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NZ GEOMECHANICS NEWS

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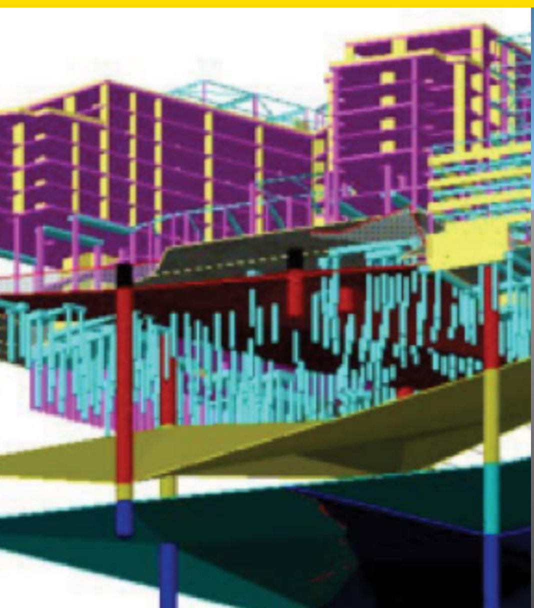
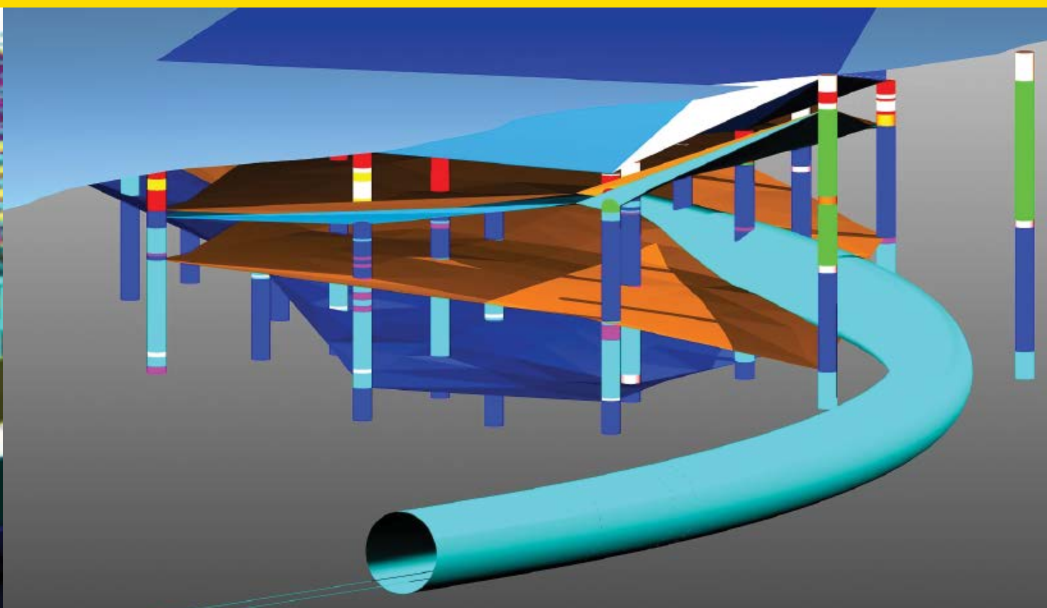
SPECIAL FEATURE GEOTECHNICS AND BIM

6ICEGE REVIEW

NZ GEOTECHNICAL DATABASE

RETAINING WALL DESIGN IN CHRISTCHURCH





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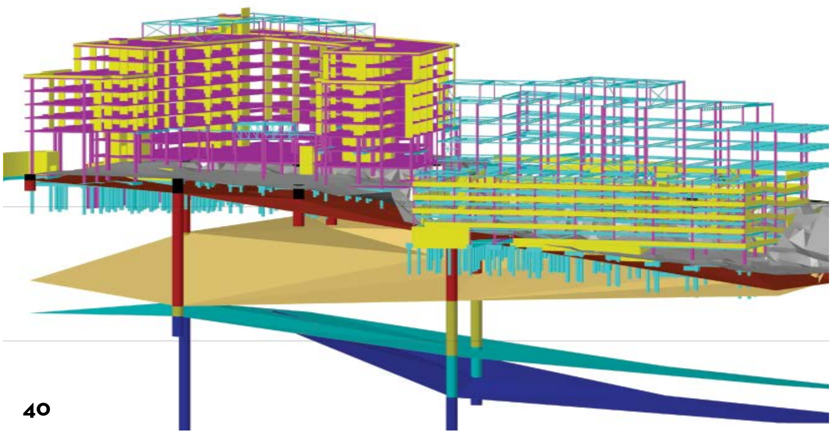
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COVER IMAGE: Top: 3D model of Watercare's Central Interceptor Project created as part of a BIM workflow.

Charlie is the Chief Geotechnical Engineer at MWH in Christchurch. Educated as a civil engineer in Dublin and an Engineering Geologist at Imperial College in London, he has worked on dam and tunnel projects in Africa, oil and gas projects in the North Sea, hydroelectric power stations in Pakistan and the UK. He moved to New Zealand in 2003 to work on Project Aqua, and spent seven years working with URS in their Christchurch office before moving to MWH in 2011.

Charlie Price
Chair, Management Committee

AS MANY OF our members will be aware we now have a new secretary. Amanda made that role her own for the last eight years, but has finally decided to return to her planning career, something she has been considering for the last couple of years. We wish her all the best in her return to her chosen career. Teresa Roetman has now taken on the role. Teresa previously ran her own business, and has spent a number of years as chairperson on two PTFA organisations.

One of Amanda's last initiatives as secretary was to combine communications to members into single weekly emails, which are issued to the whole membership, reducing NZGS emails into member's inboxes considerably. This has been operating for about six months now and appears to be successful.

6TH INTERNATIONAL CONFERENCE ON EARTHQUAKE GEOTECHNICAL ENGINEERING

The 6ICEGE has now come and gone. By all accounts this was a significant success, buoyed by the attendance of many of the world's leaders in earthquake geotechnical engineering. It was a unique opportunity for our members to listen to and get to meet names such as Isihara, Idriss, Finn, O'Rourke, Boulanger, Bray, Kramer etc all in one place, and the list goes on. As with all events of this magnitude there was a huge amount of preparation done over a number of years, initiated and led by Misko Cubrinovski. As I said in the closing session at the conference, societies such as ours are only as active and vibrant as the individual members who put in all the effort and time to make things happen, and Misko, Brendan Bradley and the rest of the conference committee have to be commended for all the effort they put into making the conference a success. Many comments have been made to me that the quality of papers presented was very high, and it was notable that the Stokoe-Verdugo discussion session over the application of shear wave velocity in liquefaction analysis was mentioned by one of the leading visitors as the best session that he had ever experienced at a conference – praise indeed. The conference proceedings are a significant body of work for future reference.

Sponsorship of the conference exceeded expectations, and the attendance of 526 from New Zealand and all around the world has ensured that a surplus has been achieved on the finances.

EARTHQUAKE ENGINEERING GUIDELINES

Much effort continues to be expended in the development of the Earthquake Engineering Guidelines, together with the organisation of relevant training which is planned to accompany their publication. Mike Stannard, chief engineer at MBIE, has taken on the role of Editor-in-chief of the guideline series, at our suggestion, with the aim of getting some consistency between the different modules. The order of the modules has been rationalised to allow for the inclusion of new modules, including an introductory module, and thus the old liquefaction module will now become module No 3 in its next revision. The new introductory 'overview' Module has been added to provide cohesion between the different modules and reduce repetition in the series. When modules are published they will all be released 'for public comment', with a revision planned after six months to allow for inclusion of comments from users.

The first of the new modules, module 5A The Ground Improvements Specification, was published 'for public comment' at the end of November; the new Overview module, module 1, and the revision to the liquefaction module are effectively complete and expected to follow over the next few months. The full list of modules currently under development is now as follows, keeping mind that this is an earthquake engineering series and only seismic related aspects are dealt with:

1. Series Overview
2. Site investigation
3. Liquefaction assessment
4. Foundation design
5. Ground improvement
5A Ground improvement specification
6. Retaining wall design

UPDATING THE NZSEE SEISMIC ASSESSMENT GUIDELINES (THE NZSEE RED BOOK)

NZGS has been contributing to updating of these guidelines and a draft including the new geotechnical elements was tabled at the SEESOC Management Meeting in August. The NZSEE intention is to release the fully revised guidelines in three parts in January 2016.

NZGS SUBMISSIONS TO GOVERNMENT

The NZGS made a supplementary submission on the Earthquake-Prone Buildings Bill Amendment on 15th July. As chair I attended a hearing of the Local Government and Environment select committee in support of the NZGS submissions on July 30th. We also made a submission on the Building Act Emergency Management Proposals to MBIE on July 25th.

SHORT COURSE OF MECHANICALLY STABILISED EARTH WALLS AND REINFORCED SOIL SLOPES

We brought over Professors Dov and Ben Leshchinsky from Delaware and Oregon State Universities in September to present a short course in MSE and RSS in Auckland, Christchurch and Nelson. We decided on Nelson rather than Wellington on this occasion due to reported high local demand and a clash with another course being held in Wellington at the time, but attendance in Nelson was disappointing. Overall the attendance in all three centres was about 85 and an excellent course was presented over two days.

DESIGN GUIDELINES

The society is represented on and reviewing a number of other design guidelines, such as the Rock Protection Structure Design Guidelines and Geotechnical Emergency Response Guidelines, both being developed under the auspices of MBIE.

ADMINISTRATION

Over the last two years IPENZ have made significant changes to their membership management and accounting systems, culminating in a new service agreement and new fee charging structure with associated societies. All societies' annual subscriptions now incorporate the services fees previously levied directly to members by IPENZ, and as a result the subs have risen to include this. The changes in IPENZ also mean changes to the running of the website.

Ross is the Ground Engineering Section Leader at Jacobs, where he indulges in his core interests of slope stability and geohazard assessment while also getting heavily involved in infrastructure from geothermal power plants to motorways and tunnels
NZ Geomechanics News co-editor

Marlène is Senior Lecturer at the University of Canterbury in Engineering Geology. She previously worked in tunnel design in Switzerland, the USA and Australia, having obtained her PhD in tunnelling at Queen's University in Canada. She currently works in rock mechanics applied to tunnelling, geothermal, petroleum, landslides and seismic amplification with a particular focus on lab testing and numerical modelling.
NZ Geomechanics News co-editor

BIG DATA HAS been the buzzword in the IT industry for a few years, but has yet to make a big impact on geotechnics. That may be changing. This edition we explore the benefits of a national geotechnical database, due to go live in early 2016, and discuss the merits of integrating geotechnical data into the Building Information Management (BIM) process. These developments – both now heading towards the mainstream in New Zealand – have the potential to transform our industry.

A nationwide database of laboratory and in-situ test data is designed to yield huge advances in site characterisation, but may well have side benefits ranging from new, better, geotechnical correlations to automatic, self-updating nationwide liquefaction hazard mapping. The IT industry has shown that once data is out there and freely available the uses can surprise everyone. Few foresaw that Google Maps would lead in just a few years to self-driving cars. While the geotechnical industry might not have the financial clout to make such large and rapid steps, we should have no doubt that changes just as dramatic (for our own little world, at least) will come our way. Traditional ways of working might become obsolete, and new challenges will rise in their place. As with so much in the world, change is likely to be the only constant.

BIM also has the potential to transform the way we work. The requirement to integrate fully into the design process rather than standing aside and providing geotechnical advice will force us to work more closely – and understand better – our colleagues in other engineering disciplines. This can only be good for our profession and for the industry as a whole. If we embrace this approach we have the opportunity to become a core part of a team bringing more efficient, effective and safer designs.

On the subject of change, Geomechanics News must also continue to evolve to avoid becoming stale. There is an unwritten rule that each co-editor stays in the job for no more than about three years in order to encourage this continued development. Although it does take considerable effort, editing this bulletin is surely one of the most rewarding jobs in the Society. If you can spare 40-80 hours each edition, have a passion for knowledge sharing and clear communication, and fancy giving this a go, please get in touch. Email a very brief resume to editor@nzgs.org, telling us in no more than 200 words why you think you'd be good at the job, and what changes you'd like to see Geomechanics News make during your tenure. We hope to appoint a new co-editor to take Ross' place early next year in time to be mentored through the process of producing the next edition in July.

Tell us about your project, news, opinions, or submit a technical article. We welcome all submissions, including:

- technical papers
- technical notes of any length
- feedback on papers and articles
- news or technical descriptions of geotechnical projects
- letters to the NZ Geotechnical Society or the Editor
- reports of events and personalities
- industry news
- opinion pieces

Please contact the editors (editor@nzgs.org) if you need any advice about the format or suitability of your material.

News – In Brief

AGS4 NZ UPDATE

AGS4 NZ is a geotechnical information interchange format used by geotechnical databases such as gINT, HoleBASE, Core-GS. It is intended to allow the exchange of data without the need for custom import routines to be written. One of the main advantages is that data input is reduced, meaning less repeated entry of test information such as job names, comments and location data. The current version of AGS4 NZ has been in place for about 5 years now and is due for an update.

With the implementation of the Canterbury and Auckland Geotechnical Databases paving the way for a national geotechnical database, set to run on the AGS4 NZ standard, there is the added need for an update before large amounts of data are input.

Some of the areas requiring attention have already been identified, and your help is requested to identify other areas for improvement. We are looking for submissions regarding additional fields and tables, along with errors and inconsistencies. For example the use of MPa where kPa would fit with external standards, or excessive numbers of decimal places.

We are reforming the working party to review the changes in early 2016. All submissions will be appreciated. Please email details of your observations to AGS@nzgs.org , along with your name and contact details

CALL FOR CONTENT: JUNE 2016 GEOMECHANICS NEWS

is the perfect place to publish your project news, technical papers or personal opinions about the industry. We welcome all contributions.".

A recent advertisement on the NZGS website for a job vacancy attracted over 50 applications.

The advertisers (employers) were impressed and a bit overwhelmed (understandably). If you have a position to advertise in your business and would like the pick of the crop – don't forget that for a very reasonable fee ($75/month plus GST) – you can advertise on the NZGS Website. Please contact secretary@nzgs.org

Stuart Finlan has been appointed NZTA Principal Geotechnical Engineer, a new national role to lead the development and implementation of geotechnical standards, processes and solutions across all elements of the state highway network including capital projects.

The role raises the profile of geotechnical engineering in NZTA and, being within the national office structures team, provides essential structural engineer education to the ways of geotechnics! Keep an eye on the LinkedIn NZGS Group which is likely to be used as sounding board.

Stuart is keen to hear from members who have a view on how NZTA may improve its geotechnical design methodologies and audit construction. Of immediate interest are ideas on how the NZTA existing rockfall hazard rating system could be refined to reflect the national variation in rock types.

Over the coming months a number of geotechnically related areas are expected to be reviewed using Technical Advice Notes (TANs) that can be accessed through the NZTA website Highways Information Portal (HIP).

11th Australia and New Zealand Young Geotechnical Professionals Conference


IMAGE COURTESY OF LUKE STORIE

11YGPC
Queenstown New Zealand October 2016

> Call for Abstracts & Nominations

The New Zealand Geotechnical Society and the Australian Geomechanics Society invite you to attend the 11th ANZ Young Geotechnical Professionals Conference (11YGPC).

The 11YGPC is for geotechnical professionals from New Zealand and Australia 35 years old and younger. It is designed for all attendees to present a technical paper on any topic of interest / experience relating to the field of geomechanics or geotechnical engineering.

Nominations
Please complete the nomination form available on NZGS website to this call for abstracts. Nominations of delegates must also be supported by a senior mentor and include an abstract of 200 words on a topic that is related to geotechnical practice or research. Successful nominations will be selected based on the quality and relevance of the abstract.

Positions are limited to approximately 50 attendees and all successful nominations will be expected to present their technical paper at the conference.

Cost
The cost of this three day event is anticipated to be approximately NZ$1000 (incl. GST). The exact cost will be confirmed at the time of nomination acceptance.

This cost includes conference venue and dinner, three nights' accommodation, an arrival drinks reception and field trip to discover the regional geology of the Queenstown region.

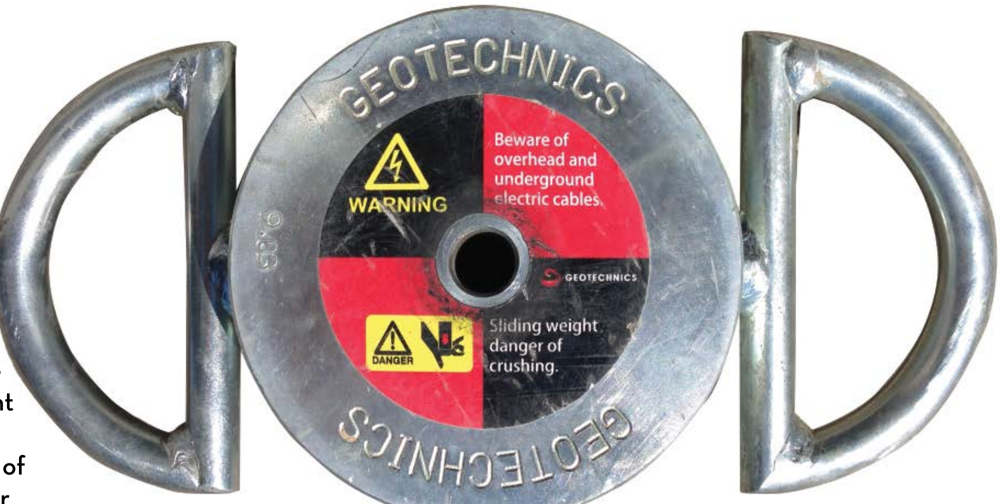
IMPORTANT DATES
(dates given below are approximate only)

- **4 March 2016** - Nominations and abstracts due
- **4 April 2016** - Nominations accepted
- **1 July 2016** - Full Paper due
- **25-28 October 2016** - 11YGPC

NEW ZEALAND GEOTECHNICAL SOCIETY INC

FURTHER INFORMATION will be available shortly on the New Zealand Geotechnical website www.nzgs.org. For any urgent queries or return of nomination forms / abstracts, please contact Frances Neeson (Organising Committee Chair) 11YGPC@gmail.com

DCP OPERATION INCIDENT



On the 14th July 2015, whilst undertaking a geotechnical investigation, a member of the Davis Ogilvie (DO) team caught his right index finger between the 9 kg drop weight and anvil of a Dynamic Cone Penetrometer (DCP), more commonly known as the Scala, resulting in injury. Due to a near miss incident involving fingers earlier in the year, DO replaced all of our Scala weights to include handles to be used during testing. This increased the distance between the pinch point and the fingers (Photo top right), however, this did not prevent the injury.

