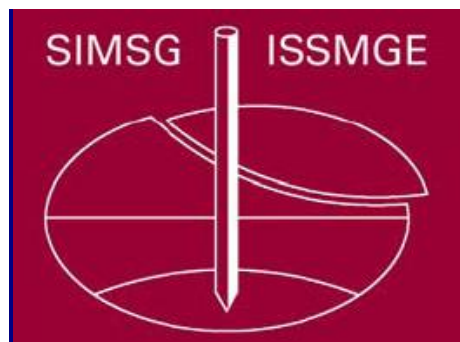




ISSMGE Bulletin

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International Society for Soil Mechanics and Geotechnical Engineering

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Research Highlights



The GeoEngineering Centre at Queens's - RMC

RMC is a team of 17 Geoengineering faculty in the Departments of Civil Engineering, Geological Engineering and Mining Engineering at Queen's University, and Civil Engineering at the Royal Military College of Canada collaborating in research and the education of graduate students in Kingston, Canada. In addition to the six geotechnical engineers listed below, the team includes five hydrogeologists, three geological engineers, two mining engineers, and a geochemist. Their research students and post-doctoral fellows represent about 20% of the total being trained in Canada. With support from Golder Associates, the weekly seminar series brings industry leaders from across Canada and internationally, and also the Rankine and Terzaghi lecturers each year to deliver the Victor Milligan Lecture. A new visiting scholar program supported by Golder Associates is bringing four visiting international scholars and technical experts from Golder Associates for extended visits to Kingston each year. Funding for research costs and student stipends comes from a range of sources, with substantial support from the Canada Foundation for Innovation and the Ministry of Education and Innovation of Ontario to build outstanding research facilities, excellent support from the Natural Sciences and Engineering Research Council of Canada for Discovery, Strategic, and Collaborative Research Projects, in addition to research contracts for many different corporate and government sponsors (including the Department of National Defence (Canada), Ministry of Transportation of Ontario, US Departments of Transportation, through the National Academy of Sciences in Washington, and the Australian Government).

Research Highlights

The GeoEngineering Centre at Queen's – RMC (Continued)



Kerry Rowe, PhD, PEng

Formerly Vice-Principal (Research) at Queen's University, Kerry Rowe is now Professor of Civil Engineering and Canada Research Chair in Geotechnical and Geoenvironmental Engineering. Much of his work is focussed on landfill and mining engineering, with specific interests in barrier system design to limit both advective and diffusive transport, with recent efforts examining the longevity of geosynthetic barrier components, and the roles of geomembrane wrinkles and temperature, on barrier performance. Other research work includes studies of embankments constructed on soft soils, the behaviour of gassy soils, and tunnels in soft ground. Dr Rowe is Editor of *Geotextiles and Geomembranes*, and is on the editorial boards of many other journals. His engineering projects span the globe extending, literally, from the Arctic to the Antarctic.



Richard Bathurst, PhD, PEng

A Professor in Civil Engineering at the Royal Military College of Canada since 1980, Richard Bathurst has made contributions to micromechanics using the discrete element method and studies of static and dynamic performance of geosynthetic reinforced soil walls. Recent contributions include calibration of load and resistance factor design of reinforced soil walls, large-scale wall testing, shake-table studies to examine the seismic response of reinforced soil walls, and the development of a transparent granular soil surrogate. Other recent work focusses on stochastic analysis of reinforced and unreinforced soil slopes. Dr Bathurst is Editor of the journal *Geosynthetics International*, and is currently serving a two-year term as President of the Canadian Geotechnical Society and is President-elect of the Engineering Institute of Canada.



Ian Moore, PhD, PEng

Professor and Canada Research Chair in Infrastructure Engineering at Queen's University since 2001, Ian Moore is also Executive Director of the GeoEngineering Centre at Queen's - RMC. Dr Moore is Editor of the *Canadian Geotechnical Journal*, and his research on buried pipe infrastructure has led to many contributions to codes and engineering practice in the US, Canada, Europe and Australia. Recent research studies include work to define ultimate limit states and develop design methods for thermoplastic pipes and large span corrugated metal culverts, work establishing the remaining strength of deteriorated steel and concrete pipes, design methods for liners used to rehabilitate water pipes, sewers, and culverts, and studies on pipes pulled into place using pipe bursting and directional drilling.



Richard Brachman, PhD, PEng

Richard Brachman is Professor in Civil Engineering at Queen's University. An expert on buried polymer structures, he conducts research on both environmental and transportation infrastructure. This work includes studies on the mechanical performance of geomembranes and geosynthetic clay liners in landfills, high density polyethylene and PVC pipes in landfills, sewers and culverts, and thermoplastic stormwater detention structures. Co-author of the book *Barrier Systems for Waste Disposal Facilities*, Dr Brachman's experimental work on buried polymer structures has influenced pipe and geomembrane engineering practice in Canada, the US and beyond. As Golder Associates Fellow, he is developing case studies that strengthen both undergraduate and graduate education.

Research Highlights

The GeoEngineering Centre at Queen's – RMC (Continued)



Andy Take, PhD, PEng

Andy Take is Associate Professor and Canada Research Chair in Geotechnical Engineering at Queen's and vice-chair of ISSMGE TC104. His work to develop and apply Particle Image Velocimetry (PIV) has transformed laboratory measurement of deformations in geotechnical systems in the physical modelling community. Use of PIV in his centrifuge experiments conducted at C-Core in St John's Newfoundland, large-scale slope tests at Queen's and work in the field is generating seminal test data on topics such as the role of precipitation in the static liquefaction of slopes, the influence of structural stiffness where continuous pipelines cross ground faults, the motion of train rails under moving loads, and thermally-induced distortion of geomembranes. As a Golder Fellow at Queen's, he is studying slope instability and other geotechnical problems.



Greg Siemens, PhD, PEng

Associate Professor in Civil Engineering at the Royal Military College of Canada, Greg Siemens is an expert in unsaturated soil mechanics with interests spanning from the laboratory characterisation of these materials, numerical modeling of hydration processes, to a variety of geotechnical engineering problems influenced by reactive soils. Recent projects include investigations on the effective use and properties of transparent soils, the hydration of geosynthetic clay liners, and gas flow through porous media. Much of his current work focusses on the hydro-mechanical behaviour of clay based sealing materials used as barriers around low and medium level nuclear waste. Dr Siemens is also the Past-Chair of the Kingston Chapter of the Canadian Geotechnical Society.

Some current/recent projects

Effects of exposure conditions on the performance of composite liner systems

Kerry Rowe, Richard Brachman, Andy Take, Greg Siemens, Amy Rentz, Lauren Ashe and Laura Bostwick

Geosynthetic materials are commonly used in combination to form a composite liner system to prevent contaminant migration from modern landfills and mining operations into the environment. These composite liner systems often include a geomembrane overlying a geosynthetic clay liner (GCL) which is placed on the foundation soil. A geomembrane is plastic liner material, commonly 1.5 mm thick. A GCL is composed of bentonite sandwiched between an upper and lower geotextile. Although GCL manufacturers recommend covering of the liner in a timely manner (which would eliminate the problems to be discussed below), it is not uncommon for these composite liners to be left exposed prior to being covered with waste or cover material for weeks, months and sometimes years. When the liner is cool, the GCL takes up moisture from the subgrade. When the liner is exposed to solar radiation, it heats up as the solar energy is absorbed by the (usually black) geomembrane to temperatures of up to 70°C in Kingston Canada and higher in some other climates. The temperature increase can cause moisture to evaporate from the GCL. In the evening when the geomembrane has cooled, the moisture condenses and then drips on the GCL allowing the GCL to re-hydrate at some locations. These thermal cycles can cause the GCL to shrink. For some GCLs, the panel shrinkage can be sufficient to cause a complete loss of panel overlap leaving a gap between GCL panels, thereby compromising the integrity of the composite liner and its ability to perform as a hydraulic barrier.

Research Highlights

The GeoEngineering Centre at Queen's – RMC (Continued)

The condensed water vapour between the geomembrane and GCL drips on the GCL at discrete points, it then runs down the slope and for some GCLs can cause erosion of the bentonite thereby compromising the integrity of the GCL with time. If left exposed long enough this can cause the formation of holes in the GCL, after which, the GCL may no longer perform as an effective hydraulic barrier (Figure 1).

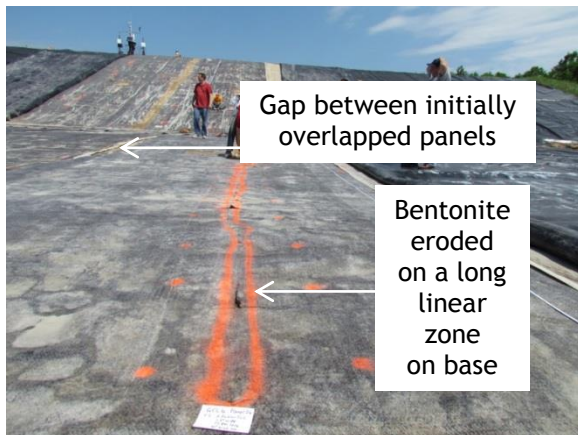


Figure 1. GCL shrinkage and erosion at QUELTS I



Figure 2. QUELTS II

To study the long term effects of exposure conditions and product selection on the performance of a composite liner system, a large-scale test site (Queen's University environmental liner test site; QUELTS) was constructed 40 km north-northwest of Kingston, Ontario, Canada in 2006. The site consists of a 22 m long south facing slope inclined at 3H:1V and a 20 m long base sloped with a 3% grading. Shrinkage of the GCL was monitored over a five year period. This field work combined with an extensive parallel laboratory study examined the effect of how the GCL is manufactured and the effect of daily and seasonal thermal cycles on GCL panel shrinkage. However it also identified, for the first time, the mechanism of down-slope bentonite erosion in each of the four GCLs examined.

To allow an evaluation of the factors affecting down-slope bentonite erosion, a second laboratory study was initiated. This study demonstrated that the issues only arose with essentially distilled water (as in the case of the condensation of evaporated water) and identified a number of candidate GCLs that appeared to have better resistance to down-slope erosion.

The original liners at QUELTS were the removed and the site was reconstructed in May 2012 (QUELTS II, Figure 2). The 86 m wide embankment had seven different test sections including a 0.3m-thick-gravel covered section, one section with a white and one control section with a black geomembrane that was identical to one of the sections at QUELTS I. These three sections all contained the same GCL. There were four other sections with four different GCL products below the same black geomembrane as used on the control section. All of the products were installed with their roll direction oriented in the slope direction. The site also includes an onsite monitoring tower collecting weather data and data from various sensors installed on site such as temperature, water vapour and moisture content data.

Following the construction of the site, field inspections were completed every few months to monitor the products with time. A total of six inspections have been conducted to September 2014.

One aspect of the field study focused on quantifying and comparing wrinkles in a 1.5-mm-thick smooth HDPE white geomembrane versus a 1.5-mm-thick smooth HDPE black geomembrane. To do so, low elevation aerial photographs were captured using an unmanned aerial vehicle (UAV) to identify wrinkle patterns and wrinkle frequency changing with time of day. To supplement these aerial photographs, detailed physical surveys of the wrinkles were completed on clear summer days.

Research Highlights

The GeoEngineering Centre at Queen's – RMC (Continued)

The effects of moisture migration were monitored during each field inspection. Aerial images of the GCL surface were taken using the UAV as well as ground photos to capture images of GCL surface streaking as a method of monitoring moisture migration between the geomembrane and GCL with time. In addition, a novel inspection method was developed to identify changes in the GCL.



Figure 3. UAV used for monitoring wrinkles and down-slope moisture movement



Figure 4. QUELTS Team (left to right): Amy Rentz, Kerry Rowe, Richard Brachman and Andy Take

Longitudinal behaviour of continuous and jointed pipelines

Ian Moore, Andy Take, Masoumeh Saiyar and David Becerril García

While many studies have been conducted to examine the circumferential behaviour of buried pipes (i.e. the two dimensional performance), failures often result because of longitudinal effects along the pipe axis. This includes bending induced in continuous pipelines as a result of differential ground movements, and leakage that results from shear forces or rotations that develop across the joint.

Design of oil and gas pipelines in seismic zones must consider the impact of ground faults, and the longitudinal pipe bending that results. A series of 1/30th scale experiments were conducted in a geotechnical centrifuge to investigate how pipe stiffness influences bending moments. Model pipes composed of aluminum (Figure 5), acrylic, polycarbonate and Teflon represented pipe materials from cast iron to polyethylene. Deformations obtained from Particle Image Velocimetry provide distributions of curvature and moment, shear force, and lateral pressures. Nonlinear finite element analysis using ABAQUS is used to evaluate the tests, and examine the impact of project geometry, soil type, and the flexural stiffness ratio. The testing and analysis are being used to understand the physical behavior and improve the available design models. Centrifuge testing has also been conducted to examine the effect of ground faults on jointed pipelines, and to establish post-break rotations across ring fractures in cast iron water pipes (using glass model pipes, Figure 5).

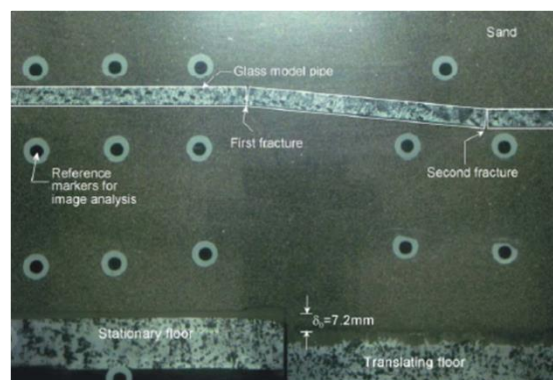
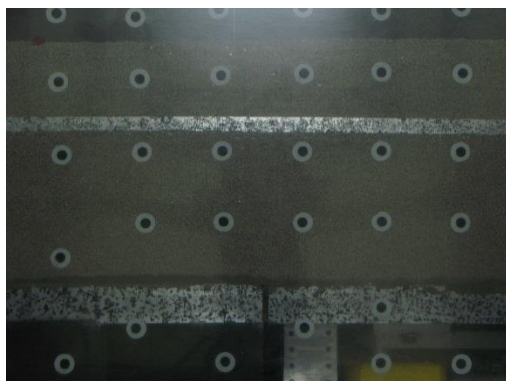


Figure 5. Ductile (aluminum) and brittle (glass) pipe models before and after testing

Research Highlights

The GeoEngineering Centre at Queen's – RMC (Continued)

Gasketed bell and spigot joints, for example, seek to provide easily constructed connections between pipe segments that also release longitudinal bending moments, and welded connections seek to pass longitudinal bending moments from one pipe segment to the next. Significant shear forces may develop across the joint as a result of vehicle loads at the ground surface or changes in bedding stiffness along the pipeline during construction. The soil-pipe-joint interactions can be complex, and influence the gasket-bell and gasket-spigot contacts that may control the ability of the joint to resist leakage under internal (or external) pressure.

Laboratory testing has been used to establish the behaviour of reinforced concrete (Figure 6), corrugated steel and thermoplastic pipes responding to vehicle loads and closed form solutions have been developed for the shear forces that act across the joint and the rotations or moments that develop across moment-release and moment-transfer joints, respectively. The calibrated solutions are currently being considered for incorporation in the AASHTO LRFD Bridge Design Specifications, and work is underway to develop standard joint leakage tests for use by the AASHTO community.



Figure 6. Reinforced concrete pipe prior to burial and testing under surface loads.

Use of geosynthetics for containing diesel contaminated soil in Antarctica

Bec McWatters, Ian Snape (AAD), Kerry Rowe (Queen's), Malek Bouazza and Will Gates (Monash)

Hydrocarbon contamination in Antarctic environments can pose potential toxic and long-term effects on the sensitive ecosystems. A 1999 fuel spill at Australia's Casey Station in Antarctica resulted in contaminant migration downstream through permafrost. Elevated hydrocarbon levels were detected in over 600m³ of soil surrounding the source. The clean-up approach required a low cost remediation technique suitable for the Antarctic conditions and to allow signatory nations to the Antarctic Treaty to meet obligations under Annex III of the Environmental Protocol. This was the first major instance in Antarctica of a comprehensive remediation strategy.

The approach employs active treatment techniques (biopiles, nutrient addition and aeration systems) specifically tailored to the site, soil conditions and risks associated with Antarctic operations and the environment. These cells employ geosynthetic composite liner system using different varieties and combinations of geosynthetic clay liners (GCLs), high density polyethylene (HDPE) geomembranes and geotextiles (Figure 7). Contaminated soil was excavated over two summer seasons (2011, 2012) and placed in lined biopile treatment cells (Figure 8). Research is also focused on the long-term performance of these geosynthetics to impede advective and diffusive contaminant migration with exposure to the Antarctic's cold and dry climatic conditions.



Figure 7. Installing geomembrane over GCL liner



Figure 8. Filling biopile with contaminated soil

Research Highlights

The GeoEngineering Centre at Queen's – RMC (Continued)

Contaminant migration through the biopile barrier system is monitored in the field using a system of monitoring pipes and sample extraction areas. Results show low levels of hydrocarbon migration below the geomembrane liner and no hydrocarbon migration below the GCL liner. Samples of the geomembranes, GCLs and geotextiles were exhumed after one and two years in the field. The Antarctic is the driest continent on earth and this can influence the hydration and performance of GCL liners. This biopile was heavily instrumented with sensors to investigate the moisture uptake/loss in the GCL liner during construction and throughout the lifespan of the cell. Bioremediation predominantly occurs during the warmer summer months where temperatures on station range from -5°C to 5°C .



Figure 9. Geotextile covered biopiles in summer



Figure 10. Dan Jones (Queen's), Tim Spedding (AAD), Lauren Wise (AAD), Kerry Rowe (Queens's) and Johan Mets (AAD) at Casey Station, Feb 2014

Testing and Three Dimensional Analysis of Static Pipe Bursting

Ian Moore, Richard Brachman, and Andy Take

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.

