GeoEngineering Centre at Queen's - RMC

Newsletter Fall 2003

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Introduction to the GeoEngineering Centre at Queen's – RMC

Between 2001 and 2002, faculty members in Kingston Ontario came together to form the new GeoEngineering Centre at Queen's - RMC. Formally recognised by the University late in 2002, the partnership involves the Departments of Civil Engineering, Geological Sciences and Geological Engineering, and Mining Engineering at Queen's University, and the Department of Civil Engineering at the Royal Military College of Canada.

The Centre focuses on the solution of problems relating to the theory and practice of soil and rock mechanics, hydrogeology and engineering geology in support of Civil, Environmental and Resource Engineering projects. It involves the activities of more than a dozen faculty and almost one hundred graduate students and postdoctoral research fellows working in six different areas of GeoEngineering that have been identified:

Geotechnical Engineering (the behaviour and design of foundations, slopes, excavations, dams, tunnels and so on):Richard Bathurst, Richard Brachman, Mark Diederichs, Jean Hutchinson, Steve McKinnon, Ian Moore, Gerald Raymond, and Kerry Rowe.

Geoenvironmental Engineering (the multidisciplinary application of geotechnical engineering, hydrogeology and geochemistry to solve environmental problems): Richard Bathurst, Richard Brachman, Djaouida Chenaf, Jean Hutchinson, Heather Jamieson, Bernard Kueper, Kent Novakowski, Vicki Remenda, and Kerry Rowe.

Geomechanics (establishing the response of earth materials to the presence or application of deforming forces): James Archibald, Richard Brachman, Mark Diederichs, Jean Hutchinson, Takis Katsabanis, Steve McKinnon, Ian Moore, and Kerry Rowe.

Geosynthetics (polymeric materials used in contact with soil/rock and/or any other geotechnical material in civil engineering applications): James Archibald, Richard Bathurst, Richard Brachman, Ian Moore, Gerald Raymond, and Kerry Rowe.

Geochemistry (chemical composition and interaction of earth materials): Heather Jamieson, Bernard Kueper, and Vicki Remenda.

Hydrogeology (the behaviour and remediation of contaminants in groundwater): Djaouida Chenaf, Bernard Kueper, Kent Novakowski, and Vicki Remenda.

Welcome from the Centre Director

It is my pleasure to introduce this first newsletter of the newly formed GeoEngineering Centre at Queen's – RMC. The vision of the Centre is to be one of the world's leading GeoEngineering research teams, featuring a large, diverse group of GeoEngineering faculty, talented and energetic graduate and postdoctoral researchers, high levels of research grant and contract funding, world-class research infrastructure, and 'leading-edge' research contributions related to a wide range of theoretical and applied projects. This newsletter describes our activities and accomplishments over the past year, including progress in realizing our objectives in collaborative research and graduate training. Furthermore, by recognizing here some of the successes of Centre members during that period, we are introducing those individuals and providing concrete examples of how the Centre's research activities are affecting GeoEngineering theory and practice well beyond the borders of Kingston, Ontario. As the Centre's activities grow over the next few years, I trust that our research work and the highly qualified personnel we train are of benefit to colleagues in Universities, Government agencies, consulting and corporate offices across North America and beyond.

Please contact us through any one of the Centre members, or through our administrative secretary, Ms Jolanda de Groot. I also invite you to review more details of the centre at our website: www.geoeng.ca.

Ian Moore
Director, GeoEngineering Centre at Queen's – RMC
November, 2003

GeoEngineering Centre members

from left to right: Gerald Raymond, Ian Moore, James Archibald, Richard Bathurst, Jean Hutchinson, Heather Jamieson, Kerry Rowe, Kent Novakowski, Richard Brachman, Stephen McKinnon, Bernie Kueper, Mark Diederichs (absent: Vicki Remenda, Djaouida Chenaf, Takis Katsabanis)

Dr. Richard J. Bathurst - Canadian Geotechnical Society Cross-Canada Lecturer (Spring 2003)

Dr. Richard J. Bathurst of the GeoEngineering Centre at Queen's-RMC was the Spring 2003 Canadian Geotechnical Society (CGS) Cross Country Lecture Tour (CCLT) speaker. The lecture tour was undertaken in May and June with a total of 12 lectures given across Canada. The venues were located in Halifax, Quebec City, Montreal, Toronto, Regina, Saskatoon, Winnipeg, Calgary, Edmonton, Prince George and Kelowna.

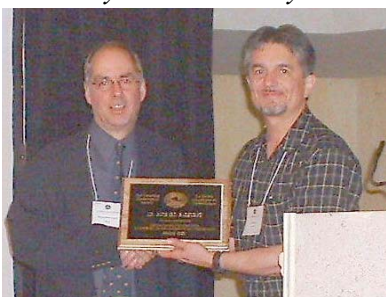
Each CGS section was asked to select from one of three lecture topics offered by Dr. Bathurst. The three topics were equally subscribed to during the speaking tour.