The injured member of staff was under the supervision of a senior geotechnical engineer and was fully trained in the use of the Scala; however, it has now become apparent that the resulting injury was due to trying to catch the weight as soon as it struck the anvil to increase the speed of testing, an element of ground investigation that I'm sure we are all guilty of at some point during our careers.

The resulting injury was de-gloving the end of the finger, complete removal of the nail and crushing of the distal bone; photos 2 and 3 illustrate the injury. Following immediate onsite first aid to stabilise the patient who had subsequently gone into shock and to control bleeding, the staff member was taken the Emergency Department of Christchurch City Hospital, where the finger was shortened by a surgical procedure and the remaining skin stitched to reconstruct finger.

The following day the senior engineer, who was onsite and had administered first aid, arranged a companywide health and safety meeting with all members of staff who use the Scala, to clearly identify that this piece of equipment has the potential to cause severe harm to the operator.

Within five working days of the accident the Department of Labour and WorkSafe were notified and the causes of the incident were fully investigated internally by the Davis Ogilvie health and safety representative. It was concluded that all procedures had been followed, the injured engineer was fully trained in the use of the Scala, and the cause of the accident was rushing on the job. Although the Department of Labour and WorkSafe were notified, they carefully considered the accident and decided not to investigate.

We at Davis Ogilvie are very appreciative of the DCP's/Scala's potential to cause harm and wish to convey this to the professional engineering world because we underestimated what this can potentially do to the operator – please take your time when testing and ensure you keep any part of your body away from the drop weight when it strikes the anvil. The photo below right illustrates what the finger looks like now two and a half months since the accident.

The DO site staff who use this piece of equipment are regularly reminded to take sufficient time and rest breaks when testing, to ensure that they are not rushing on the job and to voice any improvements that can be made to make ground testing safer for the future to ensure that an accident like this does not happen again.

TETRA TECH TO ACQUIRE COFFEY INTERNATIONAL LIMITED

Tetra Tech, Inc. (NASDAQ: TTEK) and Coffey International Limited (ASX: COF) have announced the execution of a Bid Implementation Agreement (BIA) under which Tetra Tech will make an off-market takeover offer to acquire 100% of the outstanding shares of Coffey for A$0.425 cash per share.

The acquisition of Coffey expands Tetra Tech's geographic presence and positions Tetra Tech as a leading global consulting firm for international development, supporting the U.S. Agency for International Development, Australia's Department for Foreign Affairs and Trade, and the United Kingdom's Department for International Development.

"Coffey provides a platform for growth of our international development business with multinational aid agencies," said Dan Batrack, Tetra Tech's Chairman and CEO. "In addition to Coffey's expertise in geoservices and project management, the combined company will also provide water and environmental services to support Australia's infrastructure expansion. Together, we will be able to provide an expanded scope of services to our customers and offer our combined staff even greater professional opportunities."

"Tetra Tech is an ideal partner for us," said John Douglas, Managing Director of Coffey. "This gives our people the chance to be part of a larger team of technical experts and deliver an expanded global offering to our clients. At the same time, it offers Coffey shareholders the opportunity to realize immediate value."

NATIONAL GEOTECHNICAL DATABASE – **UPDATE**

As discussed in the June edition, a National Geotechnical Database will be available in early 2016. The benefits of a well-populated database have been felt for some time now in Canterbury and are starting to impact in Hawkes Bay and Auckland where the database has only more recently been rolled out (refer John Scott's paper later in this edition). MBIE hope to realise a national roll out within the next few months and in preparation have been calling for data to pre-populate the database in key regions so it provides immediate value. NZGS believe that it is important to support this initiative and request that Consultants, where possible, contribute to the pre-population with high value historic data in densely populated areas to share the upload workload and to get as much useful information into the database as quickly as possible, in order for its usefulness to be fully realised by all.

Other actions for consultants to consider in advance of the nationwide rollout of the database revolve around client approval of data upload. In order for consultants to upload data, they need the permission of the owner of that data. Therefore uploading historically gathered data will be more time-consuming, especially where multiple clients are involved, many of whom are now not readily contactable. MBIE have committed to communicating with all government departments and territorial authorities (and hopefully with district health boards and other large groups in the future) to garner broad brush approval for data gathered for their projects. Once confirmed, this will facilitate data upload for these projects. It would be beneficial to start planning to obtain client approval for any large packages of data that could be used to seed the database.

In terms of approval for future data uploads, consultants have started amending their terms and conditions of engagement to facilitate this going forward. Examples of such additional clauses include:

Example 1

(where the standard IPENZ Short Form Conditions are used)

Add to Clause 15

The Client grants permission to the Consultant to upload any factual data collected during the works to the Auckland, Hawkes Bay or Canterbury geotechnical databases as relevant, and to the New Zealand Geotechnical Database when it becomes available.

Example 2

All new geotechnical factual information (both raw data and graphical logs) collected on behalf of the Buyer shall be uploaded by the Supplier in digital format to the Auckland, Hawkes Bay or Canterbury geotechnical databases as relevant, and to the New Zealand Geotechnical Database when it becomes available.

Please contact your legal advisors and consider requesting the addition of these or other similar clauses to your standard terms and conditions of engagement.

Please contact John Scott at MBIE if you can help seed the database or if you would like to discuss further John.scott@mbie.govt.nz

ENR GLOBAL DESIGN RANKINGS

Each year Engineering News Record assesses the amount of work undertaken by the world's largest engineering firms and ranks them based on revenue. The Top 150 Global Design Firms list, published annually in July, ranks the 150 largest world designs firms, both publicly and privately held, based on total design-specific revenue regardless of where the projects were located. The top 10, plus other companies relevant to New Zealand, are listed below.

ENR reported that the impact of the uncertainty in the world market can be seen in the results, "The Top 225 firms generated $70.85 billion in design revenue in 2014 from projects outside their home countries, down 1.1%, from $71.63 billion, in 2013. They also had $73.48 billion in revenue from domestic projects in 2014, up 1.6%, from $72.32 billion, in 2014. The total 2014 design revenue for the group was $144.34 billion, up 0.3%, from $143.95 billion, in 2013."

RANK		FIRM
2015	2014	
1	1	AECOM, Los Angeles, Calif., U.S.A.
2	2	Jacobs, Pasadena, Calif., U.S.A.
3	**	Power Construction Corp. of China, Beijing, China
4	3	WorleyParsons, North Sydney, NSW, Australia
5	5	AMEC plc, Knutsford, Cheshire, U.K.
6	6	Fluor Corp., Irving, Texas, U.S.A.
7	10	ARCADIS NV, Amsterdam, The Netherlands
8	11	China Communications Construction Grp. Ltd., Beijing, China
9	16	WSP|Parsons Brinckerhoff, Montreal, Quebec, Canada
10	7	CH2M HILL, Englewood, Colo., U.S.A.
11	9	Fugro NV, Leidschendam, The Netherlands
16	13	Tetra Tech Inc., Pasadena, Calif., U.S.A.
18	14	Bechtel, San Francisco, Calif., U.S.A.
20	20	Mott MacDonald Group Ltd., Croydon, Surrey, U.K.
24	26	Arup, London, U.K.
26	22	KBR, Houston, Texas, U.S.A.
33	50	GHD Pty. Ltd., Sydney, NSW, Australia
39	36	Golder Associates, Mississauga, Ontario, Canada
45	46	MWH Global, Broomfield, Colo., U.S.A.
48	45	Aurecon, Melbourne, VIC, Australia
76	76	SMEC, Melbourne, VIC, Australia
77	85	Opus International Consultants, Wellington, Wellington, New Zealand
87	88	Beca Group Ltd., Auckland, New Zealand

CETANZ

Civil Engineering Testing Association of New Zealand

The Civil Engineering Testing Association of New Zealand (CETANZ) are forming a CPT working group and are inviting CPT operators to register their interest.

The need for this group was initiated by the requirements of MBIE to have an association that represents the CPT industry.

The group will work towards a common goal of standardisation and improvement and will form its own specialist area that is supported by the CETANZ committee. Please note that the membership of this group will be formed by CETANZ members who are CPT practitioners

Representing the collective views of CETANZ, this group will form its own structure and will be actively involved in the development of the wider industry. The leadership of the group will report to the CPT group members and have a representative on the main CETANZ committee.

To register your interest please email info@cetanz.org.nz.

6ICEGE, 1-4 November 2015, Christchurch

THE 6TH INTERNATIONAL CONFERENCE on Earthquake Geotechnical Engineering (6ICEGE) was held in Christchurch (Air Force Museum of New Zealand, Wigram), from 1st to 4th November 2015. The 6ICEGE was organised by the New Zealand Geotechnical Society (NZGS) under the auspices of the Technical Committee TC203 (Technical Committee on Earthquake Geotechnical Engineering) of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). It was the sixth in the series of specialised conferences on earthquake geotechnical engineering following the Tokyo 1995, Lisbon 1999, Berkeley 2004, Thessaloniki 2007 and Santiago 2011 conferences.

The 6ICEGE attracted a total of 526 delegates (over 300 from overseas) including about 100 most prominent researchers in the field of earthquake geotechnical engineering. Indeed the 6ICEGE will be long remembered for the outstanding quality of talks and papers presented including 35 invited lectures.

Prof. Takaji Kokusho (Chuo University, Japan) presented the 5th Ishihara Lecture on "Liquefaction research by laboratory tests versus in-situ behaviour," while Prof. Bruce Kutter (UC, Davis, USA) presented the 2nd Schofield Lecture "Geotechnical earthquake engineering experiments into the information age".

Professors Kenji Ishihara (Chuo University; Emeritus Professor University of Tokyo, Japan), Liam Finn (Emeritus Professor University of British Columbia, Canada) and Izzat Idriss (Emeritus Professor University of California, Davis, USA) were honorary guests of the conference and presented talks in a Special Session dedicated to their founding and 50-years long contributions to the field of earthquake geotechnical engineering. This session was preceded by another special session on the TC203 Young Research Award in which Domniki Asimaki, USA, and Brendon Bradley, New Zealand, the joint recipients of the 2014 award, gave excellent presentations on some peculiar aspects of recorded strong ground motions in the 2015 Nepal earthquake and 2010-2011 Canterbury earthquakes respectively.

Ten keynote lectures were presented

Below: Misko Cubrinovski (6ICEGE Chairman) is greeting the 526 6ICEGE delegates at the Opening Session, including over 300 overseas delegates; the opening session started at 1pm 1 November 2015 (Sunday) few hours after the rugby finals

The Canterbury Earthquakes Recovery Minister, Gerry Brownlee, addresses the delegates in the General Christchurch Session

Powhiri – during the opening ceremony of 6ICEGE

by the following speakers (short-title topics in brackets):

Atilla Ansal, Turkey *(Site specific design earthquake)*

George Bouckovalas, Greece *(Isolation effects of liquefied ground)*

Ross Boulanger, USA *(Dam on spatially variable liquefiable deposit)*

Jonathan Bray, USA *(Liquefaction assessment in the CBD, Christchurch)*

Misko Cubrinovski, New Zealand *(Lateral spreading: observations & interpretation)*

Russell Green, USA *(Liquefaction triggering case histories)*

Steve Kramer, USA *(Timing of liquefaction and hazard evaluation)*

Carlo Lai, Italy *(Non-conventional methods for measuring dynamic properties)*

Thomas O'Rourke, USA *(Underground infrastructure response)*

Ikuo Towhata, Japan *(Residential land and liquefaction vulnerability)*

The following speakers delivered theme lectures: Pierre-Yves Bard, France; Brady Cox, USA; Jason DeJong, USA; Susumu Iai, Japan; Rolando Orense, New Zealand; Roberto Paoluci, Italy; Kyriazis Pitilakis, Greece; Ellen Rathje, USA; Nicholas, Sitar, USA; Paul Somerville, Australia; Jonathan Stewart, USA; S. Thevanayagam, USA; Susumu, Yasuda, Japan.

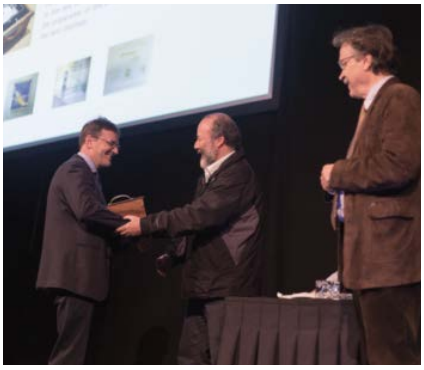
Kenneth Stokoe, USA, and Ramon Verdugo, Chile, contributed with an excellent discussion session on pros and cons for use of shear wave velocity in liquefaction assessment, while George Gazetas, Greece, and Michael Pender, New Zealand, led an equally valuable session on soil-structure interaction problems.

The conference was formally opened by the Mayor of Christchurch, Lianne Dalziel, and started with a general session on Christchurch in which Gerry Brownlee (Canterbury Earthquakes Recovery Minister), Hugh Cowan (EQC), Mike Stannard (MBIE) and Richard Fragaszy (NSF, USA) provided government, national and international perspectives of the Canterbury earthquakes and their impacts.

In addition to the exceptional technical programme 6ICEGE provided a very pleasant venue, enjoyable social programme, and memorable technical and accompanying person tours.

On behalf of the Organising Committee I would like to acknowledge:

- All delegates and presenters, because the great success of the conference was undoubtedly due to the exceptional quality of the papers and presentations.
- The conference partners, the New Zealand Geotechnical



Left: Misko Cubrinovski (as the host of the 6ICEGE) receives a seismograph representing the ICEGE symbol from Ramon Verdugo, Chile (the host of the previous 5ICEGE). The seismograph will be on display at the University of Canterbury, for the next 4 years.

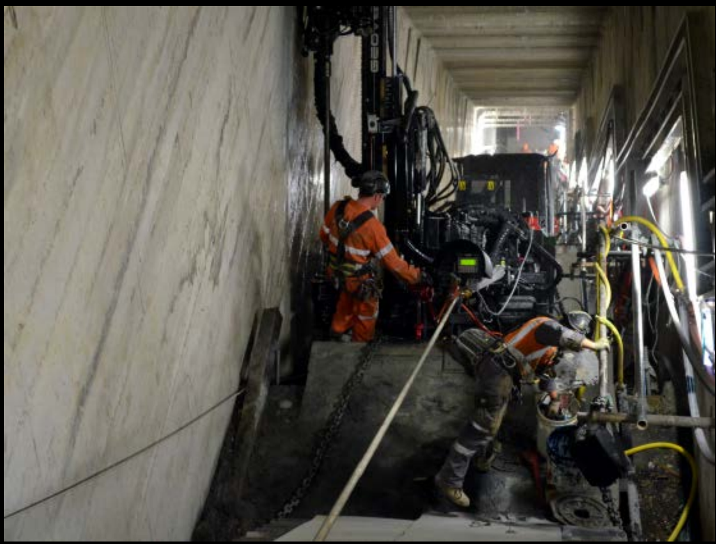
Above: The Mayor of CHC Lianne Dalziel formally opens 6ICEGE

Society (NZGS), the Earthquake Commission (EQC), and the University of Canterbury Quake Centre (UCQC)

- The 6ICEGE platinum sponsors, Tonkin and Taylor, and Golder Associates, as well as the five gold, six silver, and twelve bronze sponsors. We appreciate their great support and contribution to the success of the 6ICEGE.
- Special thanks are extended to the invited speakers for their excellent contributions and papers, which were the highlight of the 6ICEGE technical programme. The contribution of the numerous reviewers is also acknowledged and greatly appreciated.
- Finally, I would like to express my warmest thanks to our postgraduate students for their assistance in various matters associated with this conference, and to the outstanding efforts of the Organising Committee of the 6ICEGE. I particularly appreciate the exceptional efforts and contributions of Charlie Price (NZGS Chair), Brendon Bradley (UC), Liam Wotherspoon (UA) and Mark Stringer (UC), and would like to extend my personal thanks to them.

The 7ICEGE will be held in Rome in 2019.

Misko Cubrinovski
Professor, University of Canterbury
6ICEGE Chairman



Academic News

UNIVERSITY OF CANTERBURY

PROFESSIONAL MASTERS OF ENGINEERING GEOLOGY

Our first cohort of 27 students in the new 12-month Professional Masters of Engineering Geology (PMEG) will be completing their studies at the end of this month. The capstone of the students' studies is a dissertation, culminating in a conference paper. These will be made available digitally as a University of Canterbury published series, through our library. We strongly encourage collaboration between industry partners and these enthusiastic and motivated students. This year we have had successful collaboration with AECOM, Aqualinc, Department of Conservation, ENGEO, Ministry of Education, NZTA, OceanaGold, and Tonkin and Taylor. We hope to see continued and increased interest in collaboration with these student projects.

Narges Khajavi
(PhD completed November 2015)
SURFACE RUPTURE MORPHOLOGY AND PALEOSEISMOLOGY OF THE WESTERN HOPE FAULT AND CHARACTERISTICS OF COSEISMICALLY-DISPLACED BOULDERS IN THE PORT HILLS, SOUTH ISLAND, NEW ZEALAND

I used airborne light detection and ranging (LiDAR) and conducted multi-disciplinary field techniques to document the surface rupture morphology and evaluate the paleoseismicity and seismic hazard parameters of the Hurunui segment of the Hope Fault. The fault deformation zone is up to ~500 m wide and spatially variable in width, and is optimally oriented for dextral strike-slip within the regional stress field. Paleoseismic trenching and radiocarbon dating of faulted late Holocene sediments reveal six earthquakes identified at A.D. 1888, 1740-1840, 1479-1623, 819-1092, 439-551, and 373-419 indicate a mean recurrence interval of ~298 ± 88 yr for the Hurunui segment. My results show that the 1888 earthquake ruptured 44 to 70 km of the Hope Fault with a magnitude of M_w 7.1 ± 0.1. The seismic hazard parameters for the Hurunui segment including: (1) mean slip rate of 12.2 ± 2.4 mm/yr, (2) mean single event displacement of 3.6 ± 0.7 m, (3) mean recurrence interval of ~200 to 440 yr., and (4) earthquake magnitude of · M_w ~7. My research on the coseismically-displaced boulders in the Port Hills resulting from the 2010 Darfield earthquake concludes that: (1) boulder displacements are observed on N-striking (000°-015°) ridges above ~400 m elevation, (2) the prevailing boulder horizontal displacement azimuth is subparallel with the direction of instrumentally recorded transient peak ground horizontal displacements, (3) the displacement characteristics of boulders implies that seismic waves were amplified at the study sites.

WELCOME TO GABRIELE CHIARO!

