GeoEngineering Centre at Queen's - RMC

Newsletter

Fall 2004

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The year in review, Executive Director, GeoEngineering Centre at Queen's – RMC

By Ian Moore

In last year's newsletter, I introduced our vision for the Centre "*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, our second annual newsletter, provides an update on our efforts to realize this vision, including the addition of important new human and physical resources, initiation of new research projects, and our interactions with GeoEngineering and other researchers and practitioners around the globe.

It is my great pleasure to welcome our newest Research Director, Dr. Andy Take, who joined the Department of Civil Engineering at Queen's in August 2004. Andy comes to us from New Brunswick via Cambridge University. His expertise in weather-induced ground movements and slope stability, together with his new optically-based techniques for assessing ground deformations will nicely complement our existing capabilities. More details of Andy's background and experience are provided later in the newsletter.

During the past year we also appointed three Associate Research Directors: Dr Graeme Skinner, Dr. Kianoosh Hatami and Dr. 'Toshi' Mukunoki, as well as Dr. Ken Reimer of the Chemistry Department at RMC, Drs. Alison Rutter and John Poland of the Analytical Services Unit as Associate Members. Graeme and Kianoosh have since completed their work in Kingston and have moved on to new positions in industry and academia. Their contributions have been excellent, and we wish them outstanding success in their chosen careers.

Some of our graduate students and faculty

I would like to congratulate here all those Centre members who have received recognition for excellence in research, practice and education during the past year. The pinnacle, of course, is the award to Kerry Rowe of the Killam Prize by the Canada Council of the Arts, and his invitation to present the 2005 Rankine Lecture by the British Geotechnical Society. Kerry has been zealous to acknowledge the support and assistance from his many colleagues and students at Queen's, Western and elsewhere over the years. Indeed, we all benefit greatly from working with our many partners in academia and industry. I am sure the people associated with the centre will continue to strengthen those links during the coming year by maintaining and extending our relationships across North America and beyond.

Our Collaborative Graduate Program in GeoEngineering is entering its third year, and we are welcoming a new batch of graduate students, as our latest group of GeoEngineering MSc and PhD graduates are moving on to take up positions in industry and academia. At the completion of the 2003-2004 academic year, 21 doctoral and 45 masters students were working with centre members on projects in GeoEngineering and Applied Geo Science. I have had a number of invitations over the past twelve months to act as a Masters or Doctoral examiner, and have been pleased by this opportunity to study the work of my colleagues in detail, to see their excellent students in action, and to appreciate the new contributions to knowledge and practice arising from the hard work of bright, motivated people. Visits by an array of GeoEngineers and GeoScientists to support our GeoEngineering Seminar series have contributed to giving these outstanding young women and men an appreciation of the breadth of GeoEngineering endeavour, and how the art and science of GeoEngineering is advancing.

A highlight for me this year was the completion of the new Large Scale Buried Infrastructure Test Laboratory funded by the Canada Foundation for Innovation and the Ontario Innovation Trust. Indeed, we are moving into that facility during the week that I write this report. This newsletter also celebrates other commitments for new research infrastructure made to our GeoEngineering team by CFI-OIT and NSERC. These investments are helping us build the world-class research infrastructure that will provide our graduate students and postdocs with the best facilities available, and permit them to make truly outstanding contributions to GeoEngineering scholarship and practice.

I express here my appreciation of all those individuals who have actively supported the activities of our centre over the past twelve months. By working with us in research partnerships, assisting us to obtain grant and contract income, making contributions to our GeoEngineering Seminar series, investing in our graduate students, and interacting in other ways with our members, you are enabling us to achieve much more than we could alone. I also acknowledge here the excellent support of our administrative secretary, Ms Jolanda de Groot, in particular her assistance to me with management of our graduate program, our GeoEngineering Seminar Series, and our many other activities.

Please contact myself, Jolanda, or any of our members, if you would like to initiate interactions with our centre. Our website www.geoeng.ca can be consulted to obtain much more detail regarding specific people and projects.

Ian Moore
Executive Director, GeoEngineering Centre at Queen's – RMC
September 2004

Introduction of Dr. Andy Take

Dr. Andrew Take

The growth of the GeoEngineering Centre at Queens – RMC continues with the recent appointment of Dr. Andy Take as a new Assistant Professor in the Department of Civil Engineering at Queen's University. Dr Take joins the Centre from Cambridge University, where he undertook his PhD research and was later elected into a prestigious Churchill College Research Fellowship in 2002.

Since 1998, Dr. Take's primary research interests have been in the major themes of seasonally-driven progressive failure of slopes, triggering of fast landslides, long-term degradation of dams, and the development of new technology for experimental research. In particular, Dr. Take has developed new techniques for the reliable measurement of high matric suctions in unsaturated soils, control of the atmospheric boundary condition in physical models, and the optical measurement of deformations in soils based on remote digital imaging, particle image velocimetry (PIV), and close-range photogrammetry. This latter technique was developed in collaboration with Dr D.J. White (also at Cambridge) and is currently being used in collaborative research projects at research centres across five continents.

When combined, these novel technologies have allowed for the first time experimental evidence to be gathered documenting the seasonally driven progressive failure of clay slopes. Seasons of wet and dry weather, created in an atmospheric chamber flying on Cambridge's 10m beam centrifuge, subjected the slope to evaporation, the development of matric suctions and shrinkage (Figure 1a), followed by infiltration and swelling during the wet season (Figure 1b). Back analyses of the seasonal mobilisation of strength coupled with the precise record of observed pre-failure deformations has provided an excellent commentary on the enduring controversy regarding the strength parameters appropriate for the design of infrastructure slopes against first-time slides and excessive irrecoverable seasonal deformations.