Pipe bursting experiments have been conducted replacing sewer pipes in the field (Figure 11) and the laboratory, with measurement of ground surface movements using Particle Image Velocimetry. These tests have provided detailed data for pipe bursting in fine and coarse grained soils, examining the effects of burial depth and in one experiment monitoring the response of a pressure pipeline running transverse to the sewer being replaced.

The nonlinear finite element program ABAQUS is used to analyze the pipe bursting experiments and comparisons of the calculated response to test measurements allows evaluation of the performance of the computer models. Parametric studies using the ABAQUS models are used to examine the influence of key geometrical and material properties, such as the depth, diameter of the sewer being replaced, upsize (how much the diameter of the burst head is larger than the old pipe), strength of the surrounding soil and



Figure 11. Pipe bursting field tests in Illinois (Front row, Ian Moore, Heather McLeod, Jon Forster, Back row, Richard Brachman and support staff from TT Technologies)

Research Highlights

The GeoEngineering Centre at Queen's – RMC (Continued)

its initial and final densities (i.e. the magnitude of volume increase in the dense soil as it shears). Modeling captures 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. The response of other pipes in the vicinity is also examined.

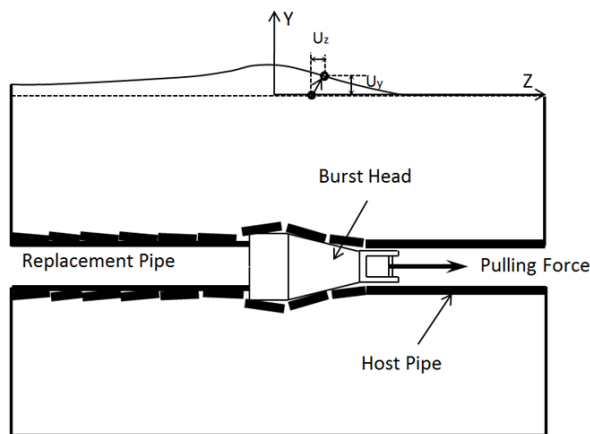


Figure 12 Schematic of the pipe bursting process

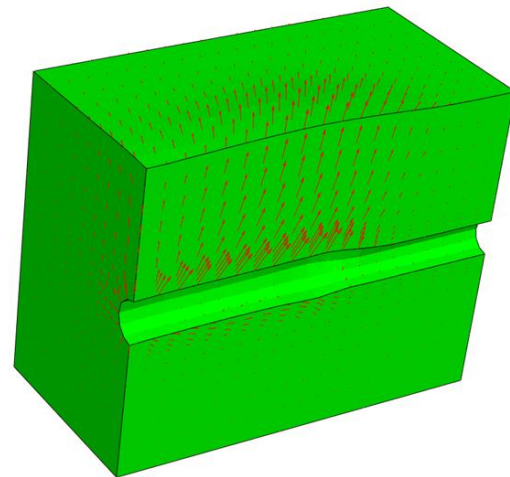


Figure 13. Calculated ground motion during bursting

Investigation of Soil-Geogrid Interaction using a Novel Pullout Test Apparatus and Transparent Granular Soil

Richard Bathurst, and Fawzy Ezzein

The performance of geosynthetic reinforced soil structures is significantly affected by soil-reinforcement interaction. Current practice to quantify the interaction between the soil and the geosynthetic reinforcement is to carry out laboratory soil-geosynthetic pullout tests or direct shear tests. One disadvantage of these approaches is that geosynthetic-soil interaction is not directly observable due to the opacity of the soil. This research project overcame the deficiencies and limitations of previous experimental studies by combining for the first time three technologies to quantitatively investigate in-soil deformation of a typical geogrid reinforcement product. These technologies were first, the use of an industrial-grade transparent fused quartz and a low-viscosity transparent liquid with the same refractive index to create a “transparent soil” surrogate for a typical natural sand material. Second, the design and construction of a novel large pullout box with transparent bottom and side windows to permit visual observation of the soil and reinforcement. Third, the use of the Digital Image Correlation (DIC) technique to capture the deformation of buried soil markers and geogrid specimens from sequential digital images taken through the bottom and side of the pullout box. The experimental program consisted of 26 pullout tests conducted in transparent soil. The parameters that were varied between tests were the surcharge pressure, length of reinforcement, and the testing rate. The results showed that as the surcharge pressure increased the longitudinal geogrid deformation profile became more nonlinear, the length of geogrid interacting with the soil decreased, and the relative displacement between the geogrid and the soil was reduced. The experimental deformation measurements were used to develop and validate a numerical model to predict the deformation and axial strain profile of the reinforcement and adjacent soil deformation. Rate-dependent load models were used to estimate the tensile load through the entire length of the reinforcement specimens during pullout. This model and the data collected during this research program can be used to investigate and quantify soil-geogrid load transfer mechanisms in the anchorage zone of geogrid reinforced soil structures.

Research Highlights

The GeoEngineering Centre at Queen's – RMC (Continued)

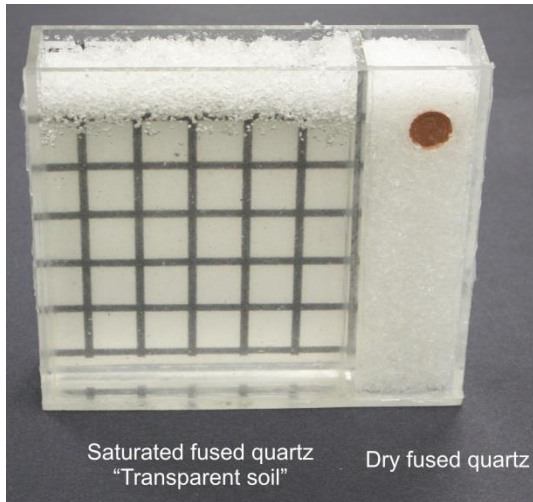


Figure 14. Fused quartz in saturated (transparent) state and dry (opaque) state

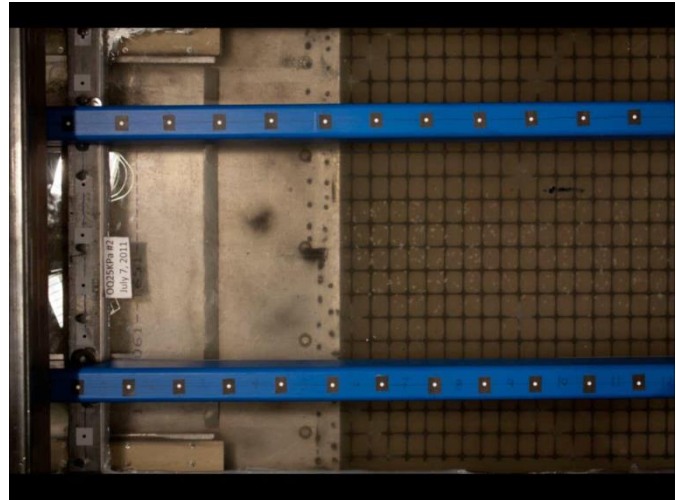


Figure 15. View through Plexiglas bottom of pullout box showing front clamp and geogrid specimen embedded in transparent granular soil

Unifying Framework for Swelling Soils

Greg Siemens and Bee Fong Lim

Swelling-induced stresses and deformations are well known to damage buildings and infrastructure constructed in expansive soil. The cost spent on the remediation and repairs due to swelling-induced damages exceed billions of dollars annually. On the positive side landfill liners and deep geologic repositories for nuclear waste depend on the self-healing capability of swelling soil to protect the environment from the waste. The Swell Equilibrium Limit (SEL) encompasses an upper bound limit of swelling-induced stresses and deformations in the prescribed boundary conditions along with the applied pressure ranges (Figure 16). The SEL is used as a unifying framework to characterise and predict swelling behaviour of expansive soils in terms of swelling-induced stresses and volume change. A SEL catalogue has been established with existing characterized materials that consist of natural and compacted materials. Index properties of each soil are correlated to SEL fitting parameters to predict a SEL for Regina clay (Figure 17). From the SEL catalogue and framework, an analysis method has been developed to model swelling behaviour with advanced swelling test data. The input variables are initial soil state and only two additional material parameters. The model predicts swelling-induced stresses and volumetric deformations for the range of potential boundary conditions (Figure 16 for example).

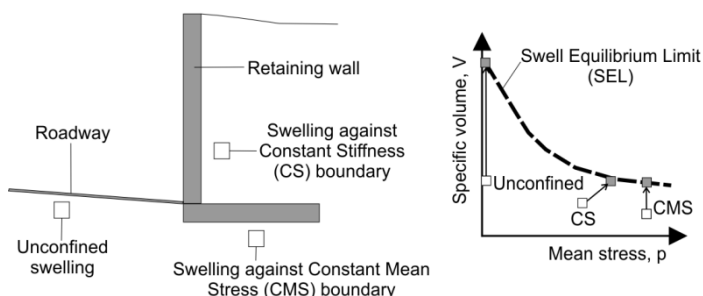


Figure 16. Swelling conditions in a retaining wall application

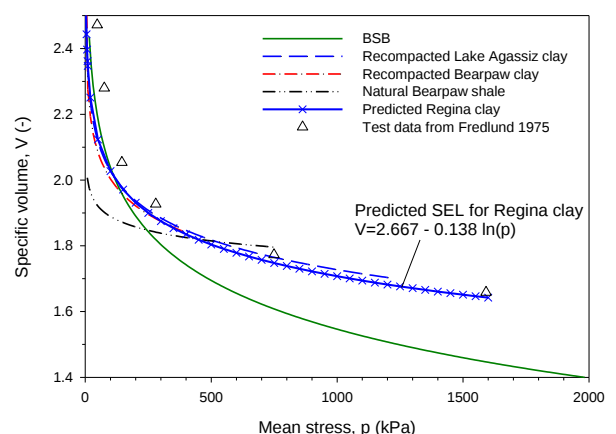


Figure 17. Swelling Equilibrium Limit Catalogue and prediction of SEL for Regina clay

Report from Board-Level Committee Awards Committee (AWAC)

Prior to the 18th International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE) held in Paris in September 2013 up to three Young Member Awards could be presented to recognise the achievements of ISSMGE members at or under the age of 35. During his Presidency, Professor Jean-Louis Briaud introduced a fourth award, the “Outstanding Young Geotechnical Engineer Award”, which was awarded for the first time in Paris in 2013. Subsequent to the conference, the Young Member Presidential Group (YMPG) was asked by the new President - Professor Roger Frank to review and make recommendations to the Board to consolidate the three Young Member Awards and the Outstanding Young Geotechnical Engineer Award as some overlapping and confusions existed among the criteria on which the awards are based.

Following the recommendations of the YMPG, it was discussed and decided at a recent Board Meeting held in Goiânia, Brazil, on Friday 12th September 2014, to combine the two types of awards for young members into one called the “Outstanding Young Geotechnical Engineer Award (OYGEA).” There would be a maximum of 3 awards made every 4 years which are presented at the ICSMGE. They would each have a cash prize of £1,000 and the nominations would be evaluated holistically based on contributions to any or all of the following criteria:

- (a) Geotechnical project development and construction,
- (b) Research contributions in the geotechnical community,
- (c) Involvement in national and international geotechnical societies, and
- (d) Publications and education in the geotechnical discipline.

Candidates will be evaluated by the ISSMGE Awards Committee in collaboration with the ISSMGE Young Members Presidential Group (YMPG) and the finalists will then be recommended to the Board for final decision. In addition to this newly merged OYGEA, the other existing awards offered by the ISSMGE to its members include the:

1. Terzaghi Oration
2. Kevin Nash Gold Medal
3. Outstanding technical committee
4. Outstanding geotechnical project
5. Outstanding innovator (individual or team)
6. Outstanding member society
7. Outstanding paper in the International Journal of Geo-Engineering Case Histories
8. Outstanding public relation award

All the award recipients would be recognised at the quadrennial ICSMGE.

Report from New Zealand Geotechnical Society (NZGS)

NZGS Events 2013 - 2014

1. Member Society's report

NZGS Membership 1034

NZGS members with International Affiliations

Society	Members
IAEG	207
IAEG Student Rate	2
IAEGJrnl	158
IAEGJrnl Student Rate	2
ISRM	162
ISRM Student Rate	2
ISSMGE	600
ISSMGE Student Rate	7



NZGA Committee members (from left): Kevin Anderson, Tony Fairclough, Charlie Price (Vice-Chair), Ross Roberts (Co-editor Geomechanics News), Kelly Walker (Co-editor Geomechanics News), Ken Read, Frances Neeson (YGP Representative), David Burns (Immediate Past Chair), Amanda Blakey (Secretary), Gavin Alexander (Chair), Guy Cassidy (ANZ2015 Conference Chair)

2. Major Projects within NZGS

Development of formal guidance in earthquake geotechnical engineering, in collaborations with various other societies, research and government agencies. These are or will be freely available on our website. Our first module, on liquefaction, is currently being updated. Subsequent modules on foundation design, retaining walls, geotechnical investigation for liquefaction assessment and a specification for ground improvement for residential properties in Christchurch, are in production and are intended to be finalised by early 2015.

Report from New Zealand Geotechnical Society (NZGS) (Continued)

3. Conference Reports

The 19th NZGS Symposium: Hanging by a thread - Lifelines, infrastructure and natural disasters was held in Queenstown in November 2013. Three hundred delegates were treated to 100 presentations over the two days of technical sessions. We were fortunate to have keynote lectures by Dr Lelio Mejia and Professor Harry Poulos, alongside a wide range of presentations by local academics and practitioners. The symposium was preceded by a series of workshops, and followed by a selection of field trips. All who attended considered the symposium a great success.

4. Upcoming Conferences

- 5th International Conference on Earthquake Geotechnical Engineering (ISSMGE TC203), Christchurch, 2015
- 12th ANZ Conference on Geomechanics, Wellington, New Zealand, February 2015 (regional ISSMGE conference)

5. Hot News such as Webinars, Awards and Honours

15th Geomechanics Lecture

John Wood who is well known for his work on the seismic design of retaining walls, and for his work with Reinforced Earth structures. John will tour his lecture around New Zealand later this year (2014), culminating in a presentation at the ANZ 2015 Conference in Wellington.

NZGS Life Membership

Life Membership was awarded to Geoff Farquhar in 2014 for his outstanding contribution to the Society over many years.

Fellow of IPENZ (Institute of Professional Engineers NZ)

Ian McCahon was made a Fellow of IPENZ (2014). IPENZ Fellows are those that have made a substantial contribution to the development of the engineering profession, its practices or IPENZ itself.

Turner Award (IPENZ)

William Gray received the Turner Award which recognises a continuing contribution to the engineering profession as demonstrated by a commitment to the ideals of a self-regulation profession.

Companion of IPENZ (Institute of Professional Engineers NZ)

Ann Williams was made a companion of IPENZ (2014), an award bestowed on those whose qualification are not in engineering but have obtained a position of significant responsibility.

New Zealand Geotechnical Society Student Awards

The New Zealand Geotechnical Society Student Awards are presented to recognise and encourage student participation in the fields of geotechnical engineering and engineering geology.

2013 Recipients:

- Luke Storie - Soil foundation structure interaction in shallow foundation spring bed modelling. (First)
- Simon Farquhar [Co-author: Michael Jones] - Effect of vertical acceleration on liquefaction. (Second)
- Robert Boddington [Co-author: Charlie Wilkinson] - Rockfall probability of failure and hazards assessment in the Port Hills area. (Third)

Report from New Zealand Geotechnical Society (NZGS) (Continued)

2014 Young Geotechnical Professionals Conference Award

The 2014 Young Geotechnical Professionals Conference Award was awarded to 10 members of NZGS to assist them to attend the Young Geotechnical Professionals Conference. This year the YGP Conference is being held in Noosa, Australia.

Winners of the 2014 award:

- Emelia Belczyk
- Elby Tang
- Martin Barrientos
- David Bruxton
- Rebecca Ryder
- Frances Neeson
- Holly Le Heux
- Gemma Hayes
- Daniel Scott
- Mark Hill

2014 New Zealand Geotechnical Society Scholarship

The 2014 New Zealand Geotechnical Society Scholarship was awarded to two recipients:

- Maxim Millen for completion of PhD studies at Canterbury University on 'Integrated Performance-based Design of Building-Foundation Systems'.
- Kelly Robinson for completion of PhD studies at Canterbury University on the 'Study of Liquefaction-Induced Lateral Ground Displacements (Lateral Spreading) in the Christchurch Area following the 2010 Darfield and 2011 Christchurch Earthquakes'

The NZGS Management Committee has agreed to provide funding for a scholarship that would enable a member of the Society to undertake postgraduate research in New Zealand that would advance the objectives of the Society. Through this scholarship, the Society hopes to encourage members to enrol for post-graduate research or undertake research which would not otherwise be possible for them.

2014 Shamsheer Prakash Geotechnical Engineering Research Award

The 2014 Shamsheer Prakash Geotechnical Engineering Research Award was awarded to Dr Brendon Bradley from the University of Canterbury. This Award recognises international research leadership.