Dr Gabriele Chiaro recently joined the University of Canterbury as a Lecturer in Geotechnical Engineering. Gabriele brings with him over 8 years of research and field work experience. He has authored over 60 scientific publications, including peer-reviewed journal and international conference papers, and has been invited to deliver lectures in Japan, Hong Kong, Italy, New Zealand and Australia. Gabriele earned his BSc and MSc Civ. Eng. from the University of Cassino and Southern Lazio (Italy) and

received his PhD from the University of Tokyo (Japan). Before joining UC in June 2015, he was a MEXT Research Scholar (2007-2010, University of Tokyo); a Postdoctoral Research Fellow (2010-2011; University of Tokyo); an ARC Research Fellow (2011-2014; University of Wollongong, Australia); and a JSPS Research Fellow (2014-2015; University of Tokyo). His research interests include mainly Earthquake Geotechnical Engineering and related problems (e.g. soil liquefaction); constitutive modelling for geomaterials; development of advanced laboratory and field testing devices (triaxial tests with static local deformation and dynamic measurements; torsional shear tests from very small to large strain levels; gel-push sampling technique); geo-hazard reconnaissance and mitigation (e.g. 2015 Gorkha Nepal Earthquake); beneficial reuse/recycling of waste materials for sustainable geo-constructions; ground improvement techniques for granular soils.

More detail regarding Gabriele's research activities and interests visit his personal website:
https://sites.google.com/site/chiarogabriele/

Waterview Tunnel Project – Alice's Big Breakthrough

FOR THE RECORD

DISTANCE TBM TRAVELLED
2,400m + 2,428m = 4,828m

DEPTH (TO TUNNEL CROWN)
maximum 37m, minimum 7.5m

TOTAL NUMBER OF RINGS TO BE INSTALLED
24,040

EARTH REMOVED
792,100m^3 (enough to fill 320 Olympic sized pools)
Each of Waterview's two tunnels is 2.4km long – twice the length of the Auckland harbour Bridge. The tunnels are the longest road tunnels in New Zealand – the Lyttleton road tunnel at 1.97km previously held the record.
It is planned to open the tunnels – and the GNRI – in early 2017.

A FEW MINUTES before midday on Monday 19 October 2015, Alice reached the end of her road. At that time, the TBM's huge cutting wheel squealed and groaned its way through the final 900 mm of its underground journey – a solid concrete cover over the tunnel portal – to lead the giant machine into the southern portal and daylight. "Everything went to plan – a text book breakthrough," says Tunnel Manager Chris Ashton. Work on site came to a standstill so that more than a thousand people could see the breakthrough. The project's invited guests watched from a grandstand in the at the portal and staff and contractors saw it "live" on video screens in the large marquee near the Maioro Street Bridge. The breakthrough ended excavation of the second of the project's two motorway tunnels and means the TBM's astonishing two-year job underground at Waterview is over. Alliance Project Manager John Burden has told everyone on site he finds it difficult to find the right words to describe the breakthrough. "Calling it a big milestone is not enough. The breakthrough underlines all the excellent work that you have done before it, and our commitment to continue our high standards for finishing right across the project over the next 14 months or so."
Brett Gliddon, the Highways Manager for the project's NZ Transport Agency client, calls it a "brilliant and remarkable effort." "The risks associated with constructing tunnels twice as long as the Auckland Harbour Bridge were always high and the Waterview team rightly needs to be congratulated for its engineering skills and innovation to complete this job safely and on time. That's a fantastic achievement."

WHAT HAPPENS NOW?
Following installation of the last 50 of the 24,000 or so concrete tunnel segments, the TBM has reached the end of the road. Chris Ashton says already the complex and carefully planned operation to dismantle and remove the TBM has started. The front section – the shield which includes the cutting wheel – goes first. Its removal includes a couple of heavy lifts: the cutting wheel weighs 322 t and the main drive 364 t. They have to be lifted by crane 28 m out of the trench to ground level. When the shield has been removed, hydraulic jacks will pull the TBM's three trailing gantries out of the tunnel so that they can be dismantled in turn. The cutting head and shield will be moved by Christmas, and all the gantries, including the culvert lifting gantry behind the TBM, will be gone by February. "Although it's the end of the road for Alice she will leave behind a lasting legacy – the world class tunnels she helped construct that will benefit Auckland and New Zealand for 100 years and more," says Brett Gliddon from the Transport Agency.

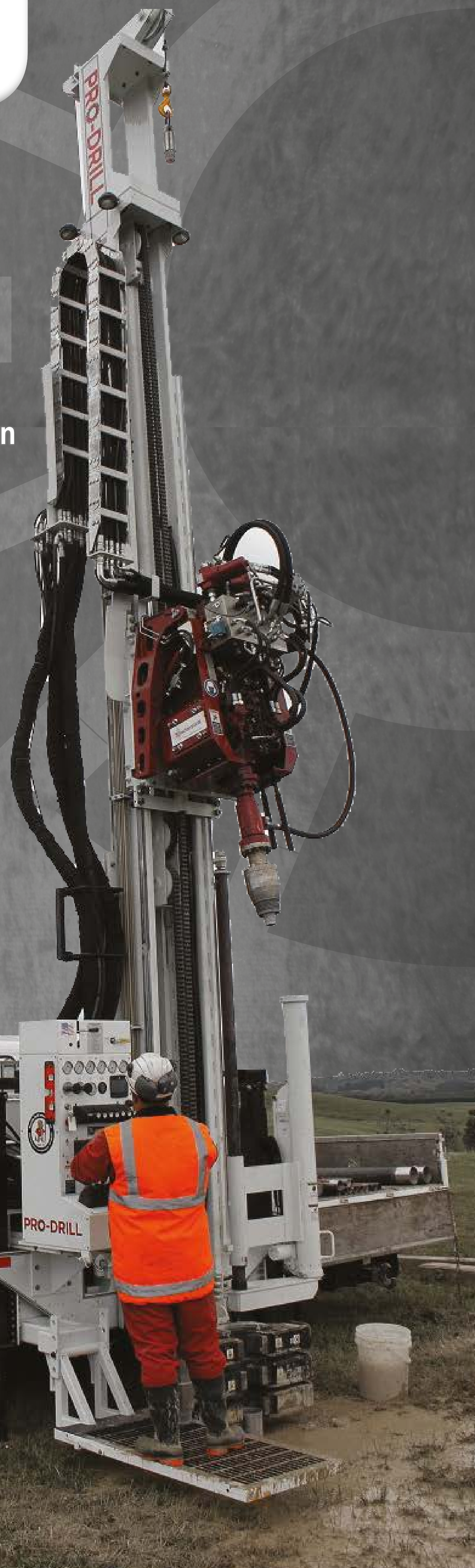
Roto Sonic Drilling

- 150 Hz Roto Sonic heads
- 100% core recovery in sands and gravels
- Boulders, Gravels, Silts, Infill, Sands, Marine, Landfill
- Fully cased holes
- 3 x faster than conventional Rotary Drilling
- Minimal water usage and spoil accumulation
- Perfect ground monitoring well installation
- Automatic SPT Hammers
- 0 – 60m Depth

Rig List

2 x Fraste 9 tone Drill rigs
1 x Mobile Sonic 1000 13 tone drill rig
1 x AMS 9 tone drill rig

New Zealand Wide Capabilities



PRO-DRILL
SPECIALIST DRILLING ENGINEERS

Leading Geotechnical Investigation Since 1987

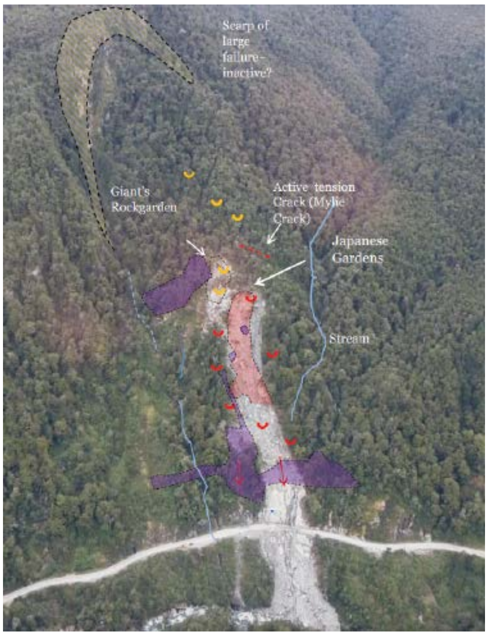
SH 6 Diana Falls Slip: Rockfall Protection

Mat Avery

Mat Avery is a Senior Engineering Geologist and Project Manager for Geovert NZ. As well as business development work he is often heavily involved in helping clients solve geotechnical problems especially in the fields of rock fall and slope stabilisation. With fourteen years' experience, six of those as a consulting Eng Geo, Mat has extensive experience in the planning and implementation of geotechnical construction projects in a variety of geological conditions.

The SH6 Diana Falls slip occurred in September 2013 during a high intensity rain event and resulted in immediate closure of the state highway over the Haast Pass, isolating the lower West Coast and crippling the local tourism industry. Following extensive investigation and preliminary design work by Geotechnical Engineers from Opus international Consultants Geovert in conjunction with Geobrugg were commissioned with a Design & Construct contract to stabilise the slip and mitigate the risk of rockfall to the road user. Construction began in April 2014 and was immediately hampered by a 300 mm weather bomb. With a total of over 4000mm of rain recorded during the construction period ongoing rockfall and movement on the slope made the site extremely treacherous. Three high energy Geobrugg rockfall attenuators were installed on the slip to mitigate the risk of rockfall to the road user. A total of over 45 tonnes of steel structure was erected on the slip including over 20 t in the lower mesh drape alone. The highway was reopened to 24 hr traffic on the 5th November 2014, 14 months after the slip first occurred and 7 months after construction began.

Overview - The site is adjacent to State Highway 6 approximately 2 km east of The Gates of Haast Bridge in South Westland, within the Aspiring National Park. In November 2013, following the main event in September, the NZ Transport Agency (NZTA) commissioned Opus to investigate and assess remedial options to stabilise the slope and to reduce the risks to the road and road user. Due to the complex geological setting, steep gradient and multiple identified triggers, no means of communication and situated in an area of extreme weather potential it was concluded that the slip had the potential to be one of the worst, if not the worst, in



NZ to date.

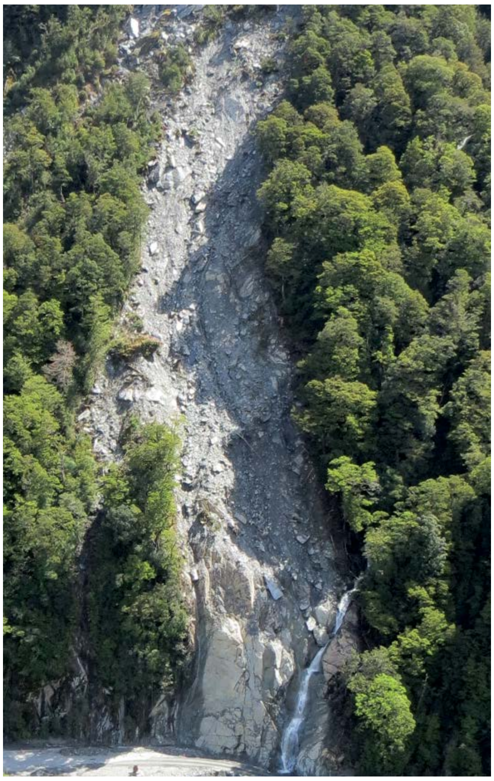
Opus concluded the design must address:

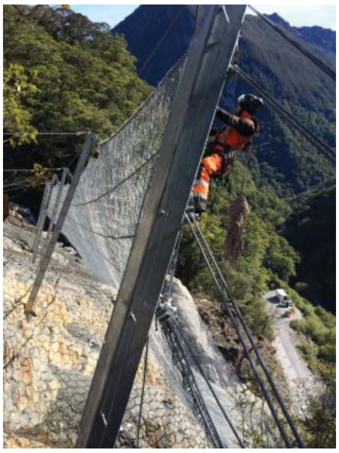
1. Short to medium term continuous debris flow and rockfall,
2. Must enable the road to reopen to a level of service comparable to that prior to the slip, within 12 months.
3. Must be relatively self-clearing as maintenance on slope is restrictive and potentially hazardous,

Additionally the design CANNOT address massive landslide failure, and CANNOT address multiple large scale rockfall from upper margin.

As a result of these investigations and assessments it was determined that a system of rockfall attenuators be used down the length of the slope to facilitate a control system for future rockfall and debris slides. The design for the rockfall protection system comprised three distinct bespoke systems as follows:

1. Upper Slope Attenuator: Geobrugg GBE3000A Rockfall Attenuator located below the head scarp area.





50m wide, 6m high with 6m tail.

2. Mid Slope Attenuator: Geobrugg GBE5000A Rockfall Attenuator located at the approximate position of The Ark feature. 50m wide, 6m high with 6m tail.
3. Lower Slope / Main Face Attenuator: Geobrugg GBE5000A Rockfall Attenuator installed at the lip of the main face. 60m wide, 6m high with 60m tail extending to roadside.

Innovation - This project was ground breaking. The combination of the 3000kJ and multiple 5000kJ rockfall attenuators has never before been implemented and the total rockfall protection system is the largest single installation in Australasia. Rockfall attenuators are a relatively new concept in that there are no globally accepted approvals or certifications available; however Geobrugg have been extensively testing the systems in Switzerland, the United States and Japan and have a detailed knowledge of how they perform under different conditions. The design of the systems installed at Diana Falls are based on the European Technical Approval Guideline (ETAG) approved Geobrugg GBE and RXE rockfall barriers.

Early investigations revealed the slip was part of a much larger feature and the underlying geological conditions were complicated. The slope model was developed by Opus Geotechnical Engineers Rob Bond and Emily Stevens. Once the driving mechanism for the large scale system was understood a series of precision monitoring instruments were installed throughout the slip site. These were surveyed monthly to ascertain background slope deformation rates and confirm the failure mechanism. This monitoring was essential to help develop remedial options for the site – was it a reactivation of the entire feature, or a smaller isolated failure? Long term monitoring is ongoing, but to allow the road to be reopened in the shortest possible timeframe, early survey results indicated that for the short to medium term treatment of risk it would be best to treat only the most active portion of the system.

Design of the rockfall and debris flow protection system required an in-depth understanding of the specific material behaviours. Failed material moves through the site as both low to medium velocity rockfall (typically 2000-3000 kJ) and low volume (< 200 $m^{3)}$ moderate velocity debris flows. With globally very few examples of similarly complex systems availability of data on slope behaviour is limited, and so the design team spent many hours observing rockfall and small scale debris flow events on the slip and modelling the behaviour to ascertain the most suitable, best fit, remedial solution. The concept design was completed by Opus and peer reviewed internally. Detailed design was completed by Geovert with Geobrugg providing technical expertise on product performance as well as supplying the systems. EnGeo NZ Ltd provided foundation design and construction monitoring.

In addition to the design the installation of the systems using helicopters, while not a new concept by any means, pushed the limits of operational performance from both the pilots and ground crews. The posts for the 5000 kJ attenuator, for example, each weighed over 1100 kg when fully assembled. Using Squirrel B2's which have a lifting capacity at sea level of around 1200 kg, required immense skill from the Wanaka based Alpine Helicopter's pilots. Post installation was completed on average in less than 4 minutes.

The volume of material installed on the slip was immense, arriving in four 40ft containers, two 20ft containers, as well as four truck and trailer loads of locally (Christchurch) manufactured materials. The total weight of materials was in excess of 45 tons. With over 100 hrs of helicopter time on site and only one near miss incident (the result of a mechanical issue on a machine from another operator) this project broke new ground in difficult access specialist geotechnical construction.

Collaboration - The partnership of Sicon Ferguson, Geovert and Opus resulted in a highly effective team with a joint desire to deliver excellence. Geovert have a long standing relationship with Opus and NZTA and as experts in the field we were involved in the early stages of site investigation and concept design at Diana Falls. Senior Engineering Geologist Mat Avery was invited to site on numerous occasions to discuss concepts, constructability issues and risk management strategies. This allowed Opus to develop their concept design into a manageable system.

Communication with the Client was a leading factor in the successful delivery of this project and Geovert have a sound relationship with NZTA, having together completed some of the most complex rockfall protection work in the country. Key to maintaining trust and respect is keeping open communication throughout contract periods. With weekly updates, as well as regular site visits including escorted access to the slip face and helicopter inspections they were very understanding of the rockfall risks and the resulting delays. The Client required the road open and safe public passage beneath the slip at the earliest possible opportunity. We presented a construction programme that would have provided this within around 4 months however due to a highly unstable slip surface, resulting from extremely high levels of rainfall during the winter months; the actual delivery date was considerably longer than originally anticipated. Working together at all levels ensured not only was the Client happy, but so too were the road user, Engineers and Contractors on the job.

Risk - With the onset of winter Geovert was faced with a construction programme challenged by weather extremes. Critical to our early planning was understanding the local environment including frequency and intensity of rainfall events (daily, weekly and monthly). Rainfall had a very real (and realised) potential to affect the construction programme as we required a mostly stable slip site to complete the contract works. We used the existing monitoring staff to assist in this understanding. With only one near miss incident involving a falling rock and staff member recorded for the whole project our carefully developed safety management plan proved to be very robust.

Prior to establishing on site a detailed, full project risk register, involving all affected parties including NZTA, Opus, Sicon Ferguson and Geovert, was developed for the site. The register was re-visited and reviewed throughout the contract period to maintain relevance. The highest construction based risk items

included injury to staff and public from rockfall, further rockfall / slip events, worker fatigue, remote location and Emergency Services Response and loss of key personnel. Robust Quality, Safety and Environmental Management Plans were developed in line with Geovert's ISO9001, OHSAS18001 and ISO14001 accreditations.

Outside of construction risks, from the Client's perspective the highest risk items were related to cost, time and road users. Once construction began time and cost variations were largely beyond anyone's control as they were typically driven by environmental (climatic) impacts. How these are managed can make a huge difference, but essentially little can be done to predict or control them. Linked closely to these however is how the road user is managed in regards to time overruns. The route over the Haast Pass is one of the most popular tourist routes in the country, not to mention a vital transport route for freight and local industry, and closing the road affects the local economy immensely. With the shortest detour available adding 1000km and 10hrs of driving to reach Wanaka having a reliable schedule of road openings and definitive dates for 24hr availability was essential for NZTA.

Efficiency - Big picture efficiencies were provided through prior planning, including programming, resourcing requirements and material deliveries. Rather than use standard Geobrugg wire rope anchors, where possible the design allowed for locally available solid or hollow bar anchors. These could be drilled and installed while the head detail was flown from Europe. Base plates and posts were manufactured in New Zealand to reduce freight time, this allowed the main superstructure to be drilled and installed while the mesh and ring net panels were on the water from Europe. It also meant any defects could be remedied or changes made easily, it also aided the local economy.

