loadings (gas pressure, leachate head, contaminant loading, etc.), and the loading will take several decades to stabilize. Controlled landfills also face challenges regarding the durability of the control systems and materials (barriers, cover system, leachate drainage system, etc.), the need for long-term safety and environmental

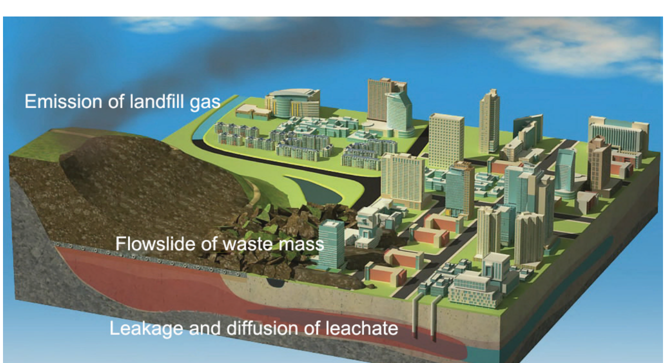

Figure 1. Geoenvironmental hazards of MSW landfills.

Figure 2. Flowslide of waste mass at the Payatas Landfill, Quezon City, Philippines (Kavazanjian and Merry, 2005).

Figure 3. Blowout of a gas-leachate mixture to a height of 5 m from a borehole drilled at a landfill.

impact monitoring, and the need for long-term post-closure care (≥30 years).

The research program proposed the development of sustainable landfill technology through manipulating the biochemical process of MSW landfills and reducing the intensity and duration of the hazards by taking more active measures, particularly during the operation stage. Based on previous research findings, the biochemical process can be controlled by controlling the bioreactor environment through the design of gas and leachate circulation systems. The new design functions of the circulation systems would include leachate recirculation, control of the oxidation-reduction environment, control of pH circumstance, three-dimensional drainage of gas and leachate, etc. It is anticipated that such active measures will significantly reduce the amount of time needed for landfill stabilization, mass loading of contaminants and post-closure settlement as well as properly control gas and liquid pressures. Experimental data indicates that the stabilization time of Chinese MSW can be reduced by 50%, and the mass loading of organic contaminants in leachate can be reduced by 60%. With a significant reduction in the loading and duration of contaminants, the landfill barriers will be able to serve for the entire life of the MSW landfill.

Key Scientific Problems, Research Topics and Targets

The development of the above-mentioned sustainable landfill technology requires a deep

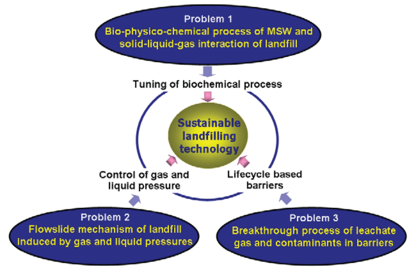

Figure 4. Key scientific problems of the research program

understanding on the following key scientific problems (see Figure 4):

(1) *Bio-physico-chemical processes of MSW and solid-liquid-gas interaction in a landfill:* The bio-physico-chemical process of MSW within a landfill is very complex and interactive, involving the bio-degradation of organics, generation of gas, leachate, heat and contaminants, changing of oxidation-reduction and pH environment, compression of the solid skeleton, conduction of gas, liquid and heat, etc. The bio-physico-chemical process and associated solid-liquid-gas interaction need to be evaluated at the full scale of the landfill. Such interaction results in significant engineering effects including changes in material properties, build-up of gas and liquid pressures, deformation of the landfill and mass loading of contaminants. The study of this problem will contribute to our understanding of the generation and evolution of hazardous sources and to developing a method for optimizing the bio-physico-chemical process.

(2) *Landfill flowslide mechanisms induced by gas and liquid pressures:* MSW landfills have a heterogeneous structure with a wide range of materials. Daily and temporary soil covers usually result in a less permeable layer. Less permeable layers or perched leachate mounds may trap the abundant landfill gas, and a build-up of gas pressure will form. The gas and leachate interact with each other and exhibit a coupled effect. The landfill flowslide mechanisms induced by the coupled effect of gas and liquid is not understood and will be investigated in this program.

(3) *Breakthrough process of leachate, gas and contaminants in barriers:*

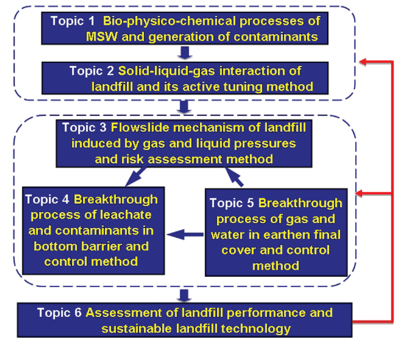

Figure 5. Program research topics

Landfill barriers include the top cover system and the bottom liner system. The top cover suffers from seasonal cycles of wetting/drying and freezing/thaw, dramatic climatic change and differential settlement. The bottom liner suffers from large surcharge loading, high liquid pressure, high temperature and large contaminant loading. From a physical view, both kinds of barriers are subjected to multi-field coupled loading. The long-term performance of the barriers under complex loading conditions is not fully understood. The breakthrough process of leachate, gas and contaminants in barriers under multi-field coupled loading conditions will be studied in this program.

The research topics identified in this program are as follows (see Figure 5): (1) bio-physico-chemical processes of MSW and generation of contaminants; (2) solid-liquid-gas interaction in landfills and active control methods; (3) landfill flowslide mechanisms induced by gas and liquid pressures and risk assessment methods; (4) breakthrough process of leachate and contaminants in bottom barrier and control methods; (5) breakthrough process of gas and water in final earthen cover and control methods; and (6) assessment of landfill performance and sustainable landfill technology. Topics 1 and 2 will be investigated on the element and landfill scale, respectively, and the research will characterize hazardous sources for the other topics. The active control or method of tuning for an optimum bio-physico-chemical process (Topic 2), the tuning method for liquid and gas pressures (Topic 3) and the lifecycle-based barriers (Topics 4 and 5) will be integrated into the sustainable landfill technology developed in Topic 6.

It is anticipated that the research will provide new theories, methodologies and technologies for the site selection, design and operation of hundreds of new landfills to be built in China as well as for the reclamation and recovery of thousands of old landfills or dumps. The research will also benefit the world, especially for countries generating wastes with high organic contents, by possibly preventing events such as the Payatas wasteslide from occurring.

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Authors

Tony L.T. Zhan, Professor, MOE Key Laboratory of Soft Soils and Geoenvironmental Engineering, Zhejiang University, China,
email: zhanlt@zju.edu.cn.
Dr. Zhan is a visiting professor at the University of Alberta.

Y.M. Chen, Professor, MOE Key Laboratory of Soft Soils and Geoenvironmental Engineering, Zhejiang University, China,
email: chenyunmin@zju.edu.cn.

G.W. Wilson, Professor, Department of Civil & Environmental Engineering, University of Alberta,
email: ward.wilson@ualberta.ca.

V. Giang, Communications and Grant Strategist, University of Alberta Geotechnical Centre, Department of Civil & Environmental Engineering,
email: viviang@ualberta.ca.

D.G. Fredlund, Geotechnical Engineering Specialist, Golder Associates Ltd., Saskatoon, SK,
email: unsaturatedsoil@yahoo.com.

ASFE
THE GEOPROFESSIONAL BUSINESS ASSOCIATION

Forward Together: An Alliance of Geoprofessionals

ASFE's purpose – to maximize the importance and value of the geoprofessions to the marketplace – will not be quickly or easily achieved, especially if ASFE is the only one beating the drum. It no longer is. In fact, ASFE's leaders have been astonished by the extent of the support being demonstrated. But how best to coordinate that support? Based on work conducted by the External Relations Committee, ASFE developed a concept statement that we issued in mid-June. It reads, in part, as follows:

"Geoprofessional services in many markets have become increasingly commoditized over the past four decades, and those who provide them – geoprofessionals – are becoming marginalized in many markets: They are treated as tangential project participants who are called on only when others believe they're needed, as opposed to being involved meaningfully from a project's inception to its conclusion. The consequences take the form of serious detriments for all geoprofessionals and those who could otherwise derive far more value from the services geoprofessionals can provide. No geoprofessionals are spared. Consultants; constructors; geoprofessionals employed by business, government, and institutional entities; even geoprofessional educators and students – all are diminished by these trends.

"In 2009, ASFE/The Geoprofessional Business Association adopted a new purpose designed specifically to counter geoprofessional commoditization and marginalization; "to maximize the geoprofessions' importance and value to the marketplace." ASFE remains intent on causing a tide that will lift all boats, not just their own member firms and not just consultants; all geoprofessionals….[And] ASFE is not alone. Responsible geoprofessional organizations have been quick to acknowledge that their members, too, believe "enough is enough," and they, too, want to make a difference. They agree that this can best be done through cooperative endeavors that, on the one hand, help geoprofessionals enhance the quality of their services (technical and otherwise) and, on the other hand, inform clients and those who influence clients that high-quality geoprofessional services (like so many others) are the least costly, thanks to the experience, knowledge, judgment, and integrity of those who provide them. Clients and those who influence clients should be receptive to such outreach given that – predictably – geoprofessional issues are the single largest source of claims on their projects.

"Precisely this issue was discussed at the June 6-8, 2011 annual meeting of the GeoCoalition, [a seven-organization "umbrella group" of which ASFE is a part]…ASFE explained that it could not achieve its purpose alone; that accomplishment would require a cooperative, coordinated effort through which each interest could help the others, and that a vehicle of some type would be needed to take geoprofessionals from here to where they want to be. ASFE floated the concept that one such vehicle might be a 501(c)(3) educational foundation dedicated to: creating widespread awareness of the value geoprofessionals can bring to the projects for which they are engaged and those who own, use, and otherwise benefit from those projects, and helping geoprofessionals improve their ability to provide such value. Tentatively titled The Geoprofessional Foundation (TGF), the organization would pursue those activities all geoprofessionals could benefit from – e.g., advertising, PR, speakers' bureau, assembling and maintaining a resource library – while encouraging consistency and programs unique to one organization or another, so all groups would sing from the same hymnal.

"To some extent, the creation of one organization supported strongly by its constituent groups would represent a reversal of the fragmentation that has so weakened engineering over the years…. The geoprofessional segment of the engineering profession is no different from engineering itself, explaining why a worsening situation has been allowed to reach crisis proportions unchallenged. Geoprofessionals' inability to speak with a common voice and a common purpose eliminated their ability to authoritatively address their common interests. Now they realize that, unless they hang together, they will hang separately. An organization such as TGF could unify the geoprofessions by serving as a catalyst for the lowering of barriers now separating geoprofessionals; by creating awareness and understanding that would encourage geoprofessionals to work with one another to enhance the overall geoprofessional service, from the classroom to the project site. And by recognizing all the many important contributions of all geoprofessionals, an organization such as TGF could pronounce to the world, 'We count,' encouraging geoprofessionals to think better of themselves, thus helping them speak with conviction to those who will benefit by doing things differently."

Guess Who's Coming to Breakfast and Lunch

All GeoCoalition member organizations have expressed their support for this concept, as have a number of others. Accordingly, the External Relations Committee will host a TGF organizational meeting on Thursday, October 6, at our 2011 Fall Meeting at the Arizona Biltmore. The organizations we expect to be represented are:

- Academy of Geo-Professionals,
- ADSC: The International Foundation Drilling Association,
- Alliance of Hazardous Materials Professionals,
- ASFE/The Geoprofessional Business Association,
- Association of Environmental and Engineering Geologists,
- CalGeo,
- California Council of Testing and Inspection Agencies,
- Colorado Association of Geotechnical Engineers,
- Deep Foundations Institute,
- Geo-Institute of ASCE,
- Pile Driving Contractors Association,
- Texas Council of Engineering Laboratories,
- U.S. University Council on Geotechnical Education and Research, and
- WACEL: An Association of Engineering Laboratories, Inspecion Agencies, and Building Officials

The road to accomplishing ASFE's purpose is taking on highway proportions. This promises to be one heck of an exciting trip! (If you're involved in a group that might want to have a representative attend, or that at least wants to be kept in the loop contact John Bachner (john@asfe.org) or Colleen Knight (colleen@asfe.org).

We Need Your Stories

ASFE's purpose is to "maximize the importance and value of the geoprofessions to the marketplace." By working to achieve that purpose, we will confront our biggest concern: the commoditization and marginalization of geoprofessionals. We will all be better off if geoprofessionals are more respected; if their contributions are more appreciated; if they are brought on board at the beginning of a project and kept on board until the project concludes. The Geoprofessionals' Value Proposition (developed by ASFE's External Relations Committee) calls that "wise deployment" and notes that:

> **Clients demonstrate wise deployment when they:**
> 1. engage geoprofessionals who are experienced and trusted,
> 2. give their geoprofessionals opportunities to contribute value, and
> 3. engage their geoprofessionals during the project's planning stage and have them serve as project-team members through project delivery.