2013 Rutherford Discovery Fellowship

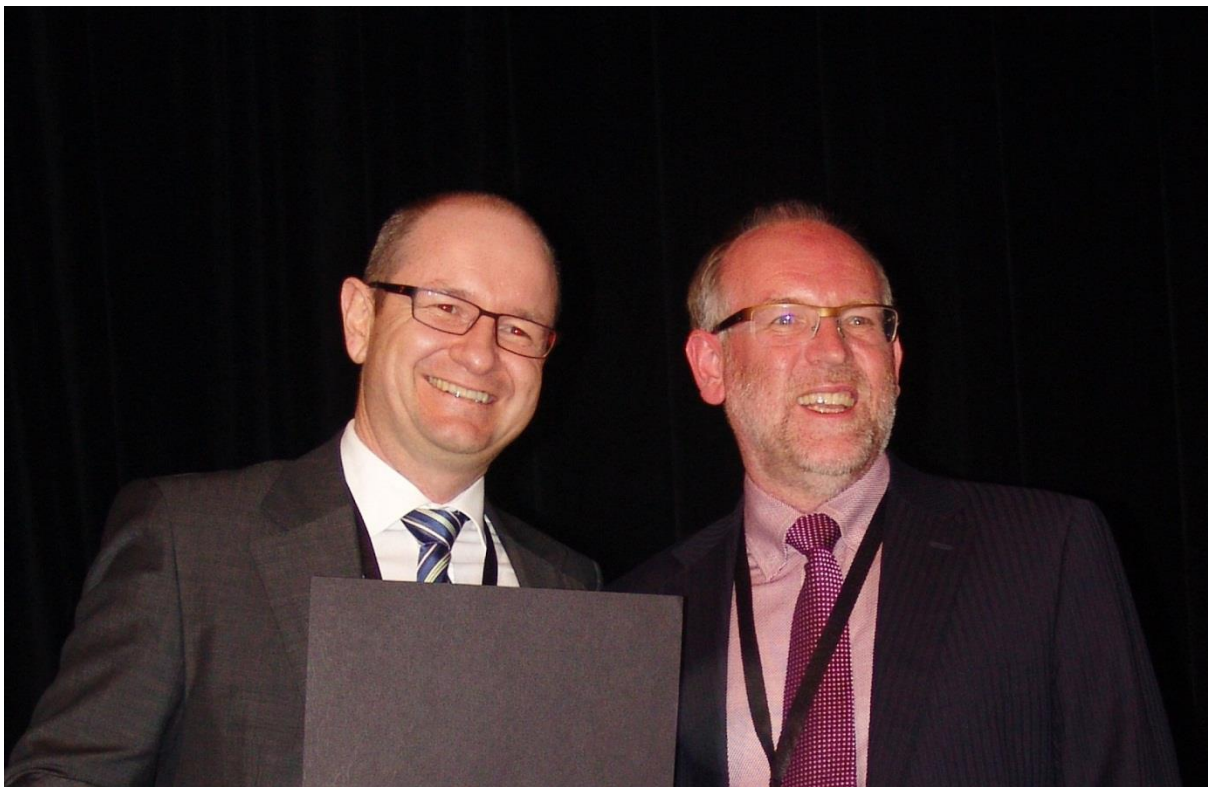
The Rutherford Discovery Fellowships support the development of future research leaders, and assist with the retention and repatriation of New Zealand's talented early- to mid- career researchers. It operates under the Terms of Reference issued by the Minister of Science and Innovation. This was awarded to Dr Brendon Bradley and provides \$800,000 funding over five years to further his research.

Brendon Bradley - background

Dr. Bradley has shown international research leadership in several emerging fields of earthquake engineering. His most notable research contributions are: (1) system-specific seismic loss assessment and methodologies for performance-based earthquake engineering, including numerous applications to soil-foundation-structure problems. (2) Empirical analysis of ground motion intensity, in particular, detailed analyses of the observed ground motions in the 2010-2011 Canterbury, New Zealand earthquakes; and (3) development and open-source implementation of the generalized conditional intensity measure (GCIM) approach for ground motion selection. Dr. Bradley's research (including over 65 journal papers) has been highly cited, and he has delivered several plenary and invited lectures at international conferences, particularly in relation to the 2010-2011 Canterbury earthquakes.

TC corner**TC106 – Unsaturated Soils****ISSMGE Technical Committee 106 on Unsaturated Soils
Technical Committee Report August 2014**

There has been “all-change” at the top of Technical Committee TC106 in 2014. Professor David Toll from Durham University, UK was elected as the new Chair and Associate Professor Adrian Russell of The University of New South Wales, Sydney, Australia was selected as the new Secretary. Professor Eduardo Alonso (Universitat Politècnica de Catalunya, Barcelona, Spain) and Professor Gerald Miller (University of Oklahoma, USA) stood down as Chair and Secretary respectively, having both completed two 4-year terms. We are very grateful to Eduardo and Jerry for their excellent service, ensuring TC106 has been well managed and successful in its outcomes over the last 8 years.



The new top team: Adrian Russell (left) and David Toll (right)

David Toll and Adrian Russell have both made significant contributions to TC106 and ISSMGE before taking on these leading roles.

David Toll has been a member of TC106 since 1999. He was an organiser of the 1st Asian Conference on Unsaturated Soils in Singapore in 2000 and the 1st European Conference on Unsaturated Soils in Durham, UK in 2008. He has been a General Reporter at the ICSMGE in Alexandria, 2009 and the ECSMGE in Athens, 2011. He is Chair of the Scientific Committee and a member of the Organising Committee for the ECSMGE to be held in Edinburgh, 2015.

Adrian Russell has been chair of the awards sub-committee of TC106 and was himself the winner of the TC106 Innovation Award in 2014.

TC corner**TC106 – Unsaturated Soils (Continued)**

TC106 continues to be a highly active Technical Committee, having just organized its 6th International Conference on Unsaturated Soils in Sydney in July 2014 (see conference report in the ISSMGE August bulletin). In addition to the international conference, held every 4 years, the TC also has strong regional conference series. The Asia-Pacific series was launched in 2000 in Singapore; the European series in Durham, UK in 2008; the Pan-American series in Cartagena de Indias, Columbia in 2013. The full list is given below:

- 1st International Conference (UNSAT 95), Paris, France, 1995
- 2nd International Conference (UNSAT 98), Beijing, China, 1998
- 1st Asian Conference (UNSAT-ASIA 2000), Singapore, 2000
- 3rd International Conference (UNSAT 2002), Recife, Brazil, 2002
- 2nd Asian Conference (UNSAT-ASIA 2003), Osaka, Japan, 2003
- 4th International Conference (UNSAT 2006), Carefree, Arizona, USA, 2006
- 3rd Asian Conference (UNSAT-ASIA 2007), Nanjing, China, 2007
- 1st European Conference (E-UNSAT 2008), Durham, UK, 2008
- 4th Asia Pacific Conference (AP-UNSAT 2009), Newcastle, Australia, 2009
- 5th International Conference (UNSAT 2010), Barcelona, Spain, 2010
- 5th Asia Pacific Conference (AP-UNSAT 2011), Pattaya, Thailand, 2012
- 2nd European Conference (E-UNSAT 2012), Napoli, Italy, 2012
- 1st Pan-American Conference (Pan-Am UNSAT 2013), Cartagena de Indias, Columbia, 2013
- 6th International Conference (UNSAT 2014), Sydney, Australia, 2014

The next International Conference on Unsaturated Soils will be held in Hong Kong in 2018, chaired by Professor Charles Ng of Hong Kong University of Science and Technology.

In 2014 TC106 has instituted a series of awards: A Distinguished Lecture (named in honour of the late Professor Geoffrey E. Blight, a great engineer, pioneer and scholar, who passed away in 2013); three International Awards for Best Journal Papers by Early Career Researchers and an International Innovation Award. It was wonderful to honour the award winners at the 6th International Conference on Unsaturated Soils in Sydney in July 2014 and celebrate the excellence in research and practice that characterises this very active and forward-looking discipline of soil mechanics and geotechnical engineering.

Young Members' Arena

Geothermal Energy for Heating and Cooling: Full-Scale Testing and Numerical Modelling

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About the Young Member

Dr G. Narsilio is a young member of ISSMGE and first recipient of the society's Outstanding Young Geotechnical Engineer Award, presented in 2013 during the 18th ICSMGE in Paris. He is joined with Prof I. Johnston for this paper, who is a Senior member and recipient of the latest John Jaeger Award for his career. Throughout his career, Guillermo has surrounded himself with great, more experienced, mentors and collaborators, including Prof V. Rinaldi, Prof C. Santamarina, Prof D. Smith and Prof I. Johnston, bringing new dimensions and directions to his work. On the geothermal theme, his partnership with Ian, who is well known and respected particularly in Australasia by both Industry and Academia, has opened up a number of doors with industry partners and Government who know and trust him, facilitating Guillermo's insertion into the local environment more quickly. Synergies of experiences, ideas, individual strengths and personalities have allowed the pursuit of fascinating work for the benefit of the profession and society as a whole.

Abstract

Ground-source heat pump (GSHP) systems efficiently heat and cool buildings using sustainable geothermal energy accessed via ground heat exchangers (GHEs). In closed loop systems, GHEs comprise pipes embedded in specifically drilled boreholes or trenches or even built into foundations, all within a few tens of metres from the surface. In the State of Victoria in Australia, more than 85% of the electricity is generated from brown coal. Thus, given that GSHP systems operate at a coefficient of performance of about 4, the substitution of commonly used electrical heating and cooling systems with geothermal systems could significantly reduce energy consumption and greenhouse gas emissions. This short article provides an overview of direct geothermal energy research and demonstration projects undertaken by the University of Melbourne in Victoria and the parallel development of numerical models based on first principles. Implemented using finite element methods, the models enable detailed studies of GHEs. The 3D heat transfer process in short and long timescales can thus be investigated in detail to optimise the thermal performance of GHEs, and adapt design to local weather and ground conditions.

Keywords: Geothermal; Numerical Modelling; Ground Heat Exchanger; Design; Sustainability

1 Direct geothermal systems

The rate of growth of the human population and associated annual per capita energy consumption has been exponential ever since the industrial revolution (Glassley, 2010). Finding renewable energy sources with low greenhouse gas emissions has become imperative to help mitigating the environmental impacts of an ever-growing human presence on the planet. Geothermal energy is a versatile and near inexhaustible resource capable of satisfying these needs. Geothermal energy can be used for the provision of heating, ventilation and air conditioning (HVAC) to residential, commercial and industrial buildings as well as for power generation (Glassley, 2010, Johnston *et al.*, 2011).

Young Members' Arena

Geothermal Energy for Heating and Cooling: Full-Scale Testing and Numerical Modelling (Continued)

Outside the volcanic regions of the world where it is readily available near the ground surface, geothermal energy can be accessed in two ways. One *indirect* form involves heat extracted using a fluid from boreholes drilled to several kilometres below the surface, where temperatures exceed 175°C, to generate electricity with turbines. This source of power has enormous potential, but is still not producing electricity on a commercial scale. The other is the *direct* form, which is well established in parts of the world, but not yet widespread despite its relative simplicity.

Direct geothermal energy systems use the ground within a few tens of metres of the surface as a heat source in winter and a heat sink in summer for heating and cooling buildings using ground-source heat pumps (GSHPs) (Figure 1). The GSHP systems can be designed to operate with open or closed ground heat exchangers (GHEs) and typically achieve higher energy efficiencies than conventional heating and cooling systems (Amatya *et al.*, 2012, Banks, 2012, Brandl, 2006, Johnston *et al.*, 2011, Lee *et al.*, 2012, Preene and Powrie, 2009, Stein and Meier, 1997). In closed loop GSHP systems, GHEs are typically placed vertically or horizontally in a variety of ways, including in foundations. In winter, the GSHP extracts heat from water (or other carrier fluid) circulating in the GHEs, upgrades the heat, and delivers it to the building or industrial process that requires heat. The cooled fluid is reinjected into the ground loops to heat up again and complete the cycle. In summer, the reverse happens with the GSHP extracting excess heat from the building and rejecting it to the ground. Within the first couple of hundred metres below the ground surface, the ground temperature is relatively constant and is initially close to the local mean atmospheric temperature. Thus, the ground tends to be warmer than the atmosphere during winter and cooler during summer. Consequently, the heat exchange process is achieved very efficiently due to this year-round narrow temperature range of the ground. GSHPs require energy input to their compressor and the pumps that circulate fluid within the GHEs to move heat around the system. However, the energy input required is typically small compared to the heat output: GSHPs typically produce around 3.5-5.5 kW of thermal energy for every 1 kW of electricity used. The ratio of these values defines a “coefficient of performance” or COP. Overall GSHP COPs are higher than COPs of air-source heat pumps.

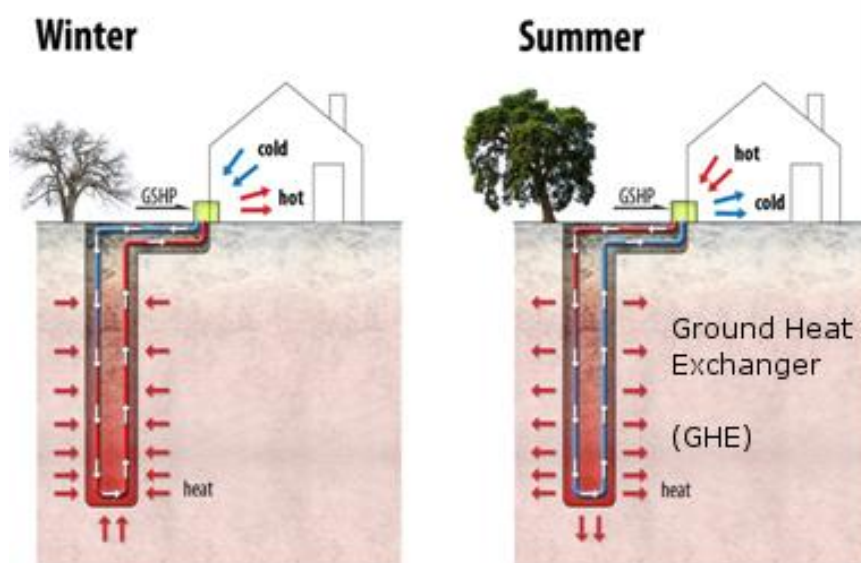


Figure 1. A schematic direct geothermal energy system in heating (winter) and cooling (summer) modes

Young Members' Arena

Geothermal Energy for Heating and Cooling: Full-Scale Testing and Numerical Modelling (Continued)

2 Research and demonstration projects for Victoria (Australia)

Under the Sustainable Energy Pilot Demonstration (SEPD) Program funded by the State Government, The University of Melbourne and its partners are collecting data on the performance of direct geothermal systems for a range of different conditions, such as geology, climate, ground loop and borehole geometry, encountered in Victoria (Australia), with focus on the “below-ground” components, the GHEs. Some new and retrofit buildings have been selected to cover a range of conditions typically encountered. While most of the buildings are residential, some other types of construction are also included. These will provide important data with respect to the overall physical performance of direct geothermal systems from a range of building types and the associated capital and operating costs along with the socio-economic energy demands of a range of buildings and the characteristics of their pattern of use by the occupiers. The program has been running for 2 years. At this point in time, there are around 18 properties which have their geothermal systems monitored, as shown in Figure 2. There are many other individuals who have indicated their willing participation across Victoria. This includes several homes, both new and retrofit with various geothermal systems: horizontal, vertical and even closed loops in a dam. It is expected to have approximately 30 monitored GSHP systems by the end of 2014. It is envisaged that the monitoring will continue for at least another 2 years. Aside from these temperate climate sites, collaborations with UK (Cambridge, Southampton), USA (Californian at San Diego) and Korea (Korea U., KAIST) will bring experimental data from sites of different climates.

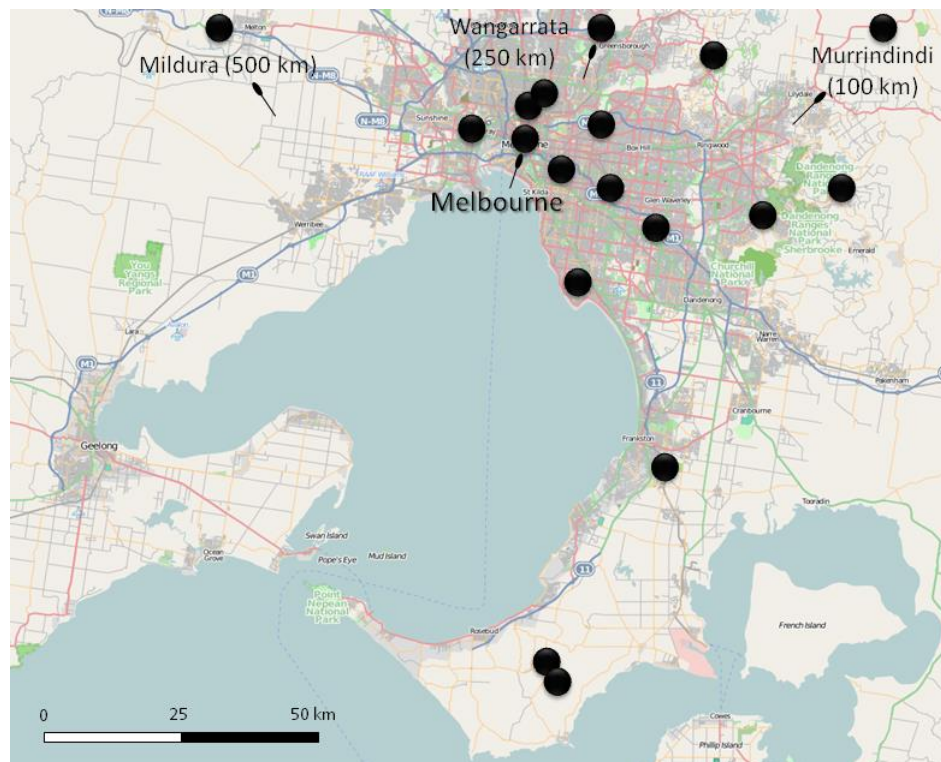


Figure 2. Map of Melbourne and surroundings (Victoria, Australia) showing locations (solid circles) where individual full scale geothermal projects are being instrumented and monitored to date (September 2014)

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Geothermal Energy for Heating and Cooling: Full-Scale Testing and Numerical Modelling (Continued)

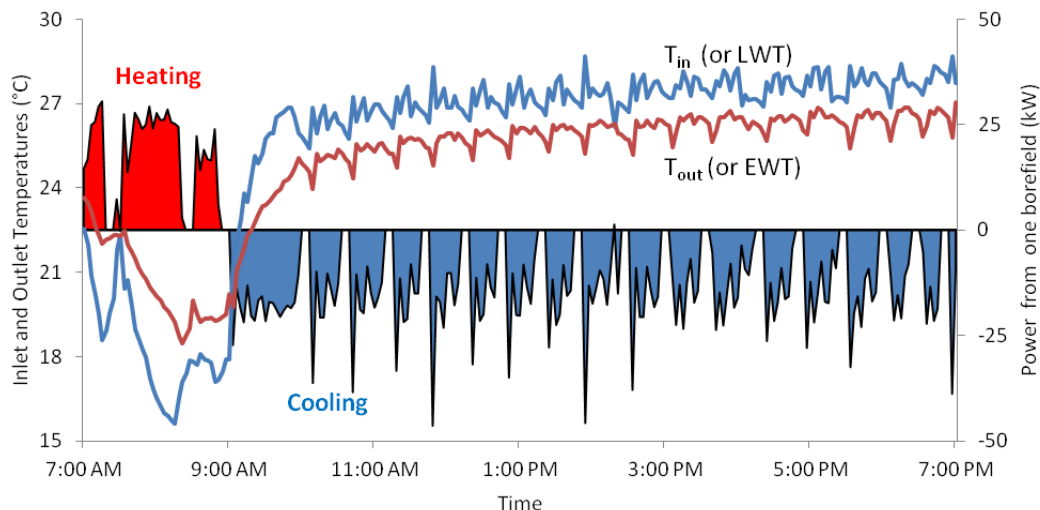


Figure 3. Some typical data retrieved from the Parkville, VIC (Australia) vertical GHE system at the Elizabeth Blackburn School of Sciences (25 March 2014 data shown)

These current multi-instrumented field facilities are unique in Australia and, overall, believed to be the largest field instrumented exercise in direct geothermal research in the world. The analysis of these experimental data will be used to advance design guidelines for GHEs.