Health & Safety - Diana Falls is a very steep and active slip. During the month of April 2014 the site received several high intensity rain events including one which topped the original triggering rain event and delivered over 300mm of rain in 24 hrs – the same week Geovert mobilised to site.

Aside from rockfall the major H&S risk faced by Geovert was a lack of reliable communication in and out of the site. A robust emergency communication plan was developed in the event a serious incident occurred on site. This included for the use of satellite phones and EPIRBs, as well as coordination with and issuing of emergency response protocols to local emergency providers.

Summary - With a strong commitment to team work and the collaborative effort by all parties, and especially the patience of the travelling public and local businesses, the Diana Falls slip was successfully treated and the road reopened to a level of service comparable to that of prior to the slip. In the words of one stakeholder once the road was open.

"Thank you all involved directly and indirectly for all the work at Diana Falls. We know it's a challenging environment to be working in, what with the geology, topography and weather. We really do appreciate all the hard work to get the road open in time for the busy tourist season. Now go and enjoy a few beers, you all deserve it!"

KEY FACTS

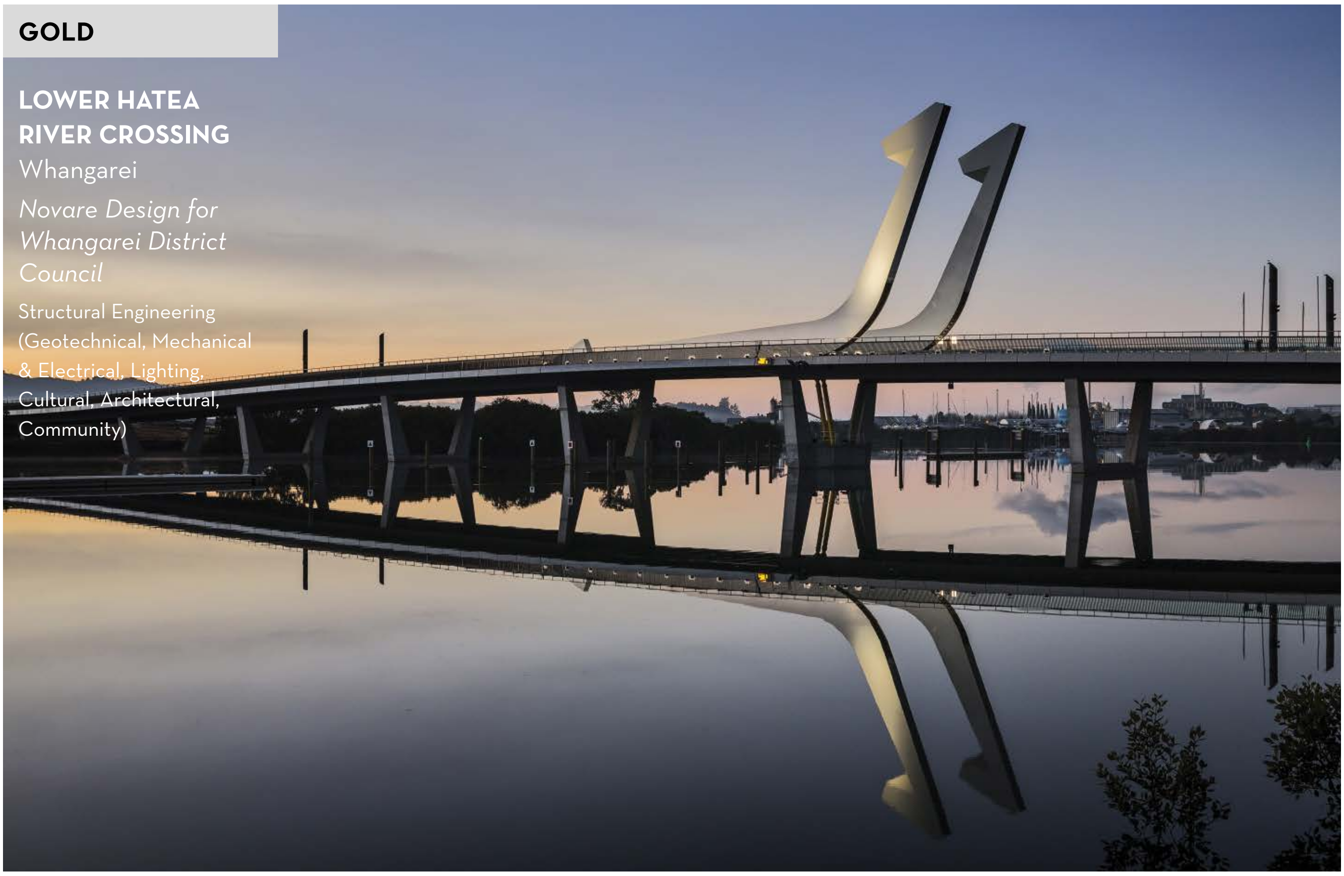
Initial slip occurred September 2013 with 40,000 m^3 debris in single event

- **State highway closed overnight for 14 months**
- **Construction work started April 2014**
- **Over 4000 mm of rainfall during contract period**
- **Over 700 man hours manual scaling to make safe**
- **Over 45 tons of steel used in construction**
- **Road open to 24hr traffic November 2014**

Innovate New Zealand Awards

GOLD

LOWER HATEA RIVER CROSSING
Whangarei
Novare Design for Whangarei District Council
Structural Engineering (Geotechnical, Mechanical & Electrical, Lighting, Cultural, Architectural, Community)



THE ANNUAL INNOVATE NZ **awards celebrate engineering excellence. Past winners include iconic sites such as the Britomart Transport Centre in Auckland, Wairakei Geothermal development, the Sky Tower, the Westpac Trust Stadium in Wellington and the USAR Specialists' Response to the Christchurch earthquake.**

ACENZ chief executive Kieran Shaw says that it is important we recognise the enormous contribution engineers have made to our lives. Many engineering projects are the platforms that modern society depends upon but so often takes for granted.

For 2015, 28 projects were submitted ranging in disciplines from fire engineering, earthquake, asset management, power & project management, to process and structural engineering and more. Winners were announced on Saturday, August 1st at the Transitional Cathedral in Christchurch. This year four projects with a strong geotechnical focus won awards.

LOWER HATEA RIVER CROSSING

The Lower Hatea River Crossing is an example of outstanding civil construction, as it demonstrates that functionality and aesthetics need not be mutually exclusive. Road bridges are typically built to a cheap design solution, yet the LHRC shows that transport infrastructure can be both practical and striking – and with lateral thinking – economical.

The Transfield Services/McConnell Dowell JV was able to achieve this with their bascule bridge modelled on the traditional Maori Fish Hook Hei Matau – representing strength, good luck and safe travel over water. The bridges form reflects its function as the 'fish hook' (J beams), which is cantilevered and rolls back to raise the bridge deck.

The new 265m bridge connects Whangarei's eastern suburbs with the

City's commercial and industrial areas along Port Road and back to the Town Basin, and is part of a package to ease traffic congestion. The project includes 1.26km of new road across the old town refuse facility on Pohe Island, three roundabouts and a three-metre shared cycle lane and foot-path. Since opening in July 2013, the bridge now carries over 8,000 vehicles per day.

Community involvement in the project was a key driver for the client, and local input was emphasised and prioritised at every stage. More than 61% of the project's value was spent locally and more than 65,000 local man hours worked. This provided significant stimulation to the local economy – a key project requirement.

Delivered through an ECI contract model, the project demonstrates how collaboration can leverage the skills of diverse groups. Auckland-based consulting engineer Novare / Gaia (formerly Peters & Cheung) led the project team. Novare / Gaia carried out structural and geotechnical design. It included Knight Architects delivering the bridge design and Eadon Consulting providing the mechanical and electrical engineering for the bascule section. Northern Civil Consulting Engineers carried out roading design. The client particularly noted the efforts of Duncan Peters in leading this international team to deliver the outstanding design result.

The geology at the bridge site generally consists of silt and clay alluvium underlain by Northland Allochthon mudstone. The depth to competent bedrock increases from about 14m at the west abutment near Port Road to more than 30m at the east abutment on Pohe Island. The geotechnical design by Peters & Cheung included a range of measures to economically address the diverse ground conditions. A grid of timber piles was driven through the silts behind the Port Road abutment to support the geogrid-reinforced approach embankment to the bridge. The bridge abutments and piers were all founded on open steel tube piles driven into the mudstone bedrock. The eastern abutment on Pohe Island is on a former landfill site with refuse fill heights of up to 12 m thick which is still settling.

Seismic analyses showed it was necessary to use a group of small-diameter driven piles and a pile cap at each pier and the abutments to limit the lateral sway of the bridge. The stiffness of the two sides of the bridge was further enhanced by having fixed connections between the bridge deck and the piers and making the bridge deck monolithic with the abutments. The majority of vessels using the river are light and the collision loads from them would be less severe than the effects of the design earthquake. However a 350t barge began operating in the Hatea River during the design development period and so this vessel was selected as the design load case for ship impact on the bridge piers.

Site preparation in December 2011 began with loading applied to areas of the eastern approaches. At the eastern abutment, the approach embankment height is around 5 m and the embankment has been made of lightweight expanded polystyrene and capped with a thin concrete slab in order to limit the amount of future settlement. The approach spans are supported by V-shaped reinforced concrete piers whose geometry varies as the vertical alignment rises towards the middle of the bridge and the deck is designed as a composite structure using a steel ladder beam arrangement with precast deck panels.

Movable bridges are usually functional pieces of infrastructure, but they can also bring drama, spectacle and delight and can reinforce the identity of a place and its community. Te Matau a Pohe has a visual clarity in its form and is designed to be recognisable by day and night. It provides a welcoming gateway to the town basin and is a form that speaks strongly of the local character and culture of Whangarei. The bridge has already featured in TV advertisements and magazines around the world.

ARA TŪHONO – PŪHOI TO WARKWORTH SECTION

The 38 km Ara Tūhono – Pūhoi to Wellsford Road of National Significance (RoNS) is one of seven RoNS established by the Government on 2009. The first stage of this scheme is the 18.5 km long Pūhoi to Warkworth section (P2Wk).

In 2013 the NZ Transport Agency (the Agency) formed the Further North Alliance (FNA) comprising the Agency, engineering & planning consultancies Jacobs and GHD, and Chapman Tripp Lawyers.

The FNA was tasked with obtaining the statutory approvals for P2Wk. An alliance unique in the world with its inclusion of legal non-owner participants, it was created with the challenging objectives of; obtaining designation and consents in record time, achieving flexible, outcome-focused conditions of designation and consent, and setting a new benchmark for the consenting of large infrastructure projects.

The alliance partners worked closely and adopted an innovative and 'norm challenging' approach to many commonly accepted practices associated with the statutory approval process that achieved all the Agency's objectives and stretched targets, and exceeded Client expectations in all respects.

Targeted design development and environmental assessments were undertaken to prepare concise application documentation. The application followed a Board of Inquiry process, administered by the Environmental Protection Authority. The expertise and experience of the alliance technical specialists, together with the Agency's exemplary track record of environmental management, combined to ensure success for a project with significant scale and technical complexities.

The Agency believes that the techniques and innovative processes devised and executed by the FNA can deliver significant productivity and cost benefits to New Zealand's infrastructure portfolios, and hence the wider NZ economy. The NZ Transport Agency was not only highly satisfied with the FNA's work, but also in its firm belief in the wider benefits achievable for the nation. This alliance model is now being used on other Agency project delivery.

Darryn Wise, geotechnical lead on the project, reported, "The combination of steep, highly weathered slopes with Waitemata Group and Northland Allochthon rocks lead to challenging geotechnical conditions to characterise and design.

The tight timeframe for the Board of Enquiry process drove the geotechnical assessment thinking throughout the project. Rapid data collection was essential to delivering the right project outcomes. Jacobs lead a combined project team to undertake a comprehensive geohazard mapping process to identify critical environmental impacts and used these to quickly progress a specimen design. An engineering geological model was created early in the project, with the intent to continuously review and update this during further stages of the project as new information is generated.

The geotechnical design philosophy was based on identifying, avoiding where possible, or minimising key geotechnical risks and environmental impacts whilst making use of geotechnical opportunities to provide a safe, secure and constructible indicative alignment and design. The engineering geological model was a critical element in achieving these aims."

ESK RIVER HYDROPOWER

The Esk Hydro Project is located at the headwaters of the Esk River, Napier. The scheme comprises two separate high head mini-hydro schemes. Drawing from separate tributaries these provide a combined output of 3.8 MW.

The schemes locations are remote and difficult to access up steep and unstable terrain. To enhance the viability of the schemes access roading development was minimised and detailed geotechnical investigations were restricted to dam sites, power houses and only where considered necessary for penstocks with engineers, client and contractor working in an informal risk sharing arrangement. Where pressures are lower penstocks are rubber ring jointed GRP. Where pressures are higher and in steep and unstable sections welded steel pipes are used. Specially designed thrust blocks were used where penstock bends were necessary and at pipe material joints. The longer of the two penstock routes is 2.8KM dam to powerhouse.

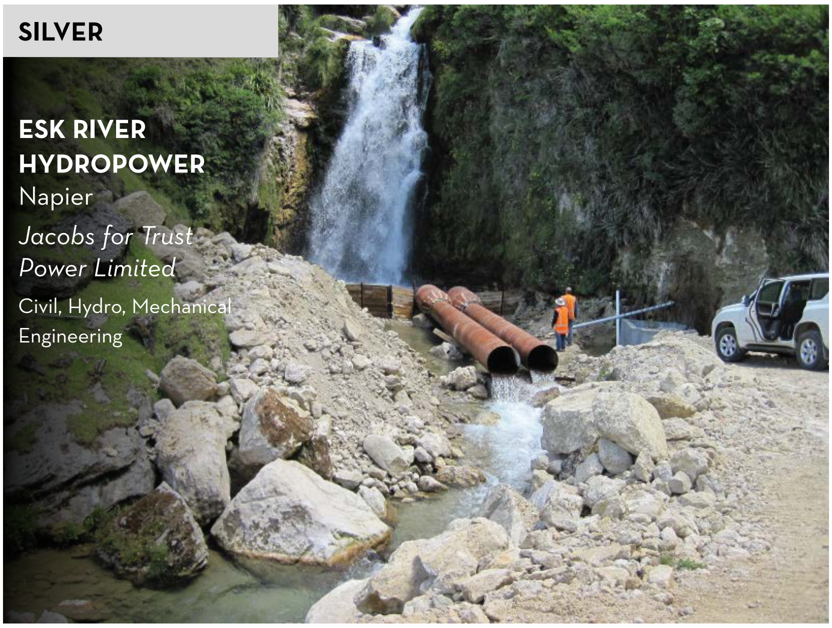
Minimal access roading development required innovative methods of sledging and bucketing materials and equipment to power houses and dams construction.

The resultant viable scheme has been achieved by economical, practical engineering and construction for low capital cost. It has virtually no impact on the environment and provides continuous renewable energy for up to 2,000 homes.

John Seward, lead geotechnical engineer on the project, reported, "The modest size of the Esk Hydro scheme belies the challenges faced by both the design and construction team. Due to the cost and difficulty in getting investigation equipment to the various locations required on such a remote site, a decision was made to limit investigation to a bare minimum early on in the project, and to control the risk and perform the detailed design during construction. Located in in an area with complex geomorphology, the numerous geotechnical challenges posed by this approach required a real back-to-basics design philosophy, and we tried to work in harmony with the ground conditions, rather than designing costly 'standard' alternatives.

The two intake sites were located in areas where unconsolidated boulders existed, so we opted to locally improve the founding conditions at the Toronui intake by tying the boulders together to form a solid foundation with drilled and grouted reinforcement. There are no standard methods for this type of design so we worked closely with the constructor to develop the appropriate methodology. Very little geotechnical information was available at the Rimu Stream intake, and again unconsolidated cobbles and boulders existed. Driven steel columns were used to reach a suitable set within the cobbles deposits and the weir was designed with a frangible lagging system to limit the loads on the columns under extreme flow conditions.

In terms of the penstock, a number of practical assessment methods were developed by the geotechnical team. Using various iterations and first principle methods we developed soil springs values in various directions for inputs to the penstock design, which in turn dictated the deflections and loads needing to be transferred to some innovative thrust blocks. Due to the expense of getting concrete to such a remote site, an



SILVER

ESK RIVER HYDROPOWER

Napier

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Civil, Hydro, Mechanical Engineering

innovative 'winged' thrust block design was developed using precast members to transfer the somewhat high thrusts generated by the penstock to the ground at key positions in typically the trickiest locations. This required close collaboration with the structural team to optimise the amount of reinforcement steel in the wings and therefore keep deflections within the tight tolerances imposed by the penstock manufacturers. A trench design using the locally sourced marginal materials was also developed in conjunction with the contractor.

A balancing pond was required part way down the Toronui scheme and required the design of a small dam and in/outlet structures using the locally sourced marginal materials. A design and operations methodology was developed with Trustpower which included a long term monitoring programme to address these issues. Design inputs to various other desander and bridging structures were also required along the scheme, in ground conditions which varied over very short distances.

Due to a limited number of options the Toronui power house was sited in a difficult setting within complex landslide terrain. Due to historic debris flow processes ground conditions including whole trees, house sized boulders were encountered overlying soft and somewhat shear rock, and a number of iterations of the final earthworks solution were required to achieve the final outcome, with the design decisions being performed in the field and during difficult construction conditions.

Needless to say it was a challenging and rewarding project for all involved, and only successful due to the tenacity and ingenuity of the contractor, client and consultant team. The project was commissioned in early 2014 and completed its first calendar-year of generation achieving just over 16GWhr generation compared to a budget of 15.2GWhr."

WAIKATO EXPRESSWAY – HUNTLY SECTION

The Huntly Section is a proposed 15.5 km four lane expressway to the east of Huntly township, forming part of the Waikato Expressway Road of National Significance. The constructed project will pass through steep and geotechnically challenging terrain and areas of high environmental and cultural value.

Bloxam Burnett and Olliver Ltd collaborated with its principal subconsultant Tonkin and Taylor Ltd, and the NZ Transport Agency, to complete the investigation of the project, develop a Specimen Design and obtain the principal statutory approvals required for construction.

The project team identified an alternative eastern corridor through the central 10km of the project that mitigated significant geotechnical risk, reduced environmental and cultural impacts, improved the geometric standard and resulted in an estimated cost saving of $72 million.