The first topic was titled "Physical and Numerical Modelling of Geosynthetic Walls and Embankments" and gave an overview of the program of physical and numerical modelling of geosynthetic reinforced soil structures that has been underway by his research team at Queen's-RMC for the last 15 years. The talk described both full-scale reinforced structures taken to failure in the RMC Retaining Wall Test facility and complimentary programs of reduced-scale model tests that have been used to study the performance of reinforced retaining walls constructed with non-select fills, and tests carried out using a shaking table to record the response of models during simulated earthquake loading. Examples of numerical modelling results of carefully instrumented RMC structures were also presented and the implications of physical and numerical modelling to new design methods identified.

The second topic was "Masonry Block Reinforced-Soil Retaining Walls: A New Technology". This lecture described recent developments related to the innovative design and construction of vertical or near-vertical geosynthetic reinforced soil retaining walls that incorporate modular masonry blocks as the wall facing. Included in the talk was a description of a unique long-term research program headed by Dr. Bathurst involving the construction and testing to failure of instrumented full-scale masonry block test walls. The results of this program are being used to refine design methods found in current guidance documents.

The third topic was "A New Working Stress Method for Prediction of Reinforcement Loads in Geosynthetic Walls". This talk was focused on a recently developed empirically-based working stress method that was developed by Dr. Bathurst and his co-workers to improve the accuracy of geosynthetic reinforced soil wall design vis a vis measured performance and to reduce excessive conservatism in current practice. The lectures were well attended including about 100 persons at the CGS South Ontario Section venue in Toronto. The CGS Cross-Country Lecture Tour is organized biennially by the Canadian Geotechnical Society and supported by the Canadian Foundation for Geotechnique through donations from Canadian "geo" companies. The 2003 Spring tour was sponsored by Jacques Whitford and Associates, Inc. and AMEC.

Editor's Note: Dr. Bathurst is Professor of Civil Engineering at RMC and is cross-appointed to the Civil Engineering Department at Queen's. His contributions to Geosynthetics research and practice include Editorship of Geosynthetics International, and completion in December 2002 of a four year term as President of the International Geosynthetics Society.



Dr. Bathurst (left) receiving CGS CCLT plaque from Mike Tanos, President of the Southern Ontario Section of the CGS at the conclusion of the spring lecture tour.

Visit by NSERC Council

Queen's University hosted a visit by the NSERC Council in October 2002, the body responsible for setting NSERC policy and overseeing budgeting and program design. During their visit, Council members were hosted by Jean Hutchinson and Ian Moore, who presented overviews of their research work, and the collaborative activities of the new GeoEngineering Centre. Council members were able to meet with graduate students and postdoctoral research fellows, and undertake a brief laboratory tour, learning first-hand how NSERC investments in infrastructure and graduate student support are translating into research and training outcomes.

Editor's Note: Dr. Hutchinson, appointed in 2001 as Assistant Professor in the Department of Geological Sciences and Geological Engineering, was granted tenure and promoted this summer to Associate Professor. Congratulations Jean!

New Research Laboratory

New Laboratory for Measuring the Physical Response of Landfill Barrier Systems

Renovations are now complete on a new laboratory located in Ellis 009 for conducting physical experiments on composite landfill liners. The laboratory houses three high-pressure test vessels capable of simulating the earth pressures at the base of landfills.

The physical response of geomembrane, compacted clay and geosynthetic clay liners is being studied when subject to vertical pressures as large as 3000 kPa. The objective of this work is to assess the long-term performance of landfill liners with the aim of improving the design on landfill barrier systems.

Development of this new laboratory was funded by the Canadian Foundation Innovation and the Ontario Innovation Trust through grants awarded to Dr. Richard Brachman.

Research students (L to R) ***Jen Lavoie*** *(BASc),* ***Simon Gudina*** *(PhD) and* ***Simon Dickinson*** *(MSc) conducting measurements following an experiment.*

NEW STRATEGIC RESEARCH GRANTS

Predicting Aqueous-Phase Transport in Complex Fracture Networks at Various Scales - Improvements in Groundwater Management

Principal Investigator: Kent Novakowski, GeoEngineering Centre at Queen's - RMC
Co-Investigators: René Therrien and Donna Kirkwood, Geology and Geological Engineering Dept., Laval University (Total value of $471,700 over the period 2003-2006)

At many locations across Canada where contamination is carried by groundwater migrating through fractured bedrock, the assessment of risk to nearby receptors (i.e. drinking water wells or surface water bodies) and the development of appropriate clean-up measures have proven to be a difficult undertaking.