It goes on to note:

> **Those who deploy their geoprofessionals wisely derive the most value, principally in the form of:**
> - lower overall cost as a result of better scopes that limit unforeseeable expenses and better designs that limit foreseeable expenses,
> - improved schedule compliance through avoidance of unanticipated delays,
> - more effective risk management that lowers the possibility of failure, and
> - sustainable solutions that minimize waste.

Representatives of clients that already understand how important and valuable geoprofessional services can be need no proof to encourage them to do things right; i.e., to continue doing what they have been doing. The owners and others clients we need to reach, along with the people and publications that influence them, are those that have been doing things wrong; who believe that geoprofessionals are commodities and, as such, marginalizing them is appropriate. But these folks are *not* stupid. If you can prove to them that "wise deployment" will save them time, money, and headaches, they'd be all for it. What we need, therefore, are actual case histories of relatively routine projects that turned out particularly well because the geoprofessional was given an opportunity to participate (wise deployment) and was able to contribute value as a result. Chances are you are aware of case histories like these, probably involving commissions for owners, developers, design professionals, and design/builders you've worked with extensively, who respect you, and who deploy you wisely even for small, routine projects. ***Those are exactly the kinds of case histories we need,*** so we can counter arguments like this: "Sure you were involved from beginning to end on that project. It's a uranium mine, for goodness sakes. I'm putting up a strip-shopping center. That doesn't relate to me."

WE NEED YOUR CASE HISTORIES, BUT we're not looking for copious detail, because the audience isn't. What we need to know is the name and nature of the project, the manner of wise deployment involved, and how that wise deployment resulted in major benefits for the client, and what those benefits were. What we hope to do is develop compelling true stories that support our basic contentions. By developing more and more of these, we'll be able to convince more and more people with a need to know that wise deployment is something worth trying at least once.

Do you believe you might have a story to share? If so, tell us a bit about it. Address your response to John Bachner (john@asfe.org) or call John at 301/565-2733, ext. 223.

Still Time (But Little of It) to Register Rising Stars for FOPP 21

"Were it not for FOPP, I would have lost the firm." That's what one FOPP alum (who went on to become his firm's CEO) responded when we asked him how important his FOPP participation was. We're not going to say it's that vital to everyone…we'll let you be the judge by evaluating what the *most recent FOPP grads had to say*.

Registration for FOPP 21 all but closed. We conduct this extraordinary class just once a year. Enrollment is limited to 150. We have some space still available and we can shoehorn in a few more if you've been delaying a decision.

The course – designed for a firm's rising stars – comprises two elements. The first involves six months of remote participation through which each FOPP participant plays the role of a project manager…by managing the six-month FOPP project! This involves reading a "fundamentals" text (*Practice Management for Design Professionals*, by John Philip Bachner) and the book *Hot: Living through the Next Fifty Years on Earth* by Marc Hertsgaard.

Participants must also complete a research assignment that will genuinely benefit the firm or the profession. Each participant is required to submit a proposal, a draft report, and a final report. Participants can choose from more than 70 existing topics or develop one of their own.

All participants work with a mentor within the participant's firm. All submissions (including five exams and one small paper in addition to the three research-assignment submissions) must be submitted on time. Those that are not are downgraded. Those that are late without a prior "heads up" receive no credit at all.

The FOPP program director plays the role of a somewhat unpleasant client representative who makes his attitude known by attacking all participant submissions with a nasty red pen.

As last year, FOPP 21 participants will be able to communicate with one another via a FOPP 21 LinkedIn group.

The remote instruction program is followed by a 2½-day seminar that involves person-to-person interaction among participants, public speaking, a case-history workshop, case-history presentations, a communications seminar, a keynote address by a "vet" who addresses "If I knew then what I know now," a unique dispute-resolution experience, and a half-day focus on the future…and more.(*http://www.asfe.org/index.cfm?pid=10284*)

What do FOPP participants think about the program? We learn that two ways. First, we ask participants to rate FOPP immediately after the course concludes. Then we ask them one year later. As to what FOPP 19 grads has to say one year after the course, here's a brief sampling:

- Increased my awareness of the profession. I tend to see more of the bigger picture.
- I am more careful on how I write and express myself among my co-workers and clients. It is better to keep it simple.
- The FOPP program taught me to write more clearly, to be a better manager of clients' expectations, and to maintain professional networking contacts within and outside of the geoprofession.
- First, I feel that I am a better writer. Second, I pay more attention to details of contract terms and conditions when negotiating with clients.
- I am a nonengineer, but they are my clients. Going through FOPP gave me an understanding of what they do and some of the challenges they face. I have a different perspective when helping them through some of their issues.
- I feel that I always was aware of the concept of professionalism, but going through the course made me realize that I was not putting it into action. The course has given me the tools and knowledge to act and work in more of a professional manner.
- It has been a stepping-stone into more senior positions and responsibility levels within my company.
- I think about every email before I send it. Pay attention to close details with all interactions with my client and make sure nothing could come back and potentially affect me professionally
- I improved my writing and communication skills significantly during the course. Additionally, I learned the how important of communication and contract development is to the engineering field.
- Open my eyes to many things. Most importantly how important it is to be a PROFESSIONAL. Full time.

See the complete report and if you'd like register as a participant for FOPP 21, just call us (301/565-2733) or send us an e-mail (*sara@asfe.org* or *suzy@asfe.org*) and we'll get it done. But you need to do it NOW!

Hal Branum

Professional Service Industries, Inc. President William Howell Branum, P.E. died suddenly on July 1, 2011. Born in Hornersville, Missouri on September 8, 1941, Hal worked on his family's farm through high school, then went to the University of Missouri School of Mines and Metallurgy, where he earned a Bachelor of Science degree. He then enrolled in West Virginia University where he earned his master's, then joined the United States Army Corp of Engineers as a second lieutenant. He left the Corps as a captain in 1975 and a few years later joined PSI. Focused on his children (and later his grandchildren), Hal always made time to coach his sons' baseball teams on the weekends and attend his daughter's dance recitals weekday nights. His family has requested that expressions of sympathy take the form of donations to St. Jude Children's Research Hospital in Memphis, TN.

Jim Suttle Wins Professional Practice Leadership and Ethics Award

James H. "Jim" Suttle, P.E., the 50th mayor of Omaha, NE, has won the 2011 ASFE/ASCE Professional Practice Leadership and Ethics Award for his superior ethics and leadership while participating as an engineer in service to the public. Elected mayor in 2009, Mr. Suttle was previously vice chairman of the board of directors of Omaha-based engineering and design firm HDR, Inc. The Foundation for Professional Practice, established by ASFE and ASCE, donated the funds to create the Award. Its intent is to recognize engineers for leadership in nonengineering venues.

You've Just Got to be Kidding

For years, our "news of the weird" feature was dominated by stories from California, for reasons we could only speculate about. We now return to the Golden State, this time with a true story that, as usual, features outrageously whacky behavior, but – for a change – is no laughing matter. Join us now, as we venture to the San Francisco-Oakland Bay Bridge, whose seismic safety hasn't been quite the same since the 1989 Bay-area earthquake, prompting the state to spend $7.2 billion for a replacement span. The 2.2-mile eastern crossing (which connects Yerba Buena Island to Oakland) is a complex suspension bridge, comprising a single, 525-foot tower, anchored to bedrock and supported by a single, steel-wire cable. "We wanted something strong and secure, but we also wanted something iconic," said Bart Ney, a California Department of Transportation (Caltrans) spokesperson.

Workers will assemble the bridge from 28 steel modules that will be fitted with a concrete road surface. The "finishing touch" should be – but won't be – be the placement of a huge, rectangular sign on either side of the bridge, writ large with the words MADE IN CHINA, because, in fact, that's where the bridge will have been made…by 3,000 engineers, steel cutters, welders, and steel polishers who, unlike many of their U.S. counterparts, have jobs rebuilding American infrastructure.

California officials like the fact that they saved so much money – hundreds of millions of dollars, they claim – by having the work done in China, by a fabricating company owned by the Chinese government. (Isn't the United States kind of opposed to government ownership of commercial enterprises?) Of course, the savings are understandable, given what *The New York Times* labels a typical worker who arrives at 7AM, leaves at 11PM, and often works seven days a week. The worker lives in company-owned quarters and earns about 75 cents an hour. Think how much more California citizens could have saved if only slavery were still acceptable in China or some other bridge-building country.

Important New CoMET Document

Let's hear it for ASFE's **Construction Materials Engineering and Testing Committee** and the new model advisory it developed for immediate use by ASFE-Member Firms that provide construction-materials engineering and testing (CoMET) services: *Important Information about Quality Assurance*. ASFE-Member Firms can download it free of charge at *www.asfe.org*. The Committee designed *Important Information about Quality Assurance* for insertion into ASFE-Member Firms' CoMET reports and other quality assurance (QA) deliverables. Its purpose is to help educate client representatives and others who may use the deliverable about who has and does not have a right to rely on the document, what to expect from CoMET services, and how to maximize the value of the services they receive. Key guidance related by the new document includes:

- Understand the Difference between Relying on Something and Having a *Right* To Rely on Something.
- If You Have Not Been Formally Authorized To Rely on a CoMET QA Report, Do Not Rely on It.
- Recognizing the Difference between Quality Assurance (QA) and Quality Control (QC) Can Help All Parties Avoid Misunderstandings.
- The Scope of QA Services May Differ from Project Specifications.
- CoMET Consultants Deal with Noncompliance as Required by Their Contract.
- CoMET Consultants Owe a Duty of Care Only to Authorized Parties.
- Do Not Misapply a Review-Only, Courtesy Copy.
- Overall Conditions Are Inferred. Inferences Are Not Guarantees.
- Do Not Assume That Conditions Found Will Stay the Same.
- Standards Complied with Are Those That Are Referenced.
- The Sampling and Testing Locations Shown Have Been Approximated.
- A CoMET Consultant's Field Representatives Have a Strictly Limited Role on Site.
- CoMET Consultants Are Not Authorized To Accept or Reject Constructors' Work or To Modify Requirements.
- Special Inspections Are Not QA Services.
- Contact Your ASFE-Member CoMET Consultant for Assistance.

The new advisory relates guidance from an industrywide, professionwide perspective. Nonetheless, the PDF version is supplemented by a members-only MSWord version, permitting ASFE-Member Firms to modify the language and have it printed on the back of various forms, like daily field reports. Modified wording cannot display the ASFE logo, nor may it be treated as an ASFE document. Only ASFE-Member Firms are permitted to use the PDF version of the document as inserts.

Strategic Association Involvement

How much money does your firm waste each year on the useless support of societies and associations? Not that societies and associations are useless; far from it. It's just that all too many firms invest unwisely in: the time its representatives spend on meetings and conventions; annual dues and meeting registration fees; and travel time and cost. If that's your firm's situation, or if you're unsure about how much money and time your firm spends on these things, it's time for you to pursue **strategic association involvement (SAI)**.

SAI is particularly beneficial for younger members of the firm, because it can teach them how to be organizational leaders, by working their way up through the ranks via committee service. On the first day of an association's new year, your firm's representative should be on a committee and, when the committee chair asks, "Who's willing to take some notes?" the individual's hand should be in the air. Why? Because the recording secretary gets the names, organization-affiliation names, e-mail addresses, etc., of all the other committee members. It helps if the person has taken ASFE's writing course so preparing and issuing minutes is easy, but no matter what, the minutes should be issued within no more than 24 hours after meeting adjournment. That can get a person noticed. And more!

Because few people actually like to take and issue minutes, a hard-working recording secretary is often named a committee's next chair. Chair the committee, learn leadership. Get done chairing the committee, chair another one or be named the vice chair or – of course – the recording secretary. Learn more about leadership and establish more relationships. Chair again and, in most cases, service on the board of directors. Then an officership. Then the presidency.

People don't learn leadership – nor do they or your firm get to reap the many other benefits available – through casual, "eat-and-burp" association or society involvement. If you really want your company's nonprofit investment to be profitable, establish this rule: Join the organization and get involved or invest your own time and money, not the company's.

Once you establish a "you-must-be-involved" dictum, the next activity is determining which associations and societies to join, something that applies to one and all, not just the youngsters.

In many firms, the general rule is for staff members to be involved in one technical society and one market-focused society, typically involving a market represented by one or several major clients. In the latter group, opportunities for board service may be limited, because the firm or its representatives may have to serve as associate members. But being an *involved* associate member – by serving on committees with representatives of client and prospective-client firms – has obvious benefits. Note, however, that the same opportunities exist in discipline-focused groups. After all, the technical employees of client- and prospective-client organizations also belong to ASCE, NGWA, NSPE, ASDSO, AEG, and USGBC, among so many, many others.

In most areas, so many associations and societies exist you won't be able to have representation in all you'd like to. So, how do you make assignments? How do you deploy your "troops"? SAI makes the choice easy: Identify your most important clients and the prospective-client organizations you most want to "bring into the fold." What organizations do they support? Almost unbelievably, many firms never make this assessment, even though they realize the marketing value to be derived from association and society involvement and networking. And which committees should you seek involvement on, assuming you're not a "newbie"? Well, which committees do the client and prospective-client reps serve on?