The high level of stakeholder engagement contributed to all statutory approvals being obtained without Council hearing or appeal to the Environment Court. The integration of Tangata Whenua into the project team resulted in their initial strong opposition to the project being transformed into acceptance, if not support. This approach was commended by the State Services Commission which observed that it may well provide a model for future engagement with iwi on similar future projects.

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WAIKATO EXPRESSWAY – HUNTLY SECTION
Huntly
Bloxam Burnett Olliver for NZ Transport Agency
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Letters to the Editors

IN RESPONSE TO the June 2015 edition of NZ Geomechanics, technical article entitled 'Recommendations for post-disaster geotechnical response for hilly terrain: Lessons learned from the Christchurch Earthquake Sequence', I have written a brief synopsis of the active and comprehensive Port Hills recovery programme run by Christchurch City Council which includes an emergency response to slope instability as part of our CDEM obligations. In addition, as part of our statutory requirements and commitment to our residents, the Council is implementing other processes to ensure not only a recovery, but future resilience in the Port Hills. This includes incorporating the key scientific findings as part of the natural hazards chapter in our proposed Long Term Plan and remediating some of the hazards where they pose a significant risk to residents and/or infrastructure.

POST EARTHQUAKE REPONSE IN THE PORT HILLS: AN INTEGRATED MANAGEMENT PLAN UNDERTAKEN BY THE CHRISTCHURCH CITY COUNCIL

INTRODUCTION

The 2010/2011 Canterbury Earthquake Sequence was a devastating experience for Christchurch, including the Port Hills where five fatalities occurred as the result of slope instability. In the immediate post-February aftermath the response by the local geotechnical community was admirable. The quick formation (in the matter of hours) of the Port Hills Geotechnical Group (PHGG) was instrumental in this response phase and is well documented by Macfarlane and Yetton in the proceedings of the 19th NZGS Geotechnical Symposium. In this paper, the authors not only discuss the role of the PHGG but also accurately delineate the key organisations involved. What was truly remarkable was the commitment of the PHGG personnel to step in to help our community and fill the gap until a formal response could be implemented through Civil Defence.

In the post- Civil Defence Emergency Management (CDEM) recovery phase the Council worked closely with CERA and helped the PHGG and GNS Science to, in the first instance, understand the science. They then then progressively utilised this to underpin their regulatory responsibilities, which include incorporating key findings within the Civil Defence Emergency Management Act, 2002, Resource Management Act, 1991 and Building Act, 2004 under which the Council has a statutory obligation to act.

Recently, the Council has transitioned the PHGG to the Slope Stability Engineering Panel (SSEP). The SSEP comprises six local consultancies; AECOM, Aurecon, Coffey, Golder, Engeo and Jacobs, who are contracted to the Council to perform key technical, regulatory and emergency response management roles.

2. CIVIL DEFENCE

Through technical advice from the PHGG and GNS, the Council has gone through a 'lessons learnt' process and enacted a formal Port Hills Slope Stability Emergency Response Plan (SSEP). There are a number of key components to this:

1. Provision of the SSEP where individual consultancies commit key qualified personnel to Council emergency response operations pertaining to slope instability issues.
2. Council provides emergency response training to SSEP personnel including key tasks and reporting procedures
3. Formulation of a 24/7 Roster where both a primary and secondary SSEP geotech is on call.
4. Alignment between the emergency services, CERA and the Council on an emergency response and the activation of a duty SSEP, or the

entire SSEP depending on the level of response required. This may be a local event or a local or regional formal civil defence response.

5. Trigger level activations for the SSEP and Civil Defence. GNS has provided key technical information on what are the key thresholds for a trigger, namely rainfall or earthquake, which are used to mobilise personnel through their sectors bearing in mind not all triggers require a formal Civil Defence activation. Where the emergency operation centre is activated the Council Senior Geotechnical Engineer attends and is responsible for coordinating SSEP resources.
6. Incorporation of SSEP call outs into a database, which is shared with GNS

3. PLANNING

Council and CERA has worked closely with GNS to provide detailed slope instability information across the Port Hills residential areas, which includes spatial mapping of risk zones for rockfall, cliff collapse and mass movement. These findings have been included in the natural hazards chapter of the proposed Long Term Plan and will provide certain planning rules which consider the life risk associated with these areas. In addition, the Council has worked and continues to work with GNS, CERA and NZTA on remediating some of the more vulnerable areas through either the mass movement remediation project or the Sumner – Lyttelton lifelines project.

4. RESILIENCE

Council has worked with MBIE on the provision of building back better in the Class II and III mass movement areas and is working with MBIE to provide rockfall protection structure design guidelines, both of which fall under the umbrella of the Building Act, 2004. Christchurch City is an active member of the 100 Resilient Cities, pioneered by the Rockefeller Foundation, 100RC is dedicated to helping cities around the world become more resilient to the physical, social and economic challenges that are a growing part of the 21st century. Council has recently created the role of Chief Resilience Officer to take on these challenges.

Communication is a key factor in our building of community resilience, something which the Mayor has a particularly keen interest in. Council has a proactive communications plan for Port Hills land stability, and the Council's communications work in this area has recently been acknowledged by the Public Relations Institute of New Zealand awarding Council Senior Communications Advisor Linda Bennett and Anne-Marie Robinson its 2015 Supreme Award for their entry titled 'Home truths – communicating the risk of landslides to Port Hills residents'.

5. CONCLUSIONS

Through the dedication and work of the PHGG (and now the SSEP), GNS Science, CERA and the Council, we, as a community have learnt a tremendous amount from the immediate post- earthquake response in the Port Hills, and continue to do so. The Council continues to not only apply our lessons learnt in the day-to-day functions we undertake, but more importantly apply these to the future recovery to make our city more resilient.

The role played by these key organisations and especially the PHGG, during the large after-shocks that immediately followed the February 2011 event, where they exposed themselves willingly to considerable risk, has contributed a huge amount to our understanding of a post-disaster response. The post- earthquake response and recovery programme for the Port Hills continues to evolve, part of this being a dedicated emergency response plan, which has key geotechnical expertise as a major role.

Key role players have been acknowledged by the New Zealand Society for Earthquake Engineering who has provided the Port Hills Response Group with an official letter of commendation, specifically: *The Port Hills Response Group is commended for their direct application of the Society's aims to "gather, shape and apply knowledge to reduce the impact of earthquakes on our communities'.* The Project Management Institute of New Zealand Society awarded Council Project Manager Marcy McCallum the 2014 New Zealand Emerging Project Manager Award for her work on two Port Hills projects – Parks and Tracks Reopening and Land Damage Assessment, Monitoring and Management. These awards highlight the intricacy of the response and the dedication of those involved.

The Christchurch City Council continues to work with key stakeholders in understanding and planning for natural disasters and is committed to disseminating their work.

Dr Ian Wright
Senior Geotechnical Engineer
Christchurch City Council

NZ Geotechnical Society 2015PHOTO COMPETITION

Hamish Foy – Ohau A at last light, oh the serenity!.tif

Gareth Hallam – Abseil Access drilling in perfect conditions

Kade Croft – Geovert at Stonefields

Congratulations to our three winners, each of whom will receive a special collectors edition proceedings pack from the NZGS

Introduction to BIM

Building Information Management (BIM) is gaining popularity around the world, and being mandated in some countries. It's now making headway in New Zealand – but is our geotechnical profession ready? In this special feature we explore the concept of BIM, discuss how it can integrate with geotechnics, and present case studies.

For this artical Ross Roberts interviewed Gary Morrin. Gary heads up Keynetix's design and support services for its products that manage geotechnical data in the BIM process. He is currently leading a two year, £540,000 "BIM for the subsurface project" funded by Innovate UK. The project team includes Keynetix, the British Geological Survey, Atkins and Building Information Modelling (BIM) pioneer Autodesk.

Ross Roberts

Ross is co-editor of NZ Geomechanics News and Section Leader for Ground Engineering in Jacobs New Zealand. He recently lead the ground investigation for Central Interceptor, one of the lagest investigations recently undertaken in New Zealand and one of the first to work within a BIM process which he helped set up.

WHAT IS BIM?

BIM is defined by the Ministry of Business, Innovation and Employment as "a digital representation of the complete physical and functional characteristics of a built asset. A BIM model can contain information on design, construction, logistics, operation, maintenance, budgets, schedules and much more. This depth of information contained within BIM enables a richer analysis than traditional processes and it has the potential to integrate large quantities of data across several disciplines throughout the building's lifecycle."

Q: *What is BIM?*

GARY MORIN:

I quite like this definition: "BIM is an intelligent 3D model base process that provides insight for creating and managing building and infrastructure projects faster, more economically and with less environmental impact".

However, it is important to stress that BIM is the combination of collaboration, standards, processes and (to some degree) technology, defining what, how and when data will be shared between project partners.

One of BIM's major benefits is that it is an ideal vehicle for soliciting a conversation on whether technology and working practices can be updated to improve the way a construction project is delivered.

BIM is more than 3D modelling. It's a process to plan, design, construct, and manage infrastructure that involves creating and using intelligent 3D models. Compared to traditional 2D drawings, these models give stakeholders a better understanding of the project.

BIM is not one technology but instead introduces a data-driven, rather than drawing-driven, approach to enable practitioners to execute work more efficiently and effectively; integrate contributions from others; make changes; explore alternatives and deliver more suitable solutions that address needs from all stakeholders.

BIM is about collaboration, visualisation, and providing a single source of truth throughout a project lifecycle from conception through construction, operation and demolition. For BIM to be successful, everyone, from the client down, must be willing to apply the same philosophy, using defined processes and methodology (along with the appropriate technology) to make it happen.

WHAT'S THE POINT?

Productivity gain is one of the major benefits of using BIM and is the top metric organisations expect to improve when they adopt the technology. Primarily, BIM realises this gain through its ability to:

- reduce uncertainty and risk
- foster communication and co-ordination
- identify errors early
- reduce rework
- reduce costs
- improve quality
- minimise project management

As well as design and layout information, each project stakeholder has access to scheduling, financial, performance and materials data from the beginning of the project. This ability to share and collaborate promotes design decisions that optimise the building at the early stages when it is still cheap and easy to make changes.

In 2010, an Australian analysis found that BIM's ability to detect and avoid conflicts prior to construction reduces unbudgeted construction changes by 40% and can save up to 10% of the entire value of a construction project when compared to a non-BIM project. Many construction businesses in the United States have seen similar results, with 65% of contractors reporting that BIM technology effectively reduces rework, cost overruns and missed schedules during construction (BRANZ, 2014 b).

Internationally, BIM's reputation for boosting productivity has made it widely accepted as a best practice approach for delivering major building projects. The United Kingdom government, for example, is mandating the use of BIM and anticipates a 20–30% reduction in the lifecycle cost of its new public-sector assets as a result.

Around the world, the number of project owners requiring the use of BIM is rising. 39 % of general contractors say that developers frequently or always make BIM a requirement (McGraw Hill Construction, 2013).

BIM IN NEW ZEALAND

The concept of BIM has existed since at least 1960s, and the term itself originated in 1992, but only really took off when mainstream software to enable the concept became available in the form of Revit in 2000.

New Zealand is now catching up, and the New Zealand BIM handbook was published by BRANZ in July 2014 with the stated aim to establish a consistent approach to using BIM.

The October 2014 NZ BIM survey (BRANZ 2014 c) identified that the use of BIM in projects is quite widespread, with 34% of projects worked on by the research group involved some use of BIM. However, it is clear from the results that most users are at the lower end of BIM complexity. Most are using it purely for 3D coordination, modelling of existing conditions and design review.

LEVELS OF BIM

BIM is commonly described by the number of dimensions (from 3D through to 7D), or by complexity from Level 1 to Level 3.

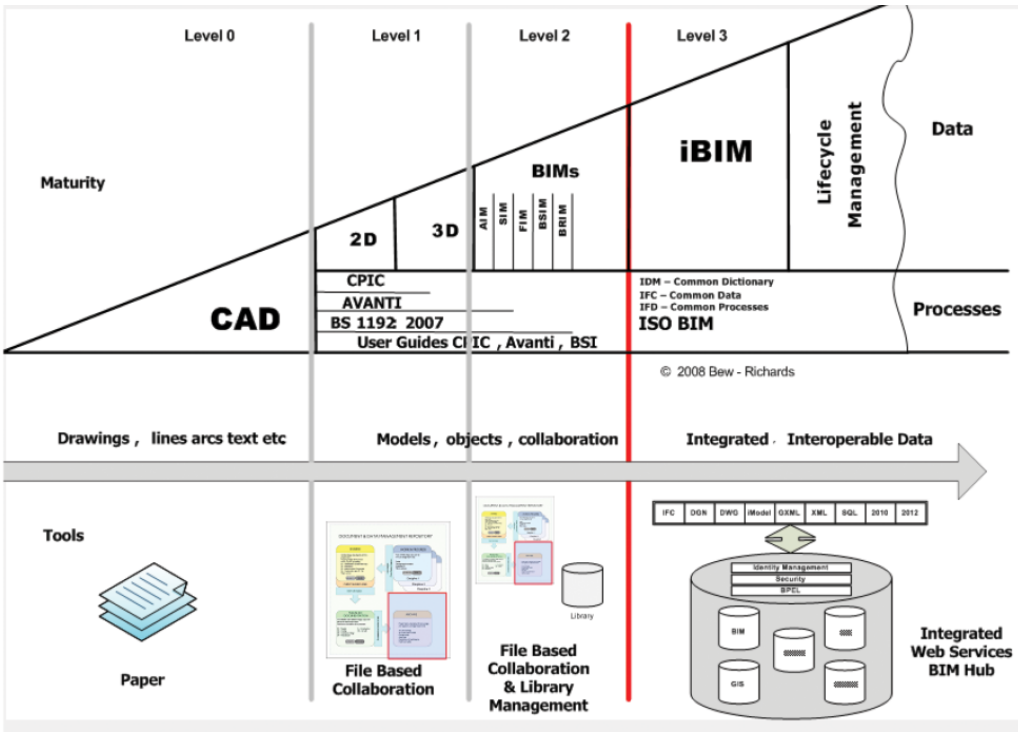

Fig 1: Levels of BIM complexity (BIM Working Party 2011)

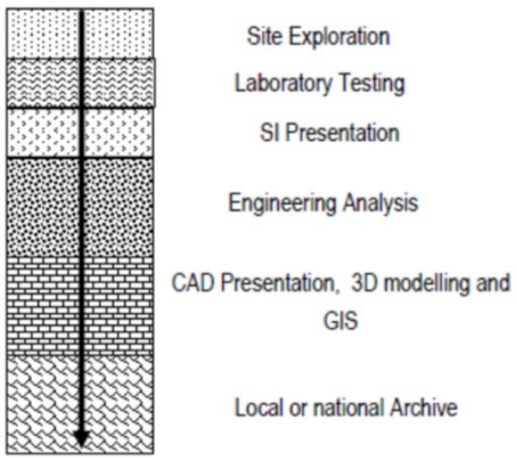

Fig 2: The traditional linear process (R Chandler & R Hutchinson, 1998)

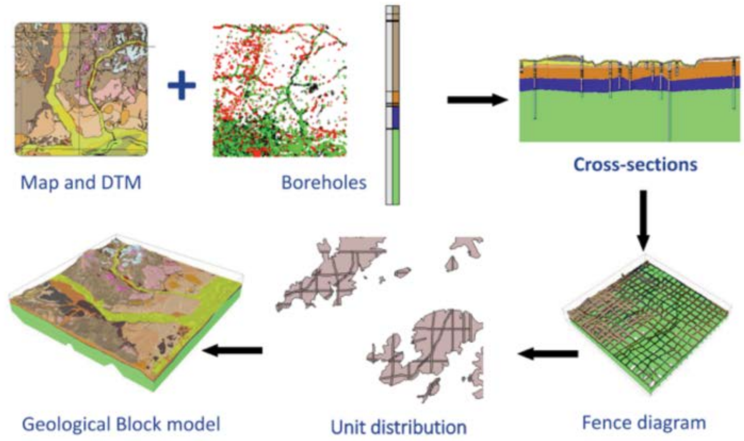

Fig 3: The British Geological Survey 3D geological modelling methodology as a linear process (Burke and Kessler 2015)

Q: *What are the different levels of BIM?*
GARY MORIN:
The terms 4D, 5D and 6D refer to the level of additional data being included in BIM. So, 4D represents the addition of a time element; 5D to the addition of costs and 6D to resources. However, there is no real need for these definitions because BIM is about integrating data for easy access and understanding, whether that is time, cost, resources, monitoring readings or laboratory test results.
BIM is also described as Levels 1-3. While related to the above these refer to the sophistication of BIM being used.
Level 1 BIM is a managed 2D or 3D CAD model, with a collaborative tool providing a common data environment, plus a standardised approach to data structure and format. Commercial data is managed by standalone finance and cost management packages with no integration.
Level 2 BIM is a managed 3D environment held in separate discipline BIM tools with data attached. Commercial data is managed by enterprise resource planning software and integrated by proprietary interfaces or bespoke middleware. This level of BIM may use 4D construction sequencing and/or 5D cost information.
Level 3 BIM is a fully integrated and collaborative process enabled by web services and compliant with emerging Industry Foundation Class (IFC) standards. This level of BIM uses 4D construction sequencing, 5D cost information and 6D project lifecycle management information.

WHY INTEGRATE GEOTECHNICS AND BIM?

Most BIM models produced to date omit any detail about the ground. Given that one of the main aims of BIM is to reduce project uncertainty this is undoubtedly a major oversight. In the UK it is reported that 70% of public projects were delivered late, 73% were delivered over the tender price (UK National Audit Office), and that 37% of project overruns cite ground problems as a major contributor (UK National Economic Development Office). Similar data is not easily available for New Zealand, but there is no reason to believe the figures would be substantially different.

Omitting the ground model from BIM will reduce the effectiveness of the whole BIM process in managing project risk and reducing project costs by centralising data.

CURRENT PRACTICE IN GEOTECHNICAL DATA MANAGEMENT

In traditionally managed ground investigations a linear process is followed from site investigation, through interpretation, presentation of results and archiving. This process can be relatively slow, results in multiple efforts at re-entering data, and means that data is often not retained or re-used. Although the recent growth in use of the AGS data transfer format in New Zealand is helping to reduce the data entry problem the process is still far from streamlined for most.

When more advanced geotechnical models are created in 3D the process may be more complex, but is typically still linear and therefore subject to the same weaknesses.

To reflect modern working practices of multiphase work this linear process has now been updated to a cyclic process.

WHERE NEXT?

Integration of geotechnical information into BIM models can be achieved in many ways. Perhaps the simplest is to add sub-surface layers into an existing model as a fixed item once the geotechnical interpretation is complete.