Protecting groundwater from contamination in fractured rock environments is an equally difficult challenge. Thus, in order to protect public health and to assuage public concerns, it is necessary to have a complete and accurate understanding of the processes of contaminant transport at a variety of scales in these environments such that accurate and reliable risk assessment, successful clean-up programs, and appropriate measures for groundwater protection can be undertaken.

At the present time there are no experimental results collected at the various scales relevant to long-term transport in fractured rock from which to resolve the transport processes in this environment. In addition, the simulation tools presently available for interpretation and prediction at larger scale are limited by computational demands that significantly exceed the present generation of computers. The objective of the proposed research is to conduct field tracer experiments and develop a new numerical modelling approach that will expand our understanding of contaminant migration through fracture networks at scales beyond that previously investigated. The results of this research will significantly improve the ability of hydrogeologists and engineers in the design of groundwater protection zones in fractured rock and in the clean-up of fractured rock sites presently undergoing remediation. Partners from Environment Canada, the Smithville Phase IV Bedrock Remediation Program (Ontario government agency), The Ontario Ministry of the Environment, the Quebec Ministry of the Environment, the Regional Municipality of Waterloo, and the Canadian Nuclear Safety Commission will participate directly in some of the experiments, and will closely follow the project.

The results of this research will be transferred to stakeholders via the training of graduate students, and through workshops targeted at groundwater professionals and groundwater managers.

Editor's Note: Kent Novakowski is an Associate Professor in the Department of Civil Engineering at Queen's University, appointed in 2000. Kent has also recently been appointed as the chair of an expert panel assembled to advise the Ontario Government on maintaining well integrity in the aftermath of E.Coli contamination in Walkerton.

Sustaining Urban Pipeline Infrastructure with Trenchless Installation and Replacement

Principal Investigator: Ian Moore, GeoEngineering Centre at Queen's – RMC
Co-Investigators: Richard Brachman, GeoEngineering Centre at Queen's – RMC, Erez Allouche, The University of Western Ontario

Centre members Dr. Ian Moore and Dr. Richard Brachman were awarded $540,140 by NSERC over the period 2002-2006 to investigate the behaviour of thermoplastic pipes 'pulled into place' using two trenchless technologies: horizontal directional drilling and pipe bursting. The project is addressing the huge repair and replacement costs associated with aging storm-water and sanitary sewer infrastructure that is reaching the end of its design life in cities across Canada. The project is being conducted in collaboration with Dr. Erez Allouche of the University of Western Ontario, and features eight graduate students working to ensure that pipes installed using these techniques have adequate performance life. Laboratory tests are being conducted at Queen's to measure ground deformations in the vicinity of the pipe bursting operations and the earth pressures that develop on the pipe, and new instrumentation developed at Western is being used in field tests to measure the axial pulling forces and grout pressures applied to the pipes during installation. Computer analysis methods developed at Queen's are being calibrated to provide rational design methods for design of trenchless projects.

Surface damage to the pipe that results during pulling operations is being assessed, as is the potential for pipe fracture under residual stresses that remain in the pipe after construction. The project seeks to maximize the potential use of trenchless technologies developed to reduce or avoid disruption to surface transportation and the environment associated with conventional 'cut and cover' construction methods. The project is being conducted in partnership with Golder Associates of Burnaby B.C., Ipex Industries in Ontario, and the contractors and owners of the infrastructure being installed and monitored in the field.

"MSc Student Brian Lapos (left) and Richard Brachman inspect a pulled-in-place polyethylene pipe (black) following an experiment. Pipe bursting was used to break away an existing clay pipe (red) to make way for the new polyethyene pipe. Ground displacements, pipe strains and pulling forces were monitored during the experiment."