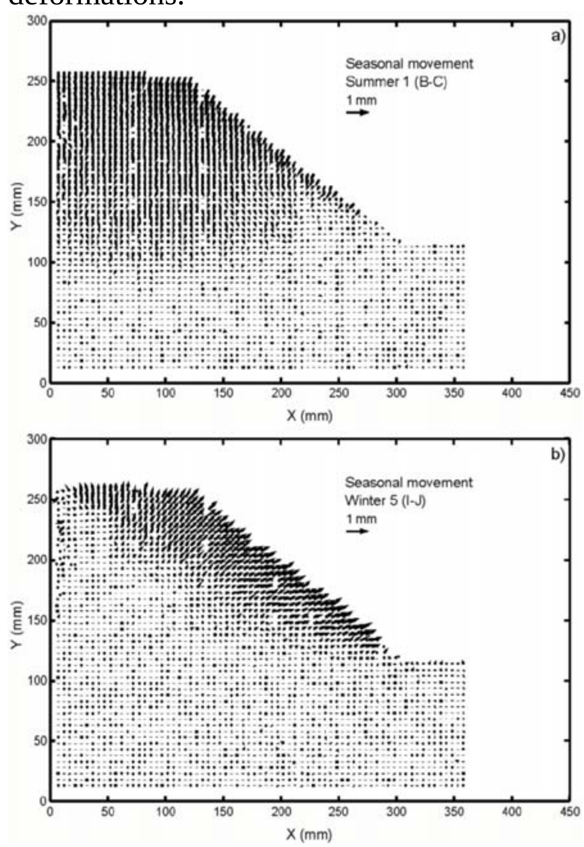


Figure 1. a) Observed vectors of summer shrinkage and b) predominantly upwards winter swelling leading to irrecoverable slope deformations and progressive failure

Our New Large-Scale Geotechnical Testing Laboratory

By Richard Brachman

Construction is now complete of Queen's new Large-Scale Geotechnical Laboratory. The principal feature of this facility is an 8 m wide, 16 m long and 3 m deep test pit to permit full-scale testing of buried structures by Drs Moore, Brachman, Rowe and their research teams.

The test pit was designed to permit real construction practices to better reproduce expected field conditions – all within the confines of controlled experimental conditions. The static response can be studied by driving real loaded vehicles over the test pit, or testing to ultimate limit state can be conducted with a 2000 kN actuator. The new laboratory will also house specialized pressure vessels used to simulate large earth pressure loading of buried structures and geosynthetic liner systems.

Funding for the new facility and research equipment was provided by the Canadian Foundation for Innovation, the Ontario Innovation Trust, and the Natural Sciences and Engineering Research Council of Canada.




Geosynthetics Under Extreme Conditions

By Richard Brachman

Drs Rowe, Moore, Bathurst and Brachman were recently awarded funding of $1.65 Million to develop new laboratory facilities to permit research on the performance of geosynthetic materials (e.g., geomembranes, geotextiles, geogrids and polymer pipes).

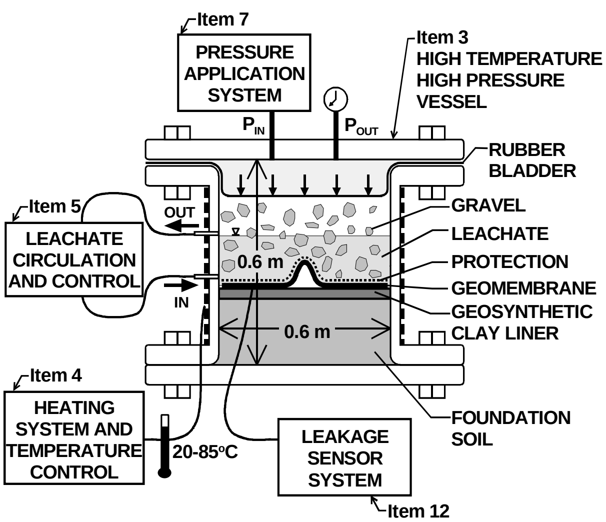


Illustration of a Geosynthetic Liner Longevity Simulator to examine performance of landfill liner systems.

Three new laboratories will be developed: (1) A High-Capacity Shaking Table to examine the behaviour and performance of geosynthetics during earthquakes, (2) Specially designed Geosynthetic Liner Longevity Simulators to conduct accelerated ageing tests on geosynthetic landfill components in extreme chemical and loading conditions, and (3) Large-Scale Polymer Pipe testing equipment (high-temperature baths with water pressure-controllers and load frames) to examine long-term strength of many different polymer pipes. This new equipment permits large-scale simulations of field conditions (rather than simplified laboratory conditions), not previously possible, greatly improving understanding and performance of geosynthetics engineering.

The proposed design guidelines resulting from the research will provide improved design and construction methods to: ensure long-term performance of geosynthetic "protection" layers in landfill liners to prevent escape of contaminants from landfills; provide long-term strength for new and replacement polymer pipes in municipal sewers, and water and gas supply lines (minimizing future sewer and road reconstruction costs); and improve performance of earth retaining structures, water, gas and sewer pipes and landfills during earthquakes.

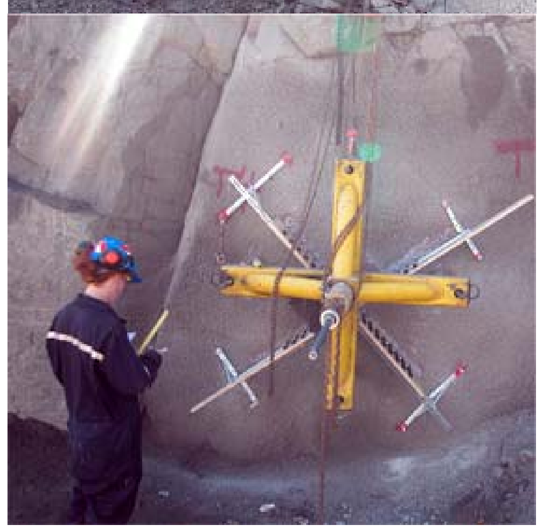
Funding for the new facility and research equipment was provided by the Canadian Foundation for Innovation and the Ontario Innovation Trust.

CURRENT RESEARCH
Mechanics of Shotcrete for Rock Support
By Mark Diederichs

Field scale pull tests of in situ shotcrete on rock substrate have been used recently by mining companies, such as INCO Ltd., for comparison of mix designs and for quality control purposes. While of great value for these applications, these tests do not offer a direct opportunity to extract key structural or rock-support interaction parameters for application in excavation support design. The boundary conditions in the test differ from those encountered in actual situations of shotcrete support for failing rock.

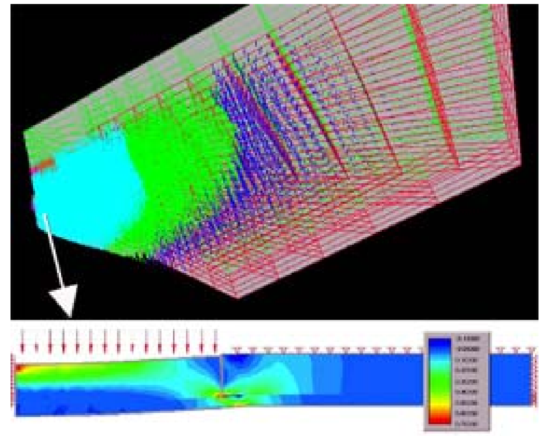
Masters student Cathy Banton, under the supervision of Drs. Mark Diederichs and D. Jean Hutchinson of the GeoEngineering Centre, is currently completing her research related to the mechanics of these tests. With financial support from INCO Ltd. and NSERC through the IPS program, Cathy has carried out a number of large scale pull tests (see photos) in the field and is currently using a system of 2D and 3D non-linear models (constructed using UDEC, 3DEC) to simulate the pull test and other standard tests (ASTM flexure etc).