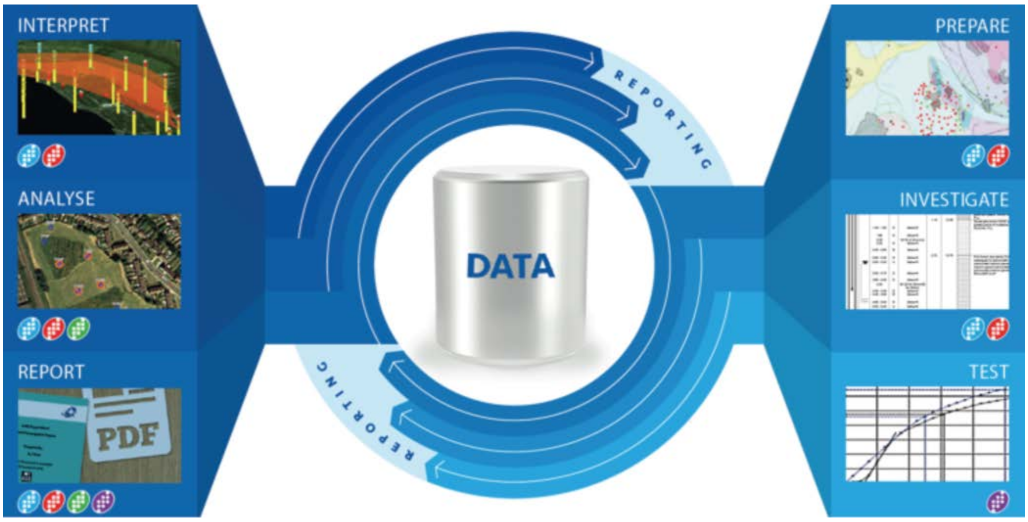

Fig 4: The British Geological Survey 3D geological modelling methodology as a cyclic process

However, this approach does not utilise the full capabilities of the BIM process. If geotechnical models and data can be set up from the start using a process that integrates with the project BIM philosophy there is the potential to create a ground model that evolves with the project. Extra complexity can be added as the project moves through from desk study to phases of ground investigation and interpretation.

FUTURE DEVELOPMENTS AGSi

One future development to watch is the proposed AGSi. This initiative, currently being workied on by the AGS data management committee in colaboration with the British Geological Survey, is a new initiative to include interpreted data and the concept of layers in the next phase of the AGS data transfer format.

Part of this is to introduce the concept of cross-sections where the unity is defiend by the base.

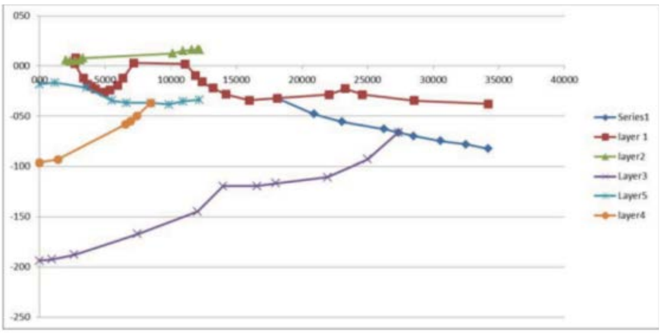

Fig 7: Proof-of-concept of a geological cross-section displayed in EXCEL transferred via xml – lines showing base of geological units

HURDLES

Uncertainty

In managing geotechnical risk the production of robust models is important, yet to date there has been no consistent approach to communicate the uncertainty that

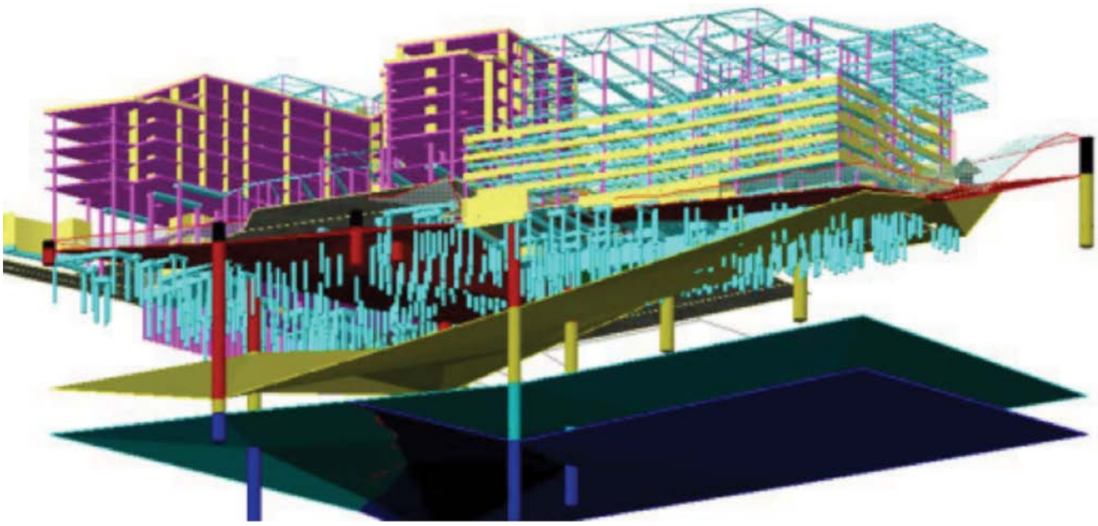

Fig 5: Examples project integrating the geology into BIM (image courtesy of Steve Hassall, Mott McDonald)

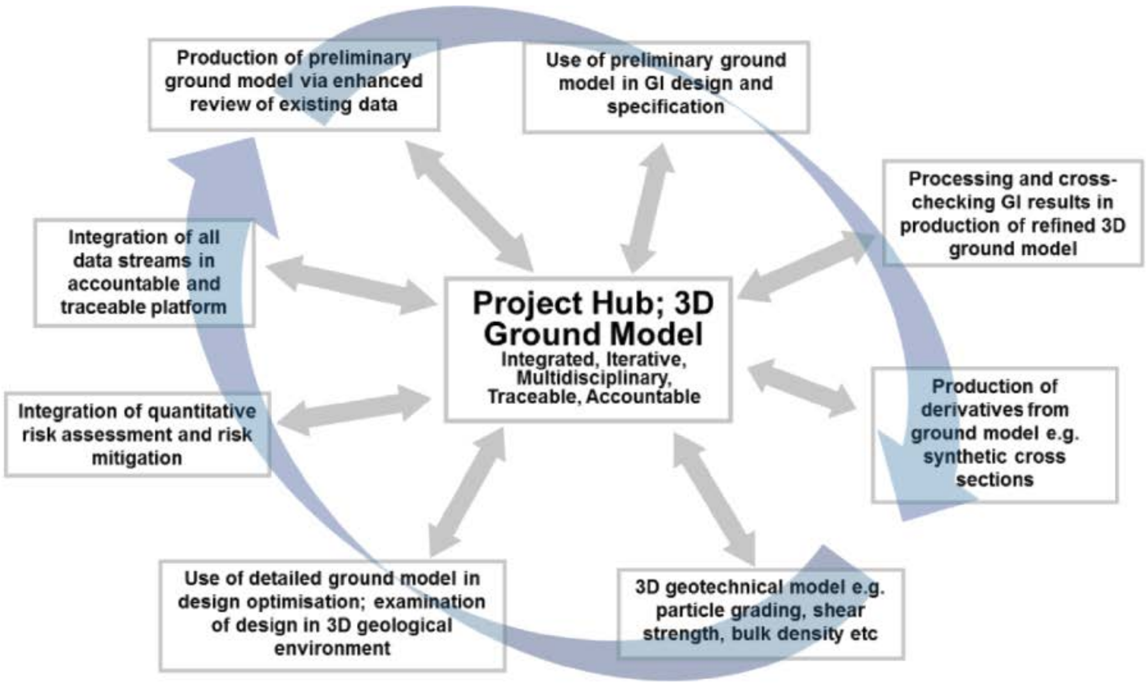

Fig 6: Proposed geotechnical BIM workflow (Fitzgerald and Dabson 2015)

Q: *How do the higher level BIM options work in a geotechnical context?*

GARY MORIN:
Software like HoleBASE SI and the extension for AutoCAD Civil 3D allows users to work at, or near, Level 2, providing one location to store geotechnical data that can be integrated with other data within AutoCAD Civil 3D and Microsoft Excel.
Keynetix is working on Level 3 BIM as part of an Innovate UK funded grant, BIM for the Subsurface. In this scenario, geotechnical professionals are responsible for all the geotechnical data stored in a central project database and allow other project partners access through web services. The important point is that the data is maintained and managed by the geotechnical team.

Q: *What does industry need to do to enable geotechnical BIM?*
Simply: There must be a willingness to fully collaborate and share data.

Q: *What tips can you share for people looking at their first geotechnical BIM project?*
The most important thing is to communicate and agree the collaboration, standards and processes to be used – and keep it simple.

is implicit in any geotechnical interpretation. Currently most geometric 3D models are best guess models which do not display uncertainty or any kind of estimation of their reliability (Jessell & al., 2014), and this limitation applies equally to BIM. There is a risk that a great looking 3D BIM model could give unreasonable confidence in ground conditions. There is a great deal of research going on in this field and one finding is that it is of great importance that all data that was used in the construction of a ground model as well as the methodologies need to be open and accessible to end users (see Kessler et al 2013).

Cost

New processes and systems take time and money to develop and implement. This hurdle, especially at the start of a project, can be hard to overcome.

Q: *Is BIM expensive to implement?*

GARY MORIN:

While ensuring the right systems (technology, working processes and communication) are in place will incur cost, this will be far outweighed by the benefits of adopting BIM. In fact, cost savings across the lifetime of a project is one of the main reasons why governing bodies around the world have embraced BIM. The UK Government, for instance, says using a Level 2 BIM has helped secure 20% savings on CAPEX.

However, this does not mean that savings will be made in every element of the construction process – although some clients may see it that way!

In fact, adopting BIM may mean that more needs to be spent at the design stage to help remove risk, because the better the modelling of individual project elements, the more effective BIM becomes. This is good news for the geotechnical industry because spending more time (and money) on site investigations and on building ground models is an excellent way of reducing project risk.

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The beauty of BIM

BUILDING INFORMATION MODELLING (BIM) is becoming more widely accepted in building design and civil engineering around the world, particularly for infrastructure projects.

According to the Building and Construction Productivity Partnership's *New Zealand BIM Handbook*, published in July 2014, the New Zealand Government is following the lead of countries like the UK, Australia and Singapore in moving towards "mandating the use of BIM for government construction projects". The driver behind this, it adds, is the "up to 20% productivity increase that is reported to be delivered through BIM".

The Handbook goes on: "An increasing number of projects are requiring the contractor to maintain the BIM model throughout the construction phase and provide an As-Built or Record Model at handover.

"To achieve this, client stakeholders, designers and constructors need to firstly embrace [BIM] processes, then develop them to maximise the efficiency and effectiveness of their particular part of the industry in New Zealand."

It is true that BIM improves productivity by encouraging true collaboration, which is essential to reap the full benefit: faster, more economical projects with less environmental impact.

However, BIM can sometimes neglect the geotechnical aspects of projects. Models often appear to start from the ground up, with the subsurface considered as an homogenous substance. This implies there is no risk in the ground, which is clearly untrue.

In fact, there is a host of benefits both to applying BIM principles to geotechnical data management and including geotechnical data in BIM: it allows considered design optioneering and refinement at the outset of a project; minimises geotechnical risk in construction and enables cost-effective repairs and maintenance of assets throughout the project's lifetime.

Using BIM also means geotechnical contractors and consultants can collaborate easily. Data sharing and central data management can result in big improvements in efficiency and quality.

Of course, sharing of geotechnical data digitally is nothing new: the UK Association of Geotechnical and Geoenvironmental Specialists (AGS) began developing its digital transfer format in 1989, which is widely used (and specified) around the world, including in New Zealand, where it has been adapted to reflect local variations in the way data is gathered and described. The latest edition, *AGS4 NZ v1.0 (AGS edition 4.0.3 – New Zealand localisation)*, was published in June 2012 by the New Zealand Geotechnical Society.

However, while there are benefits in using AGS Format, there are issues. The format is fine for factual data but does not currently allow the transfer of interpreted data, such as geological surfaces (although this is being considered for future versions).

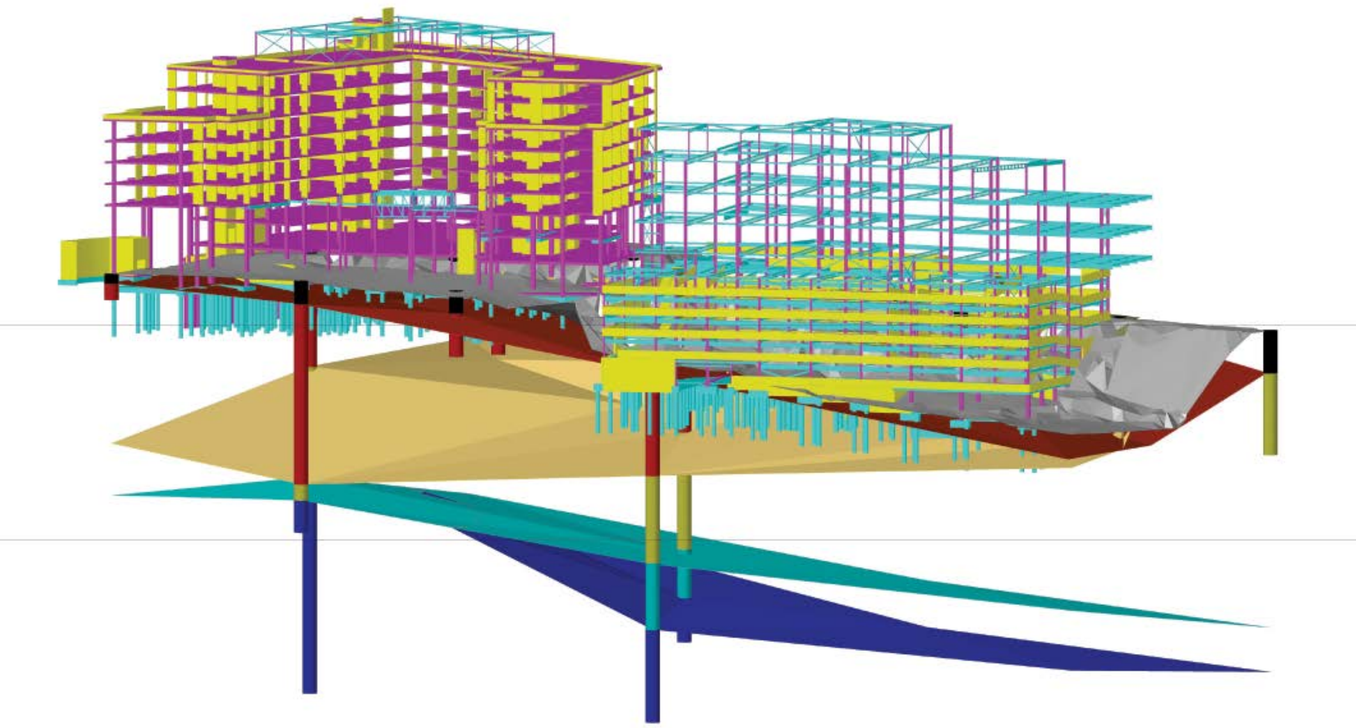
Fortunately, geotechnical data management systems are available that can export both factual and interpreted data. Keynetix's HoleBASE SI, for example, can manage all of a project's geotechnical data (including historical information) and its extension for AutoCAD Civil 3D allows visualisation of information such as geological surfaces for use in both BIM models and the AutoCAD environment.

The sharing of interpreted data appears to be one of the main sticking points of incorporating geotechnical information in BIM. While sharing of geotechnical data is common between site investigation companies, laboratories and geotechnical consultants, anecdotal evidence suggests it is rarely shared with the rest of the project team.

It appears many geotechnical teams are reluctant to supply digital data (rather than written reports) with the wider project team as they are unable to separate factual from interpreted information. This means they are concerned by the possibility of interpretative data being misused.

Gary Morin

Gary Morin is the Technical Director and Co-Founder of Keynetix. A civil engineer by training, Gary has more than 27 years' experience developing and supporting a range of software and specialises in spatial information management. Gary heads up Keynetix's design and support services for its products that manage geotechnical data in the BIM process.



Above: Incorporating geotechnical data in BIM allows considered design optioneering and refinement at the outset of a project; minimises geotechnical risk in construction and enables cost-effective repairs and maintenance of assets throughout the project's lifetime. Image courtesy of Mott MacDonald.

In fact, better data sharing should actually lead to a more complete understanding of the project elements – resulting in more informed decision-making throughout the project lifetime – and improved collaboration should also reduce the risk of interpreted data being misused.

It should be recognised, however, that determining a geotechnical BIM strategy is difficult, as what works for one project may not work for another. It may therefore be a better approach to adopt a geotechnical BIM framework which can be adapted to each project.

Having a clear image of the proposed design and access to full project information will also enable the geotechnical team to optimise the various phases of site investigation. During the desk study, for example, being able to view the latest site plans, is clearly of huge benefit in highlighting any potential points of concern and can help investigation planning.

Furthermore, it is often very difficult, if not impossible, to change the focus of an investigation, without commissioning additional phases. Having access to field data in real time and incorporating it into BIM almost immediately gives the opportunity to refocus sampling and testing mid-investigation. This should deliver more useful data, hence reducing risk and potentially saving money in the long term.

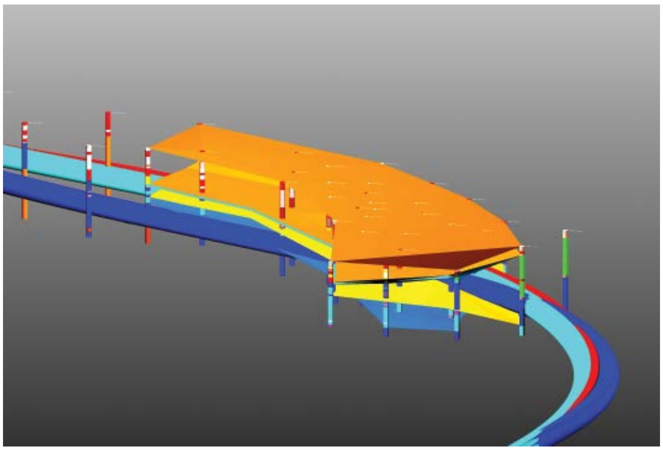
BIM will, without a doubt, become the norm in construction projects in the future. One of the biggest benefits of its adoption will be to give geotechnical teams the opportunity to share their visions and concerns for the ground conditions early in the design, as well as to provide input throughout the project, including the operation and maintenance phases.