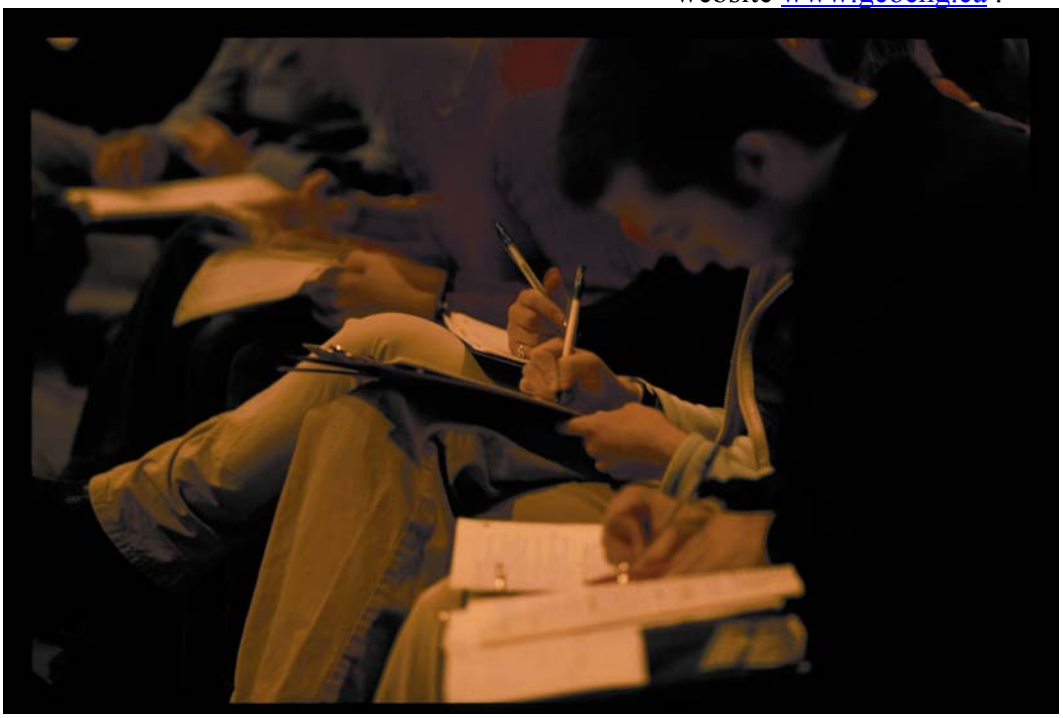
Editors Note:
Dr. Richard Brachman, appointed to Queen's in 2001 as an Assistant Professor in the Department of Civil Engineering, has interests in the behaviour and design of buried polymer infrastructure (sewers and solid waste landfills). Much of his work involves the development and use of novel testing facilities, including a facility for simulating the performance of pipes and geosynthetics under embankment loading (in collaboration with Moore and Rowe), and a new set of high pressure test cells described elsewhere in the Newsletter.
Dr. Ian Moore, also appointed to Queen's in 2001, holds the Tier 1 Canada Research Chair in Infrastructure Engineering. His research on non-linear soil-structure interaction includes work to establish, quantify and design for the limit states of metal, concrete and polymer culverts (incorporated in various international design standards), and investigations of the soil-pipe interaction during trenchless construction (the focus of the new Strategic Grant).

New GeoEngineering Collaborative Graduate Program

An innovative new Collaborative Graduate Program in the field of GeoEngineering has recently been established in Kingston. Formally approved by the Ontario Council of Graduate Studies in June 2002, the program links the doctoral and masters programs offered by the Departments of Civil, Mining and Geological Engineering at Queen's and Civil Engineering at RMC. Any students enrolled in graduate programs offered by the participating departments can elect to participate in the GeoEngineering program, offering them the opportunity to obtain broad interdisciplinary graduate education by selecting GeoEngineering graduate courses from at least two of the four departments, participating in a new GeoEngineering seminar course, and undertaking the thesis research work in one or more GeoEngineering sub-fields. Students have their final transcripts amended to recognize this specialization in GeoEngineering.

Enrolment commenced in September 2002, with 20 graduate students participating during the 2002-2003 academic year. The GeoEngineering Seminar course involved speakers from the Centre, other Canadian and US scholars, GeoEngineering consultants and visitors from Government agencies, like the Geological Survey of Canada. Each student participant is required to make one presentation each year, and the excellent series of student seminars was a highlight of the course. The honour of being the first graduate of this program will go to Jamie van Gulck, who has completed the requirements of the program and who defended his doctoral thesis in September 2003 *(congratulations also to Jamie on his recent appointment as Assistant Professor at the University of Manitoba).*

Enquiries should be directed towards Ms Jolanda de Groot, GeoEngineering Centre at Queen's - RMC, info@geoeng.ca. Further information can be found on the website www.geoeng.ca .



Recent Graduates

The following GeoEngineers associated with the Centre have recently completed their training, and have moved on to the next phase of their career.

- **Mohamed Abdel-Meguid** (Postdoc)
  Jacques Whitford, Ottawa

- **Michael Baumert** (PhD, UWO)
  Adjunct Assistant Professor, the University of Western Ontario.

- **Jason Chan** (MSc)
  Maunsell Partners, Hong Kong

- **Ashutosh Dhar** (PhD, UWO)
  Assistant Professor, Bangladesh University of Engineering and Technology, Dhaka.

- **Magdy El-Emam** (PhD)
  Assistant Professor, Zagazig University, Egypt

- **Viji Fernando** (MESc, UWO)
  Golder Associates, Burnaby.

- **Benoit Guerard**, MSc(Eng)
  Teachers College, Queen's University

- **Jason Lee** (MSc)
  Thurber Engineering Ltd, Oakville

- **H. Matt Li** (PhD)
  Golder Associates, Shanghai

- **James Reeves** (MSc)
  Lecturer, Civil Engineering Dept, RMC, Kingston

- **Andrew Rollo** (MSc)
  Lorax Environmental Services, Vancouver BC

- **Henri P. Sangam** (PhD)
  SNC-Lavalin (Toronto)

- **Graeme Skinner** (PhD)
  Assistant Professor, Queen's University.