And here's something else you're likely to discover when you make these SAI assessments: The C-level personnel of client and prospective-client organizations – the CEOs, COOs, CFOs, and such – are likely to be involved in high-visibility community organizations, because they want to demonstrate that their organizations care about the community. Your firm should be doing the same, to establish the bond that emerges when shoulders hit the same wheel. "It's important to support those who support the causes I hold dear" many client CEOs believe. And in your community, those causes are…?

Road Warrior

So there you are in who-knows-where, scanning a list of available WiFi connections when you spy one called "Free Public WiFi." You try connecting to it and nothing happens…if you're lucky. As it so happens, the "Free Public WiFi" connection is the remnant of a Windows XP networking bug that has been rebroadcast repeatedly for years: Every time a person tries to connect to it, it gets added to that person's list of available networks. *It's more than just an attractive nuisance*. A malicious user can apply the connection to steal log-in information and data from your laptop. "Free Public WiFi" is never a valid hotspot; don't connect!

New Members

We're delighted to extend a hearty "Welcome Aboard" to three new ASFE-Member Firm and a new Government Member. The three new ASFE-Member Firms are:

- **American Geotechnics** specializes in subsurface site investigations, landfill design, foundation engineering, and pavement design. **Charles E. "Chuck" Burgert, P.E.** is the firm's president. *(American Geotechnics / 5260 Chinden Boulevard / Boise, ID 83714 / Tel 208/658-8700 / Fax 208/658-9703 / www.americangeotechnics.com/)*
- **Kaskaskia Engineering Group, LLC** provides geotechnical and transportation engineering, GIS mapping and consulting, environmental science, and water-resources management services.
- **Marsia Geldert-Murphy, P.E.** is the firm's ASFE representative. *(Kaskaskia Engineering Group, LLC / 23 Public Square / Suite 404 / Belleville, IL 62220 / Tel 618/233-5877 / Fax 618/233-5977 / www.kaskaskiaeng.com)*
- **Whitlock Dalrymple Poston & Associates P.C.** provides specialized structural and architectural engineering, geotechnical engineering, and construction materials engineering and testing services. **A. Rhett Whitlock, Ph.D., P.E., Gerald A. Dalrymple, P.E., Randall W. Poston, Ph.D., P.E., S.E., and J. Eric Peterson, P.E.** are the firm's principals. *(Whitlock Dalrymple Poston & Associates P.C. / 10621 Gateway Boulevard / Suite 200 / Manassas, VA 20110 / Tel 703/257-9280 / Fax 703/257-7589 / www.wdpa.com)*

Our newest Government Member is Hope Allison Kaufman, a program manager for the New York City Department of Parks and Recreation. Hope manages the 222-acre, $160 million mayoral-initiative landfill redevelopment project, including an 18-hole golf course with outbuildings, a 10-acre community park, and a 20-acre waterfront park. (*Hope Allison Kaufman / 130 E4th Street / Brooklyn, NY 11218 / tel 646/675-0886 / hope.kaufman@parks.nyc.gov*)

Human Resources Management

Engineers and other technoprofessionals are notorious for failing to praise people whose efforts or accomplishments merit praise. And when they do praise, technoprofessionals often don't do it well.

Writing in BNET, the CBS interactive business network ezine, Jeff Haden recalled the time he was summoned to the plant manager's office. "My supervisor knocked on the [manager's] open door to announce us. The plant manager looked up, looked down at a note pad, then looked back up and said, 'Hello, Jeff. Thanks for stopping in.'

"…It turned out he just wanted to congratulate me for a number of productivity improvement suggestions I made. He didn't know what those improvements actually were, though, so he explained how shop floor employees were the real foundation of the company. Then he went to what I later realized was his go-to, standby speech about the three-legged stool (if one leg breaks the stool tips over), and sent me on my way.

"At the time I was tickled. I had never spoken to him before, so it was pretty neat he wanted to congratulate me in person. I could tell he looked at his note pad so he could remember my name, but hey, that was okay.

"A few years later I was in a different role helping to start up manufacturing operations for a new demand-print initiative. One day, to everyone's surprise, the [30,000-person-] company CEO came to our facility. Instead of looking around or talking to our manager (who literally sprinted out of his door to try to greet him) he headed straight for me. 'Hello, Jeff,' he said. 'I'm John. I'm in town for the board of directors meeting and wanted to meet you and say thanks for everything you've done. You're ahead of schedule, the customer is delighted, productivity is better than we expected… I can't tell you how much I appreciate all the hard work. Do you have time to introduce me to everyone?'

"I am as cynical as they come — okay, probably more so — but at that moment I could not have been more proud, of myself and of the rest of our group. I was genuinely pleased. It was awesome."

Think about the different approaches to praise. In one, the boss made praise a somewhat perfunctory task; a box on his to-do list that needed to be checked. He did not know the employee's name and he was not particularly familiar with what he had done to earn praise. And he had the employee come to him, in private.

In the other, the boss wanted to give value to the praise. He was briefed beforehand about who merited praise and why. He knew what he looked like and was familiar with what he had done to earn praise. He came to the employee – not the other way around – and, in front of everyone, asked the employee to introduce him to coworkers, putting the employee in a leadership spotlight.

Praising people should be a routine part of your job that you genuinely look forward to. Have you developed parameters that indicate who should be praised? Have you made clear the path by which people should call praiseworthy acts to your attention? Do you go to the employee or make the employee come to you? Do you praise in public or private?

Giving praise can have a huge impact on employee morale and productivity, yet it costs nothing. Of course, in some cases, it's worth nothing. **Bottom line:** Give praise…and give it value.

Colleen Knight Joins ASFE Staff

Colleen F. Knight has joined ASFE in the dual capacities of membership director and organizational relations director. Colleen was most recently employed as the assistant manager of membership for the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), where she was responsible for educational and networking events for the association's younger members and also assisted with the organization's recruitment and retention efforts and membership marketing. Before that, she worked for more than three years for the National Investor Relations Institute as the director of professional development. Colleen earned a Bachelor of Arts degree in English from the College of William & Mary (Williamsburg, VA) and a Master of Public Administration degree with a nonprofit management concentration from Georgia State University (Atlanta, GA).

Caution! New ASFE Practice Alert Focuses on Safety

Worker safety is hardly a new concern. In fact, a key "modern" worker-safety concept – workers' compensation – is more than 4,000 years old, dating back to 2050 BC. That's when the city/state of Ur issued the first known set of workers' comp regulations. Today's regulations are far more complex, of course, and safety itself has taken a far more important role in the work environment, because so many major clients refuse to deal with firms whose safety numbers are above 1.0. Learn more in *ASFE Practice Alert 51: Safety and Your Geoprofessional Practice*. Developed by ASFE's Business Practice Committee – with the heavy lifting done by **Randy A. Knott, P.E.** ***(AMEC Environment & Infrastructure)*** – the all-new monograph:

- provides a brief historical overview;
- identifies client attitudes and the websites they look at (and that you should, too);
- discusses the direct and indirect costs of inadequate safety;
- explains safety metrics (you need to know what TRIR, DART, LWCR, EMR, and IPMMD mean and how to calculate them);
- provides benchmarks; and
- identifies steps your firm and its personnel can take to make things safer, thus making your firm more attractive to employees and clients.

Like all other ASFE Practice Alerts, Safety and Your Geoprofessional Practice is available only to members of ASFE, and it's free of charge. Just click to www.asfe.org, sign in, and download your copy now.

Editorial

- American Institute of Architects
- American Institute of Certified Public Accountants
- American Bar Association
- American Medical Association

American Society of Civil Engineers • American Society of Mechanical Engineers • Institute of Electrical and Electronics Engineers • American Society of Heating, Refrigerating and Air-Conditioning Engineers • American Institute of Chemical Engineers • American Institute of Mining, Metallurgical, and Petroleum Engineers • National Council of Structural Engineers Associations • Illuminating Engineering Society of North America • American Society of Plumbing Engineers • National Association of Power Engineers • American Nuclear Society • National Rail Engineering Association • Society of Manufacturing Engineers • Society of American Military Engineers • American Society of Naval Engineers • American Society of Safety Engineers • American Society of Sanitary Engineering • American Society of Highway Engineers • American Association of State Highway and Transportation Officials • American Public Works Association • Society for Sustainability and Environmental Engineering • American Academy of Environmental Engineers • Association of Environmental & Engineering Geologists • Society of Fire Protection Engineers • Society of Automotive Engineers • American Academy of Water Resources Engineers • Audio Engineering Society • American Society of Test Engineers • Standards Engineering Society • Biomedical Engineering Society • Association for Facilities Engineering • American Association of Drilling Engineers • Society of Petroleum Engineers • National Association of Radio and Telecommunications Engineers • National Academy of Forensic Engineers • Society of Women Engineers • National Society of Black Engineers • Society of Hispanic Professional Engineers • Society of Mexican American Engineers and Scientists • American Indian Science and Engineering Society • American Council of Engineering Companies • National Society of Professional Engineers • Oceanic Engineering Society • Biomedical Engineering Society • National Academy of Engineering • American Engineering Association • American Society for Engineering • American Association of Engineering Societies • American Society for Engineering Management • American Society for Healthcare Engineering • National Biomedical Engineering Society • American Society of Agricultural and Biological Engineers • International Society for Pharmaceutical Engineering • Abrasive Engineering Society (my own personal favorite)

The list says it all, doesn't it? For whatever reason, engineers prefer to fixate on what separates them rather than what could pull them together. "In unity there is strength." Architects, accountants, lawyers, physicians…they all get it. And to advance their cause, each group formed a giant organization to serve as its spokesperson, advocate, and bodyguard. But not engineers (in the old-fashioned, non-P.E., technoprofessional sense). They evidently prefer to have big croaks in small ponds rather than a big croak in a big pond. Which is so silly when you consider what engineers do and what would happen if they didn't do it.

Am I the only person who gets this? Don't others realize that, without engineers, mankind would be no better off today than it was a hundred-thousand years ago? You're talking about huge potential power. All squandered.

I can understand why technical specialization is necessary. But what about the engineering spokesperson, advocate, and bodyguard? You'd think, realizing what they could have, all engineers would be eager to unite to achieve the huge benefits they all would derive from sharing what they have in common. You'd think that each would be gladly sacrifice a little to create that giant friend. You'd think.

Fact: Every attempt to do it has met with failure. But don't give up hope. ASFE is now leading what appears to be a successful effort to do the previously undoable, focusing not on engineering in general, but on those elements of engineering that comprise the geoprofessions; a pond to be sure, but one that would unite a bunch of puddles. The goal, in large part, is creating a larger supply of top-flight geoprofessional services and stimulating more demand for them, to counter the commoditization and marginalization caused by decades of geoprofessional indifference and apathy. It's about gaining respect for geoprofessionals by helping them understand that performing a valued service involves a lot more than applying technology to solve problems. It's about applying professional principles to meet peoples' needs. And sometimes, all that's required to meet those needs is an empathetic nod rather than an equation.

No one is asking any group to relinquish its identity. But we do need to unify on certain key points and move forward together to achieve a purpose we all need to share. Will it be worthwhile? Well, consider what engineering could have. And because it doesn't have it, what it has lost and probably will never regain. Now consider what the geoprofessions could have and what they will attain if we all just start getting along and working together to achieve common goals and aspirations.

As long as we all get off our apathy, we all can get this done. That means YOU.

eForum for ASFE-Member Firms' IT Staff

The **ASFE Information Technology Forum** allows communication/collaboration among ASFE-Member Firms' information technology (IT) staff and staff with IT responsibilities. Ask questions, get answers, and give answers. E-mail webinfo@asfe.org to sign up today!

Results of Latest Financial Performance Survey Available

So how's business? ASFE's **Business Practice Committee** responds to that question each year by conducting its annual Financial Performance Survey. The most recent survey is complete and its findings are conveyed in *ASFE Practice Alert No. 50: Fiscal Year 2010-11 Financial Performance Survey Report*. Topics covered include predistribution profit, discretionary profit distribution, net multiplier, utilization rate, predistribution overhead, marketing costs, group insurance, collections, fee backlog, and more. Download your copy of *ASFE Practice Alert 50* now at *www.asfe.org*. If you cannot download it for any reason, contact ASFE staff for assistance: telephone 301/565-2733 or e-mail *info@asfe.org*.

ASFE Practice Alerts are available solely to members of ASFE and, like almost everything else ASFE offers to its members, they are free of charge.

Professional Selling

If your firm is not really different from others offering more or less the same services, it's just a commodity; clients might just as well select based on fee. (Not really, of course, because bidding encourages firms to submit the skimpiest scope a professional can live with because skimpy = low cost and low cost = securing the engagement.) Of course, your firm *is* different, if only because it comprises people and no two people are the same. But does your website make it clear that your firm is one of a kind? Here's one way to find out (if you dare).

1. Go to the websites of your top four competitors.
2. Copy and paste the lead paragraph from the home page of each web-

site to an MSWord document. Do the same for your own website.
3. Black out company names and any other identifying information.
4. Number each lead paragraph. Prepare a list of the five firms and give each a letter.
5. Print out the document and circulate it in your office, asking each person to put the lead paragraph with the firm it's about.
6. Circulate the same document to a group of client representatives to learn if they can distinguish one firm from another by virtue of each firm's own words.