Above: Collecting digital data on site makes sharing simpler and faster.

More significantly, if there is a recognition by other project team members of the critical importance of high quality geotechnical information in creating an accurate BIM model, the messages that early and thorough site investigation can reduce project risk, and that geotechnical engineering is an integral part of the entire project, will be reinforced.

The geotechnical profession has been working for many years to improve the standing of geotechnics and for this reason, if nothing else, it should be embracing BIM and helping to improve the way geotechnical data is managed and shared in the future.

Tunnel Case Study



PERTH-BASED CMW Geosciences digitised geotechnical data and created 3D models to help the design of a proposed tunnel beneath Brisbane.

"The aim was to create a 3D model to aid engineering design and also to help non-technical staff better visualise the project," explains CMW Geosciences Principal Geotechnical Engineer Craig Butterworth.

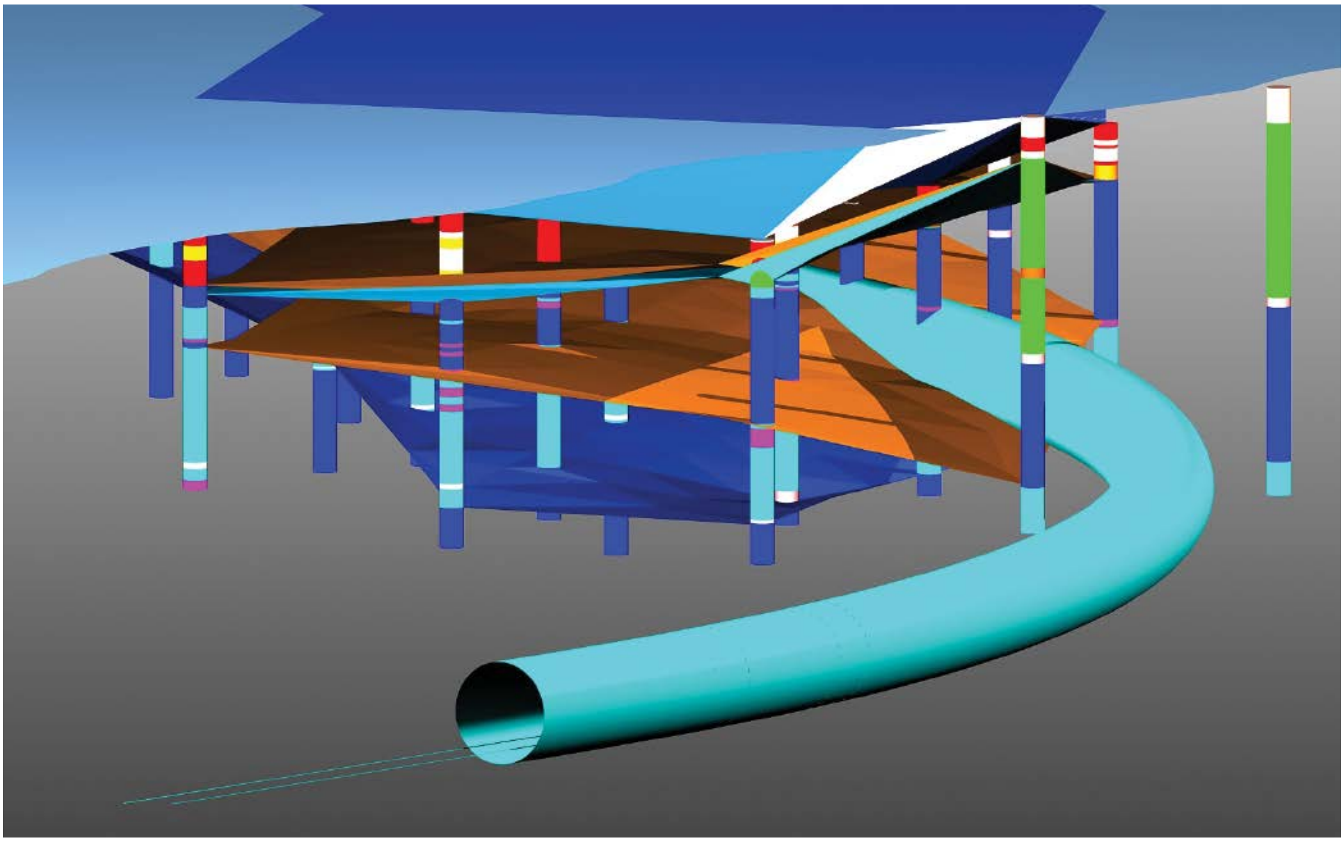
Of particular importance was the ability to develop a 'live' 3D ground model to help understand the nature of the geology through which the route passes - while site investigation was underway.

"Due to time and cost pressures, the team wanted to gain the maximum benefit from site investigation and ensure there were no significant gaps or unknowns in the ground model derived from the boreholes," Butterworth says.

As a result, data was transferred to CMW immediately after each of the boreholes was completed. CMW then transferred this data into a 3D model using the HoleBASE SI Extension for AutoCAD Civil 3D.

"The AutoCAD Civil 3D model was then sent back to the project geologists within a 3D visual viewer. As data was collected in electronic format compatible with HoleBASE SI, the process was much faster and avoided data entry errors," Butterworth explains.

"The live model helped the team visualise the ground model in three dimensions rather than using traditional 2D sections. By using geotechnical BIM, the tunnel alignment could be altered quickly as the ground model was updated with new data."



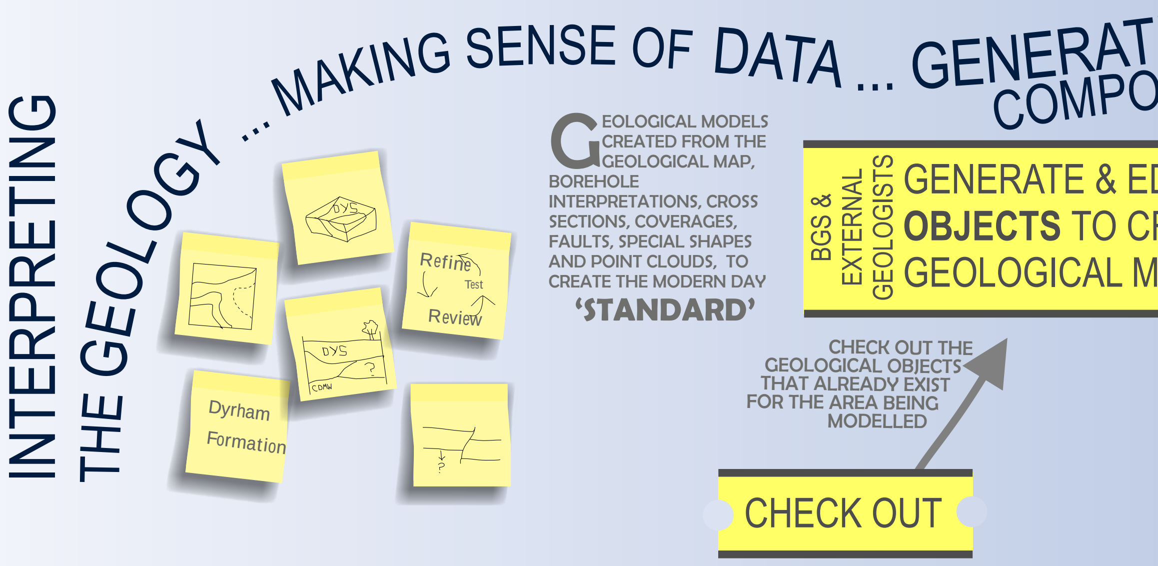
British
Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

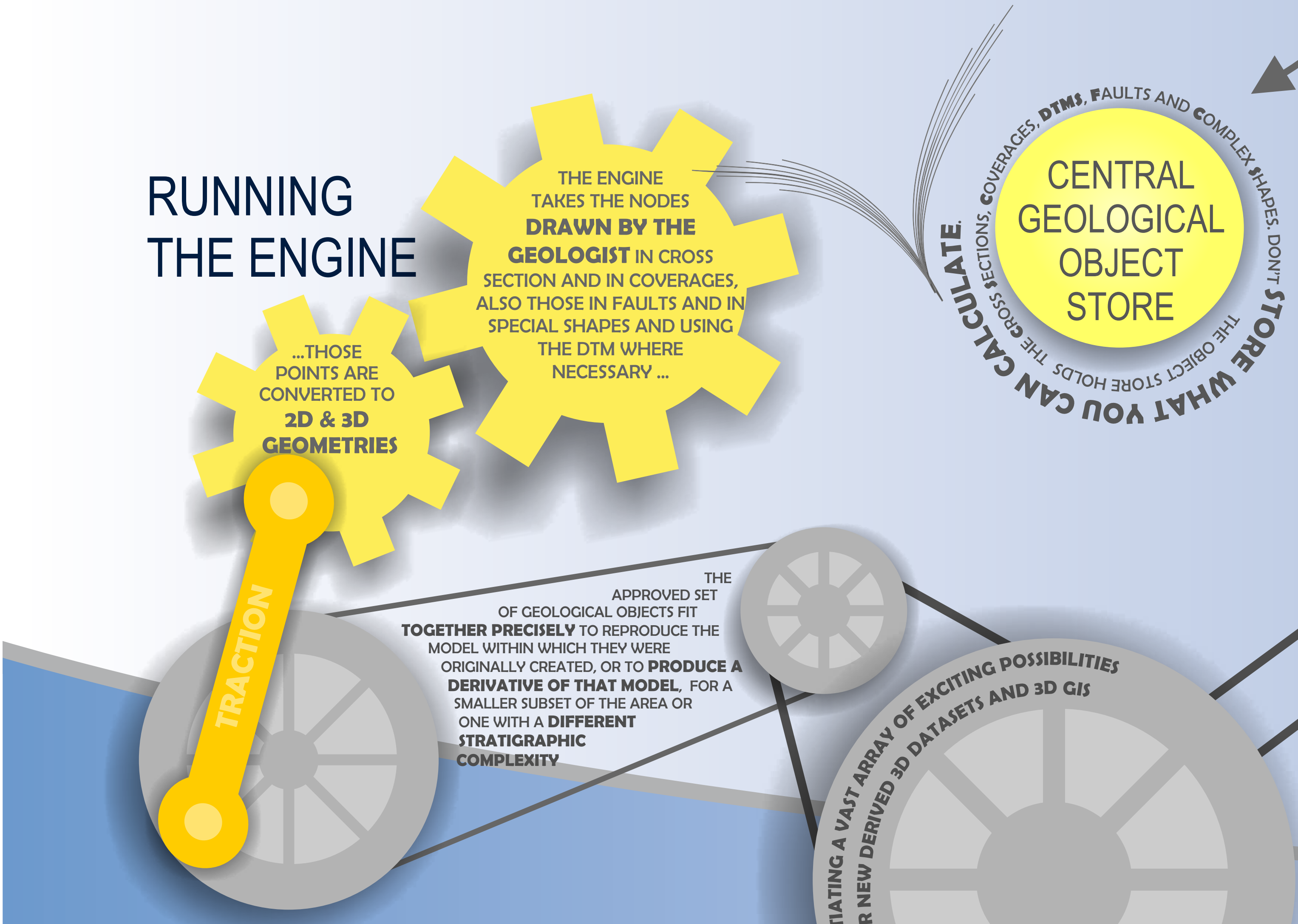
Mechanics of a 3D geological surv

R. Dearden, H. Kessler and B. Wood

The role of the 3D geological survey

- Custodian of the National Geological Model
- Development of multi-scale and multi-purpose geological models
- Long-term storage and versioning of geological model data
- Delivery in a wide variety of formats to end-users
- Management, quality control and incorporation of geological model feedback submitted by the geoscience community.





R. Dearden (rach1@bgs.ac.uk) H. Kessler (hke@bgs.ac.uk) and B. Wood (bwood@bgs.ac.uk)

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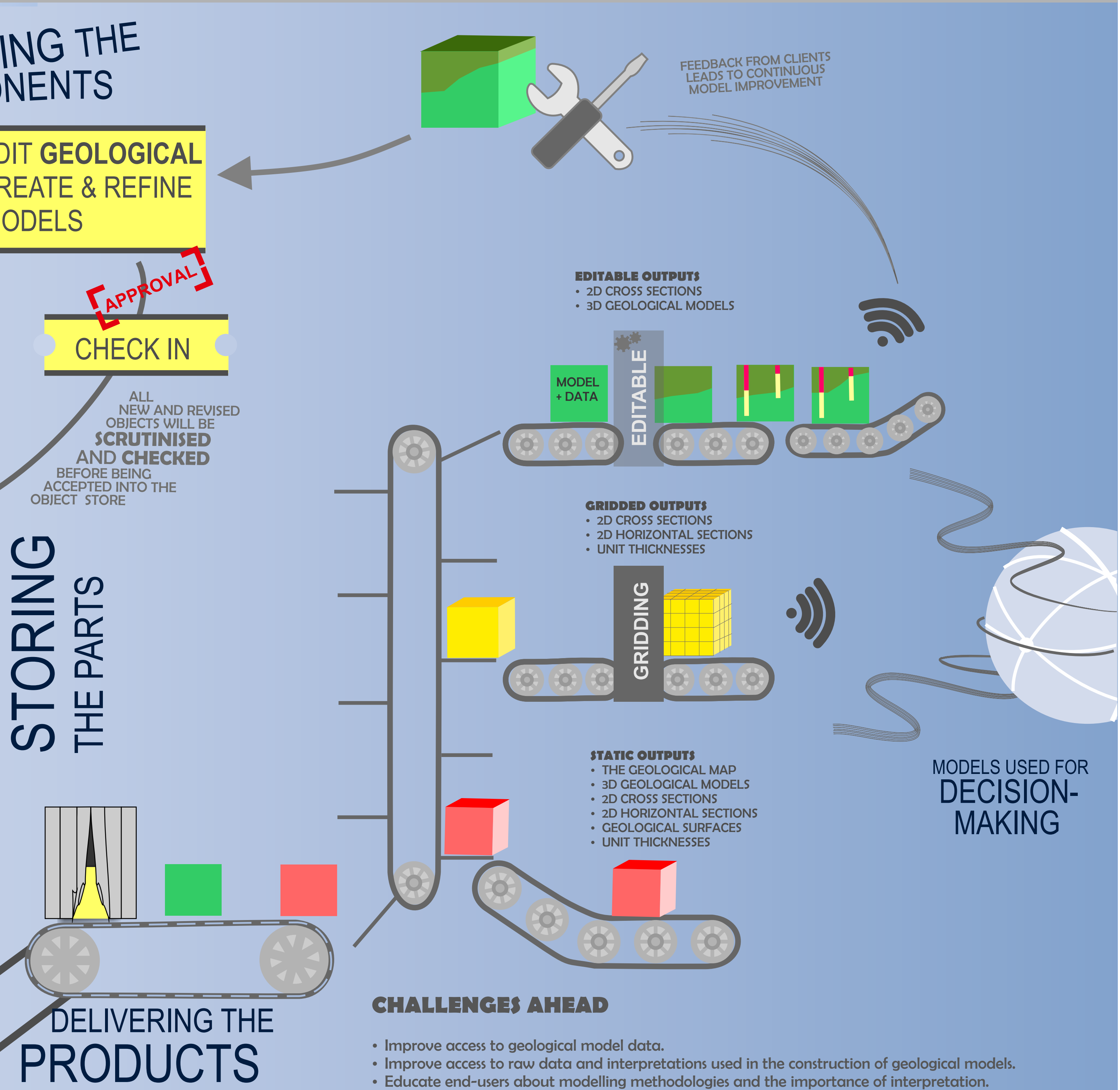


CHALLENGES AHEAD

- Improve access to geological model data.
- Improve access to raw data and interpretations used in the construction of geological models.
- Educate end-users about modelling methodologies and the importance of interpretation.
- Provide incentives for professional geoscientists to provide model feedback.
- Become pragmatic about linework quality (do we have the funds to gold plate linework?).
- Develop guided modelling environments for external users that allow them to edit models with simple tools that provide access to the relevant geological units.

BIM on Central Interceptor – a case study

THIS PAPER PRESENTS a short case study of the use of geotechnical BIM on a recent project in Auckland to demonstrate the benefits and give an indication of the processes required.

Watercare's Central Interceptor is a new wastewater tunnel proposed to run between Western Springs and the Mangere wastewater treatment plant. The tunnel will be approximately 13 kilometres in length, 5 m diameter and will lie between 22 and 110 metres below the surface. It will cross the Manukau Harbour at a depth of approximately 15 metres below the seabed, and along the proposed route it will connect to the existing trunk sewer network to divert flows and overflows into the tunnel.

With 19 shafts up to 80 m deep and 4.5 kilometres of link sewers this is one of the largest tunnelling projects ever undertaken in New Zealand.

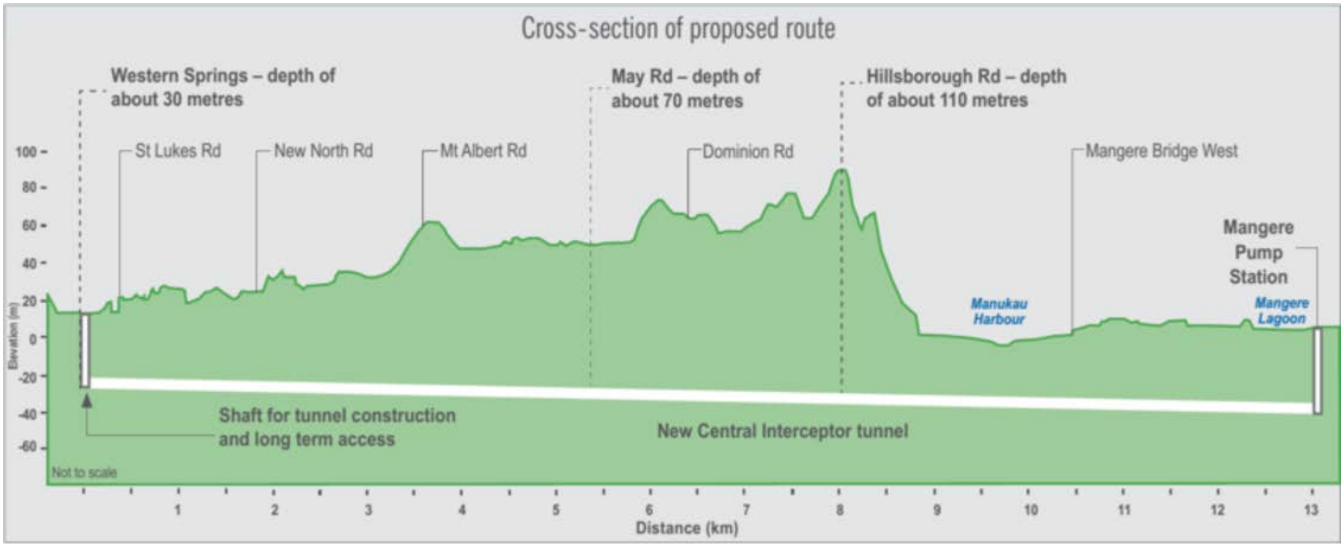
The concept design was completed at the end of 2011. Resource consent was granted in November 2013 and construction is scheduled to start in 2018, with completion expected in 2024. The tunnel provides a total storage capacity of approximately 200,000m^3. Preliminary design is nearly complete, and detailed design commences in early 2016.