As an example, typical data retrieved from one of four borefields, with 7 double U-loop GHEs, 50 m deep, at the Elizabeth Blackburn School of Sciences is shown in Figure 3. The difference between the water temperature going into the ground T_{in} (or LWT) and the water temperature coming back from the borefield T_{out} (or EWT) indicates the thermal energy exchanged with the ground. About 27 kW of heating and 25 kW of cooling on average were obtained from the ground at a flow rate of approximately 120 L/min (i.e., 8.6 L/min per U-shaped loop). Heating-cooling swing prompts a short-term thermal recharge of the ground around the GHEs. Further details about the program can be found elsewhere (Johnston *et al.*, 2014, Mikhaylova *et al.*, 2015, Narsilio *et al.*, 2014b).

3 Detailed numerical modelling of Ground Heat Exchangers

In parallel with the comprehensive full scale testing and monitoring program briefly described above, a detailed numerical model of GHEs, which includes arbitrary geometry and placement of pipes, has been developed based on the fundamental principles of fluid flow fully coupled with heat transfer mechanisms (Bidarmaghzi, 2014, Narsilio *et al.*, 2014a). The model is flexible enough to accommodate traditional and alternative GHE configurations and geometries, realistic ground conditions in terms of layering and time-varying temperature fluctuations.

Heat transfer around and in the GHEs is modelled primarily by conduction and convection. In the absence of groundwater flow, heat conduction occurs in the ground, GHE backfilling material (concrete or grout) and pipe wall, and partially in the carrier fluid; while heat convection dominates in the carrier fluid circulating in the pipes in closed loop systems. The governing equations for fluid flow and heat transfer are coupled numerically within the finite element package COMSOL Multiphysics to evaluate the performance of the GHEs.

Young Members' Arena

Geothermal Energy for Heating and Cooling: Full-Scale Testing and Numerical Modelling (Continued)

The fluid flow in the pipes is modelled by the Navier-Stokes equations (NS) in the laminar regime and by the Reynolds-averaged Navier-Stokes equations (RANS) in the transitional and turbulent regimes (a $k-\epsilon$ turbulent type model) to save computational time. The velocity field $\mathbf{v}$ in m/s, found by solving these fluid flow governing equations is coupled with a generalised Fourier governing equation for heat transfer. It is also possible to model the 3D incompressible fluid flow and heat transfer in the pipes by using 1D elements, instead of full 3D, to further save computational efforts. To solve this system of equations, appropriate initial and boundary conditions must be provided (e.g., initial ground (and GHE) temperature, time dependent carrier fluid temperature, time dependent GHE thermal load, fluid flow rate, etc.).

This model has been recently validated against a few available analytical solutions and full scale experimental data from the above program. As an example, Figure 4 depicts numerical results obtained from the modelling superimposed to data from a heat pump test with realistic operations (designated as HPT18) (Bidarmaghzi, 2014, Colls *et al.*, 2015, Narsilio *et al.*, 2014a). The agreement between the full scale experimental data and the numerical modelling, in terms of the average fluid temperature between inlet and outlet of the GHE, is remarkable.

A number of studies can be conducted with this model. For example, the total length of pipe in GHEs calculated following the IGHPA guidelines (IGHPA, 2011) could be implemented in either a larger number of GHEs but shallower in depth or fewer at deeper depths. Drilling of a shallower borehole is usually simpler and cheaper than a deeper one. Figure 5 shows some of the numerical results for such an example, with 0.6 m diameter energy pile GHEs with three 25 mm diameter U-loops and turbulent fluid flow (~ 11 L/min at each loop) and pile length (L_{GHE}) of 30, 100 and 200m. The carrier fluid temperature at the inlet is kept constant at 2°C for simplicity.

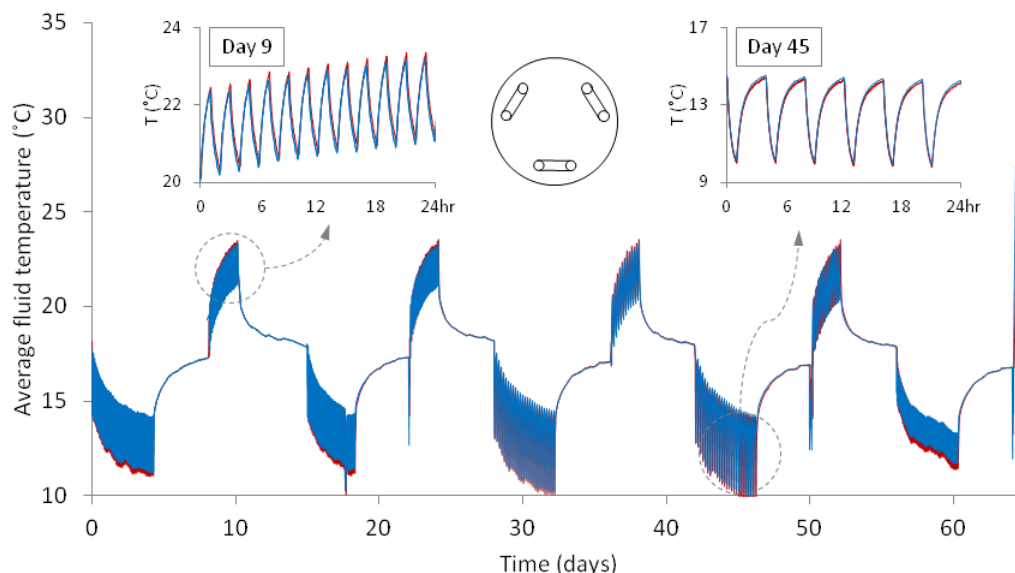


Figure 4. Example of model validation with a pile GHE containing three U-loops

Numerical results reveal that even though the overall power (W) gained by the longer GHE is higher due to achieving a significantly higher fluid temperature at the outlet of the pipe, shallower GHEs show higher heat exchange rate (q)(W/m). This result suggests that shallower GHEs are more thermally efficient than fewer deeper GHEs for the same total length of GHE.

Young Members' Arena

Geothermal Energy for Heating and Cooling: Full-Scale Testing and Numerical Modelling (Continued)

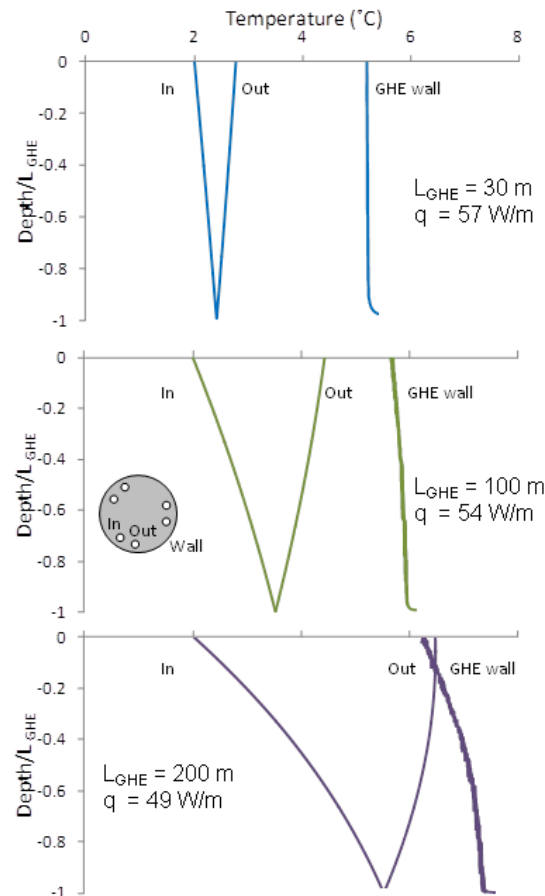


Figure 5. Example application: effect of GHE depth on thermal performance

4 Summary and Conclusion

Direct geothermal energy is becoming an important sustainable, economic and highly effective technology for heating and cooling buildings, and the design of the most costly component, the GHEs, can be improved through better understanding of their (thermal) behaviour. The geotechnical engineering profession is well to do this.

While the technologies associated with the “above-ground” components of these geothermal systems are relatively well developed, current GHE design methods are comparatively crude with clear indications that systems are often significantly overdesigned. Thus, these “below-ground” components of GSHP systems represent the best opportunity to reduce costs. An increasing number of geotechnical groups around the world have commenced various projects to demonstrate the effectiveness of the technology for a range of different conditions and to develop more effective guidelines for the design and operation of GHEs.

Acknowledgement

Support to these projects is provided by the Sustainable Energy Pilot Demonstration (SEPD) Program (Government of Victoria), the Melbourne Energy Institute, Geotechnical Engineering Pty Ltd, Golder Associates Pty Ltd and the Australian Research Council.

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Geothermal Energy for Heating and Cooling: Full-Scale Testing and Numerical Modelling (Continued)

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Major Project

Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall

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ABSTRACT

This paper presents the design approach, methods of analysis, material testing and construction of a Cement Stabilised-Shored reinforced soil wall (RSW) for Hills M2 Upgrade project in Sydney, NSW. Particular attention was given to the deformation modulus of the backfill material and stress conditions within the RSW that could promote cracking.

1 Introduction

The NSW Government announced the approval of the Hills M2 Upgrade on Tuesday, 26 October 2010. The Hills M2 Upgrade widens the existing motorway generally between Windsor Road, Baulkham Hills and Lane Cove Road, North Ryde including delivery of four new ramps to improve access to the motorway.

The Hills M2 Motorway plays a key role in Sydney's Orbital network linking the north west region to the lower north shore and Sydney's CBD. It is a key road freight and commuter route and connects the major employment hubs of Macquarie Park and Norwest Business Park. Construction began in January 2011 and is completion is estimated for early August 2013.

Due to site constraints (e.g. existing sedimentation basins, driveways, boundary restrictions etc.), there were a number of locations throughout the Hills M2 Upgrade project alignment where limited space was available for the extension of the existing relatively high retaining walls which, in most cases, were reinforced soil walls (RSW).

Construction of RSWs is often the preferred retention solution in road works as it involves a fill strengthening process that is considered very cost effective. The current industry practice typically adopts a minimum RSW reinforcement length (L) equivalent to approximately seventy percent of the design height (H) of the wall, i.e. $L = 0.7H$. However, at some locations along the Hills M2 Motorway, the use of conventional RSWs was not feasible as the available space was limited to only $0.3H$ to $0.5H$. In addition, the transfer or application of new loads to the existing Hills M2 RSWs was considered to be of high risk as movement of these RSWs had been observed under current loading.

Constructability issues were also identified in relation to the other solutions. For instance, one of the concept designs considered a hybrid retaining wall where the upper section of the wall consisted of a RSW limited to 8 m in height and a lower section comprising anchored precast panels. The total height of this hybrid wall was limited to 17 m. The limited available width resulted in anchors inclined at 45° or steeper in order to avoid cutting the geosynthetic reinforcement within the existing RSWs which had web type layout (Paraweb). As a result of the steep anchor inclination a structural facing would be required to accommodate the large vertical loads applied by the anchors, comprising precast concrete columns with plan dimensions of 1.2 m x 1.0 m and spaced at 3 m centres. It was also initially anticipated that the lower layers of steel reinforcement within the proposed upper RSW would be connected to the facing panels of the existing RSWs. However, during Detailed Design phase (DD), the design team raised concerns about the integrity of the existing RSW as significant movement of these RSWs had been observed. In addition, the construction team also identified difficulties in relation to the installation of the proposed steeply inclined anchors.

As a result, an alternative solution was required and a design procedure was developed that could consider the stabilising effect of the existing RSW with regard to the reduction of lateral loads acting on the new RSW. Under such conditions, Berg *et al.* (2009) presented two design approaches for RSW:

Major Project

Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

- i) Shored Mechanically Stabilised Earth (SMSE) walls when excavation and shoring in steep terrains would be required to establish a flat bench to accommodate the soil reinforcements with a minimum length greater than 2.5 m or 70% of the height of the wall. In this case, shorter reinforcements are possible if the shoring system is accounted for (Figure 1).
- ii) Stable Feature Mechanically Stabilised Earth (SFMSE) walls for new walls built in front of apparently stable features such as a rock face.

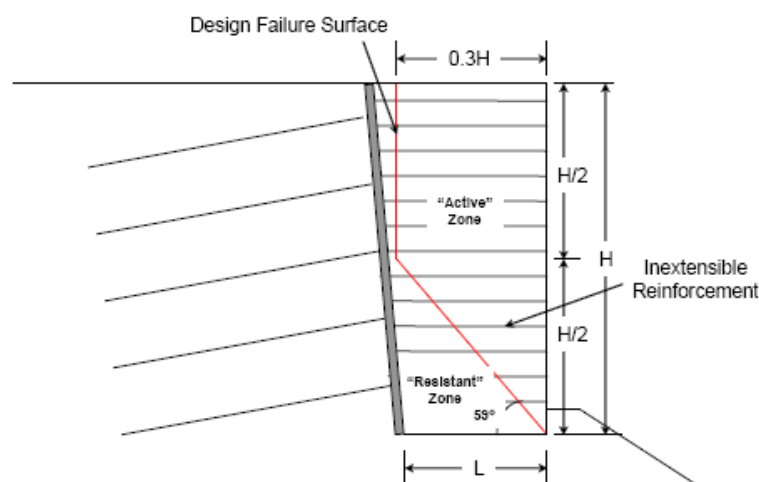


Figure 1. Sketch of a shored RSW (or SMSE) with inextensible reinforcements (after Berg *et al.*, 2009)

The above concept of Shored RSWs, with ratios as low as $0.3H$, was considered an attractive solution. However, this method was developed for low volume roads and not originally recommended in urban areas for roadway widening applications. The main reason is the relatively high risk for tension cracks at the interface between the existing wall and the new RSW under dynamic effects of traffic loading, referred to as a trenching mechanism. In addition, the design approach was mainly developed for static load conditions or in areas where the seismic horizontal accelerations at the foundation level are less than $0.05g$.

In order to reduce the risk of traffic loading induced tension cracks between the new and existing walls and for seismic horizontal accelerations greater than $0.05g$, an alternative shored RSW with cement stabilised backfill (CS-SRSW) was investigated and a new design procedure developed. The initial intent of the design was to use site-won crushed sandstone stabilised with cement as backfill material. Particular attention was given to the deformation modulus of the stabilised backfill material and stress conditions within the RSW that could promote cracking.

2 Design procedures and analysis method

The use of cement stabilised soil walls is not a new approach in geotechnical engineering. For example, as part of the original Hills M2 project, cement stabilised sandstone was used to form a gravity retaining wall up to 22 m high between Pennant Hills Road and Oakes Road (Chandler and Palmer, 1999). Another Australian example of the performance of a retaining wall with cement stabilised soil is presented by Ismail (2005). However, the key differentiator and innovation of the current application is perhaps the slenderness of the designed walls, with width to height ratios of less than 0.4, and the combination with soil reinforcement techniques. Several challenges, as described below had to be overcome before acceptance of this innovative design.

Major Project

Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

Perhaps, the first question to be addressed by the design approach is the assumed behaviour of the wall: flexible or rigid-monolithic? Conventional RSW are considered to be flexible, which would be even more pronounced at $L/H < 0.4$. However, the cement stabilisation will play a role in the deformational behaviour of the backfill, and, in fact, that was the main objective of the stabilisation, i.e. to address the “trenching mechanism” of the original SMSE concept.

As a starting point it was considered that the CS-SRSW could behave as a monolithic gravity wall due to the relatively high modulus of elasticity ($E > 1000$ MPa) targeted for the stabilised fill even at low cement content (4% to 5%). This assumption was also based on similarities with the design of retaining walls with cement stabilized soil and RSW concrete panels as reported by Derek and Crockford (1991). In their design, the main objective of the reinforcement was to hold up the concrete panels, therefore enabling the use of shorter reinforcement length than typical RSW as it was not considered for internal stability. Derek and Crockford (1991) study included numerical analyses, physical modelling by centrifuge testing and a full scale of trial wall up to 7 m high and 200 m long.

Despite the assumption of a rigid-monolithic behaviour, cracking of the stabilised material was a concern during the design phase. In order to reduce the potential for cracking initiation under design loading conditions, the design procedure aimed to control the stresses within the stabilised soil mass to within the lower range of the elastic behaviour of the stabilised material. This was initially based on the concept of cracking initiation of intact rock samples in laboratory testing. In addition, according to DoT (1986), if a cemented material is subjected to repetitive (dynamic) loading within its elastic range and is not loaded beyond the stress at which microcracking begins, then the material will likely remain intact for an indefinite period. It is also stated in DoT (1986) that, based on laboratory tests on cement stabilised materials, microcracking apparently only initiates for stresses beyond approximately 35% of the unconfined compressive strength (UCS) of the material. Cracking due to drying shrinkage and thermal effects were also considered limited due to both low cement content and low water content for the stabilised material, with cement contents targeted at 4% to 5%.

