2012 Newsletter

Fawzy Ezzein and Fady Abdelaal page 3.

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New research infrastructure funding from CFI

Recent Canada Foundation for Innovation (CFI) funding helps in developing strategies for addressing the flow of all types of fluids into soil and groundwater, as well as investigations of buried pipes.

Queen's civil engineering assistant professor **Kevin Mumford** was awarded a Leader's Opportunity Fund grant for $116,000 to continue his research. With a government focus currently on brownfield development, which is often a costly endeavour, the funding will allow the development of new strategies and optimize existing strategies. Brownfield development is the redevelopment of old, unused industrial properties. "There is a focus right now on sustainable development. Cleaning up a site is a major barrier to getting these projects off the ground. Our research will help with that," says Dr. Mumford.

CFI announced funding of $1.2M to **Drs Moore** and **Brachman** together with Queen's colleagues Filion, Hoult and Liss for their project titled "Deterioration and long term performance of buried infrastructure". These funds will allow substantial upgrades to the GeoEngineering Laboratory at West Campus used for full-scale testing of culverts, sewers pipes and other kinds of buried infrastructure. The upgrades will permit extension of the laboratory to simulate deep pipes with diameters of up to 3m, studies on erosion around leaking culverts and sewers, and preparation of deteriorated steel and reinforced concrete culverts (see pages 11 and 13 for descriptions of other recent test projects using the existing facilities).

Use of the GeoEngineering Laboratory to conduct full scale testing of a large span metal culvert under both real and simulated truck loading.

Graduate Student Presentation Awards
Canadian Geotechnical Society

Fawzy Ezzein (RMC Civil) and **Fady Abdelaal** (Queen's Civil) placed 1st and 2nd (respectively) at this year's National Canadian Geotechnical Society's (CGS) 2012 Graduate Student Competition. This is quite an outstanding accomplishment. The competition entailed a 15 minute presentation recorded in front of a live technical audience including a question and answer period. There were 10 graduate presentation entries from multiple universities across Canada.

Graduate Student Presentation Award – 1st Prize
Name: Fawzy Ezzein
Title: A Transparent Granular Sand for Geotechnical Modelling
Department: Civil Engineering, Royal Military College of Canada
Advisor: Dr. Richard Bathurst

Graduate Student Presentation Award – 2nd Prize
Name: Fady Abdelaal
Title: Cracking of HDPE Geomembranes
Department: Civil Engineering, Queen's University
Advisor: Dr. Kerry Rowe
October 2012

R.M.Quigley Award of the Canadian Geotechnical Society

At the Annual Canadian Geotechnical Conference in Winnipeg, the **R.M. Quigley Award of the Canadian Geotechnical Society** was presented to former GeoEng graduate student **Dr. Pete Quinn** together with **Drs Mark Diederichs, Kerry Rowe** and **Jean Hutchinson** for the paper titled "A new model for large landslides in sensitive clay using a fracture mechanics approach" published in the Canadian Geotechnical Journal, Vol 48(No 8): pp. 1151-1162. This manuscript was selected by the Associate Editors as the best of the 148 papers published in the journal during 2011

Pete Quinn

Mark Diederichs

Kerry Rowe

Jean Hutchinson

A Killam Research Fellowship, the Sir John Kennedy Medal, and the R. Kerry Rowe Lecture

Dr. Kerry Rowe, Professor and Canada Research Chair in Geotechnical and Geoenvironmental Engineering has received extraordinary recognition for his contributions to research and practice during 2012.

Kerry Rowe

The Canada Council of the Arts has announced the latest winners of the **Killam Research Fellowships**. Dr Rowe, one of seven Canadian scholars to be supported by this program during 2012-2014. Commenting on Dr. Rowe's selection the Canada Council of the Arts explained that "Kerry Rowe will examine the effectiveness of the modern barriers systems used in landfills to contain contaminants of emerging concern, like bisphenol-A, and develop guidelines for the design of barrier systems and landfill operations that will provide long-term environmental protection. He has received many awards and accolades for his research, including being elected a Foreign Fellow of the Royal Academy of Engineering UK in 2010. His methods have been adopted by regulatory authorities in Canada and around the world. The Fellowships, among Canada's most distinguished research awards, provide $70,000 a year for two years to each of the researchers. They enable researchers to be released from teaching and administrative duties so that they can pursue independent research".