If the results indicate that, for the most part, people cannot tell one firm from another, you clearly need to do a better job explaining why your firm is truly unique; and you'd better be able to do it up front, in relatively few words.

Survey Reveals IT Managers' Computer Issues

A survey of more than 500 U.S.-, small-business IT managers reveals that 93% of their companies have selected IT solutions based more on price than quality, causing 89% of those companies to experience IT-related problems, in particular: low-performing hardware (46%), out-of-date hardware (37%), and unreliable hardware (23%), all of which have cost far, far more than whatever savings they provided, given their drag on productivity. Conducted by Wakefield Research, the HP-sponsored survey also revealed:

- Computer processing speed (35%) and reliability (19%) are the most-needed computer improvements.
- IT managers recommend solving common concerns by upgrading to newer, better-quality components (29%), investing more money in IT systems (21%), and spending more time researching the best solutions (13%).
- Planning their company's IT strategy is a better use of IT managers' time (41%) than hardware support (11%).
- One-fifth of IT managers said their biggest computer problem is inadequate vendor support.

Less Is More; More Is Less

How do you instruct project managers to handle multiple, ongoing assignments? Just a few at a time? Or do you encourage high-level multitasking; i.e., work on all of them all the time? New guidance on this topic is now available from the National Bureau of Economic Research in a paper titled *Don't Spread Yourself Too Thin: The Impact of Task Juggling on Workers' Speed of Job Completion* (http://papers.nber.org/papers/w16502), by economists Decio Coviello (University of Rome), Andrea Ichino (University of Bologna), and Nicola Persico (New York University). They studied the way in which a group of Italian judges handled their cases during six consecutive years. The judges comprised a particularly effective sample, the researchers said, because their cases are assigned randomly (by means of a lottery system) and because the judges are encouraged to "hold the first hearing of a case no later than 60 days from filing." As such, while the judges had about the same amount of work over several years, the amount of cases they opened could vary significantly from quarter to quarter.

The research data suggest that "judges who work on few cases at the same time, opening new ones only when older ones are closed, can not only dispose of assigned cases in less time from assignment, but also increase their throughput per quarter."

True: Some judges might be smarter than others or might have tougher cases to deal with. But the three economists said they accounted for that variability and it fails to explain in toto the variation in the time required for a judge to finish a case or the growth in backlogs.

According to the authors, "A non-permanent increase in new cases opened in one period increases the duration of the cases that are yet to be completed, regardless of whether the worker is in a constant growth path." As they also state, "By adding one task to those which the worker is already juggling, she pulls resources away from her other active tasks which are closer to being completed. Moreover, the newly opened task does not benefit from being opened earlier, in the sense that it will still have to wait before all other tasks are completed."

Study Finds Serious Inadequacies in Employee Training

Organizations need to be more committed and engaged to enhance the value they derive from transferring learning to the workplace. That's the conclusion of *Applying Training and Transferring Learning to the Workplace: How To Turn Hope into Reality*, a just-released ESI International study that highlights key weaknesses in on-the-job application of learning, including: inadequate manager support and lack of trainee preparation, effective incentives, and effective program design and measurement. More than 3,000 government and commercial training-related managers responded to the survey.

According to ESI's Raed S. Haddad, "The study points out some striking contradictions in how well organizations think they transfer learning and the lack of proof to back up their estimate of learning transfer or on-the-job application. Client experience shows us that organizations often fail to establish success criteria or identify expectations for learning engagements. This is a key pre-training strategy in order to measure trainee performance against agreed upon standards."

Key study findings included:

- The top three strategies indicated as the most important for the transfer of learning are: (1) trainees have the time, resources, and responsibility to apply learning (30%); (2) manager support (23.8%); and (3) the instruction approach simulates the actual work environment (21.8%).
- While two-thirds of respondents estimate that they apply more than 25% of training knowledge back on-the-job, they have little proof. Almost 60% say the primary method for measuring this estimate is either informal/anecdotal feedback or "simply a guess."
- Sixty percent of those surveyed indicate that they lack a systematic approach to preparing a trainee to apply on-the-job learning.
- When asked what specific rewards motivate trainees, almost 60% said the "possibility of more responsibility," followed closely by an impact on their HR/performance review. Only 20% indicated that financial rewards or other incentives were involved.
- When it comes to post-learning tools and programs to help trainees recall and apply what they've learned, survey responses indicate a varied mixture of tactics, including:
- post-course discussions with the manager/team leader,
- on-the-job tools,
- informal support like social networks or on-line forums, and
- practice communities such as peer groups/coaching.
- Sixty-three percent said managers formally endorse the program; only 23% percent of managers hold more formal pre- and post-training discussions.

When asked to share specific learning-transfer tactics and identify best practices, respondents instead identified a to-do list:

- incorporate real projects in the training and make it more relevant,
- conduct more training and/or better marketing and communication about what exists,
- communicate a transparent measurement strategy,
- establish change management guidelines, and
- increase managers' involvement before and after training.

"Employees need to know that the application of learning is a priority for management," Haddad said. "This can be shown by aligning training with company strategy, motivating employees by setting expectations beforehand, and through incentives and sharing post-training reports on employee success or failure in applying what they learned."

For a free copy of the full ESI study, visit

GEO
INTEREST

the Water in the Soil - Part 5

Bill Hodge

In the earlier articles of this series the talk was mainly about idealized particles, and it wasn't until Part 4 that real soils (sands) entered the argument. As a practicing Geotechnical Engineer, idealization is of passing interest: If it can't be used in the field [practice] it's really irrelevant. And, so saying, it's now time to move from contemplating single solid spheres and advance into the confusing realm of natural soils.

The key to making that move is what I've called the Crowding Factor, with the label "K". The reason for giving it this name is that its function is to account for all the hydrodynamic differences between the magnitude of drag forces exerted on a single solid particle moving against free/open water, and the same particle interacting with the much restricted pore water within the confines of a soil-structure void space.

What the Crowding Factor needs to do is to make it possible to take what we can learn from Fluid Mechanics and be able to use it to our benefit in Soil Mechanics.

Possible Ways of Evaluating "Crowding"

My initially thoughts on how to go about assigning values to this parameter "K" ranged from theoretical to empirical.

To start with, it seems pretty clear that what most changes in the immediate hydraulic environment of a particle, between its state as a single mass moving through boundless water, and its radically more confined state within a soil-structure, is the velocity of the water interacting with it. In the soil the water is speeded up while the particle's own velocity is not.

This suggests that for any approach to find justifiable values for the Crowding Factor the obvious target for manipulation is velocity. Here, it may be recalled, that both the Bearing [F_B] and Pressure [F_P] components of drag are functions of velocity, in the latter case, to the second power. Apart from the fairly fixed physical attributes of water, the only other significant variable in these components is particle size.

The first thing that came to mind was how we normally convert open water flow, the approach velocity [v_A], to the equivalent constricted pore space flow, the void velocity [v_V]. And that is simply to take it that for any given rate of flow the velocities are inversely proportional to the cross-sectional areas available to them. So where the void ratio of the soil mass is "e", we get the average void velocity by multiplying the approach velocity by (1+e)/e. For instance, if we were to apply this rule to the loosest (e=0.91) array of uniform spheres we would get a void velocity 2.1 times faster than the approach velocity; and, for the densest (e=0.35) packing that ratio would equal 3.9.

This simple calculation would suggest that in the loosest packing the crowding effect would increase the value of the Pressure component (F_P), by a factor of 4.4. This component, you may recall, is the one I associate with pore pressure generation, and which is proportional to the square of the velocity. The equivalent multiplier for the densest packing would be 14.9.

If it were not for the fact that the diameter "D" is also part of the F_B term I might have been tempted to just leave it there, that is, go on to assume void space was the only consideration. So, where to look next ?

The ConeTec cylinder was available to me and as it had the capability of recording the water pressures in front of an object as it fell through a water column, the opportunity was there to measure the comparative effects of dropping an array of spheres rather than a single ball. The thought was to drop arrays of ball bearings while recording the pressure front as the comßposite mass approached the transducers implanted in the base of the cylinder.

By running a series of tests, where the results of various array geometries and spherical sizes could be compared with the theoretical drag forces for that particular particle size, the Crowding Factor would be known for that case. It is obvious that a great deal of testing might be required to produce useful answers, and these data would for practical reasons cover only manageable sizes such as fine to coarse gravels. Silts and sands would be out of the question because of the minute size of the individual elements of the array. Another practical difficulty in this research venture would have been the unavoidable effect the housing (containing the array) would have on the data, and then, how on earth could a means be found to abstract that influence.

While I was grappling with these experimental difficulties it dawned on me that what I was really trying to measure was nothing other than what is elsewhere known as the Seepage Force. And this Seepage Force [S_F] could much more easily be determined in a standard laboratory permeameter. In the permeameter the problem of housing effects, and the all but insurmountable difficulties in testing smaller sizes, would not exist. I should now explain what is meant by S_F.

Seepage Force

Many years ago I came across the term Seepage Force in Donald W. Taylor's 1948 MIT textbook "*Fundamentals of Soil Mechanics*". He showed that S_F per unit volume of saturated soil was the product of hydraulic gradient " *i* " and unit weight of water " γ_w", that is,

S_F / unit volume = $i\,\gamma_w$

You can derive this formulation directly from consideration of the water forces and specimen geometry of a permeameter as follows:

Let the cross-sectional area of the soil specimen be "A" and it's length in the direction of water flow be "lgt". If "H_U" is the upstream (driving) head and "H_D" is the downstream (resisting) head, then the net water force (by definition, S_F) causing flow is ΔF, where $\Delta F = A\,(H_U - H_D)\,\gamma_w$. Since the hydraulic gradient across the specimen is $i = (H_U - H_D) \div \text{lgt}$, and the soil volume is A . lgt, we find Taylor's equation as shown above.

In practice, I have found the S_F way of sizing-up the effect of water passing through soils quite useful. For those who may not be altogether familiar with the Seepage Force concept I'm going to take a slight detour which I think, apart from demonstrating that S_F is a real and significant phenomenon, should be of interest in its own right. This involves some testing my company conducted at the NRC hydraulic laboratories in Ottawa some time ago.

Model Testing at NRC Ottawa

During the 1980s hydrocarbon exploration in the Canadian offshore Arctic used artificial islands built from locally dredged sand as drilling platforms. This involved pumping pipe-line dredge discharge into the shallow waters of the McKenzie Delta. This method of construction commonly resulted in side slopes as flat as 3° to 5° which ruled out their use in deeper waters because the enormous volumes of sand required to do this could not be placed within the time frame offered in the ice-free windows.

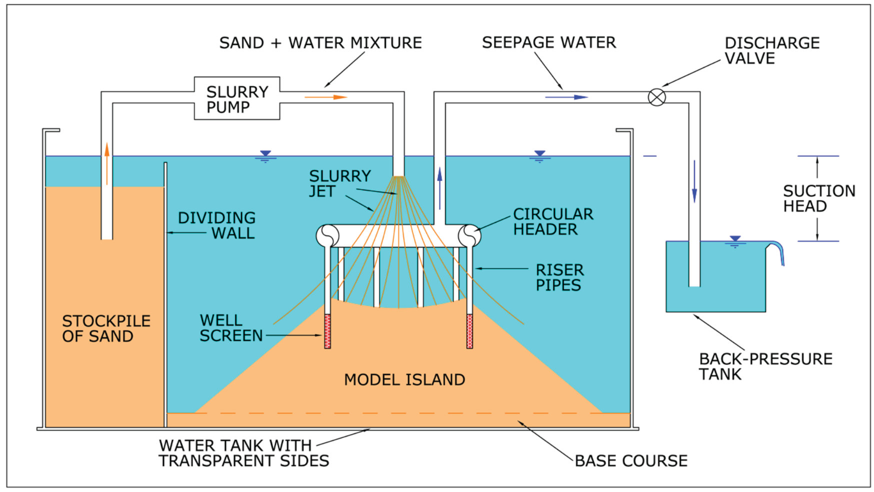

Figure 13. Schematic of NRC Ottawa model.

If steeper side slopes could be built, then the oil fields in deeper water would then be accessible. It seemed obvious to me that these flat slopes were the result of outward seepage flowing from the face of the accumulating sandfills. As I saw it, such destabilizing flows could be brought about by high pore pressures existing within the body of the growing islands as a result of the energy introduced into the soil-structure by the impinging slurry jet, as well as ongoing contractive distortions within the loose sand pile itself. So, if outward seepage was causing flat slopes, would inward seepage result in steeper slopes? Pumping water out of the sandfill while the dredge placement was progressing was maybe worth a try, – at least in the lab.

Figure 13 is a schematic of the model we used in a series of tests done to see if the idea had any chance of working. Essentially, what is being checked here is whether Seepage Forces are real and potent, and whether they can be advantageously invoked by circulating water (in the right direction) through the underwater sand pile. The test setup employs a siphon to draw water from the inside of a sand pile at the same time as a sand slurry is building it up.