However, it was also recognised that there could still be potential for cracking to occur in the long term, particularly if associated with material degradation and changes in moisture content and considering an intentional conservative approach. As a result, a second design approach was considered where the cement stabilised mass was assumed to be fully cracked, thus, behaving like a blocky medium with more similarities to a flexible RSW where the soil reinforcement plays a more significant role.

For both approaches discussed above, the following loading conditions were assumed: (a) live (traffic) load of 20 kPa acting on the wall; (b) horizontal seismic acceleration coefficient $k_h = 0.14$; (c) vertical seismic acceleration coefficient $k_v = 0.07$; and (d) maximum impact load $I = 17$ kN/m on the traffic barrier located on top of the CS-SRSW.

A minimum factor of safety (FS) of 2 under static loading and a FS of 1.2 under seismic loading were targeted for all mechanisms under analyses, except for bearing capacity where a minimum FS of 3.0 was targeted. In general, the proposed CS-SRSWs were to be constructed on a concrete platform founded on Class IV Sandstone (rock class as defined by Pells et al, 1998) or better.

2.1 Cement stabilised backfill substance parameters

During the design stage and before any laboratory test had been carried out, a cement content between 4% and 5% was assumed for the stabilised material. This value was based on the results reported by Chandler and Palmer (1999) which showed UCS values of 4.3 to 8.4 MPa for cored samples taken during construction of the cement stabilised wall of the original Hills M2 construction with a cement content of 4.5%. Chandler and Palmer (1999) also reported UCS values of 3 MPa for laboratory results on samples compacted at 98% of the standard maximum dry density within $\pm 2\%$ of the optimum moisture content.

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Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

Based on the testing of different soil types, DoT (1986) demonstrated that for well graded sands and gravel UCS values above 3 MPa could in general be achieved with cement contents in the vicinity of 5% (Figure 2).

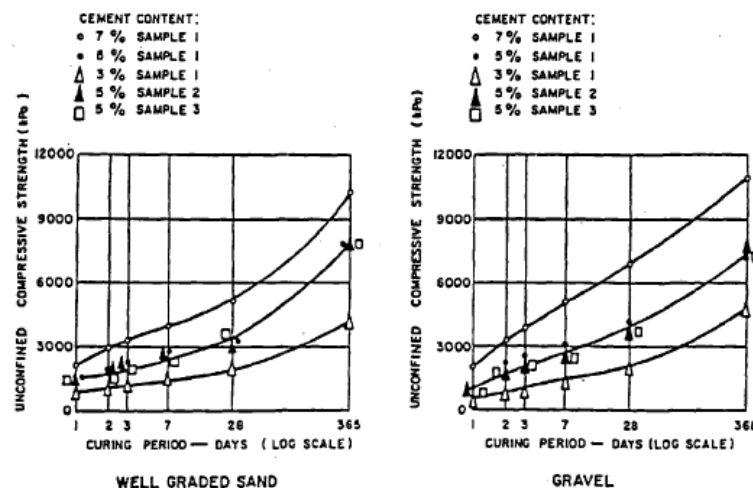


Figure 2. Strength variation with time for cement stabilised well graded sands and gravel (DoT, 1986)

The particle size distribution of the crushed sandstone samples from the Hills M2 Upgrade project indicated low fines content and gravel characteristics for all samples. As a result, an UCS value of 3 MPa was considered appropriate and achievable for the cement stabilised material for the current design.

As discussed above, an important behaviour anticipated for the stabilised material was a relatively high stiffness. In the absence of test data, the Young's modulus of the cement stabilised material was estimated based on the UCS of the material according to AS 5100.5 - Bridge Design (Part 5: Concrete) by:

$$E = 0.043\rho^{1.5}\sqrt{f_{cm}} \quad (1)$$

where ρ is the material density (kg/m³) and f_{cm} is the UCS (MPa) of the material

The estimated Young's modulus for the cement stabilised material was approximately 6600 MPa. Although this value is typical for Roller Compacted Concrete (RCC) and later field core samples gave similar moduli, this equation was considered to give somewhat high values. In addition, even if this estimate was assumed reasonable it only provides estimates for the substance modulus that does not take into account fractures or discontinuities so it would still have to be downgraded.

Indraratna (1990) stated that a "synthetic rock" will simulate real rock behaviour if the Poisson's ratio, friction angle and uniaxial strength ratio, σ_c/σ_t (i.e. compressive/tensile strength) are similar. As a result, it was assumed that the cement stabilised sandstone would present similar behaviour to that of a weathered sandstone rock. An alternative approach, based on rock mechanics correlations was then adopted (Deere, 1968):

$$E = MR \times UCS \quad (2)$$

where MR is the modulus ratio, typically varying from 200 to 1000 and UCS is uniaxial compressive strength (MPa). A modulus ratio MR of 350, typical for sandstone, was adopted for the cement stabilised material which is somewhat lower than the value adopted by Chandler and Palmer (1999) for the existing Hills M2 cement stabilised wall. The adopted modulus ratio seems to yield consistent values with those obtained by Derek and Crockford (1991) of up to 875 MPa for a cement stabilised sand with 7% cement content.

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Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

The adopted geotechnical design parameters are presented in Table 1. Considering the same select fill material as that used in conventional RSWs, a minimum friction angle of 34° was assumed for the cement stabilised sandstone. The value of peak cohesion was then back-calculated from both friction angle and UCS values. A residual cohesion of 10% of the peak value was adopted to simulate a softening behaviour due to cracking. In addition, low bound values were also considered to assess the impact of potential mixing problems during construction and which, to some degree, gave strength parameters closer to the blocky medium approach. The adopted low bound parameters were similar to a sandstone Class IV type rock with a Geological Strength Index (GSI) of 45, if the fractures are taken into account in the failure criterion as an equivalent continuum using a Generalised Hoek-Brown material model (Marinos and Hoek, 2000).

Table 1. Design parameters adopted for the cement stabilised sandstone (monolithic approach).

Range	UCS (MPa)	E (MPa)	Poisson ratio	Friction angle (degrees)	Peak cohesion (MPa)	Residual cohesion (MPa)	Tensile strength (MPa)
Characteristic	3	1000	0.25	34	0.80	0.08	0.1
Low bound	1	350	0.25	34	0.25	0.08	0.1

2.2 Effects of existing RSW on new wall

As the main objective of the CS-SRSW design is to consider the stabilising effects of the existing walls with regard to reduction of lateral loads acting on the new wall. The design approach presented by Berg *et al.* (2009) assumes that no load is transferred from the existing shoring system to the new wall. To adopt such an assumption, the geotechnical capacity of the existing RSWs on the Hill M2 Upgrade was checked under their current loading (as no additional loads would be imposed by the new walls) for their "as-built" condition based on available designs drawings.

However, the polyester-polyethylene based geosynthetic soil reinforcement (Paraweb) of the existing RSW is known to exhibit some creep behaviour, and the movement restriction imposed by the new wall could result in the new wall being loaded by the existing wall if the Paraweb straps continue to creep over time. Maccaferri (2009) presented a number of typical isochronous creep curves for the Paraweb reinforcement varying from 1 hour loading up to 120 years (temperature based extrapolation). The relevant curves for the design are presented in Figure 3a. As one would expect, the creep behaviour is dependent on the current level of applied load and larger creep extension is observed for loadings approaching the reinforcement tensile capacity.

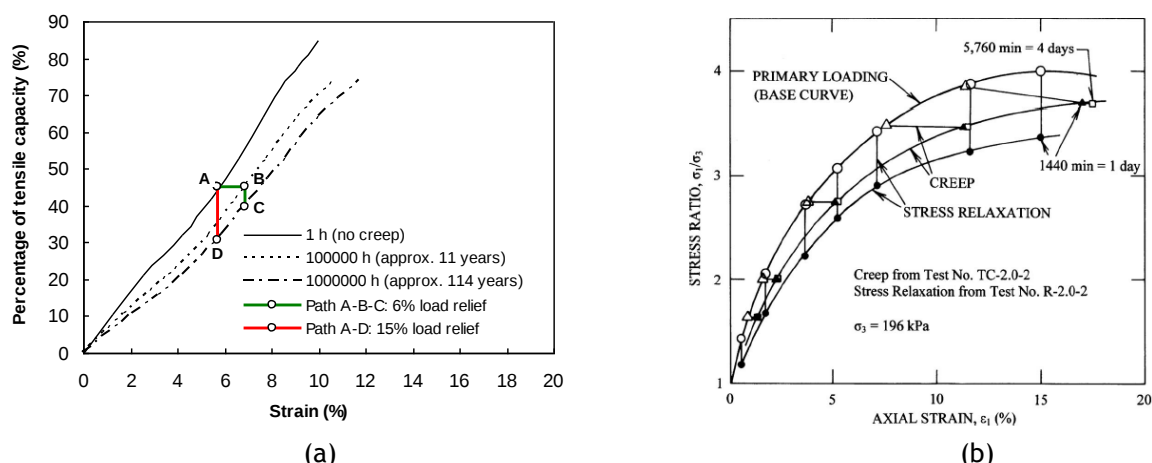


Figure 3. (a) Paraweb creep isochronous curves and load transfer approaches (modified from Maccaferri, 2009) (b) Time dependent behaviour - creep and stress relaxation - of a sand in triaxial compression (after Karimpour and Lade, 2010)

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As the existing RSWs were constructed some 13 years ago, it would be reasonable to expect that a large proportion of the wall movement due to creep effects would have already occurred, particularly given the logarithmic time scale creep behaviour. This is in fact observed in Figure 3a where the horizontal distance between the 1 h curve and the 11 years curve is, at any stress level, significantly larger than that between 11 years and 114 years. In addition, a compressible infill material was recommended at the interface between the existing RSW and the new wall, thus, negligible pressure would be expected to be transferred to the new wall. Nevertheless the effect of creep was further assessed and considered in the design.

Detailed assessment of time-dependent behaviour associated with creep typically requires a reasonable modelling effort in geotechnical analyses. As a result, a simplified but conservative approach was adopted for the design. It is understood that creep is the development of time-dependent shear and/or volumetric strains that proceed at a rate controlled by the viscous-like resistance of the material structure. If a tensile load applied to the soil reinforcement is kept constant, the structure of the polyester-polyethylene material will likely rearrange which causes additional elongation, and wall deformation, for an unrestrained RSW face. In contrast, if the strain or elongation is kept constant, i.e. restrained from further displacement, at a particular stress, the rearrangement of the reinforcement structure promotes a decrease in the tensile load. This phenomenon is called stress relaxation. Both these time-dependent phenomena are also observed in granular materials. In sands these phenomena are associated with particle breakage and in clays with particle rearrangement. For example, Karimpour and Lade (2010) present an example of stress strain curves generated for both creep and stress relaxation behaviour of a sand under triaxial compression (Figure 3b). The sub-horizontal lines from the primary loading curve represent creep and the sub-vertical stress relaxation.

With the above mechanisms in mind, all geosynthetic reinforcement layers were conservatively assumed to be loaded to their design strength, independent of the actual mobilised tensile load, which corresponds to 45% of the ultimate capacity after all reduction factors are applied (installation damage, creep etc.). If the reinforcement is allowed to deform for approximately 11 years (time elapsed since construction of the original Hills M2 RSWs), the stress-strain state of the reinforcement would follow the path A-B as depicted in Figure 3a. Assuming that the new wall could behave in a fully rigid manner, i.e. not allowing lateral deformation or movement, any additional elongation of the reinforcement would be restricted, thus promoting the stress relaxation path B-C for the next 103 years in Figure 3a. This indicates that the new wall would have to sustain a load of approximately 6% of the ultimate capacity of the reinforcement, i.e. the difference in percentage of tensile capacity from B to C, without deforming. In theory, the new wall would also deform under these new loads, thus the path B-C would not be vertical but inclined downwards which would result in a lower load value being transferred. A similar assessment could be made if one assumes that no creep occurred in the first 11 years and the new wall is then positioned in front of the existing RSW. In this case a 15% load relief is estimated after 114 years, i.e. path A-D in Figure 3a. Given the uncertainties on creep behaviour, this higher load relief value was adopted, which generally resulted in approximately 20% of the active earth pressure acting on the existing wall face transferred to the back of the new wall.

2.3 Gravity Wall - Monolithic approach

Limit equilibrium analyses were adopted to assess the stability of the proposed CS-SRSW under traffic and impact loading as well as under a pseudo-static earthquake loading condition. The following conventional mechanisms were investigated:

- Sliding
- Overturning
- Bearing capacity
- Internal stability
- Eccentricity

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Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

It is important to note that, even for a conventional RSW the above mechanisms would be investigated. However, in the current monolithic approach the focus is on the behaviour of the wall without considering the effect of the reinforcement or at least only with a later mobilisation.

In order to prevent yielding of the cement stabilised material and consequent reduction in shear strength due to cracking, special attention was given to the eccentricity mechanism and its effect on concentration of stresses within the front part of the wall that could initiate cracking (Figure 4). Firstly, this was assessed using conventional limit-equilibrium methods (foundation type analyses) and limiting the maximum foundation stress, σ_{max} , to 30% of the UCS value of the intact stabilised material. Additional numerical analyses were later completed to further assess this mechanism.

In order to assess the internal stability of the CS-SRSW, internal failure planes ranging from the friction angle of the cement stabilised material to 85° from the horizontal plane were considered (Figure 4) ignoring the effect of the reinforcement. Assuming monolithic behaviour, it was confirmed that the cement stabilised wall would not require additional soil reinforcement. However soil reinforcement was included as previously discussed for the following reasons:

- To allow for a RSW construction method which uses the same type of face panels as the existing RSW where these panels also act as formwork for the wall.
- To provide temporary support at the face until the cement stabilised material achieves the required strength.
- For the blocky medium approach to be valid.

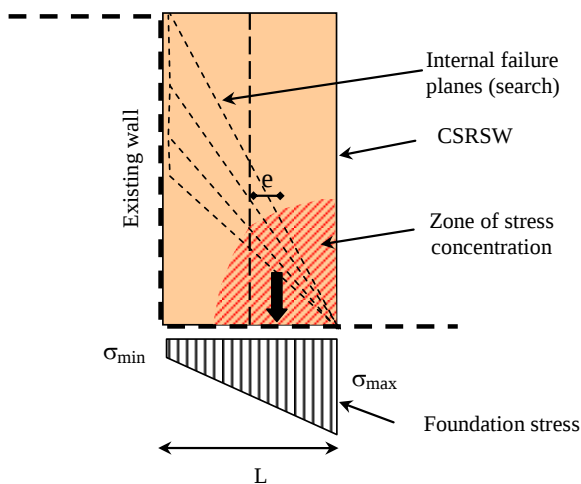


Figure 4. Internal stability analysis and effect of eccentricity on foundation loading and internal stress

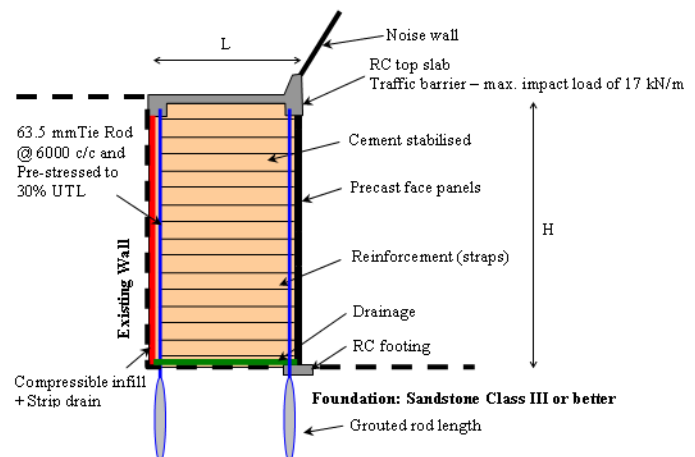


Figure 5. CS-SRSW concept

In order to improve the behaviour of the CS-RSW gravity block under earthquake loading, vertical pre-tensioned tie-rods were included in the design to provide additional overturning resistance and reduce stress concentration in the front of the wall due to eccentricity. These act mostly as passive reinforcement due to the low pretension value adopted to avoid cracking initiation at the top of the wall. Figure 5 presents the concept sketch of the proposed the CS-SRSW with $0.3 < L/H < 0.4$.

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Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

2.4 Numerical model

In addition to the analytical limit equilibrium analyses briefly described above, numerical modelling using the commercial Finite Difference (FD) code FLAC2D was also carried out to assess the development of stresses within the cement stabilised block and the magnitude of displacements under the applied loading conditions.

The cement stabilised material and rock units were modelled as linear elastic-plastic materials. The rock unit follows a perfectly plastic Mohr-Coulomb failure criterion with friction angle $\phi = 35^\circ$, cohesion $c = 250$ MPa and Young's Modulus $E = 1000$ MPa. These parameters are equivalent to a sandstone Class IV type rock with a GSI = 45, i.e. where rock defects are taken into account in the failure criteria as an equivalent continuum. A strain-softening elastic-plastic model was used for the cement stabilised material to simulate potential cracking and consequent reduction in strength. The adopted parameters were presented in Table 1 above.

The tie rods were modelled in FLAC2D as cable elements with properties automatically "smeared" to account for the out-of-plane spacing ($s_h = 6$ m). The rod was assumed to be anchored in sandstone Class III / shale Class II or better material with a minimum grouted length $L_b = 4$ m and ultimate bond stress of 1000 kPa. A pre-tension of 500 kN was adopted. The top slab was modelled as elastic beam elements, structurally connected to the tie rods. A slab thickness of 0.3 m and Young's modulus $E = 30$ GPa were adopted.

Soil reinforcement straps were modelled using the FLAC2D strip element option, which is similar to a cable element. A friction coefficient $\mu = 0.5$ was adopted for the reinforcement straps.