The Engineering Institute of Canada awarded **Dr. Rowe** the institute`s highest honour, the **Sir John Kennedy Medal**. Their award citation notes that "he is known for his seminal and outstanding contributions to the engineering science and practice of Geoengineering. Dr. Rowe has led international research efforts in both Geosynthetics and Landfill Engineering, transforming practice in Canada to the highest level internationally, and reaching across boundaries to guide the development and implementation of engineering science on these topics in many countries".

Dr. Rowe was also recently honoured by the Indian Geotechnical Society by being invited to present their most distinguished lecture, the IGS-Ferroco Tezaghi Oration. This lecture, which honours the worlds most distinguished geotechnical engineers, is presented every two years. Rowe's lecture, presented to a packed auditorium at IIT Delhi in New Delhi on 5th October 2012, was on "Design and construction of barrier systems to minimize environmental

impacts due to municipal solid waste leachate and gas".

Dr. Rowe was honoured with the Queen Elizabeth II Diamond Jubilee award in November 2012 for award-winning contributions to the investigation of landfill development, soft-ground tunneling and the reinforcement of embankments. Dr. Rowe has provided scientifically justified, environmentally responsible and economically sound solutions.

Lastly, Dr. Rowe has received extraordinary recognition from the **International Society of Soil Mechanics and Geotechnical Engineering** and Technical Committee 215 on Environmental Geotechnics, who have established the **R. Kerry Rowe Lecture**, "in recognition of Professor Rowe's outstanding impact in the field of Environmental Geotechnics and excellence in scholarly achievements". The lecture is to be given at the opening plenary session of the Environmental Geotechnics Congress held every 4 years. The inaugural lecture is scheduled to be given at the 18th International Conference on Soil Mechanics and Geotechnical Engineering to be held in Paris, France, in September 2013 and at the 7th International Congress on Environmental Geotechnics to be held in Melbourne, Australia, in November 2014. The lecture will be delivered by a person "having made a distinguished recent contribution to the theory and practice of Environmental Geotechnics".

Kerry Rowe with Richard Brachman (left) & Andy Take (right) at the Godfrey landfill barrier test site north of Kingston.

Michael E. Argent Memorial Scholarship

Mohamed Almahakeri was awarded the Michael E. Argent Memorial Scholarship by the North American Society of Trenchless Technology at the 21st NoDig Conference in Nashville. Mohamed is studying for a PhD.

Mohamed Almahakeri
President of the NASTT QU Student Chapter

Best paper award, GeoRisk

Dr. R.J. Bathurst and former graduate student **Dr Bing Huang** are the recipients of the 2011 Best Paper Award of the international journal *Georisk* for their paper titled "Load and resistance factor design (LRFD) calibration for steel grid reinforced soil walls". The paper was co-authored with Mr Tony Allen of the Washington State Department of Transportation State Materials Laboratory.

They also are the recipients of the 2011 Best Paper Award of the journal Geotextiles and Geomembranes for their paper "Analysis of installation damage tests for LRFD calibration of reinforced soil structures, Geotextiles and Geomembranes, Vol. 29, No. 3, pp. 323-334". The paper was co-authored with Mr Tony Allen of the Washington State Department of Transportation State Materials Laboratory

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NSERC has announced the award of **Discovery Accelerator Supplements** to two members of the GeoEngineering Centre, **Drs Jean Hutchinson** and **Kerry Rowe**. These highly competitive awards, given to just 4 of the 38 scholars at Queen's receiving new Discovery Grants this year (and about 1 in 25 discovery grant award holders nationally), are awarded to proposals that suggest high-risk, novel or potentially transformative research that could contribute to groundbreaking advances in the area of study.

The GeoEngineering team has been exceptionally successful receiving these funds since the accelerator supplement program was initiated six years ago. A total of six of these awards have been made to our sixteen team members, a success rate that is almost ten times the national average. Further information is provided at http://www.queensu.ca/news/articles/queens-researchers-receive-34-million-nserc-funding.

Dr. Ian Moore delivered the opening keynote lecture at the **3rd International Conference on Pipelines and Trenchless Technology** in Wuhan, China, on Saturday October 20th, a conference jointly supported by the ASCE and the China University of Geosciences. His presentation, 'Large scale laboratory experiments to advance the design and performance of buried pipe infrastructure' described experiments in the Geoengineering Laboratory developed at West Campus in collaboration with **Dr. Richard Brachman,** seminal studies conducted by current and former graduate students **Mohamed Almahakeri, David Becerill-García, John Cholewa,** and **Andrea Lougheed.**

The Victor Milligan Lectures sponsored by Golder Associates

This Victor Milligan Lectures are a distinguished lecture series named in honour of the late Dr. Victor Milligan, one of the founders of Golder Associates, a Terzaghi Lecturer and the first Editor of the Canadian Geotechnical Journal. The lecture series brings the Rankine and Terzaghi Lecturers to the GeoEngineering Centre at Queen's-RMC each year to speak to our graduate and undergraduate students, faculty members, visitors and guests. Three Victor Milligan Lectures were delivered in 2012.