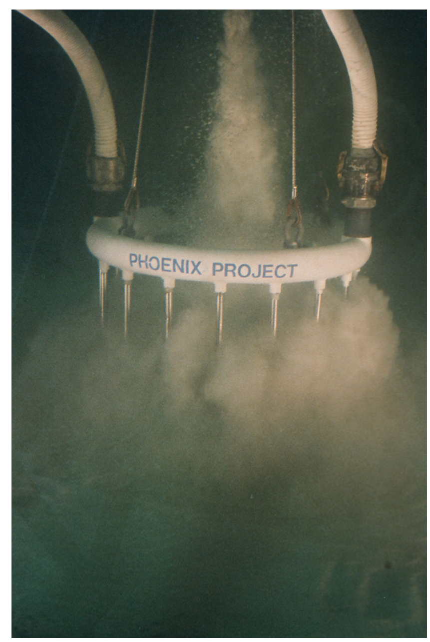

Figure 14a. Underwater sand slurry jet.

Figure 14a is a photograph taken through the transparent front of the water tank showing the sand-water slurry jetting down through the water onto the space between the ring of well screens. Here it can be seen that the slurry has some features in common with liquefaction: individual sand grains, having little, if any, solid contact with one another; surrounded by water; and, all moving energetically.

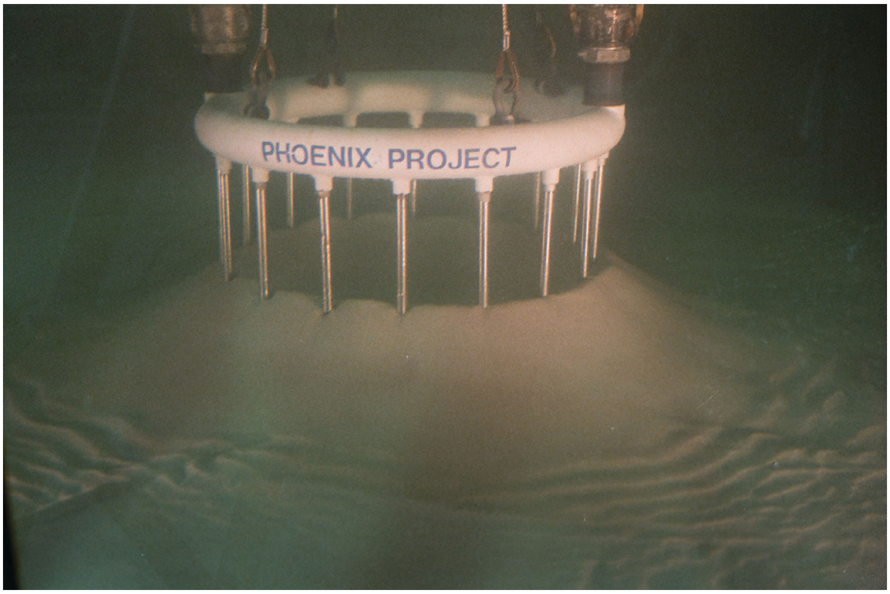

Figure 14b. Jetted sand accumulating around well screens.

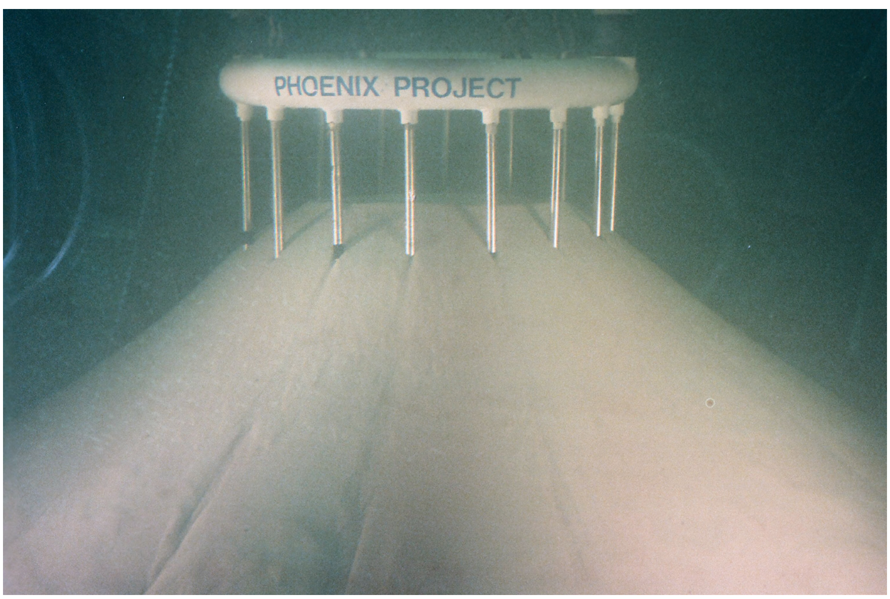

Figure 14c. Steep underwater side slopes made by Seepage Force.

Figure 14b was taken during an interruption in sand placement. It can be seen that, at this stage, the sand is accumulating in a ring around the alignment of the well screens. This establishes that where the S_F is intense/concentrated enough to be potent, sand particles can be captured from the jet.

The Seepage Force is now acting in reverse (to its natural tendency). It is working to our advantage.

Figure 14c shows the sand pile which resulted after the wells had been progressively elevated (by gradually hoisting the circular header) as the slurry jetting continued. Average slopes of up to 38° were achieved, with slopes locally as steep as 45° nearer the well screens. These slopes, built dynamically in the abrasive environment of the impinging jet, significantly exceed the 29° submerged angle of repose achieved by placid means, but without the aid of an inward S_F.

Two important geotechnical forces are to be seen at work in these photographs and model results: the forces of Drag and Seepage.

1. Discrete sand particles jetting down the slope of the model are literally dragged into the face of the slope, and then secured in place, by the water velocity created across them by inwardly flowing water.
2. Otherwise overly-steep side slopes, of non-cohesive material, are made stable in a severe hydrodynamic context by the potency of the S_F as it pushes discrete particles into the face, thereby greatly increasing the effective normal stresses on them.

At a fundamental physical level these forces are closely coupled in their origin and influence, and perhaps should not be spoken of as separate behaviours. They are both a result of relative movement between the phases, in this case with the water doing the most of the moving.

Now that we have recruited the concept of the Seepage Force we can move on to building a bridge between the Drag Forces that can be calculated for a single particle, and those forces acting on the same particle size when it is just one among a multitude of particles of various sizes within a cramped and crowded soil-structure.

Defining the Crowding Factor K

The approach to both defining, and calculating, the Crowding Factor is as follows:

It is taken that the Seepage Force exerted on a given volume of saturated soil due to water flowing through it is a direct consequence and result of the summation of the Drag Forces exerted on its individual grains.

Furthermore, the individual particle Drag Forces are taken as being equal to those proposed by Fluid Mechanics for spherical particles of equivalent size when exposed to the flow velocity existing within the voids of the soil-structure.

The value of the ratio between the water velocity in the void space [v_V], as compared to that of the approach flow [v_A], is K.

The definition of the Crowding Factor may therefore by stated as follows:

$K = v_V \div v_A$

such that if v_V is applied to the calculation of F_D, then the Drag Force per particle will be numerically equal to the S_F when v_A is used in the calculation of the Seepage Force for the soil (solid + water volume) associated with the same particle.

So the problem comes down to finding the factor by which the velocity term in the F_D equation must be multiplied to make the F_D force associated with a single particle equal to the S_F force for a single particle.

Theoretical/Idealized Approach

In order to give mathematical expression to the relationship between Seepage Force and Drag Force we must limit ourselves to dealing with spherical particles of uniform size.

By looking at a single particle and the volume occupied by that single particle we can write:

$S_F = i\,\gamma_w\,(1+e)\,D^3\,\pi/6$

$F_D = C_D\,\rho\,(v_V^2/2)\,D^2\,\pi/4$

In this particular instance I have chosen to temporarily revert to using C_D rather than using the component F_B and F_P , and this is simply for convenience: More mutual terms cancel out.

Now, setting $S_F = F_D$ and recalling that $v_A = i\,k$, we get:

$v_V^2 = 4\,g\,D\,(1+e)\,v_A \div 3\,k\,C_D$

which gives,

$v_V \div v_A = K =$

$2\sqrt{(\,g\,D\,(1+e) \div 3\,k\,C_D\,v_A)}$

This equation for K, it should be noted, requires an iterative process to recognize the fact that C_D, and in non-laminar flow situations, k, are both functions of relative velocity. Such numerical awkwardness is avoided in the alternative approach outlined below.

The implication of the above mathematical derivation is that a value can be given to the Crowding Factor once the permeability of the soil has been established. Although I offer a theoretical solution for evaluating saturated soil permeability in the next article, it must be said that such solutions are at best approximations, and lab testing of good specimens is really the only way to go if there is any hope for accuracy in subsequent computations.

The above theoretical approach is useful inasmuch as it provides mathematical continuity to the overall hypothesis, however, the following approach is likely to be more useful in practice.

Empirical/Practical Approach

Earlier in this article I used the permeameter to help explain the Seepage Force. Now it would make sense to look again at this standard piece of laboratory equipment for an empirical solution to our current problem. What we can get from this tool is not only the permeability [k] needed to solve the above equation, but furthermore, we get a direct measurement of the actual Seepage Force exerted on the volume of soil comprising the specimen. And in fact, this is all we need to know in order to determine the value of K for whatever real soil, and degree of compaction, used to make the specimen.

How this is accomplished for a soil containing a range of particle sizes requires some explanation. Full details of this procedure, and a computer program to facilitate the calculations will be given in the next article. Suffice to say at this time, that what is involved is finding, by iteration, the unique value of v_V which will achieve the criterion that the summation of the individual Drag Forces on the particles within the mass should equal the Seepage Force for that volume of soil.

Although the permeameter is a standard piece of equipment in geotechnical labs, my preference for this particular investigation is for using the triaxial apparatus instead. There are four reasons for this choice:

1. Triaxial technicians are familiar with constructing specimens to explicit specifications and they know how to saturate and de-air soils. Air entrained in an otherwise saturated soil would artificially decrease the measured permeability and increase the Seepage Force.
2. The flexible membrane in which the specimen is enclosed provides a good boundary for the outer soil particles once the cell pressure exceeds the pore water pressure. A rigid (metal or glass cylinder) encasement of soil results in significantly higher void spaces around the specimen perimeter and this leads to artificially high values of permeability and lower Seepage Forces. This is particularly important in coarse uniformly graded materials such as can be tested in the large diameter setups available to us nowadays.
3. After the permeability and Seepage Force have been determined in the drained-mode the specimen can then be strained to see whether the soil tends to contract or dilate. This tells us whether deformation of the soil modeled in the test specimen will lead to increases or decreases in pore water pressure.
4. It is a simple matter at this stage to perform a routine drained or undrained compression test at the deformation rate of interest.

So Where Are We Now?

Fluid Mechanics and Hunter Rouse have given us access to hydrodynamic aspects of water flow at various velocities around spherical particles of various diameters, and that allows us to separate such energy flow losses into those which create water pressure and those (viscous) which do not. The visit to Fluid Mechanics also gave us a way of looking at liquefaction and the idea that the structural collapse/fall came before the pore pressure rise. Following this valuable excursion into Fluid Mechanics, it is appropriate to return to Soil Mechanics once it comes down to non-discrete particles in crowded assemblies, and to those aspects of soil-structure and agglomerations which geotechnical engineering is all about. I believe the combination of these sister disciplines gives us the best of both worlds.

In the Next Article

The next article, Part 6, will be the last in this series. The details of how to calculate the pore water pressure generated in any gradation of a saturated soil-structure under deformation will be explained.

I will make some general statements about what I believe to be the most important facts about the water in the soil.

W. E. Hodge, P.Eng, M.ASCE
(778) 997-4505
wehodge@shaw.ca

The GROUT LINE

Grout Line

Paolo Gazzarrini

Overture

We are at the 26th edition of the Grout Line (more than 4 years have passed since the first edition) and a lot of material for this issue.

I start with very sad news that I would like to share with you; A. Clive Houlsby, a very renowned rock grouting expert passed away last September. I didn't know him personally but I am very well aware, as is everyone in our industry, of all the enormous work and dedication he provided for the grouting industry. I thank Jim Warner for preparing the following.

In Remembrance of A. Clive Houlsby

Renown rock grouting expert A. Clive Houlsby passed away peacefully at age 82, on September 17, following six weeks of hospitalization in his ongoing battle with cancer. Houlsby revolutionized North American grouting practice through presentation of his well documented case history data, as an instructor at the annual Short Course on Grouting Fundamentals and Current Practice, now sponsored by the Colorado School of Mines, and as an Invited Keynote lecturer at the once each decade International Conference on Grouting in 1982. He leaves his wife of 55 years Betty and two daughters Susan and Janet. He is to be honored as a "Grouting Great" at the awards ceremony of the upcoming International Conference on Grouting and Deep Mixing to be held in New Orleans, in February 2012. A citation previously prepared for that ceremony follows.