These integrated simulations will serve as tools to relate the complex behavioural result of a field pull test to the critical design parameters such as adhesion, stiffness, peak and residual shear and tensile strength and the rate of strain weakening after cracking.



The latter property is critical for assessing fibre-reinforced shotcrete, currently the industry standard.

This important work will provide useful tools, for the mining and underground construction industry, to relate these important field tests to design parameters which can then be used for new and untested excavation geometries, support combinations (including boltless shotcrete) and cure times (early application and service).



Big Tunnels through Hard and Soft Rock

By Mark Diederichs

Navigable ground space is at a premium in populated European countries and this presents a tremendous challenge for the development and updating of transportation infrastructure. In addition, topography and environmental concerns impose practical limits on the extension and upgrade of above-ground motorways and railway corridors. Tunnelling, therefore, has become one of the most impressive growth industries in the European Union with annual contracts well exceeding $10 Billion/year.

Queen's University GeoEngineering Centre PhD students Marlène Villeneuve and Nicholas Vlachopoulos are currently involved in research to improve tunneling performance predictions based on geological factors and consideration of near-face geomechanical processes. These students are both involved in a combination of numerical experimentation and field-based research. While the former common component of the two research projects is facilitated by the new Computational Geomechanics Laboratory based in Miller Hall at Queen's University, the latter places them in a number of the most significant tunneling projects in Europe, working closely with industrial collaborators on-site.

Co-supervised by Dr. Mark Diederichs of the GeoEngineering Centre , and Peter Kaiser of MIRARCO, Laurentian University (www.mirarco.org), Ms. Villeneuve carries out her research field work in Switzerland, focusing on engineering and geological factors affecting rock behaviour and tunneling efficiency associated with what will be the longest and deepest tunnel ever constructed, the 57km long, twin 10m diameter tube, Gotthard Base Tunnel. This tunnel, which will have a variable cover at times exceeding 2.5km depth, will be a high speed rail link from one side of the Swiss alps to the other. Marlène has also collected research data at the 35 km Lotchberg tunnel site, also a deep base tunnel under the Alps to the west.

This work is funded by Herrenknecht AG of Germany through MIRARCO and is also supported by NSERC as well as by in-kind contributions from a number of contractors and on-site individuals. This research promises to yield valuable tools for performance prediction in deep, hard rock tunnels.




Mr. Vlachopoulos, also supervised by Dr. Mark Diederichs, is in the process of data collection and geological surveying related to several of the longer tunnels associated with the Egnatia Project in northern Greece. This project is a 700+ km highway with 90km+ of single tube tunnels (10 to 12m equivalent diameter) though very weak rock masses near surface and up to 500m depth. His research will focus on several of the longer tunnels in the Pindos Mountains and is aimed at formulating equivalent material constitutive relationships for mixed rock-soil materials encountered in neo-tectonic regions such as northern Greece. In addition, he will investigate the performance of face and near-face reinforcement systems and provide more rational guidelines for design analysis and optimization of these components. This project is supported by NSERC and PREA, with inkind support from Egnatia and the Canadian Armed Forces. The project is proceeding in collaboration with Dr. Paul Marinos and graduate students at the University of Athens.

More pictures on next page

The Potential for Geochemical and Microbial Remobilization of Arsenic from Sediments in Yellowknife Bay, Great Slave Lake

By Heather Jamieson

Dr. Heather Jamieson has received approximately $170,000 from Indian and Northern Affairs Canada (INAC) to investigate the potential for remobilization of arsenic from sediments in Yellowknife Bay. This will form the basis of the MSc thesis of Claudio Andrade and builds on the PhD thesis on characterization and long-term stability of arsenic-bearing phases in mine tailings from Yellowknife conducted by Stephen Walker.

Diver preparing to install sampling equipment.

Over sixty years of gold mining in the Yellowknife area has left a complex environmental legacy that is now a public liability. Arsenic-bearing sulfide minerals are closely associated with the gold ore. Mining and processing have released arsenic to the surrounding soils and lake sediments, much of it in the form of arsenic-bearing oxides produced in the roasting processes. Yellowknife Bay, which is the part of Great Slave Lake on which the City of Yellowknife is located, received mine waste in the form of direct disposal of tailings on the shoreline during the early history of the mine, as well as later accidental and intentional releases. Sediments in the area that are most impacted by mine tailings contain 1000 to 3000 ppm As, much higher than the CCME criteria of 5.9 ppm.

Claudio Andrade collecting core samples.

Although the arsenic concentration in the surface lake water generally meet water quality criteria, the fact that much of the arsenic-bearing solids in the sediments are in the form of iron oxides has raised the possibility that these materials will become unstable in the oxygen-deficient bottom sediments and dissolve, releasing arsenic to the overlying waters. Arsenic cycling in the sediment-water environment often involves microbial processes.

Collaboration with Drs. Danielle Fortin and Tanmay Praharaj of the University of Ottawa has provided the opportunity to incorporate their expertise in geomicrobiology to the project.

Claudio Andrade and Tanmay Praharaj collecting core samples

The geochemical controls on the release of arsenic from sediments, soils and industrial waste to surface and ground water and the resulting effects on human and ecosystem health has received an enormous amount of attention recently. The results of this research conducted at Queen's will further our understanding of whether arsenic-bearing industrial waste dispersed in the environment is an environmental risk. It will also contribute to INAC's participation in the federal Environmental Effects Monitoring program, designed to determine if effluents are causing effects on ecosystems.

Claudio Andrade and Heather Jamieson on Yellowknife Bay.