Ken Stokoe

On September 12, **Dr Kenneth H. Stokoe II** from the University of Texas at Austin, gave the lecture titled "Seismic Measurements and Geotechnical Engineering" which was the 2011 Terzaghi lecture

Dr. Stokoe is the holder of the Jennie C. and Milton T. Graves Chair in Engineering in the Civil, Architectural and Environmental Engineering Department at the University of Texas at Austin. He has been working in the areas of field seismic measurements, dynamic laboratory measurements, and dynamic soil-structure interaction for more than 40 years. He has been instrumental in developing several small-strain field methods for in-situ shear wave velocity measurements. He has also developed two types of resonant column systems that are used to evaluate dynamic soil and rock properties in the laboratory.

On October 10, **Dr David E. Daniel**, President of the University of Texas at Dallas, present the 2012 Terzaghi Lecture "Geoenvironmental Engineeering – Problems Solved and Challenges Remaining". Dr Daniel trained at the University

David Daniel

of Texas at Austin and served on faculty there from 1980 to 1996. From 1996 to 2005 he served as Dean of Engineering at the University of Illinois. Dr. Daniel's professional work has focused on Geoenvironmental issues associated with waste containment and clean-up of contaminated sites with particular emphasis on low-permeability clay materials used in lining and capping systems. Dr. Daniel chaired the panel of the American Society of Civil Engineers, which reviewed causes for the failure of New Orleans' levees during Hurricane Katrina, and subsequently served on the panel investigating the causes for the explosion, fire, and oil spill from Deepwater Horizon in the Gulf of Mexico.

Malcolm Bolton

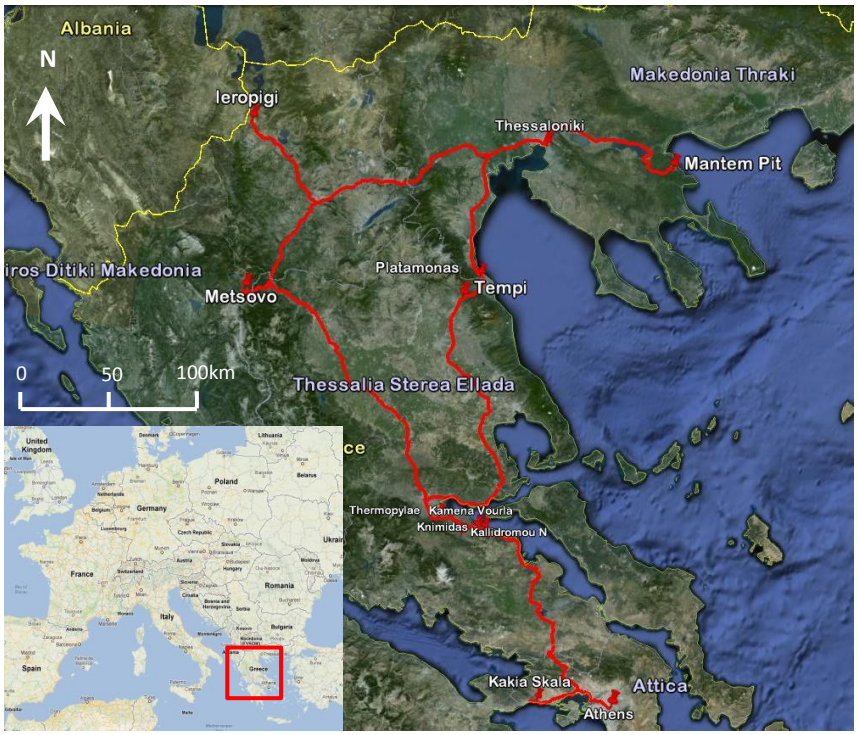
And on October 17, **Professor Malcolm Bolton**, Director of the Schofield Centre at the University of Cambridge, UK, presented his Rankine Lecture "Performance-based design in geotechnical engineering". Trained at Cambridge University and the University of Manchester, he helped to develop the UK's first geotechnical centrifuge in Manchester, but returned to Cambridge in 1980 where he is now Professor of Soil Mechanics and Head of the Geotechnical and Environmental Group in the Department of Engineering. He is the author of a book and 200 publications covering the fundamental mechanics.