A. Clive Houlsby.

A. C. Houlsby Sydney, Australia

A keen interest in engineering and construction came naturally to Clive Houlsby. As a child he reveled in constructing sand castles and dams on the beaches of his native Australia, where he became keenly aware of the importance of the ratio of water to the sand, too much and the shape slumped, too little, it wouldn't stand. But his greatest delight (and future career) were established at age 9, when he discovered *"This stuff which could be mixed with sand to form all sorts of interesting shapes. And a day later the shapes were hard and were permanent! Glorious enjoyment limited only by the supply of cement from father's small resources."* Based on his prior experience on the beach, *"it came naturally to apply appropriate water:cement ratios to the cement molding."*

And so, his life of playing with cement continued until graduation from Sydney Technical college in 1952, with a Diploma in Civil Engineering. He then entered the real world, working in a design office for a few months. But he couldn't play with cement in a design office, so in 1953, he transferred to the Sydney Water Board as a Construction Engineer assigned to the new Warragamba Dam construction. Grouting wasn't well established in Australia and experienced people were lacking, besides it was considered dirty and beneath their dignity by most engineers. So young Clive was assigned to oversee the grouting work where he "was given free hand by the bosses".

Warragamba Dam was to be the largest concrete gravity dam in the southern hemisphere and serve as the main source for Sydney's water supply. It's a 351 meter long, 142 meters high, with a thickness of 8.5 meters at the top and 104 meters at the base, and was cast in massive blocks, which due to drying shrinkage, requiring grouting of the joints.

The joint grouting became of most interest to Clive; unlike the foundation, movement of the grout could be followed and observed in the exposed joints. The massive undertaking continuing for about four years with *"a crew of 60 men operating the various valves under my direction from a control centre. It was ticklish work!"* He did a lot of experimentation including the use of dye testing to identify leakage paths, pre and post injection observation by use of a borehole periscope, use of different grout consistencies, and vacuum injection. But the periscope examination was of most interest; even though the thinnest grout used was 3:1 water to cement (thick by U.S. standards of the time), he observed many bleed pockets which convinced him that thicker grouts were better.

Clive became the Countries grouting expert. As such he became embroiled in a huge controversy in 1962. An American engineer from the USBR was consulting on the Snowy Mountains Hydroelectric Project and insisted very thin (12:1 w/c) grout should be used. Clive was adamant; nothing thinner than 3:1! This led to an extensive test program wherein subsequent inspection disclosed the thicker grouts provided superior results. Clive went on to oversee all grouting operations at his agency, but his duties expanded to directing all site investigations, specification preparation, and head of the Dam Safety Unit.

He has consulted on projects throughout the world, was a speaker at numerous technical events, and from 1980 to 1995, provided the rock grouting portion of the week long Annual Short Course on Grouting, now sponsored by the Colorado School of Mines. He was a Keynote Speaker at the 1st International Conference on Grouting in 1982. He is the author of numerous technical presentations and the landmark book, Construction and Design of Cement Grouting, a Guide to Grouting in Rock Foundations, John Wiley & Sons, 1990. But perhaps most notable is his internet presentation ROCKGROUT (www.users.tpg.com.au. houlsby1) which in spite of failing health, he continued to improve until his recent hospitalization. The comprehensive ROCKGROUT site even includes a variety of grouting simulators, and can also be accessed through the ASCE Geo-Institute, Grouting Committee website (www.grouters.org). Clive Houlsby is truly a Grouting Great!

Jim Warner

The Gin Method Discussion Continues

I received also an additional comment from Dr. Donald Bruce related to the past 2 articles about the GIN Method, as an answer to Dr. Lombardi article published in September 2011 issue.

"I am delighted that my article has stimulated debate on the current challenges facing the evolution of the dam grouting industry in North America, and am obliged to Prof. Lombardi for his most thoughtful contribution. In 2003, I invited Prof. Lombardi to present the keynote lecture (on rock grouting) at the New Orleans International Grouting Conference. At its conclusion, I, as session chair, stated that if he had given this "GIN Lecture" in the U.S. in the 1980's or 1990's, then contemporary practices in North America would likely be so very different from what they had evolved into. I still believe that opinion to be true. However, res ipsa loquitur, and the res is that today our best practices are now somewhat different from those based on advanced GIN theory, even as implemented by the experienced and knowledgeable contractors in such non "remote" countries such as Switzerland and Austria. In this regard, I personally appreciated very much the details of the newer GIN developments."

Donald Bruce

We continue with an interesting article from Michael Byle D.GE, F.ASCE about grouting in karst. Mike is the National Discipline Lead for Civil/ Geotechnical Engineering at Tetra Tech EC, Inc. He holds both Bachelor and Master of Science degree from the University of Michigan. He has more than 30 years of experience in dealing with geologic hazards including karst. He is a past Chair of the Geo-Institute Committee on Grouting and current President of the International Conference Organization for Grouting. He is also the Co-chair of the 4th International Conference on Grouting and Deep Mixing to be held in New Orleans in February, 2012. (Michael.byle@tetratech.com – Tetra Tech-Langhorne, PA)

Managing Risk for Grouting in Karst

Michael J. Byle

Grouting in karst is fraught with difficulty and uncertainty that increase performance risks for grouting operations. Managing this uncertainty is essential in producing a successful result when seeking to stabilize or provide hydraulic cutoff in karst. Uncertainty is due to the unpredictable nature of the solution process and inability to detect the resulting openings with great certainty. The greatest risk results where grouting methods selected are either inappropriate or not adaptable to the conditions present. This paper will discuss the nature of karst features, methods to evaluate formations for their presence and methods to assess the performance and make adjustments to the grouting process to optimize performance. The approaches will include a discussion of geophysical methods and intrusive drilling and boring methods and how to integrate results statistically and geologically to better characterize the formation, as well as, including the Observational Method to reinterpret the characterization based on grouting performance data.

Figure 1. Vertical solution feature in flat lying limestone.

Figure 2. Isolated karst conduit in otherwise intact rock.

Introduction

The risks to a grouting project in karst are manifold. These include the potential for delays and cost overruns due to difficulty in drilling, reduced productivity during grouting for various reasons, material overruns, and equipment problems; as well as the risk of failure of the process to achieve the required objectives, or to provide long term performance. Risks can be effectively managed if they are adequately understood. Conversely, the risk to the project is greatest when uncertainty is greatest. The combination of all of the above uncertainties taken together with normal project risks (i.e. labor issues, material pricing, weather, etc.) will reveal the total project risk. This paper will deal exclusively with the risks associated specifically to karst, since the other normal project risks are routinely managed and covered elsewhere in the literature.

Uncertainty in Karst Grouting

Risk analysis has been applied to subsidence risk in karst (Kaufmann, 2008; Doctor et al., 2008, Perlow, 2008, Zisman, 2008, etc). Most of this type of work has been focused on development risk and not on identifying the specific risk of karst features being present at any specific location, though similar approaches can be used, provided sufficient site specific data is available. There are a number of categories of uncertainty associated with the planning and execution of a grouting program that must be addressed and managed for successful grouting outcome. These can be divided into site uncertainties, methodological uncertainty and temporal behavior uncertainty.

Site Uncertainties

For the purposes of this discussion, the term site uncertainties is defined as those unknown conditions present in the subsurface of the site that will affect the grouting performance and outcome. Site uncertainties would affect the rate and difficulty of drilling grout holes, the number of grout holes and injection locations, the quantity and distribution of grout in the subsurface and the overall effectiveness of the grouting program. The site uncertainties include site geologic variability, formational structural variability (i.e. the occurrence of fractures, folds or other features), the degree of weathering and karstification, the maturity of the karst, the presence of infilling, caves, etc., as well as, the depth and condition of soil overburden and the geo-hydrologic conditions.

Geological uncertainty relates to the nature of the formation as defined in geologic terms. That is the type of rock, rock material properties. This occurs where the nature of the geologic formation is either not known, or poorly defined. An example of this would be where a formation is mapped that consists of alternating beds of differing rock types, without a defined sequence or where bedrock mapping is incomplete. Bedrock mapping is often incomplete where it is overlain by a thick mantle, or where surface geomorphology is not residual, such as where the karst stratum is overlain by a alluvium, glacial deposits, or other such soils that would mask the presence and nature of the underlying bedrock. This can obscure contacts between formations. Another instance of geologic uncertainty would be where complex faulting or folding results in local disruption of the regional geology that may not be completely mapped.

Structural uncertainty refers to uncertainty related to the geologic structure. This includes location and condition of joints, faults, as well as, voids in the bedrock formation which comprise the secondary porosity of the formation. Structural geology informs the search for voids, since solution is typically more pronounced in areas of higher transmissibility where rock is fractured or broken and along discontinuities such as unconforming geologic contacts. Resolving or reducing structural uncertainty probably has the greatest impact on setting up the drilling patterns for a grouting program.

Hydrologic uncertainty arises from complexity of groundwater flow in karst. The impact of groundwater hydrology on the grouting can be profound. Injecting grout above the water table, below the water table or into flowing water will have quite different results that can seriously affect both the quantities of materials needed and the performance of the completed grouting.

Geomorphology is the study of the processes, characteristics and configuration and evolution of rocks and land forms. It is important to know what stage of the geomorphologic process the formation is in. Karstification is a geomorphologic process involving many stages from the initial dissolution of rock minerals, and formation weathering, to the erosion and infilling of voids, to the ultimate decomposition of the rock matrix. Understanding this process in a particular formation is necessary to assess whether voids are active conduits, plugged paleo-karst, or something in between. An excellent discussion of karst conditions and their formation is included in Waltham et al (2005) and White (1988).

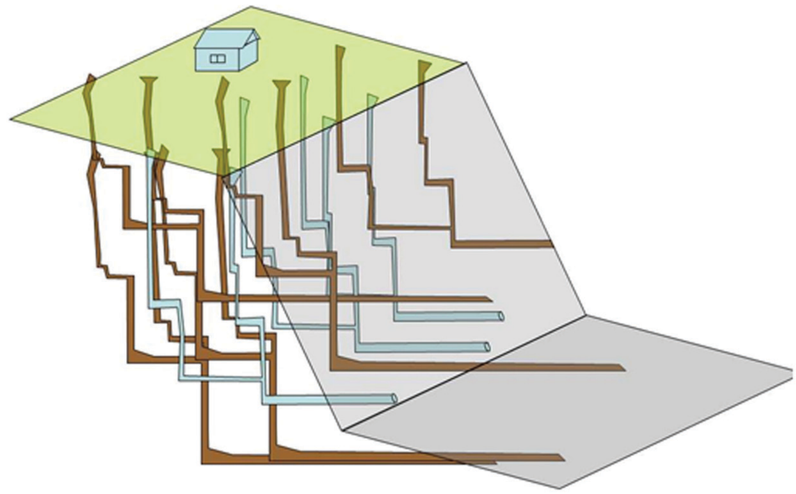

Figure 3. Karst conduits can be connected or isolated, soil filled, air filled or water filled.

Methodological Uncertainty

The application of this methodology used in grouting poses its own uncertainties. Whether a low or high mobility grout is selected; whether displacement by compaction grouting, replacement by jet grouting, displacement by fracture grouting, or void filling. Void filling would seem to be a relatively simple process, but it can be complicated where the voids are interconnected, where flowing water is present, the voids are partially filled with soil, or other factors. Grouting controls and materials can radically affect the performance of the grout. If the geology, structure and geomorphology are sufficiently understood, the grouting method and materials should be selected to provide effective performance. The method must allow versatility to accommodate uncertainties and adapt to varying subsurface conditions.

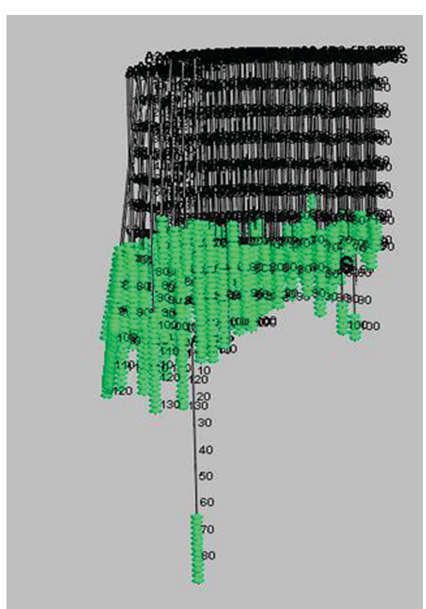

Figure 4. Results of grouting 20 ft into top of rock in karst with battered holes.