- **Jamie van Gulck**, (PhD)
  Assistant Professor, University of Manitoba, Winnipeg

- **Sammy Wong**, (MESc student at UWO)
  Cambridge Pipe, Cambridge Ontario

AWARDS

2002 Rocha Medal
Awarded to Dr. Mark Diederichs

Dr. Diederichs receives the Rocha Medal from Dr. Marc Panet, President of the ISRM

Dr. Mark Diederichs, a member of the centre and an assistant professor in the Department of Geological Sciences and Geological Engineering, was awarded the 2002 Rocha Medal awarded by the International Society of Rock Mechanics. The Rocha Medal is the most prestigious of its kind in the field of rock mechanics and was awarded for his Ph.D. thesis entitled 'Instability of hard rock masses: the role of tensile damage and relaxation'. The award recognizes the most innovative and valuable doctoral contribution to rock mechanics in 2002.

Dr. Diederichs' thesis was co-supervised by Dr. Peter Kaiser of the Geomechanics Research Centre at Laurentian University and Dr. Maurice Dusseault at the University of Waterloo. The medal and a research summary lecture were presented at the International Rock Mechanics Symposium in Madera Portugal. Part of this research was also presented by Dr. Diederichs in a keynote lecture at the 2002 North American Rock Mechanics Symposium in Toronto.

Dr. Diederichs delivers the Rocha Medal Lecture at the 2002 International Symposium.

Editor's Note: Dr. Mark Diederichs joined the Department of Geological Sciences and Geological Engineering at Queen's University in 2001 following a decade in industry undertaking specialized consulting work for hard rock mining industry.

Dr. Kerry Rowe receives 2002 K.Y.Lo Medal

Dr. R. Kerry Rowe was recently presented with the K.Y. Lo Medal of the Engineering Institute of Canada, at a ceremony in Ottawa in early April. This medal is awarded in recognition of international contributions to engineering practice, and is named in honour of Professor Emeritus K.Y. Lo of the University of Western Ontario. The citation read at the ceremony noted: *"Dr. Rowe's technical and scholarly achievements have contributed greatly to the international community, which has led to his recognition as one of the most distinguished engineers of his generation. Effective collaboration with other universities and industry has been a hallmark of his world-class applied research. Dr. Rowe also has worldwide experience in consulting engineering, particularly in the design and peer review of landfills, which now number more than 40 major projects on four continents."*

Editors Note:
Following his appointment as Vice-Principal (Research) at Queen's University in September of 2000, Kerry Rowe has been a significant catalyst in bringing together the GeoEngineering faculty in Kingston. Kerry's GeoEngineering interests and activities are extensive, including the training of many graduate students, his recently completed term as President of the Canadian Geotechnical Society (2001 and 2002), and his ongoing editorship of Geotextiles and Geomembranes.

Killam Research Fellowship awarded to Dr. Ian Moore

Recognized as "among Canada's most distinguished research awards", the Killam Research Fellowships announced each year by the Canada Council of the Arts "support scholars of exceptional ability engaged in research projects of broad significance and widespread interest". These awards are funded through lifetime and testamentary gifts to the Canada Council from Mrs. Dorothy J. Killam.

Awarded a fellowship for the 2002-2004 period, Ian Moore of Queen's University was selected in the field of *Engineering*, to investigate the "Engineering Mechanics of Buried Pipes, During and After Repair, Replacement or Installation Using Trenchless Technologies". This release from teaching is permitting Ian to accelerate his work to establish the fundamental characteristics of trenchless soil-pipe interaction, at a time when the use of trenchless technologies and the demand for a rational understanding of their behaviour is growing.

Editors Note:
The resources from the Canada Council are being used to fund a two-year appointment for Dr. Graeme Skinner. Graeme is undertaking Ian's teaching duties during the period of the Killam award, and is also assisting with the co-supervision of graduate students and administration.

Geochemical Stability of Diamond Mine Waste from Arctic Canada

By Heather Jamieson

Since the 1991 discovery of the first economically viable diamond deposits in the Canadian Arctic, diamond mining has become one of Canada's newest mining sectors. By the end of 2003, Canada will produce 10 to 15% of the world's diamonds by value.

Andrew Rollo has recently completed a MSc thesis entitled "Processed Kimberlite-Water Interaction in Diamond Mine Waste, Ekati Diamond Mine, NWT" under the supervision of Dr. Heather Jamieson in the Department of Geological Sciences and Geological Engineering at Queen's. The objective of this thesis was to investigate the waste produced from Canada's first operating mine and its effect on the Arctic environment.