Expanding Horizons: Queen's Geological Engineering Goes to Greece!

By: Cortney Palleske, E.I.T., and Michelle van der Pouw-Kraan, E.I.T.
Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, Ontario

From December 2 to 7, 2012, five Queen's University students from the Department of Geological Sciences and Geological Engineering travelled to Greece for a technical tour of the geology, design and construction of tunnels with Dr. Nicholas Vlachopoulos of the GeoEngineering Center in Kingston. The Kingston 'contingent' joined approximately 30 Greek students from the National Technical University of Athens, the Aristotle University of Thessaloniki and their respective professors, Dr. Paul Marinos, Professor Emeritus, and Dr. Vassilis Marinos, Lecturer. The Professors are experts in the world tunneling profession and have extensive experience with the tunnel sites visited on the tour. Throughout the trip, students learned about industry-standard rock classification techniques and how to assess support for tunnels from the individuals who have been setting those standards.

The tour began in Athens and wound around the Greek mainland with overnight stops in Kamena Vourla, Platamonas, Thessaloniki, and Metsovo, before returning to Athens. Several sites were visited each day to allow students to observe tunnels in various stages of construction – from portal construction to completion – in the wide variety of ground conditions present across the Greek landscape. The map below shows the sites visited on the trip.



In very broad terms, tunneling conditions in Greece can be divided in to three major regions: the south, the northeast and the northwest. In the south, tunnel design must account for seismic activity, including crossing active fault zones. In the northeast, strong rock can change to weak rock and back again over very short distances due to the effects of weathering.

Figure 1: Greece technical tour route map. Stops are marked with a red pin.

The northwest has rock types typical of Greece – including flysch and molasse, more on these later – which were encountered along the 670 km long east-west Egnatia Highway (or "Odos" in Greek) built across nearly every geological zone in the country.

Stops in all three regions afforded students the opportunity to observe first-hand the rocks, ground support methods, and in a few cases, the construction process that went in to building the tunnels.

In the south, the Kakia Skala highway tunnels follow a rugged coastline formed along steep, active faults oriented parallel to the coast. "Kakia Skala" translates to "Evil Staircase", for mythology tells of a man named Sciron who threw people off the steep cliffs into the sea below, until Theseus, a founder-king of Athens, arrived and defeated the tyrant and threw him into the water. Thanks to careful investigation and planning, the tunnels do not cross the faults along this section of highway, and the tunnel continuity will not be affected by seismic events. North of Athens, on the Greek National Road 1, the Knimidas tunnel crosses a fault zone that experts have predicted could undergo up to 0.15 m of vertical displacement over the tunnel's design life. This movement was incorporated into the design by over-excavating around the tunnel, and then back-filled; if the fault moves, the concrete lining can be ground down, smoothed out, and the tunnel quickly reopened.

At the Olympus Mine project in the Chalkidiki region in the northeast, gold mining works are being developed and several tunnels are being excavated to facilitate these operations. Because of the tectonics in the area, rock previously located and weathered at the surface has been thrust down to tunnel depth in places.

Figure 2: The Queen's contingent (left to right: Michelle van der Pouw Kraan, Jeff Oke, Dr. Nicholas Vlachopoulos, Cortney Palleske, Jenn Day and Ehsan Ghazvinian) with the Ieropigi Tunnel portal

This can create extreme strength variations in the rock over short distances, making it very difficult for miners to predict what type of ground support will be required as the tunnel face advances. To anticipate upcoming ground conditions, the face is

carefully inspected by geologists who record subtle changes in the rock after each 1m excavation step.

From Thessaloniki, the students travelled southwest towards Metsovo, following the recently completed Egnatia Odos - part of the trans-European road network - through many of the 100 kms of tunnels along the highway alignment. The project roughly follows the first Roman road built outside of Italy in the 2nd century B.C. and parts of the original pavement were encountered during construction. The many rock cuts along the highway afforded students a glimpse of the rock the tunnels were excavated through. These cuts included flysch: a sequence of siltstones and sandstones deposited in front of a future mountain chain and subsequently thrust upwards by tectonics, and found widely in Greece. Typical support requirements for tunnels in this rock type were discussed.

While the main north-east to south-west route of the Egnatia project has been completed, many north-south access roads are still under construction. The students saw the beginnings of the Ieropigi Tunnel, part of the road which will provide access from Albania to the Egnatia Odos. The tunnel is being excavated through molasse – a sedimentary rock sequence of siltstones, sandstones and conglomerates deposited in a tectonically 'quiet' zone behind a mountain chain. This rock type is uncommon in North America, but typical of Greece.