The cement stabilised block and foundation units were discretised in the numerical model as solid elements. The assumed effects of the existing RSW were modelled as a pressure applied onto both the rock foundation and to the rear of the new wall. Construction of the CS-SRSW was modelled in stages (layers of 1.0 m thickness were assumed for modelling purposes) to simulate the development of internal stresses during construction. Traffic load was modelled as a surcharge pressure applied to the top of the wall. Impact and earthquake loads were modelled as linear pseudo-static forces applied to the top and centroid of the wall, respectively. Under impact and earthquake loading conditions the new wall was assumed to behave independently from the existing wall as no tie connections are proposed even though the creep pressure was maintained.

In order to assess the factor of safety in the numerical analysis, the same modelling sequence was repeated with strength reduction factors (SRF) applied to the shear strength parameters of the stabilised mass. Overturning and eccentricity were identified as the critical failure mechanisms in the limit equilibrium analyses, mainly due to the point of application of impact and earthquake loads. As a result, only one case of the CS-SRSW was modelled with a limiting height $H = 17$ m and base width to height ratio of 0.35 ($L/H = 0.35$).

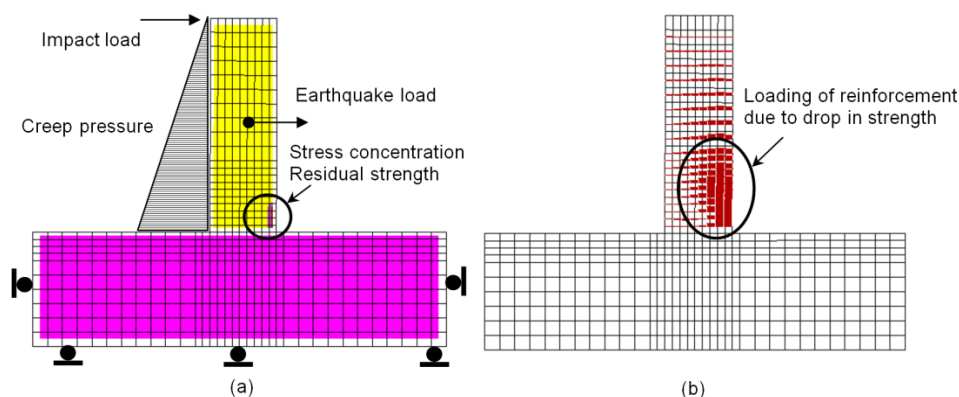


Figure 6. FLAC2D results for low bound case under impact loading: a) boundary conditions and material yielding b) reinforcement loads

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Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

Selected FLAC2D output and results are presented in Figure 6 and Table 2, respectively. It can be noted that for the low bound case, the maximum principal stress, σ_1 , within the CS-SRSW exceeds the material UCS value of 1 MPa which causes a reduction in strength of the cement stabilised material due to the strain-softening constitutive model adopted and the lower confinement near the wall boundaries. As a result, loads are transferred to the reinforcement which controls further propagation of material damage (yielding). In theory, the target UCS of the stabilised material was 3 MPa so this stress level would only represent initiation of microcracking of the wall which confirms the benefit of having the soil reinforcement.

Table 2. FLAC2D results (H=17 m L/H=0.35 - monolithic approach).

Model stage	Low bound Properties				Characteristic Properties			
	Hor. ⁽¹⁾ (mm)	Vert. ⁽¹⁾ (mm)	σ_1 ⁽²⁾ (kPa)	σ_t ⁽²⁾ (kPa)	Hor. ⁽¹⁾ (mm)	Vert. ⁽¹⁾ (mm)	σ_1 ⁽²⁾ (kPa)	σ_t ⁽²⁾ (kPa)
Wall construction	0	1	500	20	0	1	520	0
Traffic load and existing wall pressure applied.	18	5	1000	0	11	2.5	1050	0
Impact load applied	25	6	1160	15	15	4	1200	25
Impact load removed and earthquake load applied	26	6	1140	33	16	4	1300	30

Notes: 1) Maximum cumulative horizontal and vertical displacement at the top of the wall at the end of the respective stage. 2) Maximum compressive and tensile stresses observed within CS-SRSW.

2.5 Blocky medium or Flexible approach - EXCEPTIONS to RMS R57

The blocky medium approach was adopted as an alternative design check assuming the cement stabilised mass may fully crack. Under such a condition, the CS-SRSW behaves more akin to a conventional RSW. As a result, the method suggested by the FHWA design guidelines (Berg et al., 2009) for shored walls was considered appropriate. The main advantage of this design was that the stabilised blocky material will still have a higher value of Young's modulus and better interlocking of particles (i.e. blocks) than a conventional granular backfill, hence reducing the likelihood of trenching at the interface between the shoring system and the new wall. In addition, the tie rods will provide additional safety against seismic loading.

According to the FHWA guidelines (Berg et al., 2009), sliding, overturning and eccentricity are not considered valid failure modes for shored RSW. Lateral pressures acting on the RSW are self-induced as the shoring wall effectively reduces external loading, and these self-induced pressures would not realistically induce these modes of failure in walls designed in accordance with the guidelines. Analyses for sliding, overturning and eccentricity modes of failure, though conducted for traditional RSW, are not required for shored RSW design. Internal failure of a shored RSW is the primary failure mode and is addressed with appropriate backfill materials, suitable vertical spacing of reinforcement and adequate reinforcement strength and lengths.

For inextensible reinforcement cases, the critical failure surface has been assumed to be bilinear with the lower point passing through the toe of the wall (Figure 1). The FHWA guidelines state that this assumption is conservative compared to observations from centrifuge modelling.

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Internal design differs from conventional RSW design with regard to pullout of the reinforcement noted as an exception to the RMS R57 Edition 2 Rev.1 (2007) design standard. Conventional RSW design requires that each layer of reinforcement resist pullout by extending beyond the estimated failure surface. In the case of a shored RSW system, only the lower reinforcement layers (i.e., those that extend into the resistant zone) are designed to resist the pullout force for the entire “active” RSW mass. As a result, the required pullout resistance of the reinforcement within the resistant zone is calculated as the pullout force derived using a slope stability or wedge approach considering the failure surface as shown in Figure 1. Therefore, the effect of the stabilisation is already taken into account by the material parameters of the backfill as presented below. The calculation of the pullout resistance in the resistant zone followed traditional design methods such as those outlined in RMS R57 ignoring any potential adhesion promoted by the cement stabilisation or additional interlocking in the case of steel ribbed reinforcement. However, the maximum tensile force with respect to rupture of the reinforcement requires an additional modification (exception) to the RMS R57 equation.

The above discussion was noted on the design drawings as exceptions to the RMS R57 standard, including the effect of the blocky behaviour in reducing the earth pressure applied onto the concrete face panels and reducing the maximum tensile force with respect to rupture of the reinforcement.

It is important to note that the effect of a higher pH environment on the durability of the steel reinforcement promoted by the cement stabilisation was a point of significant debate and further investigation is still required. For the current design, it was agreed that to achieve a 100 year design life a sacrificial corrosion thickness of 1.5 mm was considered appropriate on either side of the steel reinforcement when a certain rate of corrosion was assumed, in addition to a galvanising protection of 85 μ m.

2.5.1 Material parameters and assessment of equivalent face earth pressure

As discussed above, the CS-SRSW was assumed equivalent to a synthetic rock simulating the behaviour of a weathered sandstone rock. Consequently, if cracks (discontinuities) are included, the stabilised mass may be treated as an equivalent fractured rock mass.

Cracking of the stabilised mass was conservatively assumed to be very intense resulting in closely spaced discontinuities (60 mm to 200 mm). Despite the intense cracking, the stabilised mass is assumed to be only partially disturbed and the resulting medium is equivalent to a very blocky rock mass.

It is important to note that continuous cracks that could structurally control the failure mechanism would only occur if failure planes develop. As a result, the initial cracks are unlikely to be persistent and the cracked stabilised mass may be represented by an equivalent pseudo-continuum where the discontinuities are accounted for through the material model for which the Generalised Hoek-Brown (GHB) failure criterion was adopted. The equivalent GSI of the cracked stabilised mass is shown in Figure 7a. Although drainage measures are recommended to reduce saturation of the stabilised mass, water effects inside the cracks are taken into account by modification to the GSI value as recommended by Marinos and Hoek (2000).

The adopted GHB parameters are: $GSI = 45$, $\sigma_{ci} = 1$ MPa (target design value of the cement stabilised sandstone with a material reduction factor of 3 applied), $m_i = 17$ (typical value for sedimentary sandstone type rocks), and a disturbance factor $D = 0$. It is important to note that the assumed rock mass parameters are consistent with the parameters proposed for sandstone Class IV (Bertuzzi and Pells, 2002) which according to the Pells' classification comprises weathered sandstones with $UCS > 2$ MPa, defect spacing > 60 mm and 10% of allowable seams (clay seams and/or poor quality crushed/sheared rock bands).

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Since the design of RSW is more conveniently carried out with respect to shear and normal stresses, Mohr-Coulomb (MC) parameters were back-calculated from the GHB model to suit the expected range of confining stresses/normal stresses. The equivalent MC envelope is shown in Figure 7b which gives an equivalent friction angle $\phi = 34^\circ$ and cohesion $c = 50$ kPa. The equivalent MC parameters are reasonable considering that for the cracked stabilised mass dilation is expected to occur promoting interlocking of the blocks and that cohesion is obtained because the discontinuities are not fully interconnected, not persistent nor oriented in the same direction.

If the modulus of the cracked stabilised mass is calculated according to the relationship with GSI as proposed by Hoek and Diederichs (2006) and the modulus of the intact mass is assumed to be $E_i = 1000$ MPa, a cracked modulus $E_{rm} = 230$ MPa is found which is somewhat similar in magnitude to that adopted for the monolithic approach low bound.

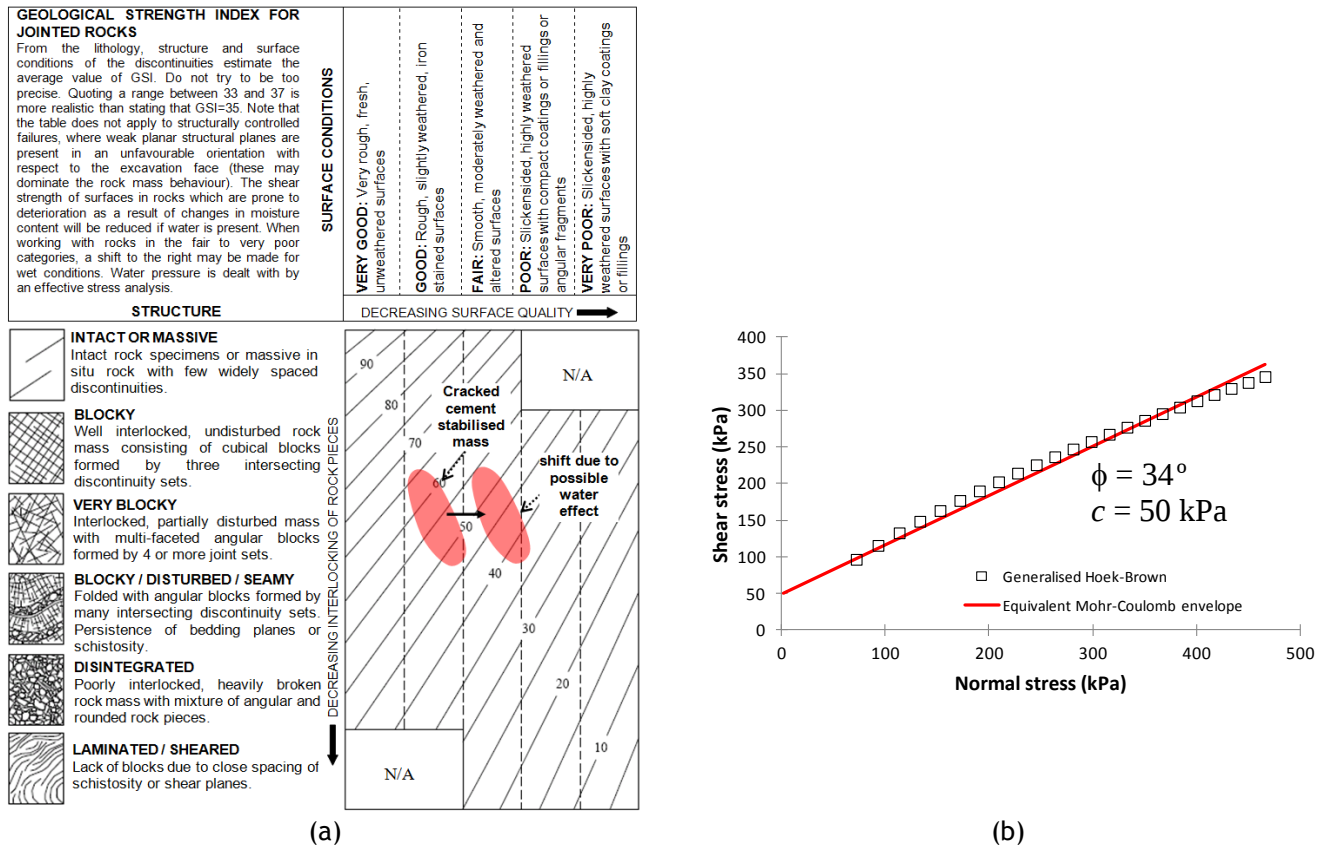


Figure 7. (a) Geological strength index for jointed rock masses (modified from Marinos and Hoek, 2000) (b) Equivalent Mohr-Coulomb parameters for the cracked stabilised mass

Using the above strength parameters, the maximum tensile force acting per metre width at the j^{th} layer of reinforcement due to loads acting on the face of the wall in the non-resistant zone (i.e. inside the failure zone in Figure 1), could then be calculated with a modification to the RMS R57 formula by:

$$T_{pj}^* = \left\{ K_{1(z_j)}^* \sigma_{vj}^* - 2c \sqrt{K_{1(z_j)}^*} \right\} (S_{vj} + S_{vj+1}) 0.5 \quad (3)$$

where $K_{1(z_j)}^*$ is the earth pressure coefficient in accordance with RMS R57 but using the above friction angle, σ_{vj} is the vertical stress at the depth of the j^{th} layer, S_v is the vertical spacing of the reinforcement.

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3 Laboratory testing of the cement stabilised material

As discussed above, during the design phase and prior to any material testing, it was assumed that a minimum uniaxial compressive strength $UCS = 3$ MPa at 28 days could be achieved with a well graded sandy gravel (crushed sandstone) stabilised with 5% cement.

After several rounds of discussions between the design team, Transurban and RMS, it was agreed that the cement content would be increased to 7% to address potential mixing problems and the design strength of the blocky approach would be limited to an $UCS = 1$ MPa, after applying a reduction factor of 3 to the above targeted laboratory UCS strength. This reduction of 3 was requested by RMS with the view of possible saturation of the stabilised material, as at that time no test results were available. The effect of material saturation on strength of the stabilised material was later further investigated by triaxial testing. In order to validate the design assumptions above, a number of laboratory tests were then carried out on the stabilised material, prior to construction.

3.1 UCS testing

Figure 8 presents the test results for crushed sandstone samples stabilised at different cement contents (5% and 7%) and different compaction delay times. All samples were soaked for a minimum period of 24 hours prior to testing. The compaction delay time was assessed as an important factor as no batching plant (pug mill) was allowed to be set up along the Hill M2 Upgrade project. Therefore, the stabilised material had to be mixed off site and transported. Due to traffic conditions, delays in compaction after mixing of in excess of 4 hours could occur and by that time the hydration process of the cement would be reasonably advanced. The delayed compaction would then break some of the already established “bonds” reducing overall future strength.

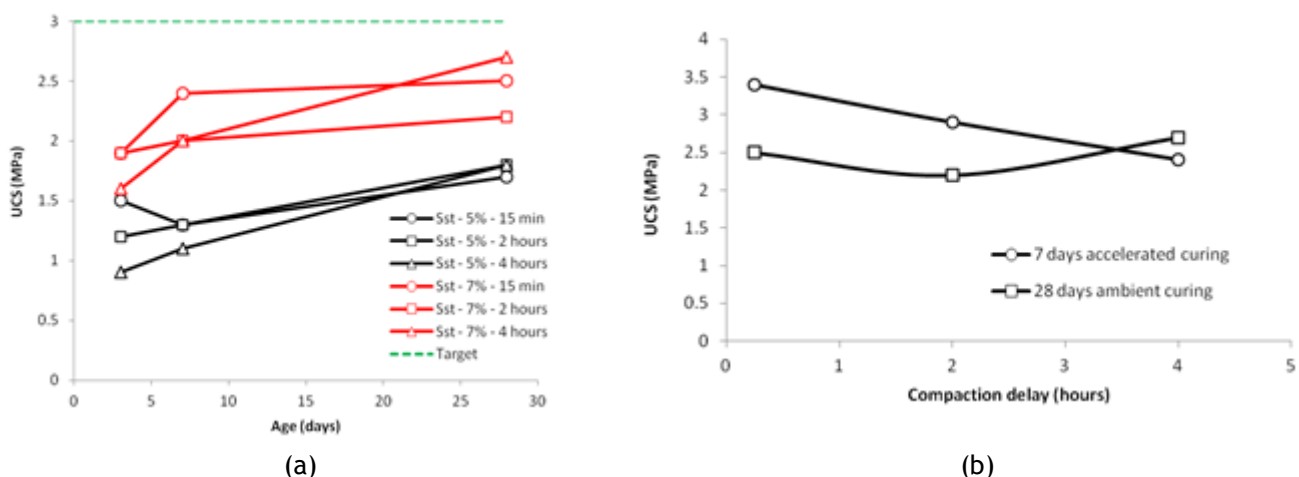


Figure 8. UCS results for crushed sandstone (a) with different cement content, compaction delay time and age (b) 7% cement content with varying compaction delay time and curing

As noted in Figure 8, the proposed site-won crushed sandstone did not achieve the target strength of 3 MPa even at 7% cement content and no delay in compaction (i.e. 15 min). The maximum strength that could be assigned for such material would be approximately 2 MPa at 7% cement content. A likely cause of this lower strength was attributed to the grading of the crushed sandstone, possibly associated with further break down during compaction. The particle size distribution of the proposed material was observed to be gap (poorly) graded gravelly sand instead of the recommended well graded sandy gravel. It is interesting to note that some samples yielded higher UCS values at 7 days accelerated (oven) curing than those obtained at 28 days ambient curing. This may indicate a potential increase in strength for ages greater than 28 days.