Panda pit at Ekati diamond mine in 2001

The Ekati Diamond mine is located within the Lac de Gras drainage basin, which forms the headwaters of the Coppermine River that flows north to the Arctic Ocean. Waste kimberlite and process water is stored in an engineered containment facility.

Water from this containment facility is discharged to the receiving environment, provided it meets stipulated requirements. Surficial deposition of crushed kimberlite increases the potential for reaction and dissolution of minerals in the waste, resulting in an increase in dissolved solids in the containment facility water. Diamond mining is in its infancy in Canada and few studies have been conducted on diamond mine water, particularly in the Arctic.

Processed kimberlite fines containment facility.

The results of Andrew's work indicated that the major dissolved constituents in the containment facility waters are SO_4, Ca and Mg. Water pH is approximately neutral and dissolved Fe is low. The most significant controls on water chemistry are evaporation and reactions occurring during mineral processing.

Andrew received a Canadian Water Resource Association award for his work. His research was supported by BHPBilliton and NSERC.

Editor's Note: Heather Jamieson is an Applied Scientist with appointments as Associate Professor in the Department of Geological Sciences and Geological Engineering and the School of Environmental Studies at Queen's. Her work focuses on Geochemical aspects of a variety of Geoenvironmental projects. She was the recipient in 2003 of the Chancellor's Research Award from Queen's University for her project titled: "Geochemical Controls on the Human Health Risk Associated with Contaminated Soils".

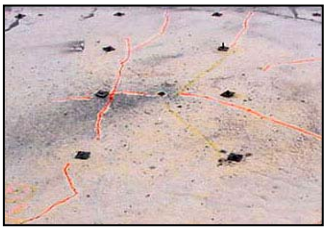
Queen's Rockburst and Rock Support Research

By Jamie Archibald and Takis Katsabanis

The need to supply effective ground support in mines is important when it is realized that one third of all fatal, and a large proportion of serious injury, incidents which occur in Ontario result from falls of ground and rockbursts. One way in which injury reduction might occur could be through use of rapidly-deployable spray membrane supports, commonly designated as thin, spray-on linings (TSL's) or polymer coatings. A research effort for the Workplace Safety and Insurance Board (WSIB) has been completed by Jamie Archibald and Takis Katsabanis of Queen's Mining to specifically assess the capabilities of spray-on polymer liner materials for providing structural support and rockburst resistance in underground hard rock mines.

Large-scale crater blasts, to simulate rockbursts, were used to test the effectiveness of spray-on liner and conventional support materials for limiting rock ejection hazards during such events. A total of seventeen different support media were subjected to near-identical blasting influence in a highly homogeneous rock material to create rock damage responses typical of those which would be experienced during actual rockburst events.

Observation of rock and support damage following "bursting" was used to assess each liner's capacity to restrict rock movement and mitigate damage associated with dynamic rock failure. Typical burst conditions experienced by conventional and spray-on liner support materials are shown in the following figures.



The results obtained have confirmed that new spray-on linings can provide equivalent or substantially better rock support and damage resistance than conventional supports, such as bolts or bolts-and-mesh. The entire range of polymer lining types evaluated showed capabilities to deform substantially, undergo minimal layer damage, and to significantly constrain fragment or loose rock ejection created by energetic rock breakage as generated by rockburst simulation. In so doing, these tenaciously-adhering, deformable cover materials therefore demonstrated potential for substantially mitigating damage often seen to result when catastrophic unsupported rock failure occurs. This research will be continued, and eventual application of TSL supports for future deep mining activity in ultra-high stress environments may be realized.

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Editor's Note: Jamie Archibald and Takis Katsabanis are two of our GeoEngineering members from the Mining Deparment. They are actively researching in a number of areas conducting fieldwork at two test sites near Kingston

Development of the Geotechnical In-Situ Technology Network (GIST) for the Management of Geohazards

By Jean Hutchinson

Figure 1: Ground movement associated with: 1) mine subsidence, and 2) mine pit wall instability.

Funding has recently been awarded to a multi-university, cross-province research team to develop an intelligent GIS based decision support system for analysis of ground surface instability. The team comprises R. Harrap of the Queen's University GIS Lab, J. Hutchinson and M. Diederichs, Department of Geological Sciences and Geological Engineering at Queen's University and GeoEngineering Centre Members, P. Graniero from the University of Windsor and D. Martin from the University of Alberta, as well as a number of graduate students from each department. Two years of research funding, supported by BC Hydro and NRCan, was awarded by GEOIDE[1] (**Geo**matics for **I**nformed **De**cisions), a federally funded Networked Centre of Excellence, in partnership with CCRS[2] (Canadian Centre for Remote Sensing). Funding for the initial concept study by Hutchinson and Harrap on networked geotechnical sensors was provided in 2002 by CRESTech and CCRS.