In addition to observing tunnel building in a variety of rock types, other issues affecting tunnel construction were also highlighted. In Thessaloniki, the tunneling for the metro is proceeding relatively uneventfully; metro station construction, however, has been significantly delayed as archaeologists catalogue 2,700 years' worth of the city's history encountered as excavations proceed to the depth of the metro tunnels. Along Egnatia Odos, designers were tasked with planning a road through rugged mountain terrain. However, slow-moving landslides along the originally proposed route necessitated realignment of certain sections where stabilizing the landslide wasn't feasible. The options considered in these cases were either placing the road on the opposite side of the valley, often necessitating impressive bridge structures, or constructing long tunnels in the stable rock behind the moving ground. Many of these slide zones were pointed out to the students to explain external factors that contribute to the ultimate road location.

As part of this international technical course, the students also experienced a cultural exchange with their hosts. The Canadians were consistently impressed with the generosity and warmth of the Greek people, as well as their love for experiential learning. Of particular note was the Greek 'Name Day' tradition, where individuals with a shared first name of a Saint, on that Saint's calendar day, were expected to provide treats for all others (akin to a reverse birthday). As St. Nicholas' day is on December 6th, a generous selection of treats was presented over the course of the day, as there were 3 Nicholas' in the group, and a few others encountered en route!

By any measure, the course was a success. It is practical opportunities like these that make the educational experience at Queen's exceptional, and help to create well-equipped future leaders.

Assessment of Deteriorated Corrugated Steel Culverts

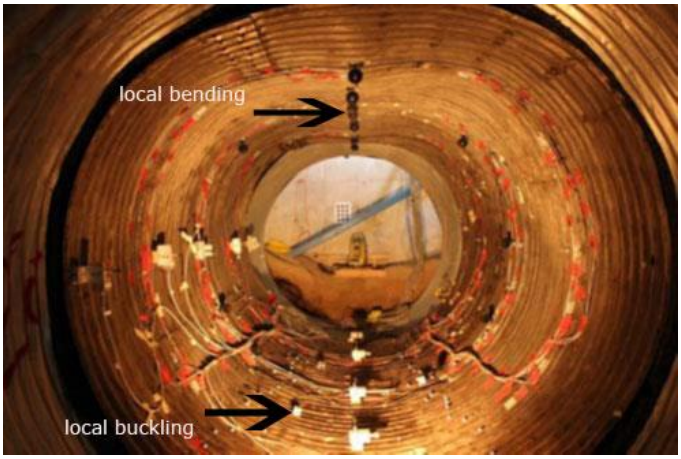
Van Thien Mai, MASc, Geoengineering Centre at Queen's – RMC
Supervised by: **Neil A. Hoult**, and **Ian D. Moore**
Sponsors: NSERC, US Academy of Sciences through the Transportation Research Board

Millions of deteriorated culverts and storm sewers across North America need evaluation and possibly repair or replacement. Almost all buried pipe studies have examined new structures, and much still needs to be learned about the strength of deteriorated pipes. This project examined the strength of corroded corrugated metal culverts. First, a technique was developed to measure the remaining wall thickness in corroded structures. Next, patterns of wall loss were established for two deteriorated test culverts provided by the Ministry of Transportation, Ontario. Finite element calculations were performed to predict the stability of the two deteriorated culverts. Full scale experiments were then undertaken using the facilities in the GeoEngineering Laboratory at Queen's. Each structure was buried in coarse grained backfill, and deformations and strains measured under single wheel pairs and single axle loading. The more heavily deteriorated structure (shown in the photograph) was then tested to collapse, and the failure mode established: local bending across the culvert crown, and local buckling of remnants of steel left between corrosion-induced perforations at the haunches. Post-test analyses established the poor performance of existing design equations in Canadian and US highway bridge codes, and provides guidance on the use of finite element analysis for stability assessments.

Current culvert assessments often rely on the opinions of the individual inspector regarding the need for repair or replacement. Van developed an objective quantitative assessment procedure for deteriorated metal culverts based on:

A. characterisation of remaining steel plate thickness using ultrasonic thickness measurements

B. Calculation of deteriorated culvert stability using culvert analysis package CANDE or other finite element programs (e.g. ABAQUS).