Limit States Design of Thermoplastic Culverts

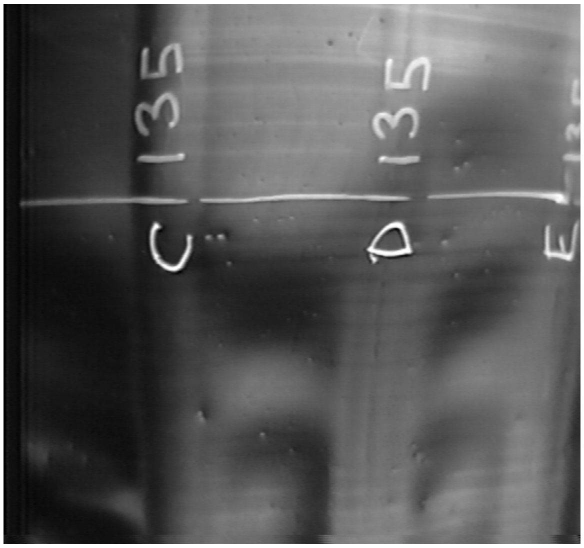
Principal Investigators:	Ian Moore, *GeoEngineering Centre at Queen's – RMC,* Tim McGrath, *Simpson, Gumpertz and Heger, Boston MA*
Co-Investigators:	Richard Brachman, *GeoEngineering Centre at Queen's – RMC* Grace Hsuan, *Drexel University, PA*

Sponsor:	US Departments of Transportation through the National Collaborative Highway Research Program (pipe samples also provided by Advanced Drainage Systems, Big 'O', Contech Construction Products, Hancor, & KWH Pipe)

Buried thermoplastic pipes rely heavily on support provided by surrounding backfill in resisting the loads brought to them by that same backfill material (see illustration). A five year research project is nearing completion during which time new stability limits have been identified for profiled polyethylene and PVC pipe products, and new design equations and design procedures have been developed to capture those limit states. The final goal of the project is the new set of design material drafted for incorporation into the Highway Bridge Design Standards of the American Association of State Highway and Transportation Officials (AASHTO).

Profiled HDPE pipe being installed near Chatham, Ontario

During the project, testing has been conducted to induce three-dimensional response in these profile wall structures. Computer analysis of local bending and new computational techniques to estimate the onset of local buckling have modelled behaviour observed during pipe tests conducted in the hoop compression and biaxial buried pipe test cells by students Trudy Laidlaw (MESc, 1999), Michael Tait (BESc, 1998), and Ashutosh Dhar (PhD, 2002). These include loading to induce local buckling in both the smooth inner wall of the pipes and the corrugation elements (see illustrations). A series of tests by current MSc student Scott Munro has just been completed, to study how poor, variable stiffness backfill support under the bottom half of the pipe may enhance local bending strains in the pipe wall.



Local buckling induced at the Springline of a profiled HDPE pipe under high simulated overburden pressures.

The tests have also demonstrated how positive arching associated with compressive hoop strains can reduce the magnitude of the earth pressures reaching the pipe, and have demonstrated the performance of a new equation for estimating pipe deflection that incorporates the effects of these hoop strains, Dhar et al. (2004) *(Details of this and other recent publications can be found elsewhere in the newsletter).* The AASHTO standard will incorporate Moore's 'elastic continuum' based flexible pipe buckling theory that has been previously incorporated into other North American and International buried pipe design codes, as well as new HDPE performance limits developed by Dr. McGrath in collaboration with Dr. Grace Hsuan of Drexel University.

Pipe being installed in the biaxial pipe test cell at Queen's University

Recent Graduates

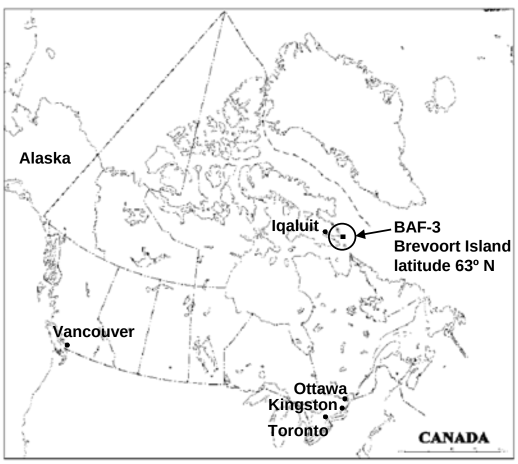
The following GeoEngineers associated with the Centre have recently completed their training, and have moved on to the next phase of their career.

- Matt Kennedy, MSc
  Golder Associates, Burnaby BC
- Brian Lapos, MSc
  Golder Associates, Mississauga ON
- Dr. Graeme Skinner
  Golder Associates, Calgary AB
- Michael Law, PhD
  Mueser Rutledge Consulting Engineers, NY
- Neil Kjelland, MSc Eng
  AMEC, Edmonton AB
- Tatsu Iryo, PhD
  SNC Lavalin, Toronto

Installation and Monitoring of a Geocomposite Barrier System at an Arctic DEW-line site

By Richard J. Bathurst and R. Kerry Rowe

The research activities of the GeoEngineering Centre now extend to the Arctic. Drs Bathurst, Rowe and Reimer were contacted by the Department of National Defence (DND) to design a short-term solution to stop subsurface hydrocarbon migration into the ocean at a remote DEW-line site on Brevoort Island in the Canadian eastern Arctic due to a series of fuel spills. A successful plan would then allow time to devise a permanent remediation scheme.

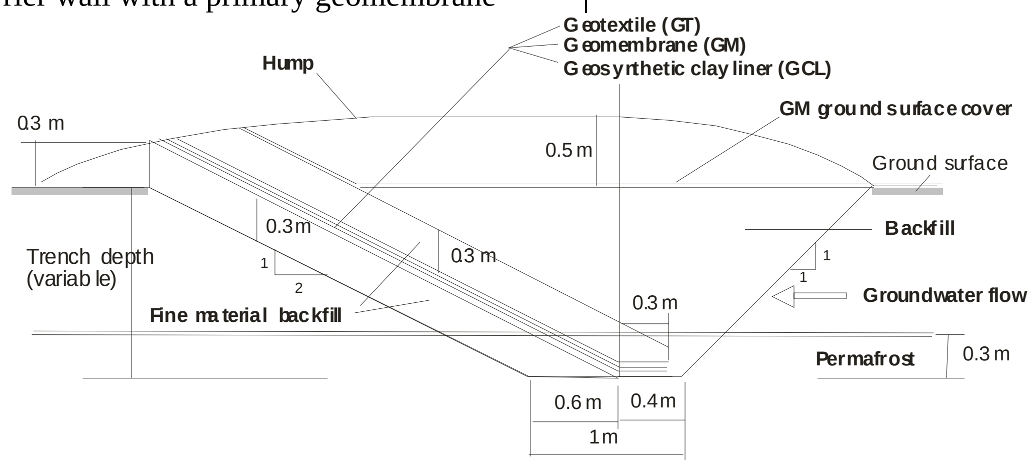


Location of Brevoort Island site

A geosynthetics solution was selected based on a geosynthetic composite barrier wall with a primary geomembrane liner and a secondary geosynthetic clay liner (GCL) as the key components. The DND request was made in January of 2001 and the writers designed the barrier, supervised its installation and instrumented the system all by the end of August 2001!