Ground instability, induced both by natural and human processes, occurs regularly, in the form of landslides and ground surface subsidence (Figure 1). In some cases, where impending failure is anticipated and where the consequence of failure is not tolerable, geotechnical monitoring is used to gain some understanding of the processes involved, to assess the expected rate of movement and to provide early warning of important changes in the state of stability. Both in situ sensors and/or remote sensors may be used in the data collection exercise. The data may be collected, reduced and presented using software supplied with automated data acquisition systems or with customized spreadsheet or database programs.

Increasingly Geographic Information System (or GIS) software is being used to compile and display such data. However, little work has been done to-date on using spatial analysis and visualization tools in

[1] http://www.geoide.ulaval.ca
[2] http://www.ccrs.nrcan.gc.ca/

GIS as a platform for sensor data fusion and intelligent analysis.

The Geotechnical In-Situ Sensor Network (GIST) project combines sensor network monitoring tools with intelligent systems technology to embody geotechnical, physical, and geospatial rules, and to feed results to a GIS-based Decision Support System interface (Figure 2). The Decision Support System interface provides spatial analytical tools for operator-driven use as well as an interface for rule-based programming, built on commercial off-the-shelf GIS technology. A supporting data library and archive interface provides access to historical data archives, supporting documentation and operator training materials. Development of the rules within the Decision Support System is based upon analysis of the ground instability using numerical modeling tools, calibrated to site conditions derived from site investigation and monitoring approaches.

Rules expressed in GIST combine multiple sensors into abstract clusters, perform automated spatial analysis for pattern detection, and monitor overall system performance to guarantee near-real-time response. Second order rules provide the ability for the system to postulate new rules, to perform exploratory spatial analysis to judge rule relevance, and to link to numerical modeling codes. Reliance on extensive case-study libraries of ground instability and data archives provides opportunities for machine-learning techniques to be applied towards the generation of potentially novel rules.

GIST thus provides a framework for testing sensor array configurations, new sensor analysis paradigms, automated rule generation, and linkages between numerical modeling and GIS approaches to geotechnical monitoring.

For further information about the GIST project please contact Jean Hutchinson (jhutchin@geol.queensu.ca).

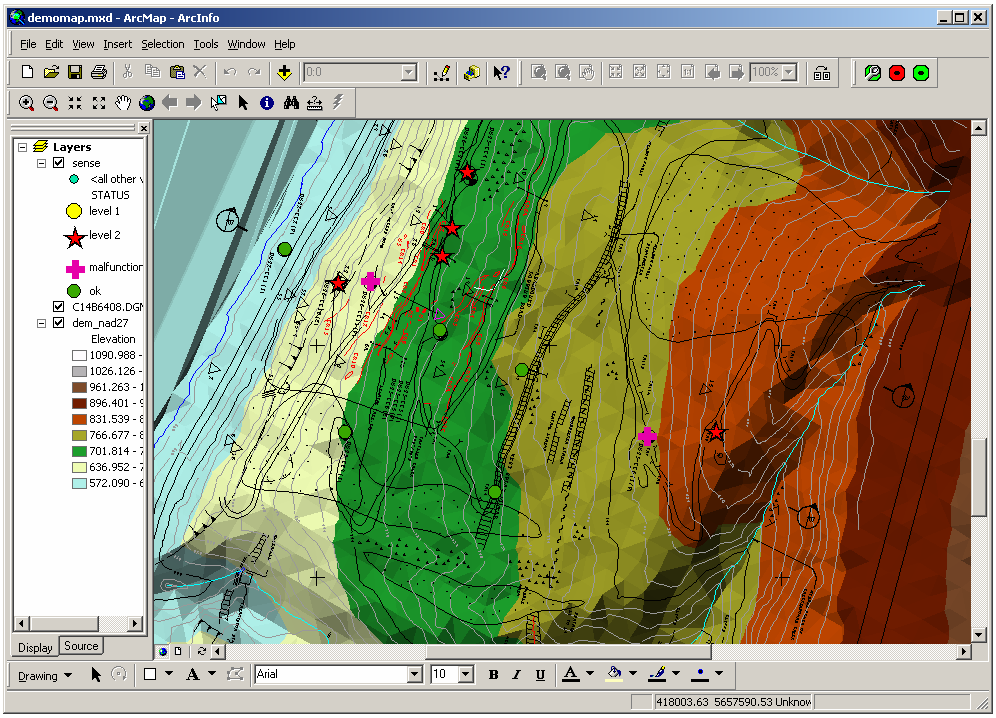

Figure 2: ArcGIS display of CLIPS results for GIST software (under development). Alert levels for different geotechnical instruments, based on time series analysis of the network of geotechnical data, are shown.