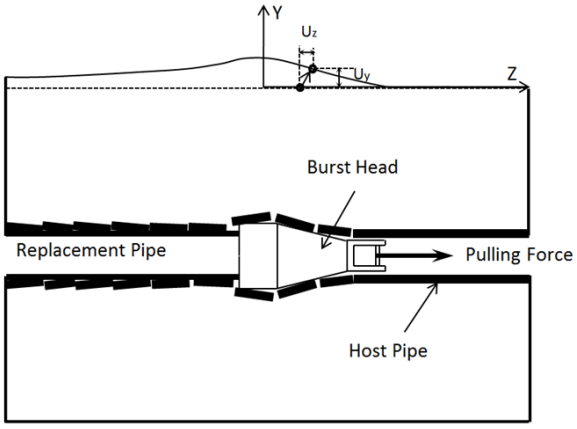
Failure mode for culvert tested to its strength limit


Van measuring thickness in the field.

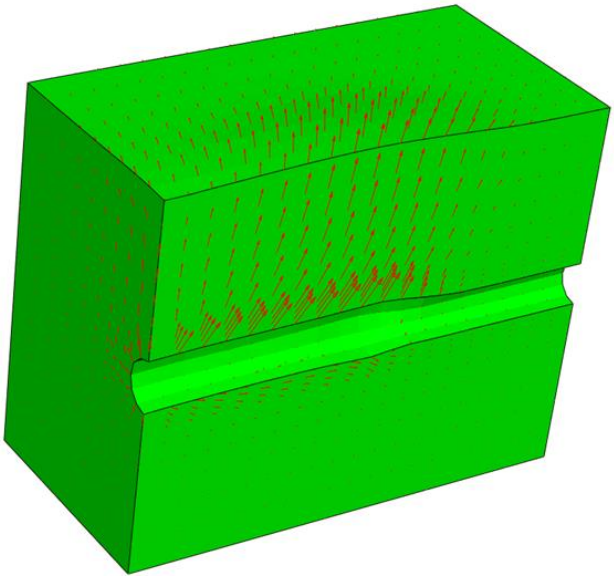
Three Dimensional Numerical Analysis of Static Pipe Bursting

Kazi Rahman, PhD, GeoEngineering Centre at Queen's – RMC
Supervised by **Ian Moore** and **Richard Brachman**
Sponsors: the Natural Sciences and Engineering Research Council of Canada (NSERC)

Static pipe bursting is a trenchless technology that permits installation of buried thermoplastic pipes. A cone shaped expander is used to fracture an existing pipe, displace the resulting fragments out into the surrounding ground, and pull a new HDPE or other pipe into place through the resulting cavity. The soil movements that result in the surrounding ground can damage overlying pavements, and can also fracture pipe structures running parallel or transverse to the pipe being replaced.



Schematic of the pipe bursting process



Calculated ground motion caused by the burst head

Kazi Rahman used nonlinear finite element program ABAQUS to analyze pipe bursting experiments conducted in dense sand and gravel by former graduate students Brian Lapos and John Cholewa, and used comparisons of the calculated response to test measurements to evaluate the performance of the computer models. He then undertook parametric studies using his ABAQUS models to examine the influence of key geometrical and material properties, such as the depth and diameter of the old sewer being replaced, the upsize (how much the diameter of the burst head is larger than the old pipe), the strength of the surrounding soil and its initial and final density after bursting (the extent to which the dense soil increases in volume as it is sheared). Modeling captured the nonlinear response at the interface between the burst head and the old pipe, shear failure and nonlinear dilation of the dense soil, and the large changes in geometry. Kazi also studied the response of other buried pipes in the vicinity of the sewer being replaced.

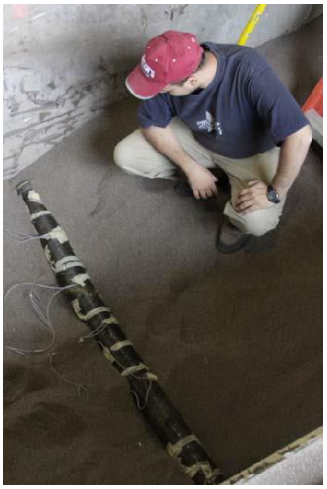
Steel and Fibreglass Pipes Subjected to Lateral Ground Movement

Mohamed Almahakeri, PhD, GeoEngineering Centre at Queen's – RMC
Supervised by **Ian Moore** and **Amir Fam**