This installation is the first of its type in an Arctic environment. Furthermore, this application is the first extensive use of a special fluorinated HDPE geomembrane as a primary barrier to hydrocarbons. In order to monitor subsurface performance of the barrier system, 6 piezometers and 16 thermocouples were installed at the site and the instrumentation readings are being recorded continuously by a solar powered data logger.

Another unique aspect of the on-going project has been the exhumation of geomembrane and GCL coupons to assess the durability of these materials under extreme environmental conditions created by the combination of freeze-thaw cycles and contact with hydrocarbon contaminated groundwater.

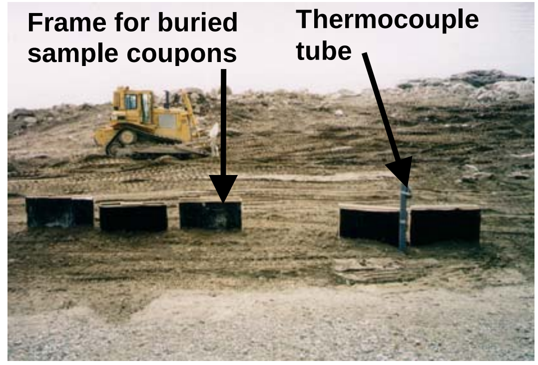


Cross-section of geosynthetic barrier system

Installation of barrier system in 2001

A wider parallel laboratory investigation is underway in the Civil Engineering Department at Queen's, which is focused on quantifying the changes in mechanical and hydraulic properties of GCLs and a wide range of geomembrane products using accelerated testing simulating many years of exposure to northern conditions.

The laboratory tests examine diffusion and sorption characteristics of BTEX compounds (the lighter and more mobile components of the diesel fuel contaminant at the Brevoort site) with time as they migrate through GCL specimens. Specialized permeameter equipment has also been developed to investigate changes in permeability of GCL specimens with respect to water and fuel under a range of confining pressures and in combination with freeze-thaw cycles. The performance of non-fluorinated and fluorinated HDPE geomembranes with respect to hydrocarbon diffusion is also underway, again subject to extremes of temperature and freeze-thaw.



Burial of geosynthetic coupons and installation of thermocouples in 2001

On site during coupon retrieval summer 2004 (bear monitor at left)

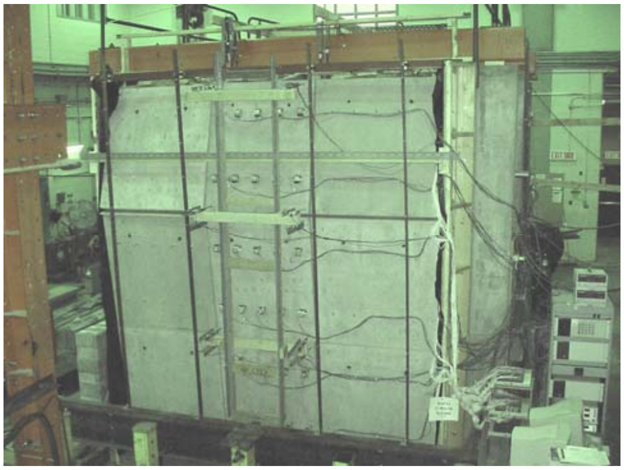
Queen's-RMC team summer 2002

While the work has been focussed on the particular application at the Brevoort site, the findings have much broader application to the containment of similar fuel spills at other DND radar sites in the Arctic and, indeed, to the performance of geosynthetic containment systems installed around fuel tanks and fuel lines at more temperate locations.

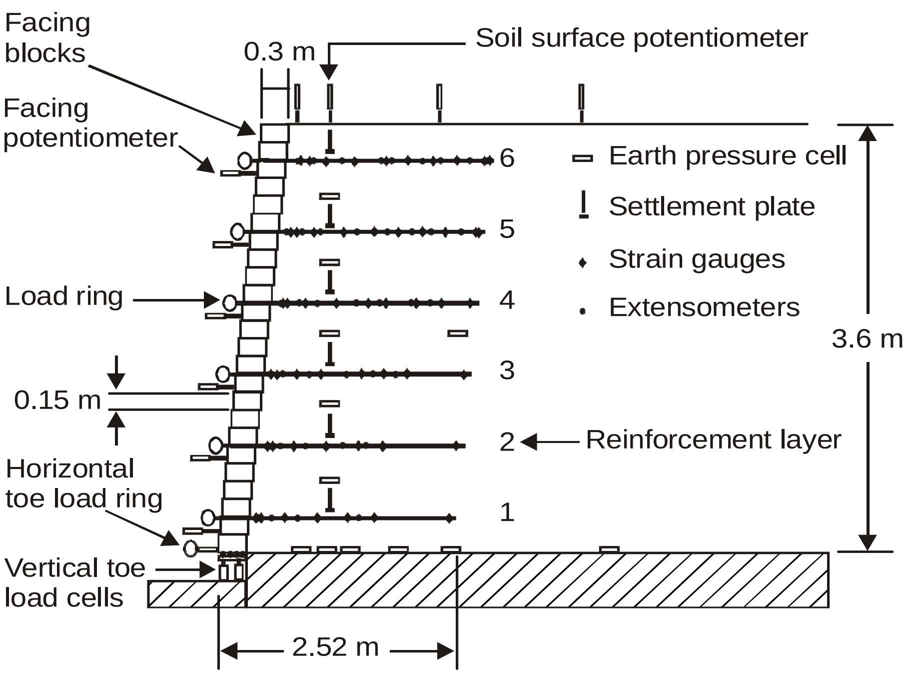
Taking Reinforced Soil Walls to the Limit

By Richard J. Bathurst

The GeoEngineering Centre has a full-scale retaining wall test facility located at RMC which is unique in the world. The facility is being used to construct reinforced soil walls with both geosynthetic and metallic reinforcement materials at prototype scale. The walls are 3.6 m high, 3.2 m wide and retain soil extending to 5.5 m behind the facing. Each wall is heavily instrumented with more than 300 channels of data acquisition. The structures are monitored during construction and under uniform surcharge loading to failure using a system of airbags that can apply pressures up to 130 kPa. The current investigation involves the construction and testing of a series of 11 walls in which one key component is varied (i.e. soil reinforcement type, number of layers, facing type and wall facing batter).