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Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

Although a laboratory strength of 2 MPa could potentially be used if a lower material reduction factor could be proved acceptable and also considering that field samples could potentially have higher strength due larger particle size, it was decided that a material with better crushing and grading process control would be beneficial. It was decided to use a commercial material known to be well graded. A Dense Graded Base with maximum particle size of 20 mm (DGB20) from Boral blended with a slow setting binder (Stabilment) was chosen as it was also compliant with the RMS 3051 specification. This product is supplied by Boral as a Roller Compacted Concrete replacement which targets RMS R73 specification for Heavily Bound Pavement courses. The DGB20 consists of high strength basalts which present reduced micron dust when crushed.

Figure 9 presents the UCS results for the stabilised DGB, and shows that the target strength of 3 MPa is attained for all samples even with a delayed compaction of 6 hours. Similarly UCS values at 7 days accelerated curing were higher than those obtained at 28 days ambient curing. Figure 9b also highlights the benefit of the slow-setting binder in the delayed compaction.

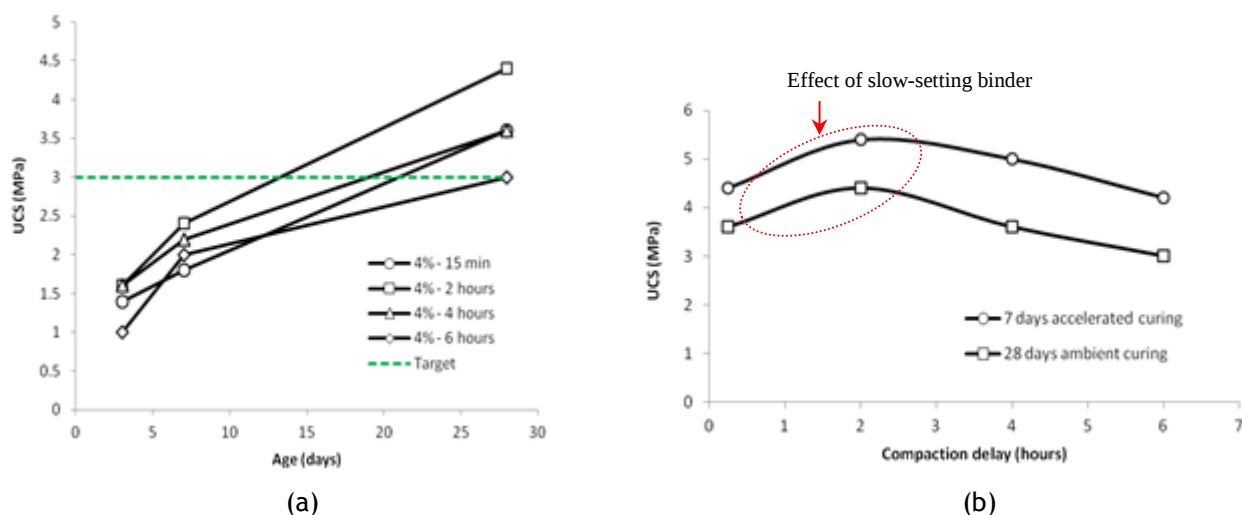


Figure 9. UCS results for DGB20 with 4% stabilment with different compaction delay time (a) at different ages (b) with different curing

3.2 Triaxial testing

Due to limits of the testing equipment used, only two samples of the stabilised sandstone were successfully tested. These samples were blended at 7% cement content with delayed compaction of 2 hours and tested after 7 days of accelerated curing under zero and 50 kPa confining stresses. The DGB20 samples were not tested.

Due to the limited number of successful samples, the most valid use of the triaxial results were perhaps the assessment of possible saturation and its effects on material strength as the samples were subjected to a water back pressure in the triaxial cell. After 3 days of backpressure up to 300 kPa, both samples had a pore pressure coefficient $B = 0.93$ which indicates a partial but possibly near saturation condition.

From the results, this partial saturation caused no significant drop in strength. For the unconfined sample, an axial stress of 3 MPa was observed, comparable to the 2.9 MPa shown in Figure 8b for the 7 days accelerated curing with 2 hours delay. Although the stabilised DGB20 material has not been tested for the effects of saturation, it was assumed that similar results could be expected considering that this material is better graded.

Major Project

Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

The triaxial test results indicate that the material reduction factor of 3 to account for saturation may have been too conservative. Even under a pressure equivalent to 30 m of water (300 kPa) for 3 days, the stabilised sandstone did not fully saturate, and at this partial saturation no significant drop in strength has been observed. The CS-SRSWs were not designed for such extreme condition, i.e. a 30 m water column, which is not expected to occur, particularly considering the double drainage system installed at the rear of the new wall: one vertical drain for the existing wall face and another for the new wall separated by a membrane. It is also important to note that this reduction factor was to be applied to the intact stabilised material only. The effect of water within cracks would be taken into account when converting the intact parameters (already reduced by the above factor) to the blocky medium parameters which has reduction factor due to water of approximately 1.3 with respect to compressive strength. Based on these testing results, the material reduction factor could be reduced, e.g. to 2, though to account for construction and mixing variations, it was kept at 3.

4 Construction

When the wall was nearly completed, cored samples were taken from the CS-SRSW for further testing of the *in situ* stabilised material. Care was taken with the location of the cores to reduce the risk of drilling through the steel reinforcement. Figure 10 presents a photo with the cored samples, indicating a good quality of the final material and its similarity to a rock or roller compacted concrete material. UCS testing with measurement of the Young's modulus was carried out on 9 samples taken at different depths. In general all these samples had ages in excess of 28 days but less than 90 days. The minimum UCS observed for those samples was 5.9 MPa, maximum of 12.3 MPa and an average of 8.3 MPa. The intact or substance Young's modulus varied between 10 GPa and 12 GPa which indicates that the predictions with Equation (1) would be acceptable or using the upper values of the modulus ratio in Equation (2). Nevertheless, the substance Young's modulus would still require to be downgraded to account for cracking and any discontinuities, and the relationship with GSI as before, cement stabilised mass modulus would still be in excess of 2 GPa, even higher than the characteristic value adopted for the rigid-monolithic approach. Figures 11 and 12 present some photos during the construction of the CS-SRSW.

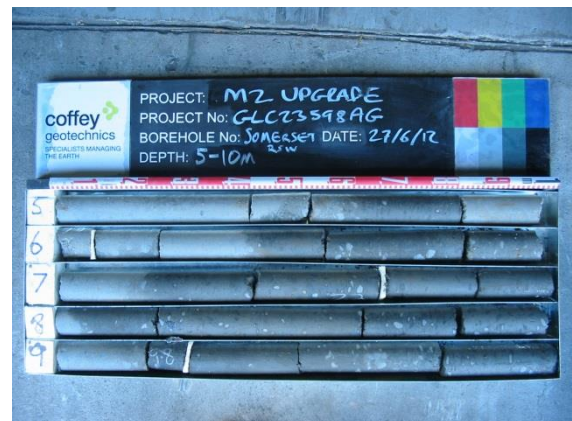


Figure 10. Core samples of the stabilised DGB20



(a)



(b)

Figure 11. Construction of the CS-SRSW (a) Concrete platform completed (b) Initial layers of the stabilised DGB20 with details of the face panels and back double drainage system

Major Project

Design and Construction of A Cement Stabilised-Shored Reinforced Soil Wall (Continued)

5 Conclusions

Site constraints precluded the use of conventional RSW at a number of locations throughout the Hills M2 Upgrade alignment where limited space was available for the extension of the existing relatively high retaining walls. An innovative design approach was adopted considering the stabilising effect of the existing RSW with regard to the reduction of lateral loads acting on the new walls, and targeting the safe design and construction of slender RSWs. Several challenges, as described above, had to be overcome before acceptance of this innovative design.

The concept of Shored RSW was adopted with improvements to the backfill behaviour in order to address some of the potential issues. Material testing on both laboratory and field samples confirmed the targeted behaviour of a stiffer backfill.



Figure 12. Aerial view of the CSRSW at its final height in June 2012

It is important to note that RMS acceptance of CS-SRSW in the Hills M2 Upgrade project was to a very specific case, when pulling down the existing wall in order to build the new RSW was not an option. If such cases occur again, they will require similar investigation and deliberation before any decision is made, i.e. the previous RMS acceptance does not constitute a blanket acceptance of CS-SRSW for similar future cases. Likewise, the deviations from the RMS Specification R57 and R58 in this project are specific to this case and there should be no corresponding changes to RMS Specifications R57 and R58 as they were not intended to cover such situations.

Acknowledgements

Without the contribution and collaborative discussions of all members of the Hills M2 Upgrade project such innovative design would not be possible. As a result, the authors would like to acknowledge the significant contributions of Leighton Contractors, AECOM, Transurban, SKM and the RMS.

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Conference Report

All-Russian Conference with International Participations

"Deep Foundations and Problems of Underground Space Development"

This conference took place in Perm National Research Polytechnic University, Perm, Russia, from 27th to 28th, May, 2014. This scientific conference was devoted to the 80th birthday of Professor Adolf Bartolomey who was formerly the Rector of the Perm State Technical University (1982-1999) and was also a corresponding member of the Russian Academy of Sciences.

Professor Adolf Bartolomey (Photo №1) was one of the leading scientists in the field of soil mechanics, foundation engineering, geotechnics and geoecology. He created the scientific school on problems of soil mechanics and pile foundation engineering and is well known in Russia and abroad. He was the Chairman of the Technical Committee on problems of the bases of deep foundations of the Russian Society on Mechanics of Soil, Geotechnics and Foundation Engineering and represented Russia in the International Technical Committee of ISSMGE on the same problems. Under the leadership of Prof. Bartolomey, there were defended 41 Ph. Dr. theses and with the help of his scientific consultations 15 Dr. Eng. theses were also successfully defended. He headed the specialized Councils for defending of doctors and theses.

The main directions of scientific activity of Prof. Adolf Bartolomey are experimental and theoretical researches of interaction of the pile foundations with surrounding soil; development of new designs of piles of the increased bearing capacity and methods of design of the foundations on limit states; forecast of buildings and constructions stability; construction of waste storages in difficult engineering-geological conditions; strengthening of bases of the foundations; theory of elasticity, plasticity and creep; complex inspection of buildings and constructions.

Based on the results of complex experimental and theoretical researches by A. Bartolomey and his co-authorship, there have been published over 500 papers, including 11 patents, 50 monographs and books, 115 articles in the central editions and Proceedings of the international congresses and conferences on mechanics of soil and the foundation engineering that were carried out in Austria, America, England, Brazil, Hungary, Italy, Canada, China, India, Poland, the Czech Republic, Singapore, Russia, Sweden, Japan, Kazakhstan and other countries. He took part in the development of six departmental, four all-Union and All-Russian normative documents on rational application and design of various foundations.



Photo 1. Professor Adolf Bartolomey (1934-2003), Rector of the Perm State Technical University (1982-1999)

Along with official duties, intensive research and pedagogical activity, Prof. A. Bartolomey took an active part in the public work. He was the member of Board of the Russian Society of Soil Mechanics, Geotechnics and Foundation Engineering, the member of the Presidium of the Ural Department of the Russian Academy of Sciences.

In total 100 participants attended of this Conference which was held at the resort "Ust-Kachka" of Perm Prefecture. The conference's geography captured higher education institutions and the research organizations of various regions of Russia, the Ukraine, Kazakhstan, France and the Czech Republic. 68 reports of 146 authors were submitted to the conference. Proceedings of the conference consisting of 3 volumes were published at the Perm National Research Polytechnic University.

Conference Report

All-Russian Conference with International Participations (Continued)

The oral technical sessions and discussions were carried out in three main sections:

1. Features of engineering researches, technologies of the device, strengthening of bases and reconstruction of underground elements of buildings and constructions. Co-chairmen - Prof. Polishchuk A.I., KUBGAU, Krasnodar, Prof. Yushkov B. S., PNRPU, Perm;
2. Experimental and theoretical researches of deep foundation's work. Co-chairmen - Professor Gotman A.L., Bashniistroy, Ufa, Prof. Skibin G. M., YuRGU, Novocherkassk;
3. Applied problems of geotechnics, examples from practice of underground space development, geotechnical monitoring. Co-chairmen - Dr. Shulyatyev O. A. (Photo №2), NIIOSP, Moscow, Prof. Nuzhdin L.V., NGASU, Novosibirsk.



Photo 2. During time of opening discussion
(Discussionner is Dr. Oleg Shulyatyev, Vice-Director of the NIIOSP, Moscow, Russia)

Invited lectures at the conference were delivered by:

- Prof. Ilyichev V.A., Vice-President of Russian Academy of Architecture and Construction Sciences, President of Russian Geotechnical Society;
- Prof. Ter-Martirosyan Z.G., MGSU-MISI, Moscow, Russia (Photo №.3);
- Prof. Varaksin S., ISSMGE TC211, (France);
- Prof. Vanichok I., Immediate Past Vice-President of ISSMGE for Europe, Czech Republic (Photo №.4);



Photo 3. Invited lecturer, Prof. Zaven Ter-Martirosyan (MGSU-MISI, Moscow, Russia)



Photo 4. Invited lecturer, Prof. Ivan Vanichok, Immediate Past Vice-President of ISSMGE for Europe (Czech Republic)

Conference Report

All-Russian Conference with International Participations (Continued)

During the conference work, experimental and theoretical research results in the field of design and calculation of deep foundations and underground space development were presented. Further, practical experiences of reconstruction of existing buildings and construction of new engineering objects in Russia and abroad were discussed (Photo 5).



Photo 5. Meeting of Heads of Departments of Civil Engineering of Russian Civil Engineering Universities



Photo 6. The invited lecturer is Prof. S. Varaksin (Paris, France)

The conference was held with an active participation of foreign professors who presented the progressive methods of design and researches of the bases and the foundations of buildings and constructions.

Within the framework of the conference, a seminar was organized on "The Pressuremeter According to MENARD and Proposed Rules" under the leadership of Mr. S. Varaksin, Vice Chairman TC 211, Scientific Advisor APAGEO (Photo 6).

Under the auspices of the conference, master classes of leading scientists from universities of Russia (Photo 7) and foreign countries were carried out at the Faculty of Civil Engineering of the Perm National Research Polytechnic University. Students and undergraduates of the Geotechnical direction, post-graduate students and young scientists (Photo 8), representatives of Perm design and construction organizations took part in them.

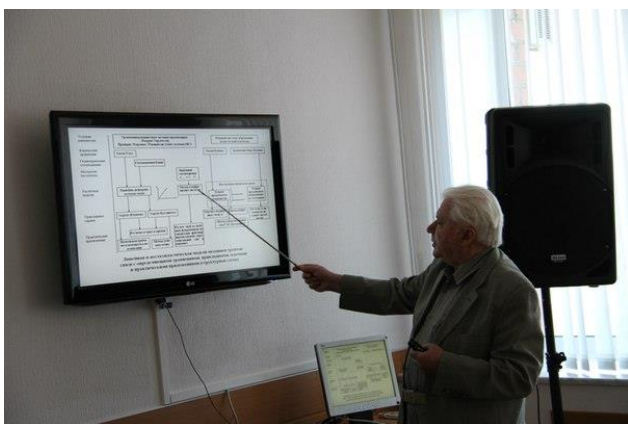


Photo 7. Oral presenter is Dr. D.M. Shapiro, Prof. of Voronezh State University of Architecture and Civil Engineering (Voronezh, Russia)



Photo 8. Students Musical Concert of Perm National Research Polytechnic University

Conference Report

All-Russian Conference with International Participations (Continued)

The conference's participants noted the essential volume increase of practical researches and the growth of young scientists activity and paid attention to the need of more thoughtful theoretical preparation.

The high level of the organization and operation of the conference were admitted by participants of the conference as well as the level of registration and preparation of all conference materials.

Such an exchange of opinions on discussed problems will promote foundation engineering development, strengthening of traditions and expansion of communications between scientists and experts in the fields of soil mechanics and geotechnics (Photo 9).



Photo 9 The group photo of the conference participants

Hot News

Obituary – Prof. Dr. Nguyen Truong Tien (1950 – 2014)



In honour of Professor Nguyen Truong Tien

Vietnam Society for Soil Mechanics and Foundation Engineering (VSSMGE) sadly notice that Prof. Dr. **Nguyen Truong Tien**, VSSMGE president, has passed away peacefully at Vinmex Hospital, Hanoi, on Thursday 16th October 2014, in his 64th year.

Tien was born on 18th June 1950. He was educated in Civil Engineering at Havana University, Cuba and graduated in 1973. Tien got Master Degree in Geotechnical Engineering at Havana University and British Columbia University, Canada in 1975. He obtained Ph.D. degree in Geotechnical Engineering at Chalmers University of Technology, Sweden in 1987. He was visiting Prof. of Havana University and Hanoi National University Civil Engineering (NUCE), Fonder and Fellow member of ASEAN Academy of Engineering and Technology (AAET), former Vice-President of Hanoi Construction Corporation (HACORP.), President of Vietnam Geotechnical Institute (VGI), President of AA Corp., and President of Vietnam Society of Soil Mechanics and Geotechnical Engineering (VSSMGE). He was chairman, co-chairman, key speaker of many international, regional and national conferences and seminars. His contributions to the development of soil mechanics and geotechnical engineering in Vietnam are enormous. Tien was not only a geotechnician, but also a philosopher, a poet and a writer.