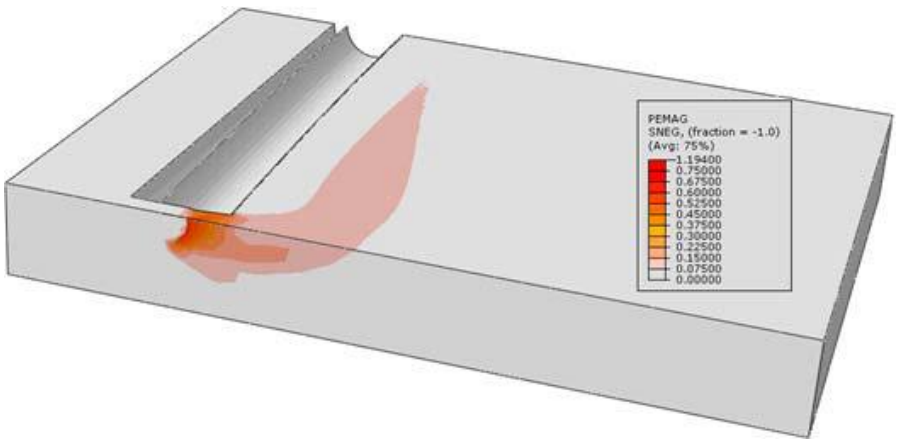
Oil and gas transmission pipelines can be subjected to lateral ground movements when passing along slopes that experience slow or rapid down-slope soil movements. Pipelines need to be designed for the lateral forces that then develop. This includes conventional steel pipes that are the normal choice for high pressure pipes, and the fibreglass pipes now being selected for their corrosion resistance. Mohamed Almahakeri designed and conducted lateral loading experiments on 100mm diameter steel and fibreglass pipes of equivalent pressure rating. The tests were designed to evaluate a segment of pipe spanning between two points of zero moment towards the boundaries of a zone of moving ground. These provided measurements of the lateral loads that develop, as well as the longitudinal bending deformations and axial strains along the pipeline. Some longitudinal bending occurred in the steel pipeline, but was substantially higher in the fibreglass pipe which is much more flexible.

Finite element modeling was then undertaken using ABAQUS, where the nonlinear phenomena controlling the behaviour are considered, such as shear failure and dilation of the dense coarse-grained soil, large deformations at the soil-pipe interface, and separation of the pipe from the soil.

The three dimensional analysis captures the progressive development of shear failure along the pipe, as the soil moves further past the ends of the pipe, and mobilizes the strength and stiffness of the soil at that location well before the pipe midsection. The analysis also models the effects of the orientation of the glass fibres, and the effect of burial depth on lateral soil loading and pipe resistance to failure in flexure.



Mohamed inspects a test pipe.



Contours of plastic soil strain below and ahead of the test pipe.

SCIMAGO rankings of GeoEngineering Journals

SCIMAGO has recently released their new journal ranking system based on the Scopus database. This includes assessment of the 96 journals in the category Geotechnical Engineering and Engineering Geology. Details of these rankings are available at: http://www.scimagojr.com/journalrank.php?area=1900&category=1909&country=all&year=2011&order=sjr&min=0&min_type=cd%20.

The SCIMAGO ranking is based on 'SJR', a new assessment measure that uses average weighted citations over a three year period, and which omits self cites. The listing indicates that the top five journals ranked for their impact and influence are

1. Geotextiles and Geomembranes (edited by centre member **Kerry Rowe**)
2. Geotechnique
3. Geosynthetics International (edited by centre member **Richard Bathurst**)
4. Structural Dynamics and Earthquake Engineering
5. Canadian Geotechnical Journal (edited by centre member **Ian Moore**)

These journals are ranked ahead of the remaining journals in this category, including others widely acknowledged for their excellence. Other members of the GeoEngineering Centre also sit on the boards of these and other journals ranked highly by SCIMAGO.