The temporal factor is one that is often ignored in grouting solutions. The passage of time will allow natural processes to continue that can alter the long term performance of the grouted formation. Erosion and transport of sediments around the grout may continue, albeit at a slower pace, but can undermine the effectiveness of the grout by opening new passages through previously plugged conduits, or through soils surrounding the hardened grout (Lolcama, 2009). To be effective, the grouting design and execution must consider the full consequence of the

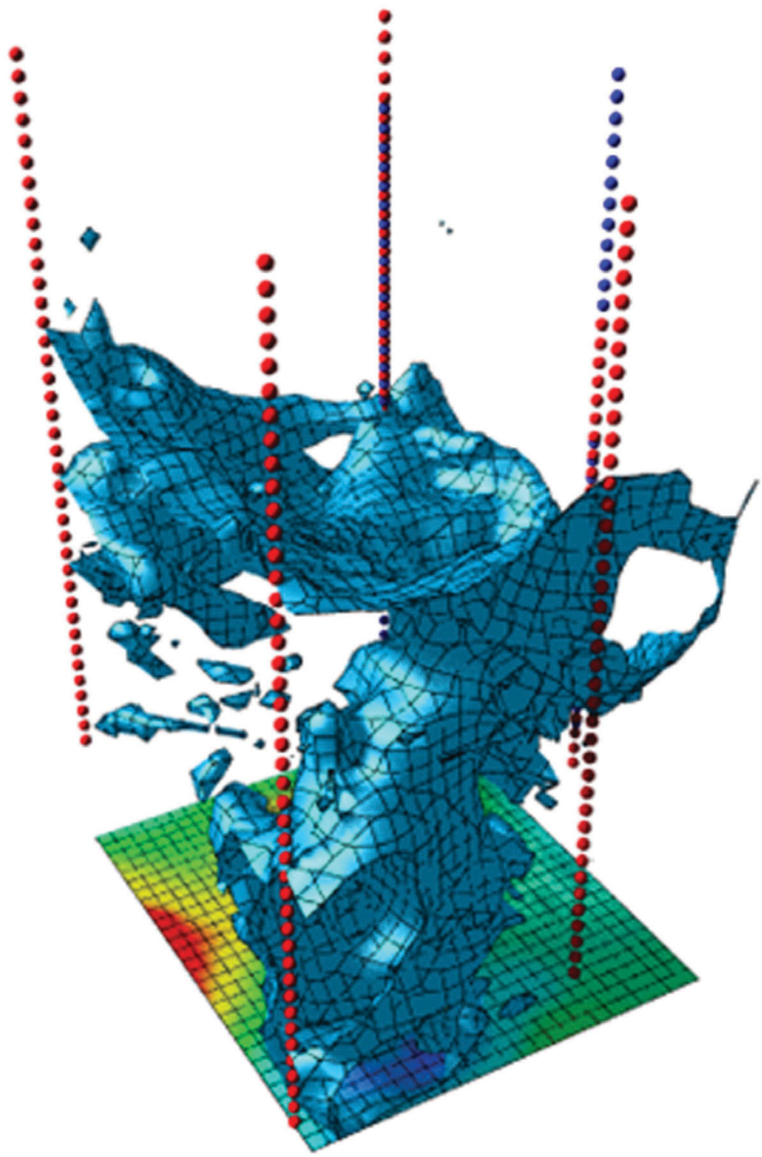

Figure 5. Crosshole seismic tomography image of sinkhole.

grout on the subsurface conditions, the long term stability of the grout material, and time dependent processes that can undermine the effectiveness of the grouting solution.

Managing Site Uncertainties

Uncertainties associated with site conditions can be effectively managed through proper site investigations in advance of the grouting program design. The investigation must be tailored to each site and should include the following:

1. Geologic Assessment
2. Hydrogeological Assessment
3. Subsurface Exploration
4. Karst Assessment

The Geologic Assessment must include an evaluation of the formations present including identification of the rock type,behavior, and layering; frequency of fractures and orientations; strike and dip of the rock beds, locations and orientation of dikes, faults, and unconforming contacts; presence and types of karst features present, and geomorphologic history of the materials at the site. Often times this can be accomplished by a review of technical publications and maps together with a site visit. The literature review should include review of previous studies and maps of the project site, and review of well drilling logs, a review of historic and current aerial photos can provide input on the distribution of karst features and changes in them over time as well as, enable fine tuning of the geologic data through identification of lineaments and other features.

A key factor in the geologic assessment is to develop a geologic site characterization. This characterization must include an evaluation of the distribution of identified karst features, faults, fractures and other features that can be related to karst activity or rock variability. The geologic assessment should characterize the type and distribution of karst features and the expected pattern of weathering.

The formation of karst features is always water related. The history of groundwater conditions over geologic time ultimately produced the karst conditions that remain within the rock at present. Except in the case of highly soluble formations, dissolution of rock is unlikely to be a significant ongoing problem; however, the current hydrologic conditions are likely to be a significant factor in the occurrence of activity in sinkholes and subsidence. The Hydrogeological Assessment must assess these items, from a geologic, historic, and current perspective. The Hydrologic Assessment should include an assessment of groundwater levels and flows, from both a static and dynamic perspective. The nature of groundwater flow should also be addressed, as to whether the karst voids are highly interconnected forming a 'water table' behavior or whether the voids form isolated conduits producing erratic water levels and potentially high velocity flows.

It is essential that the subsurface investigation be planned to consider the conditions identified in the geologic and hydrogeologic assessments to ground truth the conditions expected that should be treated by grouting. The subsurface explorations in karst are frequently conducted to refusal at the top of rock. This can be misleading, since karst is often pinnacled and may contain 'floaters', boulders that are remnants of prior collapse or differential weathering. The subsurface investigation must penetrate rock sufficiently to assure that sound bedrock has in fact been reached, or that the condition of the rock meets the requirements for support or conductivity needed for the intended site use. This can be a significant risk factor where the intent is to grout the soil overburden and takes are grossly under estimated where grout can migrate into undiscovered openings in the rock below.

The number of borings/corings/test pits must be sufficient to be statistically significant relative the variability of the conditions. In order to do this, there must be good understanding of the geologic conditions. It is imperative to have some idea as to whether the surface of the rock is highly variable and pinnacled and at what spacing karst features might be expected. If the surface of the rock is pinnacled with large pinnacles spaced 10 m apart, or with tall narrow pinnacles 3 m apart, or if it is a relatively uniform flat rock surface with irregularly spaced vertical karst conduits, a different exploration is necessary. The objective of the investigation is not necessarily to identify and locate every karst opening, but should be sufficient to project the quantity, type and size of openings such that an appropriate grout hole spacing can be defined.

Where the exploration reveals conditions inconsistent with the geologic assessment, the geologic interpretation should be revisited and revised to provide the best picture of the subsurface. Where the purpose of grouting is to control permeability, or where high velocity flows can be expected, wells should be included with appropriate measurements made. Where grouting in rock is required, it is necessary to assess whether voids detected by coring contain soil. This can be done using a small diameter split spoon that can be inserted through wireline coring drill stem.

Additional exploration tools such as borehole video, borehole geophysics, and other geophysical investigation methods should be used where appropriate. When using geophysics it is essential to understand the resolution and limitations of the methods used. Most methods cannot identify small voids more than a few meters deep. Even large voids can be difficult to identify at depth. When using electrical and compression wave methods it is essential to understand that the absence or presence of water can radically alter the result. All geophysical methods must be ground truthed using boring, and/or coring.

The Karst Assessment includes evaluation of all of the data and conclusions from the Geologic Assessment, Hydrogeologic Assessment, and Subsurface Exploration in concert to develop a unified model of conditions that fits all of the data and site conditions. To do this effectively requires a geotechnical engineer with a thorough understanding of geology, hydrogeology and karst processes. This model is used to design the grouting program.

Controlling Methodological Uncertainties

The effectiveness of a grouting methodology in karst is inextricably linked to site conditions. Without a proper understanding of the site conditions, it is impossible to select the correct method and approach to mitigation. That said, there are measures that can be taken to improve the prospect of obtaining as a satisfactory result and reducing cost and schedule. The key issues come down to control:

- Control of materials
- Control of drilling
- Control of the grouting process

These control measures together with a clear focus on the goals of the grouting program and an understanding of the mechanism by which the goals are to be achieved will provide a higher likelihood of a successful outcome. A summary of karst grouting approaches can be found in Warner (2004) and Byle (2001).

Grouting Goal Setting

The materials and methods used in grouting in karst must be selected to provide the performance desired. The performance must be carefully defined so that success can be measured. Some big picture goals may include:

- Creating and impermeable barrier
- Stopping seepage
- Preventing sinkholes
- Stabilizing an active sinkhole
- Providing a sound structural base for foundations

Figure 6. Karst grouting approaches.

The reader will notice the absence of 'filling voids' as an objective. This is because such an objective must be defined as to why it is desired to fill the voids. Such an objective is incomplete since it implies no clear endpoint and even if completed, may not yield the desired result.

For example, one may be willing to invest the huge sum necessary to completely fill all of the voids within a given area, but there is no assurance that doing this will prevent sinkholes, form and impermeable barrier, or provide long term structural support for foundations. Often voids are filled or partially filled with loose sediments and mud that can erode after grouting and undo the work of the grouting program. The complication with such an objective is that there is no practical way find and verify that all voids have been filled; and complete filling of all voids is seldom needed for satisfactory performance. One must view the filling of subsurface openings as part of the solution and not the end goal.

One must set goals that reflect real measurable performance and that define the purpose of the subsurface improvement. One of the key reasons for grouting failure is using a grouting method where it is inappropriate. One must be careful not to presume the solution when setting the goal. In some cases, the most effective solution might be to excavate from the surface and complete the improvement with concrete and compacted fill with no grouting at all. Often times, a combination of methods will be most appropriate and these may include more than one type of grouting, or grouting in combination with another measure.

Tactical Planning

Once the overarching goal has been defined, the focus can shift to the tactical level, where methods and mechanisms are reviewed to select the appropriate approach. In grouting, there is always more than one way to skin the proverbial cat. One can fill a void with anything using a variety of methods, from dumping gravel into a hole, to pumping through a tube á manchette and everything in between. The trick is to fill the hole with the right something in an economical way to achieve the project goal.

The first real step is identifying the type, frequency, and orientation of the voids in question and assessing what impact they will have on the end site use; and then to examine the distributaion statistically to determine the probability of encountering a void that would adversely affect the end use within the project footprint. Once that has been established, it becomes a question of determining what approach will decrease this probability to acceptable levels. This then becomes the tactical objective. The presence, absence, and flow of water in voids will also affect the grouting method selection. High velocity flows may require special methods (Warner, 2008; Bruce et al., 1998).

With this understanding together with knowledge of drilling and grouting technology and achievable performance, one can conduct an economic analysis weighing the relative cost of drilling and grouting using various methods. Where voids are to be filled, the first job is to drill casings into them. This is where knowledge of the orientation and distribution of voids is critical. The grout holes must be spaced such that grout will travel the amount needed to effectively treat the area required.

Structural applications are often simpler, because high strength is easier to achieve than low permeability. For structural applications, it may not be necessary for 100% coverage, since high strength limited mobility grout can create structural columns within the rock mass that may be sufficient without filling of intermediate voids. An example of this approach is included in Berry et al (2001).

For a hydraulic cutoff, it will be necessary to completely seal all hydraulic connections across the barrier location. This can be complicated by the presence of sediments within the rock voids that can be difficult to dis-

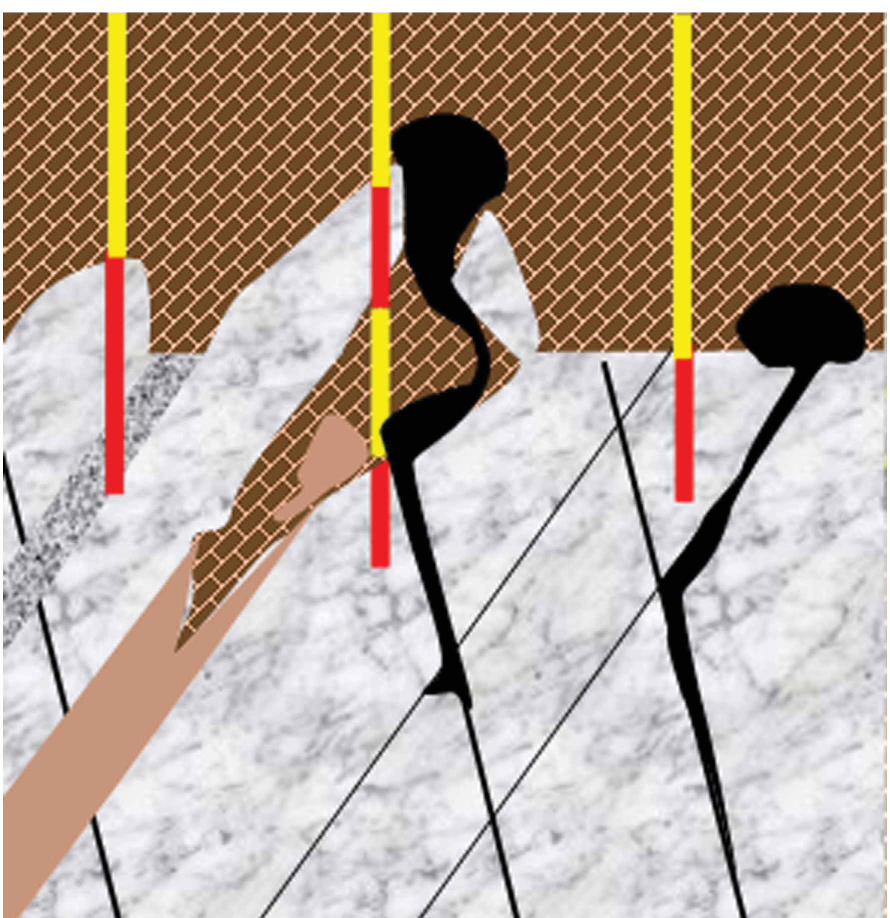

Figure 7. Vertical holes in karst can be ineffective orienting grout holes can increase success.

place or permeate. In such instances, the hole spacing must be close enough to permit overlap of grout injection between holes.