Funeral service and memorial ceremony will be carried out on Tuesday 21th October 2014, between 12h15 and 14h45, at the Defense Minister Funeral Home, 5 Tran Thanh Tong St, Hanoi, followed by interment at Van Dien Cemetery, Hanoi.

On behalf of VSSMGE,
Dr. Phung Duc Long,
Vice-President, International Relations

Hot News (Continued)

The XV Pan American Conference on Soil Mechanics and Geotechnical Engineering

The XV Pan American Conference on Soil Mechanics and Geotechnical Engineering will be held in Buenos Aires, Argentina, on 15-18 November 2015. The event will also host the VIII South American Congress of Rock Mechanics and the VI International Symposium on Deformation Characteristics of Geomaterials, sponsored by TC-101.

A very high-level technical program has been organized. Seven plenary lectures - including the Casagrande, Mercer and ISSMGE Bishop lectures - and seventeen keynote lectures are scheduled for the three Conferences. Also, nine panel sessions will discuss hot topics in various aspects of geotechnical engineering.

Papers will be peer reviewed, edited by IOS Press and indexed in several scientific databases and uploaded to ISSMGE website. Copyright will remain with the authors of the papers. Selected papers will be invited to be completed and submitted to *Soils&Rocks*, the brazilian-portuguese journal on Geotechnical Engineering. The deadline for abstract submission is October 31, 2014. Abstracts can be uploaded directly to the Conference website conferencesba2015.com.ar

Buenos Aires is a wonderful city for social life and one of the top tourism destinations in the world. The social side of the Conference is yet being organized. We can nonetheless guarantee that it will match the excellence of the technical program.

Please visit conferencesba2015.com.ar and see the impressive list of lecturers that will be contributing to the success of this venue. We hope to see you in Buenos Aires in November 2015. Save the date!

Event Diary

ISSMGE EVENTS

Please refer to the specific conference website for full details and latest information.

2014

XIV Colombian Geotechnical Conference-XIVCGC and IV South American Young Geotechnical Engineers Conference -IVCSIGJ

Date: Wednesday 15 October 2014 - Friday 17 October 2014

Location: Universidad Nacional de Colombia, Bogota, BOGOTA D.C., Colombia

Language: Spanish, Portuguese, English

Organizer: Colombian Geotechnical Society-SCG

Contact person JUAN MONTERO O.

Address: Calle 12C No.8-79 Of. 512, 11001000, BOGOTA D.C., COLOMBIA

Phone: 57-1-3340270

Fax: 57-1-3340270

E-mail: scg1@etb.net.co ; scg1@colomsat.net.co

Website: www.scg.org.co

Correspondence and information Ángela Vázquez (Spanish only), scg1@etb.net.co, scg1@colomsat.net.co

Organizing Committee / Juan Montero-Olarte, juanmontero170@gmail.com

South East Asia Conference on "Soft Soils Engineering and Ground Improvement"

Date: Tuesday 21 October 2014 - Thursday 23 October 2014

Location: Bandung, West Java, Indonesia

Language: English

Organizer: Parahyangan Catholic University and Universiti Tun Hussein Onn Malaysia

Contact person: Aswin Lim

Address: Parahyangan Catholic University, 40141, Bandung, West Java, Indonesia

E-mail: softsoils2014@gmail.com

Website: <http://www.softsoils2014.com>

7th International Congress on Environmental Geotechnics

Date: Monday 10 November 2014 - Friday 14 November 2014

Location: Melbourne Convention and Exhibition Centre, Melbourne, Victoria, Australia

Language: English

Organizer: Engineers Australia

Contact person: Hayley Le Gros

Address: WSM, 119 Buckhurst Street, Vic 3205, Melbourne, Victoria, Australia

Phone: 61 3 9645 6322

E-mail: 7iceg2014@wsm.com.au

Website: www.7iceg2014.com

XXVII National Meeting of Geotechnical Engineering

Date: Wednesday 19 November 2014 - Friday 21 November 2014

Location: Puerto Vallarta, Jalisco, Mexico

Language: Español-ingles

Organizer: Sociedad Mexicana de Ingeniería Geotécnica A.C.

Contact person: Eduardo Botero Jaramillo

Address: Valle de Bravo 19 Col. Vergel de Coyoacán Del. Tlalpan, 14340, Distrito Federal, México

Phone: 0155 56773730

Fax: 0155 56793676

E-mail: smmsgerencia@prodigy.net.mx

Website: <http://www.smig.org.mx/en/rnig-en>

Event Diary (Continued)

Geohazards 2014 International Symposium on Geohazards: Science, Engineering and Management

Date: Thursday 20 November 2014 - Friday 21 November 2014

Location: Kathmandu, Nepal

Language: English

Organizer: Nepal Geotechnical Society

Contact person: Dr. Netra Prakash Bhandary

Address: Dept. Civil Environmental Eng, Ehime University, 790-8577, Matsuyama, Ehime, Japan

Phone: +81-89-927-8566

Fax: +81-89-927-8566

E-mail: netra@ehime-u.ac.jp

Website: <http://www.ngeotechs.org/ngs/index.php/geohazards-2014>

VIII Chilean Congress in Geotechnical Engineering

Date: Wednesday 26 November 2014 - Friday 28 November 2014

Location: Centro de Convenciones Hotel Intercontinental Santiago - Av. Vitacura 2885, Las Condes, Santiago, Chile

Language: Spanish

Organizer: Pontificia Universidad Catolica de Chile

Contact person: Christian Ledezma

Address: Vicuna Mackenna 4860, Macul, 7820436, Santiago, Chile

Phone +56(2)2354-4207

E-mail: cledezma@ing.puc.cl

Website: www.sochige2014.cl

7th International Conference on Scour and Erosion (ICSE-7)

Date: Tuesday 02 December 2014 - Thursday 04 December 2014

Location: Rendezvous Grand Hotel Perth, Scarborough, Perth, Western Australia

Language: English

Organizer: ISSMGE TC213 / University of Western Australia

Contact person: Liang Cheng

Address: M051, 35 Stirling Highway, 6009 Perth, Western Australia

Phone: +61 8 6488 3076

Fax: +61 8 6488 1018

E-mail: liang.cheng@uwa.edu.au

Website: <http://www.2014icse.com/index.html>

2015

Sixth International Geotechnical Symposium 2015

Date: Wednesday 21 January 2015 - Friday 23 January 2015

Location: IIT Madras, Chennai, Tamilnadu, India

Language: English

Organizer: IIT Madras and IGS Chennai

Contact person: Dr. R.G. Robinson

Address: Department of Civil Engineering, IIT Madras, 600036, Chennai, Tamil Nadu, India

Phone: 914422574286

E-mail: robinson@iitm.ac.in

Website: <http://igschennai.in/6igschennai2015>

Event Diary (Continued)

12th Australia and New Zealand Conference on Geomechanics - The Changing Face of the Earth: Geo-Processes & Human Accelerations

Date: Sunday 22 February 2015 - Wednesday 25 February 2015:

Location: Wellington, New Zealand

Contact person: Amanda Blakey

E-mail: secretary@nzgs.org

XVI African Regional Conference on Soil Mechanics and Geotechnical Engineering - Innovative Geotechnics for Africa

Date: Monday 27 April 2015 - Thursday 30 April 2015

Location: Hammamet, Tunisia

Language: English and French

Organizer: ATMS

Contact person: Mehrez Khemakhem

Phone: +216 25 956 012

E-mail: organisation@cramsg2015.org

Website: www.cramsg2015.org

ISP7 - PRESSIO 2015

Date: Friday 01 May 2015 - Saturday 02 May 2015

Location: Hammamet, Tunisia

Organizer: Tunisian Association of Soil Mechanics (ATMS)

Contact person: Dr Wissem Frikha

Address: Enit BP37, 1000 Le Belvedere, Tunis, Tunisia

Phone: +21698594970

E-mail: isp7_organisation@cramsg2015.org

Website: <http://www.cramsg2015.org/isp7-pressio2015/?lang=en>

ISFOG 2015

Date: Wednesday 10 June 2015 - Friday 12 June 2015

Location: Holmenkollen Park Hotel Rica, Oslo Norway

Language: English

Organizer: NGI

Contact person: Vaughan Meyer - NGI

Address: PO Box 3930 Ullevaal Stadion, N-0806, Oslo, Norway

Phone: +47 22 02 30 00

Fax: +47 22 23 04 48

E-mail: isfog2015@ngi.no

Website: www.isfog2015.no

3rd International Conference on the Flat Dilatometer DMT'15

Date: Monday 14 June 2015 - Wednesday 16 June 2015

Location: Parco dei Principi Grand Hotel & SPA , Rome, Italy

Language: English

Contact person: Simona Rebottini - Studio Prof. Marchetti

Address: via Bracciano 38, 00189 Rome, Italy

Phone: 0039 06 30311240

Fax: 0039 06 30311240

E-mail: simona@marchetti-dmt.it

Website: www.dmt15.com

Event Diary (Continued)

XVI European Conference on Soil Mechanics and Geotechnical Engineering

Date: Sunday 13 September 2015 - Thursday 17 September 2015

Location: Edinburgh International Conference Centre, Edinburgh, Scotland, United Kingdom

Language: English

Organizer: British Geotechnical Association

Contact person: Derek Smith

Address: Coffey Geotechnics Limited, The Malthouse, 1 Northfield Road, Reading, Berkshire, RG1 8AH, Reading, UK

Phone: +44 1189566066

Fax: +44 1189576066

E-mail: derek_smith@coffey.com

Website: <http://www.xvi-ecsmge-2015.org.uk/>

Workshop on Volcanic Rocks & Soils

Date: Thursday 24 September 2015 - Friday 25 September 2015

Location: Isle of Ischia, Italy

Language: English

Organizer: Associazione Geotecnica Italiana (AGI)

Contact person: Ms. Susanna Antonielli

Address: Viale dell'Università 11, 00185, Roma, Italy

Phone: +39 06 4465569 - +39 06 44704349

Fax: +39 06 44361035

E-mail: agi@associazionegeotecnica.it

Website: <http://www.wvrs-ischia2015.it/>

6th International Conference on Earthquake Geotechnical Engineering

Date: Monday 02 November 2015 - Wednesday 04 November 2015

Location: Christchurch, New Zealand

Contact person: The Conference Company

Address: PO Box 3727, Christchurch, New Zealand

Phone: +64 3 365 2217

Fax: +64 3 365 2247

E-mail: 6icege@tcc.co.nz

Website: <http://www.6icege.com>

The 15th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering -New Innovations and Sustainability-

Date: Monday 09 November 2015 - Friday 13 November 2015

Location: Fukuoka International Congress Center, Fukuoka, Kyushu, Japan

Language: English

Organizer: The Japanese Geotechnical Society

Contact person: Toshifumi Mukunoki

Address: 2-39-1 Kurokami, Chuou-ku, Kumamoto, JAPAN, 860-8555, Kumamoto, Japan

Phone: +81-96-342-3535

Fax: +81-96-342-3535

E-mail: 15tharc@kumamoto-u.ac.jp

Website: <http://www.jgskyushu.net/uploads/15ARC/>

Event Diary (Continued)

XV Pan American Conference on Soil Mechanics and Geotechnical Engineering

Date: Sunday 15 November 2015 - Wednesday 18 November 2015

Location: Hilton Hotel, Buenos Aires, Buenos Aires, Argentina

Language: Spanish - Portuguese - English (simultaneous translation)

Organizer: Argentinean Society for Soil Mechanics and Geotechnical Engineering

Contact person: Dr. Alejo Oscar Sfriso

Address: Rivadavia 926 Suite 901, C1002AAU, Buenos Aires, Buenos Aires, Argentina

Phone: +541143425447

Fax: +541143423160

E-mail: presidente@saig.org.ar

Website: www.panam2015.com.ar

Geo-Environment and Construction European Conference

Date: Thursday 26 November 2015 - Saturday 28 November 2015

Location: Polis University, Tirana, Albania

Language: Albanian, English

Organizer: Polis University, Albanian Geotechnical Society and Co-PLAN

Contact person: Msc. Eng. Erion Bukaçi

Address: Polytechnic University of Tirana, Faculty of Civil Engineering, 1001, Tirana, Albania

E-mail: erion.bukaci@gmail.com, Correspondence and information, MSc. Eng. Erdi Myftaraga

(erdi.myftaraga@hotmail.com), Prof. Dr. Luljeta Bozo (lulibozo@gmail.com)

2016

NGM 2016, The Nordic Geotechnical Meeting

Date: Wednesday 25 May 2016 - Saturday 28 May 2016

Location: Harpan Conference Centre, Reykjavik, Iceland

Language: English

Organizer: The Icelandic Geotechnical Society

Contact person: Haraldur Sigursteinsson

Address: Vegagerdin, Borgartún 7, IS-109, Reykjavik, Iceland

Phone: +354 522 1236

Fax: +354 522 1259

E-mail: has@vegagerdin.is

Website: <http://www.ngm2016.com>

3rd ICTG International Conference on Transportation Geotechnics

Date: Sunday 04 September 2016 - Wednesday 07 September 2016

Location: Vila Flor Cultural Centre and University of Minho, Guimaraes,, Portugal

Language: English

Organizer: Host: Portuguese Geotechnical Society and University of Minho

Secretary:

Contact person: Prof. A. Gomes Correia (Chair)

Address: University of Minho, School of Engineering, 4800-058, Guimarães, Portugal

Phone: +351253510200

Fax: +351253510217

E-mail: agc@civil.uminho.pt

Website: <http://www.webforum.com/tc3>

Event Diary (Continued)

NON-ISSMGE SPONSORED EVENTS

2015

Geosynthetics 2015

Date: Sunday 15 February 2015 - Wednesday 18 February 2015

Location: Oregon Convention Center, Portland, Oregon, USA

Language: English

Organizer: Industrial Fabrics Association International / Geosynthetics Materials Association

Contact person: Barbara Connett

Address: 1801 County Road B West, 55113 Roseville, Minnesota, USA

Phone: 651 225 6914

Fax: 651 631 9334

E-mail: bjconnett@ifai.com

Website: <http://www.geosyntheticsconference.com>

International Conference in Geotechnical Engineering - ICGE-Colombo 2015

Date: Monday 10 August 2015 - Tuesday 11 August 2015

Location: Colombo, Colombo, Sri Lanka

Language: English

Organizer: Sri Lankan Geotechnical Society

Contact person: Eng. K. L. S. Sahabandu

Address: Central Engineering Consultancy Bureau, 415, Bauddhaloka Mawatha, Colombo 7, Sri Lanka

Phone: +94 11 2668803

Fax: +94 11 2687369

E-mail: gm@cecbsl.com; sahabandukls@gmail.com

Website: www.slgs.lk

The 2nd International Symposium on Transportation Soil Engineering in Cold Regions (TranSoilCold2015)

Date: Thursday 24 September 2015 - Saturday 26 September 2015

Location: Siberian State University of Railway Engineering, Novosibirsk, Russia

Description: The 2nd International Symposium on Transportation Soil Engineering in Cold Regions

Date: Thursday 24 September 2015 - Saturday 26 September 2015

Location: Siberian State University of Railway Engineering, Novosibirsk, Russia

Language: English, Russian

Organizer: Universities of Russia, China, USA

Contact person: Yury Moryachkov

Address: Novosibirsk, Russia

E-mail: transoilcold@inbox.ru

Website: <http://transoilcold2015.stu.ru/>

5th International Symposium on Geotechnical Safety and Risk (ISGSR 2015)

Date: Tuesday 13 October 2015 - Friday 16 October 2015

Location: WTC, Rotterdam, The Netherlands

Language: English

Organizer: KIVI, GEOSnet, Geo Impuls

Contact person: Maarten Profittlich

Address: Zekeringstraat 41A, 1014BV, Amsterdam, The Netherlands

Phone: +31206510800

E-mail: nssmge@kivi.nl

Website: www.isgsr2015.org

FOR FURTHER DETAILS, PLEASE REFER TO THE WEBSITE OF THE SPECIFIC CONFERENCE

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News from Corporate Associate

Projects from Hayward Baker

Ohio River Bridge: Hayward Baker (HB) recently finished stone column and rigid inclusion work for 42 retaining wall and embankment structures for The Downtown Pursuit portion of the Ohio River Bridges Project in Louisville, KY. Soils generally consisted of urban fills followed by silty clays and silts, subsequently underlain by alluvial and gravelly sands with variable fines content. Settlement was a major risk due to large fill placements and the requirement of no more than 1 inch of settlement following paving.

Elliot Bay Seawall Repair and Replacement Project: HB recently began an initial test program on the Elliot Bay Seawall in Seattle, Washington. The seawall requires repair and replacement due to deterioration over time and increasing vulnerability to storm and earthquake damage. HB was awarded a \$41 million contract to construct a grid of approximately 5,700 jet grouted soilcrete columns to depths of up to 85 feet, providing seismic stability and foundation support. Following ground improvement, the seawall repair and replacement project will be carried out over a period of approximately two years.

About Hayward Baker Inc.: Hayward Baker [www.haywardbaker.com] is North America's leader in geotechnical construction, annually ranked by *Engineering News-Record* (ENR) magazine #1 in the profession. With a 60-year record of experience, Hayward Baker offers geotechnical construction technologies through a network of more than 20 company-owned offices and equipment yards across the continent. Project applications include foundation support, settlement control, site improvement, slope stabilization, underpinning, excavation shoring, earth retention, seismic/liquefaction mitigation, ground water control, and environmental remediation.

Hayward Baker Inc. is part of the Keller Group of companies, a multinational organization providing geotechnical construction services throughout the world. Web site address: www.keller.co.uk.



Photo 1. Working within confined areas, such as between the mainline and ramps, were among the constraints of ground improvement on the Ohio River Bridges - Downtown Pursuit project



Photo 2. HB will construct jet grouted soilcrete columns to provide seismic stability and foundation support for the Elliot Bay Seawall Project.

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The Foundation of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) was created to provide financial help to geo-engineers throughout the world who wish to further their geo-engineering knowledge and enhance their practice through various activities which they could not otherwise afford. These activities include attending conferences, participating in continuing education events, purchasing geotechnical reference books and manuals.

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