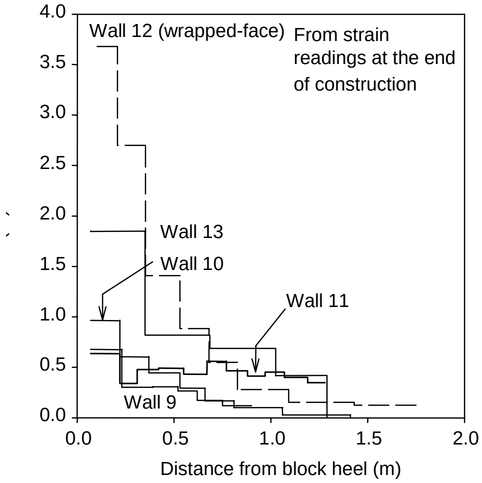
Concrete panel wall at collapse under uniform surcharge loading



Cross-section of modular block wall showing instrumentation

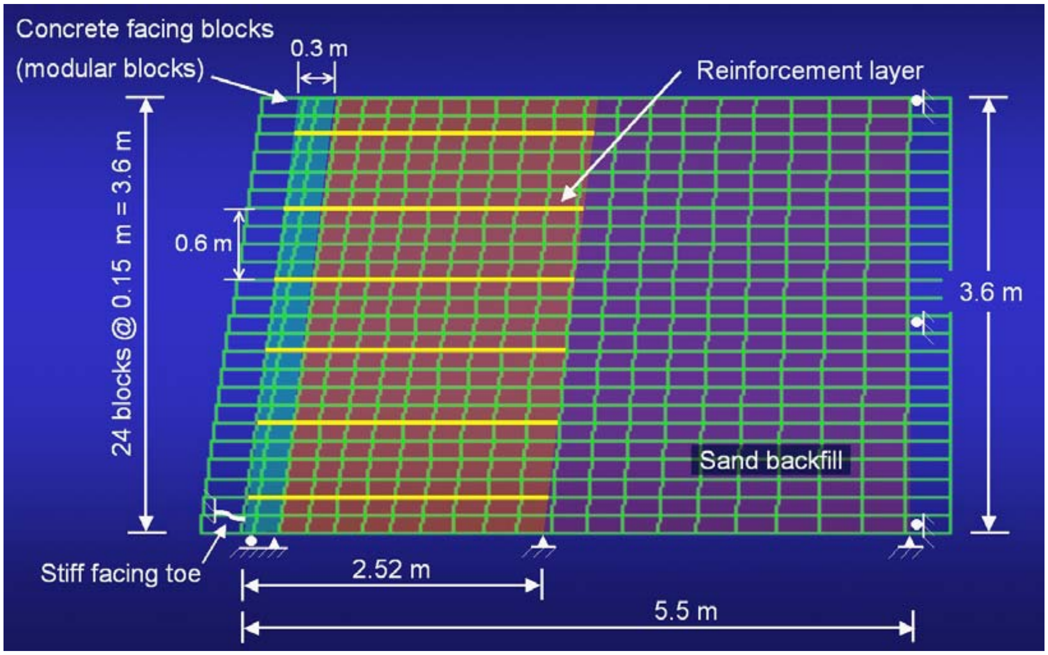
This strategy allows the contribution of each component to wall performance to be isolated and quantified. A graduate student has been responsible for the experimental design, supervision of research technicians and the reduction of data for each wall in this test series. Renald Nelson is the current graduate student working on this project.

The work is being used to validate a new working stress design method developed by the writer and co-workers to be adopted by AASHTO in the USA for reinforced soil walls. In addition, the high quality data is being used to validate numerical codes that can then be used to extend the database of physical test results. Two field walls are currently being monitored in Washington State as part of a collaborative research project with the GeoEngineering Centre to further examine the new design method developed by the team in Kingston.



Distribution of strains in reinforced soil walls with different reinforcement types and facings

Funding for this ongoing work is provided by 12 different US State Departments of Transportation, the Ministry of Transportation of Ontario, NSERC, the Department of National Defence and industry.



FLAC numerical grid for geosynthetic reinforced soil wall

Hydrocarbon and PCB Remediation in the Canadian Arctic

By Indra Kalinovich and Krysta Paudyn

The application of geosynthetics as filters and sorbents are being investigated for use at Resolution Island, Nunavut. Resolution Island was a former military base in the Canadian Arctic, part of the Polevault Line system of radar stations that connected the Distant Early Warning (DEW) Line to southern defence headquarters in the United States.

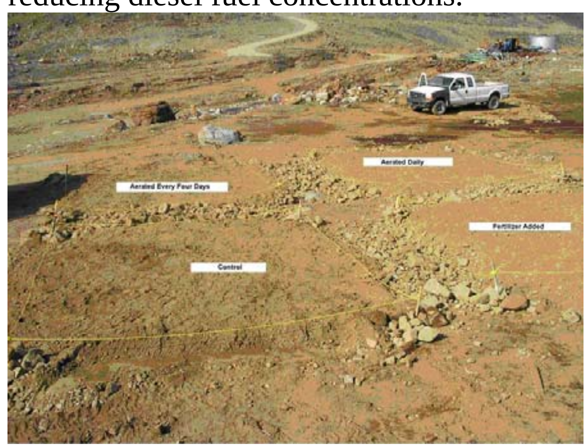
The summit station at Resolution Island, Nunavut

The base was built during the cold war, but subsequently abandoned in the 1970s. Currently there are several former military sites undergoing remediation in the Canadian Arctic. Many of the sites are contaminated with polychlorinated biphenyls (PCBs), metals and hydrocarbons. Cost effective, long-term remediation technologies, such as permeable reactive barriers (PRBs) and bioremediation, are being investigated for use at these sites.

Hydrocarbon Remediation

Hydrocarbon contamination is a considerable problem at these sites. The large size of the sites and their remote location requires that any viable, cost-effective remediation process use as little equipment as possible. Landfarming is one such solution. The term generally refers to a process where hydrocarbon contaminated soils are spread out in a layer approximately 0.5m thick, nutrients are added, and the soils are mixed periodically. During landfarming, hydrocarbons can be lost through volatilization or bioremediation and thus landfarming refers to the combination of the two processes.

Temperature plays a major role in the Canadian Arctic in determining if bioremediation will take place at a practical rate and whether aeration will be successful. Trial landfarm plots set up in 2003 have successfully demonstrated that both aeration and bioremediation have been successful in reducing diesel fuel concentrations.



Trial Landfarm Plots

Barriers with geosynthetic sorbents and granulated activated carbon were built in 2004 in a hydrocarbon contaminated drainage pathway downstream to investigate their potential for containment and the remediation of diesel fuel.

Simulations in the laboratory have been designed to mimic the field trials and to determine the relative rates of degradation of hydrocarbons under various conditions. A closed system has been designed and constructed using small bioreactor chambers, which can be rotated to simulate rototilling or the use of a harrow. Air is passed over the diesel contaminated soil in the chambers and any hydrocarbon aerated is collected on charcoal traps, thus allowing for the relative amounts of hydrocarbon lost through aeration and bioremediation to be calculated using a mass balance. Sets of aeration chambers have been operated to observe the effect of temperature, aeration rate and fertilizer application on hydrocarbon loss. Translation of these results to the field should significantly improve the efficacy of landfarming of hydrocarbons in cold climates.