Recent Graduates and Postdocs

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

Basso, Tina, MES, (supervised by Nick Vlachopoulos, RMC), independent consultant, Toronto
Becerill García, David, PhD, Postdoctoral Fellow at Queen`s (supervised by Ian Moore).
Chappel, Melissa PhD (supervised by Kerry Rowe, Andy Take & Richard Brachman), CTTG, Montreal
Dutton, Mike, MSc, (supervised by Andy Take & Neil Hoult), Hatch Mott McDonald, Mississauga
Foster, Jonathan, MASc, (supervised by Andy Take), BGC Engineering, Vancouver
Hansen, Scott, PhD, Postdoctoral Fellow (supervised by Bernard Kueper), Weizmann Institute, Israel
Irfan, Uma, MSc, (supervised by Rowe and Brachman)
Jaggard, Heather, MSc, (supervised by Heather Jamieson), Golder Associates, Sudbury
Lay, Geoff, MSc, (supervised by Richard Brachman), Golder Associates, Mississauga
Mabrouk, Ahmed, PhD, (supervised by Kerry Rowe), Golder Associates, Calgary
Rahman, Kazi, PhD, (supervised by Ian Moore & Richard Brachman), KGS Consulting, Winnipeg
Rodriguez, David, PhD, (supervised by Bernard Kueper and Pascal Champagne), Arcadis Consulting, Syracuse, NY
Verge, Ashley, MASc, (supervised by Kerry Rowe), AMEC, Mississauga
Wolinsky, Eric, MSc, (supervised by Andy Take), BGC Engineering, Vancouver
Yu, Yan, PhD, Postdoctoral Fellow, (supervised by Kerry Rowe), Civil Engineering, Queen's University.

Publications for 2012

Abdelaal, F.B., Rowe, R.K., Smith, M. Brachman, R.W.I and Thiel, R. 2012OIT depletion of HDPE and LLDPE geomembranes without HALS in extremely low pH solution, 2nd Pan American Geosynthetics Conference, GeoAmericas 2012, Lima, Perú - May 2012**.**

Alexandra, R., Gerhard, J.I. and Kueper, B.H., 2012. Hydraulic Displacement of Dense, Non-Aqueous Phase Liquids. Journal of Ground Water, Vol. 50, No. 5, pp. 765-774.

Almahakeri, M., Fam, A. and Moore, I.D. 2012. Experimental investigation of the flexural behavior of GFRP composite pipes in dense sand, 6th International Conference on Advanced Composite Materials in Bridges and Structures, Kingston, ON, Canada, May, 8pp.

Almahakeri, M., Fam, A. and Moore, I.D. 2012.The flexural behavior of buried steel and composite pipes pulled relative to dense sand: experimental and numerical investigation, 9th Int. Conf. on Pipelines IPC2012, Calgary, AB, Canada IPC 2012-90158, 9pp.

Anderson,R., Rayhani,M.T., and Rowe, R.K. 2012Laboratory investigation of GCL hydration from clayey sand subsoil, Geotextiles and Geomembranes, 31: 31-38.

Azad, F., El-Zein, A., Rowe, R.K. and Airey, D. 2012.Modelling of thermally induced desiccation of geosynthetic clay liners in double composite liner systems, Geotextiles and Geomembranes, 34: 28-28.

Balkaya, M., Moore, I.D. and Sağlamer, A. 2012.Study of non-uniform bedding support due to erosion under cast iron water distribution pipes, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 138, No. 10, pp. 1247–1256.

Balkaya, M., Moore, I.D. and Sağlamer, A. 2012.Study of non-uniform bedding due to voids under jointed PVC water distribution pipes, Geotextiles and Geomembranes, Volume 34, October 2012, pp. 39–50.

Balkaya, M., Sağlamer, A. and Moore, I.D. 2012. Conta bağlantılı PVC boruların deformasyon davranışının laboratuvar deneyleri ile belirlenmesi (Laboratory experiments to determine the deformation behavior associated with gasketed PVC

Basso, T. and Vlachopoulos, N. 2012. Investigation into the Suitability of Green Building Evaluation Strategies for use within the Canadian Department of National Defence. Society of Civil Engineering Conference (CSCE), June 2012, Edmonton, Alberta, Canada.

Basso, T., Vlachopoulos, N., and Hulley, M. 2012.Green Buildings and Sustainable Infrastructure for the Canadian Forces. The International Polar Year 2012 Conference: From Knowledge to Action, April 2012, Montreal, Quebec.

Bathurst, R.J., Damians, I.P., Josa, A. and Lloret, A. 2012. Influence of foundation compressibility on reinforcement loads in geosynthetic reinforced soil walls, 5th European Geosynthetics Congress, Valencia, Spain, Vol. 5, pp. 43-47

Bathurst, R.J., Hatami, K. and Alfaro, M.C. 2012. Geosynthetic reinforced soil walls and slopes: Chapter 17 Seismic aspects. Geosynthetics and Their Applications (S.K. Shukla Ed.), 2nd Edition, Thomas Telford, pp. 317-363.

Bathurst, R.J., Huang, B. and Allen, T.M. 2012. Interpretation of laboratory creep testing for reliability-based analysis and load and resistance factor design (LRFD) calibration, Geosynthetics International, Vol. 19, No. 1, pp. 39-53.

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