26th Annual OGG Student Forum

By Graeme D. Skinner

March 4 marked the date of the 26th Annual Student Forum presented by the Ottawa Geotechnical Group, a chapter of the Canadian Geotechnical Society. This annual forum gives graduate students an opportunity to discuss their research work, and to better acquaint the local engineering community with the research activities currently being undertaken by the universities. The forum audience typically consists of members of the geotechnical, hydrogeological and geoenvironmental communities from consulting firms, academic institutions, government and industry.

This year the event was hosted in Kingston by Queen's University and the GeoEngineering Centre at Queen's – RMC, and numerous members of the GeoEngineering community from Ottawa, Kingston, and the surrounding areas braved the less then ideal weather to attend the event. The day began in the afternoon with technical tours of the facilities at RMC and Queen's, including the impressive wall and pipe testing facilities of Drs. Bathurst and Moore, and the geoenvironmental and geosynthetic testing facilities of Drs. Rowe and Raymond. The tours finished with a wine and cheese reception, giving everyone a chance to meet new and old friends, catch up on news, and socialize.

The student forum followed the reception, and the first presentation was given by Karina Lange from Carlton University who discussed the physical and numerical modelling of fractured rock surrounding tailings facilities. This was followed by Patrick Brisson from the University of Ottawa who talked about determining the partially saturated flow of mine tailings, and Simon Leung from the Royal Military College of Canada (Kingston) who discussed reduced-scale modelling of geosynthetic-reinforced soil walls. Finally, Michael Law presented his work at Queen's on the design of flexible liners to repair damaged gravity flow sewers.

All of the presenters are congratulated on the high quality of their presentations, and the interesting questions and answers generated from the audience. After a short discussion, the judges awarded the small cash prize and nomination for financial support to attend the Annual CGS Conference to Michael Law. Congratulations to Mike on a job well done and on his upcoming appointment to Mueser Rutledge Consulting Engineers in New York City.

Michael Law

Finally, thanks to all the people who made the event run smoothly and successfully, including the OGG, the tour and student presenters, and the support staff at Queen's and the GEC.

Editor's Note: Dr. Graeme Skinner is an Assistant Professor in the Department of Civil Engineering, appointed for a two year period using funds from the Canada Council of the Arts.

56th Annual Canadian Geotechnical Conference, Winnipeg

Both faculty members and students associated with the GeoEngineering Centre were active participants at this year's annual CGS conference in September/October, and a number of individuals and student teams received awards and other recognition at the conference.

A team of undergraduate students from Queen's supervised by **Dr Kent Novakowski** won the prize for the best Canadian undergraduate team-based report for 2003 (this award was provided by the Canadian Foundation for Geotechnique). Lauren MacKay, Bronwen Smith, Michael West, Anna Westlund and Grace Yungwirth conducted a feasibility study for phytoremediation of a contaminated site. They completed an extensive literature review, conducted field-testing and performed numerical analysis as part of this yearlong Design Project (Grace and Mike are now undertaking graduate studies in the Centre).

(Grace Yungwirth and Michael West)

This year's graduate student prize was won by **Jamie van Gulck**, who completed his PhD under the supervision of Dr Kerry Rowe in mid-September. Jamie presented his paper as part of the plenary session on Wednesday morning.

The Mercer Lecture of the North American Geosynthetics Society, a keynote address presented at their conference was delivered by **Dr Richard Bathurst** (this year NAGS held their conference in association with the Canadian Geotechnical Society annual conference). Dr Bathurst summarized research work conducted over the past decade in his unique retaining-wall test facility at RMC, and described the substantial design improvements that have resulted for Geosynthetic reinforced retaining walls. Dr Bathurst was also awarded the A.G. Stermac award for service to the Society.

Members of the GeoEngineering Centre participated in 12 papers presented in the conference, and one short course. **Dr Toshifumi Mukunoki** and his 7 co-authors were runners up this year for the best paper award in the NAGS award of Excellence program.

The CGS Colloquium Address (a keynote lecture delivered by a younger member ofthe society) was presented this year by **Dr Mark Diederichs**. Dr Diederichs presented material describing recent developments to improve our understanding of rock failure, work that is already permitting mining engineers to greatly improve the stability of complex mine workings.

Dr Jean Hutchinson's contributions to rock mechanics were honoured with the John A. Franklin Award of the Rock Mechanics Division of the CGS. In particular, this award was given in recognition of her recent work in mine reclamation, ground subsidence, and her highly successful book on rock bolt design (co-authored by Mark Diederichs), used internationally by mining engineers.

Finally, the R.F. Legget medal was awarded to **Dr Kerry Rowe** at the annual awards luncheon. This is the highest honour of the society, and is reserved for individuals who have made truly outstanding contributions to Canadian Geotechnique.