Barriers to Contain PCB-Contaminated Soils

Up to 30,000 m^3 of soil, contaminated with PCBs from transformers used at the radar station, is being excavated at Resolution Island. Not all the contaminated soil can be excavated due to site conditions, therefore it is inevitable that some PCB contamination will remain on site. A funnel-and-gate-barrier system was proposed and accepted in 2002 as a long-term solution for PCB containment in the main drainage pathway at the site.

A prototype barrier system was constructed in 2003. Barrier design changes were made in the summer of 2004 after viewing the spring snowmelt runoff.

Data from the previous season indicated that the initial design was not capable of handling the unexpectedly large volume of sediment in the drainage pathway. Future optimization of ponds to slow down spring-run off, combined with the modelling of the movement of PCB-contaminated sediments within the containment ponds, will give a better understanding of how such a design can be applied to remediate PCBs in cold regions.

Also being investigated is the application of geosynthetics as filters and sorbents in the barrier system. Field data, combined with column and batch test data from the laboratory, are being used as criteria to help in refining the field design. Interface sorption kinetics are being determined for the various materials along with technical properties of geosynthetics being used. These parameters will be used as criteria to evaluate materials for the barrier system. The application of laboratory results to the on-site conditions is a critical aspect of the project, as one of the initial concerns in designing this system is how the geosynthetics will perform in the harsh Arctic conditions. Key parameters such as permittivity have been examined after material exposure to UV and freeze-thaw conditions.

The challenging weather conditions at this very remote site and its unique PCB problem have driven the research into an expanding field of remediation technologies. Moreover, the technologies developed for use at this site could readily be applied to contaminated sites in other cold regions.

This research is being supervised by Drs. Allison Rutter and John Poland (Analytical Services Unit, Queen's University) and Dr. Kerry Rowe.

Funnel and Gate Barrier under Construction, 2004 Field Season

Ground Subsidence Assessment for Canadian WWI Memorial Sites in France

By Jean Hutchinson and Mark Diederichs

Ground surface failure events have been observed in recent years at the Canadian WWI Memorial Sites located in Vimy (Figure 1) and Beaumont Hamel, France.

Figure 1: Vimy Ridge Memorial Site, France

These sites commemorate Canada's important efforts during the war, and are underlain by a network of dugouts, headquarters, and tunnels used both for troop and supply transport and for military mining purposes (Figure 2).

Figure 2 and 3: Tunnels remaining from WWI at the Vimy Ridge Memorial Site. The photos show the condition of the chalk near the ground surface (top), and at approximately 20m depth (below). Access to these tunnels was only recently re-established.

Figure 4: Ground subsidence resulting from failure of a dugout at the Beaumont Hamel Memorial Site. The parallel ridges, running across the photograph from left to right, mark the top of the trench line. This subsidence event is located in the part of the site which is fenced to prevent public access.

While limited in extent at this point, the subsidence events (Figure 4) have prompted concern for maintaining safe conditions for the 1,000,000+ visitors to the site each year. Work by Dillon Consulting Limited, for Veteran's Affairs Canada, is ongoing to locate the excavations using geophysical and intrusive approaches, and to develop a risk assessment framework for the site. Geomechanics research work by the authors includes characterising the ground conditions for soft rock (chalk) and assessing changes in the rockmass and excavation stability over the long-term. Guidelines for long-term stability for typical excavations have been developed, based on field observations of stability and the chalk and clay units (Figure 5), and on numerical simulation of the excavations (Figure 6). The objectives of further research work will include development of an optimal mapping, monitoring and numerical simulation approach to assess the stability of these excavations.

Figure 5: Condition of the rockmass exposed in a quarry, near Beaumont Hamel Memorial Site.

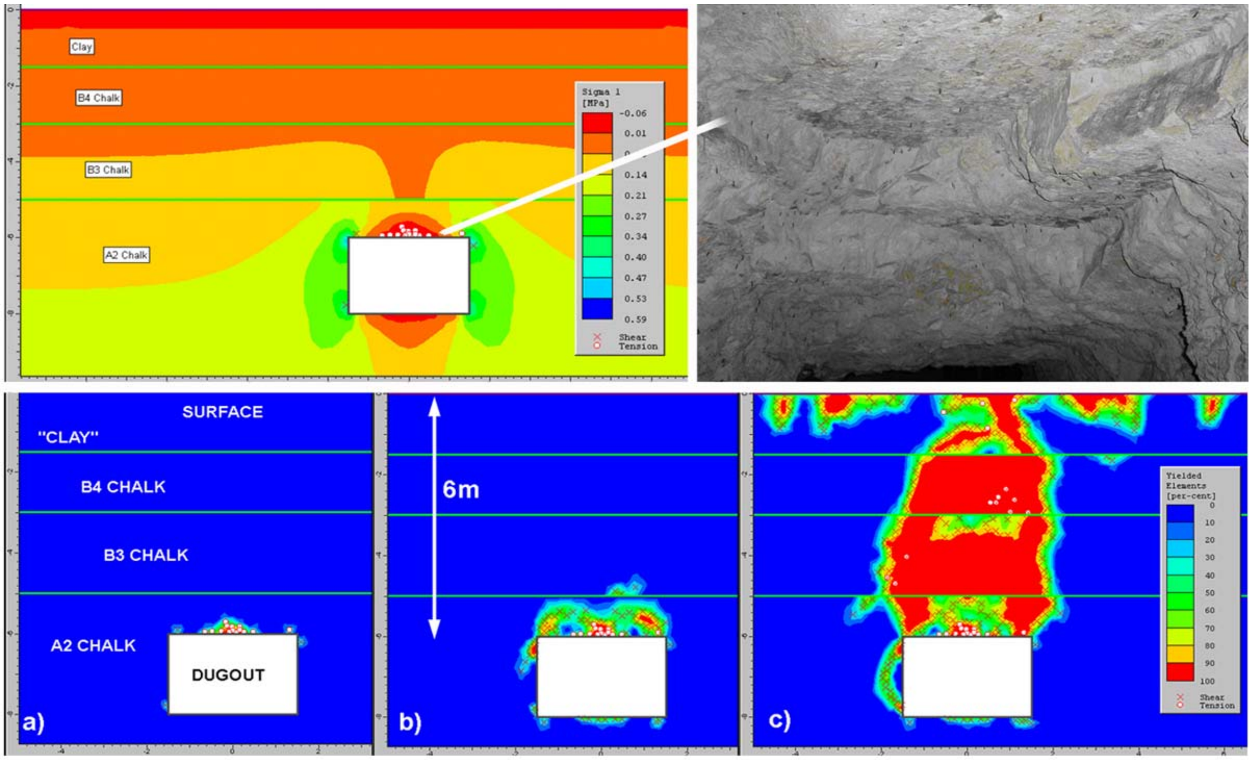


Figure 6: Stability assessment using numerical simulation tools, and generic rockmass and excavation geometry properties. Top Right: Typical model of dugout at depth immediately after excavation. Typical tensile damage (circles) in roof and mild corner crushing (shown as 'x'). This tunnel would have been observably stable with minor slabbing at this point as shown at top left. Contours illustrate perturbation of maximum stress (compression) due to the presence of the tunnel. Bottom: Analysis showing the effect of progressive degradation of the chalk due to weathering showing potential for delayed cave to surface.