The orientation of grout holes should be selected to maximize the intersection of karst zones. This may involve steeply angled holes where steeply dipping or vertical features are present or vertical holes, where horizontal or horizontally connected features are present. Grout holes should be oriented across faulted zones or other areas within a project site where additional karst features would be expected.

The materials and methodology of grouting can be selected based on economics and performance. The effects of groundwater, where present, must be considered to prevent dilution and loss of grout effectiveness. A limited mobility grout should be selected where displacement and/or compaction of sediments is required, or where it is desirable to limit filling voids to specific areas without significant lateral spread of the grout. For very large voids, gravity filling with a concrete mix may be appropriate followed by secondary grouting with a finer or more fluid grout mix to seal remaining openings.

The key in successful planning is to anticipate variability. Even though large interconnected voids may not have been encountered, it is essential to have a plan to address them whenever grouting in karst. Identify volume alert levels so that the grouting plan may be changed to limit the loss of large volumes of grout. If grouting with a high mobility grout, be prepared to change to a limited mobility grout or other appropriate method, should an unanticipated large take occur.

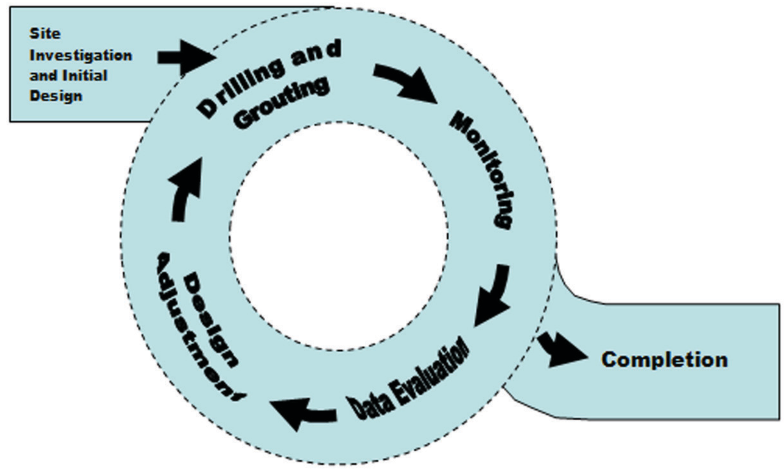

Figure 8. Grouting in Karst Design Cycle.

Managing the Drilling

The drilling should be used as an investigative tool as well as a means to make grout injections. All holes should be logged and evaluated to verify that conditions are as anticipated and are appropriate for the methods planned. Automated drilling equipment that records down-pressure, torque, and depth can effectively communicate drilling conditions in real time without the delays and labor required for hand logging. Have a plan of action to adapt to changing conditions. For example, if it is anticipated to grout small fractures, and large cavities are discovered during drilling the notifications to the engineer and owner, must be immediate so that an evaluation can be made as to whether and how to proceed with handling this new condition.

The drilling should attempt, to the extent practical, to assess whether voids in rock are soil filled and continuous. The continuity of voids is often observable as lost circulation of drilling fluid (air or water) appearing in adjacent holes and should be recorded and reported where it occurs. The conditions in each hole should be evaluated by the project engineer prior to the grouting. A hole should never be terminated in a void without direction from the engineer, since it may be desirable to deepen the hole and it will shave cost to do this while the rig is already present than to have to move it back into place later.

In karst it is not uncommon to encounter rock drops that bind the drill casing or for the casing to become wedged due to drift of the drill string on sloping rock surfaces. In these instances, it may be of value to change the orientation of the boreholes. The boreholes should be oriented to be as close to perpendicular to the feature surfaces as possible. This can reduce the potential for casing drift and make it less likely for sections of rock to fall at an angle to the drill string.

Managing the Grouting

The actual injection of the grout may or may not achieve the desired result. It is essential to closely monitor and interpret the observed behaviors during grouting to assess whether the grouting is likely to meet the project objective. While the cost for engineering observation during the grouting is often considered excessive, the cost for a failure of the grouting or for later regrouting the site will be considerably higher. The engineer in the field must have a clear understanding of the subsurface conditions, what the grout is expected to do in the ground, and what the overall objective of the grouting is, to be able to make good decisions.

Monitoring of the grout properties is essential to interpreting the grouting records. The viscosity, and thixotropy of the grout will directly determine grout behavior. Low viscosity grouts will penetrate fine openings and travel farther than higher viscosity or limited mobility grouts under the same pressures and rates of injection. The grout material properties, both wet and in the hardened state, must be consistent with the planned injection procedures and controls, and with the final objective of the grouting.

Refusal criteria must be established to permit effective grouting while maintaining adequate control. The danger of causing damage with the grouting increases directly with the volume and pressure of grout injected. So, refusal criteria should include provisions to prevent high pressures applied to large volume injections. Additional criteria relating to the effectiveness of the grouting should be selected to identify when the resistance to the grouting (as measured by pressure) is consistent with the degree of penetration desired for the grout. Setting target values of grout injection in soil is helpful, where displacement and compaction are possible; but seldom appropriate in rock, unless the conditions of the karst are well understood and known to have a well defined distribution of openings for the grout to enter.

Setting criteria for changing grout type or consistency may also be of value. In some situations, compaction grouting, permeation grouting, and filling of open voids may be required at a single location at various depths within a hole. Anticipating the different mechanisms for grouting and establishing criteria for each is an important way to control grouting overruns and poor performance. Such a criteria must contain a diagnostic component such that the performance of one type of grouting is used to assess the need for another. In such instances, it is common to start with a relatively fluid grout and step up to increasingly stiff or lower mobility grouts as various criteria are reached for volume and pressure.

All refusal criteria must include a rate of injection. The rate of injection will affect the pressure measured. Higher rates of injections will produce higher grouting pressures and may lead to early refusal due to viscosity effects and line pressures that may not be reflective of the ground conditions.

Closing the Loop

Once the planning is complete, controls are established and the work begins, it is essential to establish a feedback loop (Figure 8) whereby the additional information obtained by drilling and grouting is evaluated and employed to supplement the initial assumptions and conditions. This constant flow of new information will reveal conditions not identified in the original investigation. This is primarily due to the increased frequency of soundings over what can practically be accomplished during the initial investigations. Hole spacings are always closer in the execution of the grouting program than during the investigation and this additional information can only be neglected to one's own detriment.

Likewise, the grouting records will indicate how effectively grout penetrates features identified during the hole drilling. This can provide useful information about the continuity of openings and infilling that may not have been detected. There may be cause to use a different grouting approach to determine if it can be more effective or to reveal additional information about the formation. For example, if limited mobility grouting is encountering repeated refusal with low volumes in identified voids, it may be worth attempting a more fluid grout to assess whether there is low or higher permeability infilling. It may also be worth considering using a borehole camera to visually assess the conditions prior to grouting.

It is essential to do this in real time. There is no point in injecting 150 points to depths of 10's of meters only to determine at the end of the work, that there was no real benefit and another approach is necessary. Such cases often lead to conflict among owners, engineers and contractors over who is responsible for the method and who will pay for the fix. It is far better to find out and handle such problems early. As a wise man once said, "Bad news does not improve with age."

Conclusions

Karst can be very complex and important features are largely invisible from the ground surface. Geologic investigations together with geotechnical engineering evaluations can produce a viable characterization of conditions, but rarely can they provide a complete 100% picture of conditions. The characterization is as important, if not more important, than the findings of the tests, borings and geophysics. Variable conditions are likely in karst and should be anticipated in setting the project criteria.

The grouting program must be based on a clearly defined goal for the grouting program and tactical selection of materials and methods to achieve that goal. The goal should relate to required performance and not just to an arbitrary objective such as filling voids. The tactical solution should focus on meeting the required performance with a composite economic evaluation of materials, drilling, and injection processes to meet the required performance goal.

Adequate controls must be in place to monitor all aspects of the grouting including the grout properties, drilling conditions and results, grouting parameters including rates, pressures, volumes and depth. Automated drilling records and grouting that can be easily communicated in real time enhances the ability to make on-the-fly adjustments to the grouting to achieve optimal performance and to adapt to unanticipated conditions.

All of the data collected from the initial investigation must be considered together with real-time field data from the drilling and grouting operations to form a feedback loop. Continuous evaluation of the actively acquired data must be used to evaluate the effectiveness and performance of the grouting operation and to make appropriate adjustments to improve the effectiveness where appropriate.

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Michael J. Byle, D. GE, F. ASCE,
Tetra Tech EC, Inc.
820 Town Center Dr., Langhorne, PA 19047

Last but not least a reminder to everybody interested in Grouting, Jet Grouting and Soil Mixing. This is the last issue before the 4th International Conference on Grouting and Deep Mixing, so an important occasion before the next grouting conference that will be held in **10 years time, or 2022! Register now. (PS. I did!)**

With that I close this issue, wishing everybody a Merry Christmas and a phenomenal 2012.

Remember that, if you have additional comments or interesting grouting stories or case histories, you can write to me: Paolo Gazzarrini, fax 604-913 0106 or paolo@paologaz.com, paologaz@shaw.ca or paolo@groutline.com.

Ciao!

MARKET PLACE

Earthquake Early Warning System can shut down plants and critical processes

In 2011 an earthquake and tsunami severely damaged the Fukushima Daiichi power plant in Japan.

As a way of preventing similar future incidents, Weir-Jones Engineering Consultants Ltd. of Vancouver has introduced an innovative technology that provides advance warning of an impending earthquake. Known as the Earthquake Early Warning System (EEWS), it provides operators with enough time to bring processes or equipment to rest or to deny access to critical structures such as bridges or tunnels before the onset of a seismic event.

The amount of warning time depends on the distance between the epicentre of the earthquake and location of the EEWS. Normally, for shallow and close epicentres this time difference is a few seconds and for deep and distant seismic events is up to two minutes.

Weir-Jones conceived the idea when the Ministry of Transportation in British Columbia was looking for a way to protect motorists who use a tunnel that takes traffic under the Fraser River south of Vancouver. By June 2009, the EEWS was fully designed and deployed at the designated location and the system entered the test phase.

The system, which is the only installation to date, relies upon the output from geophone sensor packages in boreholes north and south of the tunnel. The boreholes are about two kilometres apart and both sensor packages have to produce similar signals within a predefined time window for the analytical software to declare that a dangerous seismic event is pending.

The EEWS consists of four major parts: vibration sensors, data acquisition units, a central processing computer and an alarm system.

It relies on the well-known phenomenon that the destructive energy of an earthquake is related to large secondary shear waves (S-waves) that are preceded by the less destructive primary compressive waves (P-waves). When an earthquake occurs, the P-waves propagate much faster through the earth's crust compared to the more destructive S-waves. Based on this principle, the scale of an impending earthquake can be predicted by detecting and analyzing the P-waves.

The EEWS detects and characterizes P-waves and issues an alarm if the magnitude exceeds the pre-set limit. To achieve this, the EEWS constantly monitors the ground motion in real-time and searches for signatures of P-waves of a strong earthquake.

Shutting down transportation routes, plants or processes is costly and should be avoided unless an imminent hazard is foreseeable. To achieve a high level of reliability and make the system not prone to false alarms, multiple layers of redundancy have been considered in the EEWS design.

Contact: Iain Weir-Jones at iain.weir-jones@weir-jones.com.

Boring Log Data on Rugged Tablet PC

The newest version of WinLoG 4.5 can now run on tablet pcs that use Windows 7 operating system. This new version offers many great advantages for field use:

- Rugged tablet PCs can withstand water, dust, and are shock resistant. Some can include cameras and GPS.
- Logs can be completed in the field and emailed to the office. Minimize the amount of office work required.
- The data in the final log will be more accurate, reduces the possibility of transcription errors.
- Macros can be used to quickly insert predefined text and symbols into lithologic layers.
- Macros can be used to quickly add standard well diagrams.
- The program is identical to the desktop version, so there is no additional learning curve.

For more information or to get a free demo of the program contact sales@gaeatech.com.

Instantel Partners with Brüel & Kjær to Provide Noise & Vibration Monitoring Services

Large infrastructure construction projects take several years to complete and are often located within built-up areas. This can give rise to significant noise and vibration nuisance which, if left unmanaged, can lead to project delays and significantly increased costs. Importantly, excessive vibration from pile driving and other construction activities can lead to damae to nearby property and potential litigation.

Brüel and Kjær has been active for many ears providing noise monitoring solutions to manage noise nuisance around the world and is pleased to announce a partnership with Instantel to add vibration monitoring to its Noise Sentinel managed services.

Contact: Ron Mask at Instantel, email: ron.mask@sbdinc.com

YOU NEVER SEE OUR BEST WORK...
But you have confidence in knowing we've been there. tm
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