Centre Sponsors, 2003 - 2004

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AWARDS

By Ian Moore

By anyone's standards, Kerry Rowe is having a good year. Awarded, for the second time, the Gold Medal of the International Geosynthetics Society, Kerry has also been recognized during 2004 by the award of two other honours.

The Canada Council for the Arts announced on May 3rd that Kerry Rowe was among five scholars recognized for outstanding career achievement in engineering, natural sciences, health sciences, social sciences and humanities. Inaugurated in 1981, the $100,000 Killam Prizes are financed through funds donated to the Canada Council by Mrs. Dorothy J. Killam before her death, in memory of her husband, Izaak Walton Killam. The prizes were created to honour eminent Canadian scholars and scientists actively engaged in research, whether in industry, government agencies or universities.

Kerry Rowe receives Killam Award

Kerry has also been invited by the British Geotechnical Association to deliver their Rankine Lecture in London next year. He is only the fourth Canadian to be selected since the lecture's inception in 1961.

"Rankine lecturers are chosen on the basis of their international standing and reputation, their technical expertise and contribution to geotechnical engineering, their ability to deliver an outstanding lecture, and to produce a published paper that would serve as a landmark to industry," says BGA director Tony Bracegirdle.

Of these latest honours, Dr. Rowe says: "I see this as recognition of the contribution to engineering science and practice of a wonderful team with whom I have had the privilege of working. I wish to acknowledge all those who have contributed to the research that is being recognized by my selection for this very significant honour – the more than 50 graduate research students and many colleagues and collaborators both at Queen's and around the world. I am looking forward to this opportunity to both look back over the past, but also to highlight key issues that we are currently examining, in my Rankine Lecture."

4th Year Geotechnical Design Group Wins Award

By Richard Brachman

Presentation of the 2004 Stantec Award at June convocation. L to R: Dave Turcke, Jen Lavoie, Kimberly Read, Nick Stoute, Alex Williams and Richard Brachman

Jen Lavoie, Kimberly Read, Nick Stoute and Alex Williams (BSc 2004) were selected as the recipients of the 2004 Stantec Consulting Ltd. Award for the *BEST* student project in our 4th year design course CIVL 467. The award winning team worked with Dr. Paul Dittrich (BSc 1991) of Golder Associates and faculty advisor Dr. Richard Brachman on a challenging project called the Sinking Causeway. The students produced settlement predictions and conducted stability assessment investigating several construction options. This is the inaugural presentation of this now annual award generously sponsored by Stantec Consulting Ltd. for excellence in industry design. If your company would like to suggest a design project for our students to work on, please contact Dr. Kent Novakowski at kent@civil.queensu.ca .

Canadian Geotechnical Society Student Competitions

By Jean Hutchinson and Richard Brachman

The excellence of our students has been recognised again through the 2004 Canadian Geotechnical Society Student Competitions. Design teams from Queen's were awarded First AND Second prizes in the Undergraduate Group Report.

A team of undergraduate students from Queen's supervised by Drs. Jean Hutchinson and Gerhard Pratt won the prize for the best Canadian undergraduate team-based report for 2004 (this award was provided by the Canadian Foundation for Geotechnique). Andrea Catley, Adam Shales and Amanda Lockhart completed a project entitled "Vimy Ridge Memorial Site: Void detection and subsidence assessment". Following an extensive literature review, the team modelled the geomechanical stability and assessed geophysical data collected on site by Dillon Engineering, to locate possible voids and to provide input into a public safety risk management plan. Andrea is currently undertaking graduate studies, Adam is working for Fugro Airborne Surveys and Amanda is working for Golder and Associates.

Second place was awarded to Jana Levison, Kirsten Moran, Lukas Novy and Victoria Spacic for their work on the Chinguacousy Landfill Groundwater Remediation Project supervised by Dr. Kent Novakowski.

Second place in the Graduate Student Competition was awarded to Ryan Krushelnitzky for his presentation on Large Scale Laboratory Test and Numerical Modeling of a Landfill Drainage Pipe Buried in a Trench. Ryan is a PhD Student working with Dr. Richard Brachman.

Two GeoEngineering Centre members honoured for their engineering excellence

Two GeoEngineering Centre researchers are among 30 engineers inducted into the Canadian Engineering Academy (CAE) recently.

Canada Research Chair in Infrastructure Engineering Ian Moore (Civil Engineering, Queen's) and Richard Bathurst (Civil Engineering, RMC) join 250 CAE fellows from across the country.

"Election to the Canadian Academy of Engineering is one of the highest national honours within the profession," says Queen's Vice-Principal (Research) Kerry Rowe. "The induction of these new fellows from Queen's illustrates the university's excellence in the applied sciences. We are very proud of the achievements of our new Fellows and we congratulate them for this highly distinguished honour."

Richard Bathurst (left), and Ian Moore (right)

Richard Bathurst was cited for his expertise on geosynthetic-reinforced retaining wall systems. His physical testing and modelling has led to the development of practical guidelines for the design of these systems, and to the safe and economical design of a new generation of retaining wall systems that are now used by industry throughout the world.

"I am very pleased to be recognized for research that has been carried out over many years," says Dr. Bathurst. "The body of work that has led to this recognition would not have been possible without the contribution of a dedicated group of graduate students at RMC and Queen's."

Ian Moore was cited for his expertise on soil-pipe interaction. He has developed and used computer models and laboratory tests to define collapse conditions for concrete, metal and thermoplastic pipes. His findings define how most major pipe manufacturing companies in North America design and use pipe products.

Canadian Academy of Engineering fellows are selected from 160,000 practising members within the engineering profession of Canada.

The Academy enhances the promotion of well-being and the creation of wealth in Canada through the application and adaptation of science and engineering principles.

For more information visit the Canadian Academy of Engineering: http://www.acad-eng-gen.ca/

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