During preliminary design a significant ground investigation was undertaken by Jacobs and AECOM comprising approximately 5,000 m of borehole drilling, along with associated laboratory and in-situ testing. This resulted in a very large data-set of geotechnical information. Crucially, because the information was collected in parallel with preliminary design there was a need for a continuously updated ground model to allow design to take place in accordance with the most

up-to-date information. Data was collected digitally on site using Jacobs tablet computers and transmitted back to the master geotechnical database in real time, allowing near-live updating of the geological model.

Kent Langdon

Kent Langdon is owner/director of Enzdata Limited, a 3D Engineering, Data Modelling, and Visualisation consultancy in Auckland, New Zealand. He has been wrangling data in, out, and through the CAD environment for nearly 25 years. With 15 years' experience in Civil 3D, HoleBASE SI & Geotechnical (AGS) data, 'Geotechnical BIM' is pretty-much 'where he lives'. Kent has been working with the Central Interceptor Design team, comprising Jacobs Engineering, AECOM and McMillen Jacobs Associates.



INTRODUCTION TO BIM

Building Information Modelling isn't just about buildings, and it's not just about information – it's about collaboration and modelling.

All models need to be considered as idealised representations of real world conditions. Modelling is not producing documents, or linework, but building something real to represent something more complex. Something with real shape and size in the real world – hence the fact that 3D is the only way to go. Additionally, you're not just creating a 'dumb' 3D tube or box – your object has a name, it serves a specific purpose, and will likely have a long and hard working life. This is where the *information* comes in – it's a pipe of a certain dimension, wall thickness, material, weight and cost. It's following an alignment with certain location and design constraints. It's got to get the job done for decades to come – many BIM projects are developed with the intention that 'the model' is not just for design and construction, but will be used for future management of that infrastructure.

So, modelling is building in the virtual world first, and setting things up so that documentation (your drawings) are a by-product of an accurate and well planned modelling practice – and not the core workflow.

The *collaborative* part of the BIM process, particularly in the engineering design process, is what BIM is all about – the idea that there is one model. It is a source of data and a destination for data. The team can get access to the model, and then contribute to it. This doesn't mean just one file. There are thousands of files connected in various ways to the models on the Central Interceptor project (*See 'a few statistics', below*). It's that connection – and understanding the data-workflows and inter-model connectivity – that's the real trick. And what turns that trick into a *command performance* is that that the connection provides *dynamic updating* to the model which can be seen by all those contributing to the project.

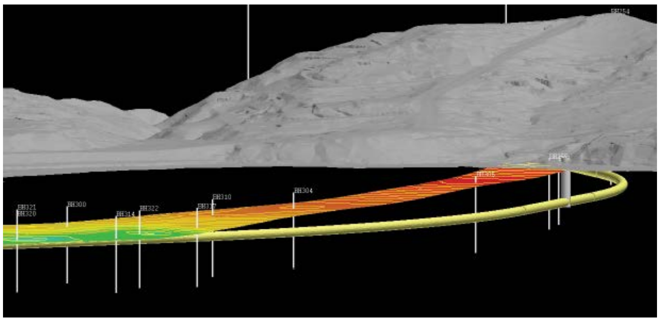
BIM had its beginnings in the construction and building world, most notably utilizing products like Revit which are essentially 3D modelling packages with intelligent libraries or databases. They're purpose built for structures, mechanical engineering or architectural design – generally very localised and 'object' based.

When objects are more spatially spread, typical of civil infrastructure jobs, or just curved in two directions for that matter (think vertical and horizontal curves), design tools like Civil 3D are the tool of choice.

Using a model-based approach has numerous benefits, and one of the most easily measured is the drafting effort saved. A typical example is your ground surface. Most engineering design is somehow tied back to your ground surface. Change that and you're looking at updates to alignment designs, long section profiles, lid levels, depths to invert values and more. Traditional drafting may be looking to re-calculate thousands of intersection points.

When models are loaded with new data, you can get an on-screen notification of a topo-survey upgrade, hit 'refresh', and all those numbers for cut profiles, intersections automatically update. Not only that, but your alignments and pipe depths either automatically adjust to allow crown clearance or show you a warning that your design is now needing a check or revision.

In a design world where everything is subject to change and rework costs time and money, anything that can save on having to repeat work will be worth its weight in gold. It was primarily for this reason that a geotechnical BIM process was set up on Central Interceptor – although there are many other longer term benefits to the BIM process.



Above: Collaboration in action – ground model and geotechnical data being shared for analysis in Vulcan.

THE WORKINGS

BIM in the project context involved heavy use of Civil 3D's modelling capability, data shortcuts, and dynamic updating. With a client-driven requirement for discrete CAD-file based deliverables, we implemented a BIM process at the front end – providing context, informing design, and then creating CAD content for drafting use (largely in the form of CAD reference files).

The project team was made up of multiple consultants (Jacobs, AECOM and McMillen Jacobs Associates) disciplines, multiple tunnel alignments, and 20 local sites, as well as above and below ground challenges. There were many hundreds of drawings to produce. With limits to drafting resources, we were determined to reduce the manual processing of drawing content wherever we could, making gains on an extensive work programme, reaping time and cost benefits for the project and for Watercare.

CIVIL BIM

The entire project was built on a skeleton of Civil 3D alignments – centrelines of mainline tunnel, link sewers, and connection sewers – upon which could be assembled whatever was required. Pipe networks were added to alignments, and vertical profiles 'hung' for inverts, crown, and consented corridor limits.

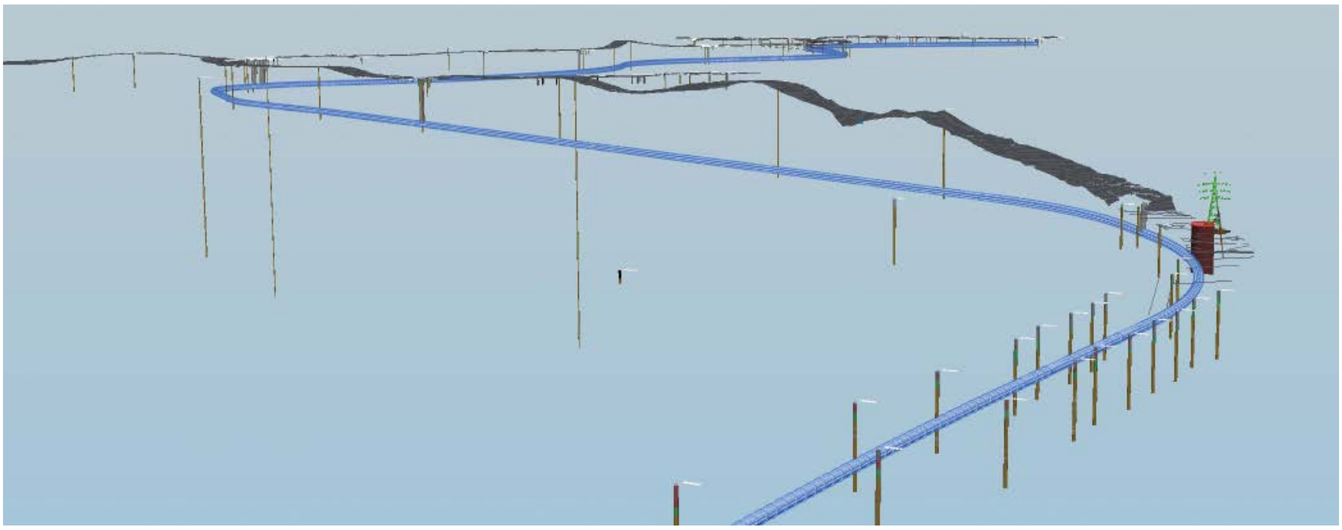
Using Civil 3D's data shortcuts, these master alignments could be referenced in a working design drawing – say – for pipe network long sections, and if the source file updates, the alignment updates in any drawing which refers to it. Also, the ground profile at each section location was linked to an active surface. When that surface changes, the surface slices on the sections update (and also, the hundreds of numbers along the bottom of the profiles, for example – which previously our 2D drafting staff would have manually changed.)

This was particularly powerful for long sections – a project of this type generates a lot of sections.

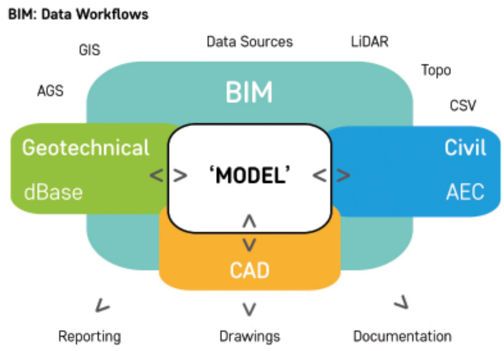
The project was set up with a series of 'master' models:

- Master Alignment Centrelines, Profiles, and Existing Ground Level (EGL) profiles
- Master Design Sections (Pipe Network Model Content – ie 'structures')
- Master Surfaces (Ground Level, Bathymetry, Basalt)

A note about existing ground surfaces: A 13 km alignment (plus 5 km of link sewers) with a 200m project width, and surface elevation points every 0.25 m from LiDAR sources results in millions of triangles in your surface model. The widest surface on CI involved 35 million 'triangles' over 62 million square metres – essentially the central core of the Auckland Isthmus .Modelling teams need to be aware that large models take considerable computing power, time to process and require some specific data and file-management techniques!



Above: View along the main alignment showing partial topographic model and boreholes.



There were at least 60 sections contained in each model, so some careful planning was required at the outset to set up a CAD reference 'grid layout' to set all profile insert-points, chainages, and vertical extents and scales – to enable functional overlay of references files into CAD sheets later.

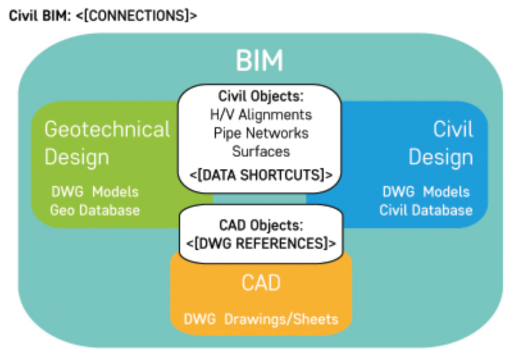
With all the sections laid out, design content and profiles, that meant we could now overlay a few hundred boreholes to 60 different sections and calculate offsets from multiple alignments and chainages.

GEOTECHNICAL BIM

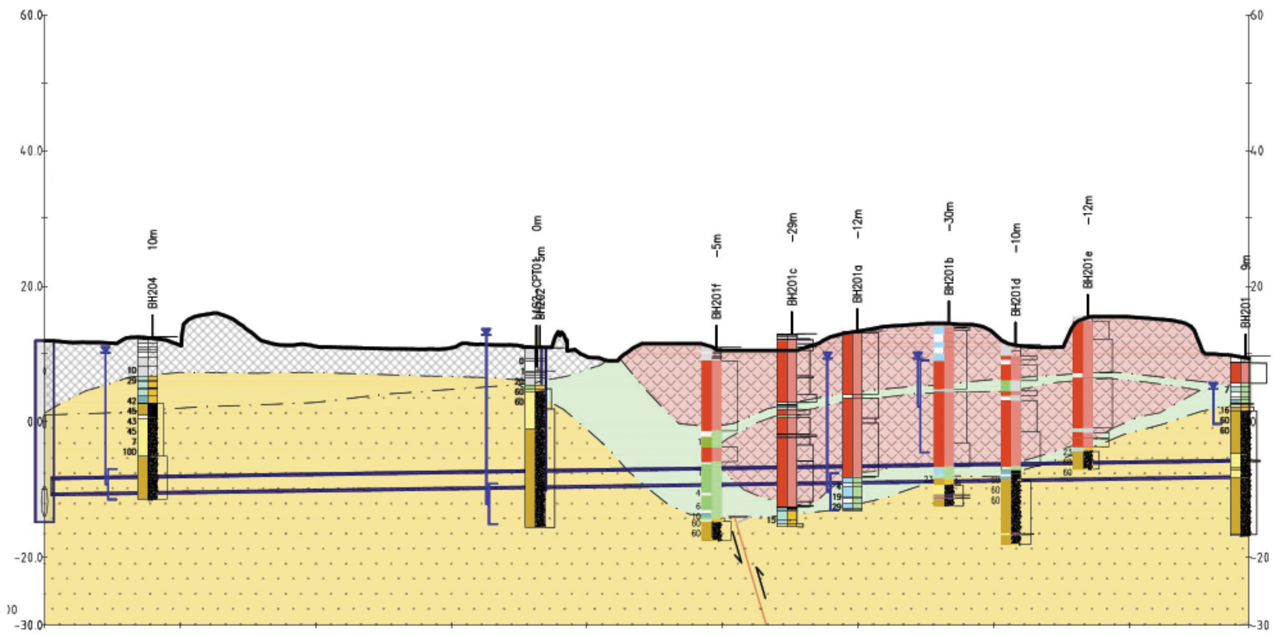
On Central Interceptor the core tools used to create Geotechnical BIM were gINT, HoleBASE and Civil 3D. When you splice the DNA of a great geotechnical database with the power of parametric 3D modelling capability you get Geotechnical BIM.

The first physical task in any geotechnical project is getting the drilling and the logs done – and soon after comes the long sections. The core project database was a Bentley gINT system – which held all current investigation data and archival data – but didn't have an overly effective CAD capability.

HoleBASE SI database and its Civil Add-In brought a workflow which would enable not just CAD content, but due to its active connection to real time database, it resulted in 'dynamically updating' BIM workflows.



In a civil model, you choose the alignment you'd like to plot your borehole data to, tell it what offset it should set



CHAINAGE (m)	100	200	300	400	500	600	700	800	900	988
GROUND LEVEL (mRL)	11.94	14.02	11.11	10.89	9.60	10.50	13.34	13.03	15.46	9.18
CROWN LEVEL (mRL)		-7.91	-7.61	-7.31	-7.02	-6.72	-6.43	-6.13	-5.83	-5.57
INVERT LEVEL (mRL)		-10.31	-10.01	-9.71	-9.42	-9.12	-8.83	-8.53	-8.23	-7.97

Above: Typical Geotechnical Long Section. This portion of the Link Sewer has now been altered to avoid challenging ground conditions.

to go 'searching for boreholes', click a section location and you're done! To see a visual demonstration of this process take a look at a short video by the author at the following link http://youtu.be/uHq8LNGOcGA

AGS 4.0 NZ TO THE RESCUE!

Using the AGS4 NZ data transfer format, files were exported from gINT, and were brought into HoleBASE SI's Database.

Once in, styles and formatting could be set globally for all sections generated for the project. Once boreholes and downhole data was plotting as required, long sections would simply be 'refreshed' and re-exported to CAD models for drafting use.

One of the great benefits of using civil sections/alignments was the HoleBASE SI would remember the 'distance buffer' configuration for borehole plotting – and if you dragged your 'dynamic section' in the master plan, the relevant boreholes would simply 'appear' on your 'sideways or longer' section. No picking, choosing, exporting, overlaying, and redrafting!

CIVIL BIM – DESIGN & CONTEXT

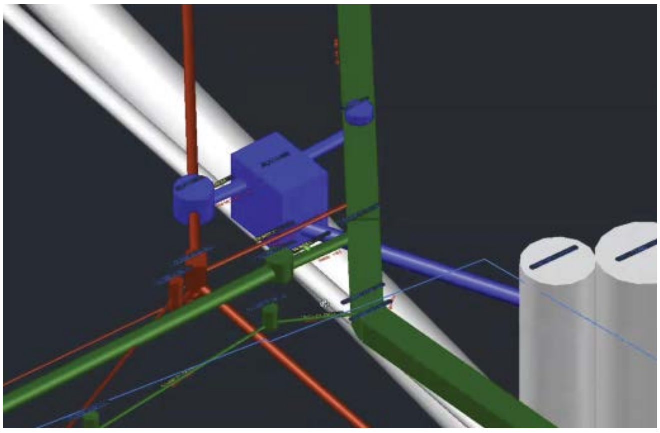
With items having been designed and built as 'real objects' in 3D, generating 3D visualisation content is also a fairly straight-forward. Seeing depths of the tunnel, locations of shafts, and nearby infrastructure all adjacent to 3D boreholes in their as-drilled location – provides relevant and highly useful context to the design process.

Let's not forget some of the perks for 2D drafting also – just something simple like the ability to select scale in the model, meant you could create all the alignments and long sections in the same DWG model file, at, say 1:2000 for distorted, large scale mainline sections, export a file to CAD, then flip the scale and export to create a CAD model for the multiple, small and true scale local site sections. It saves drafting effort at the output end and it saves modelling time by keeping everything in one place.

STUCK FOR SPACE – 3D SOLUTIONS

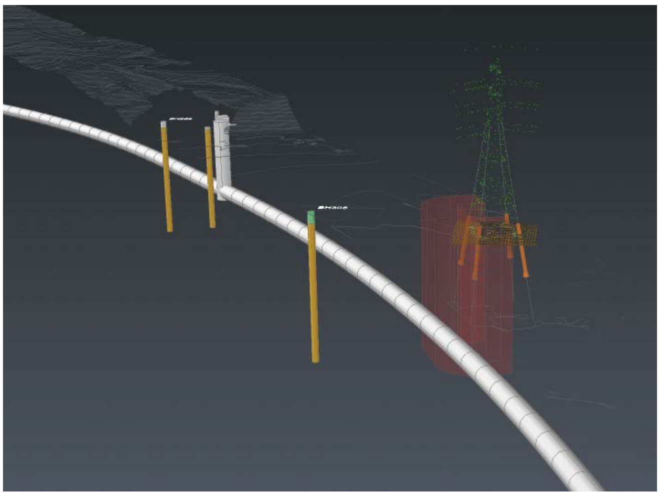
There were a few key locations where the questions being asked could only be effectively addressed with a 3D approach:

One was a complicated site in Mt Albert where location and extent of existing utility networks was critical to informing the layout of the shaft site.



Above: Complex site layout at Mt Albert

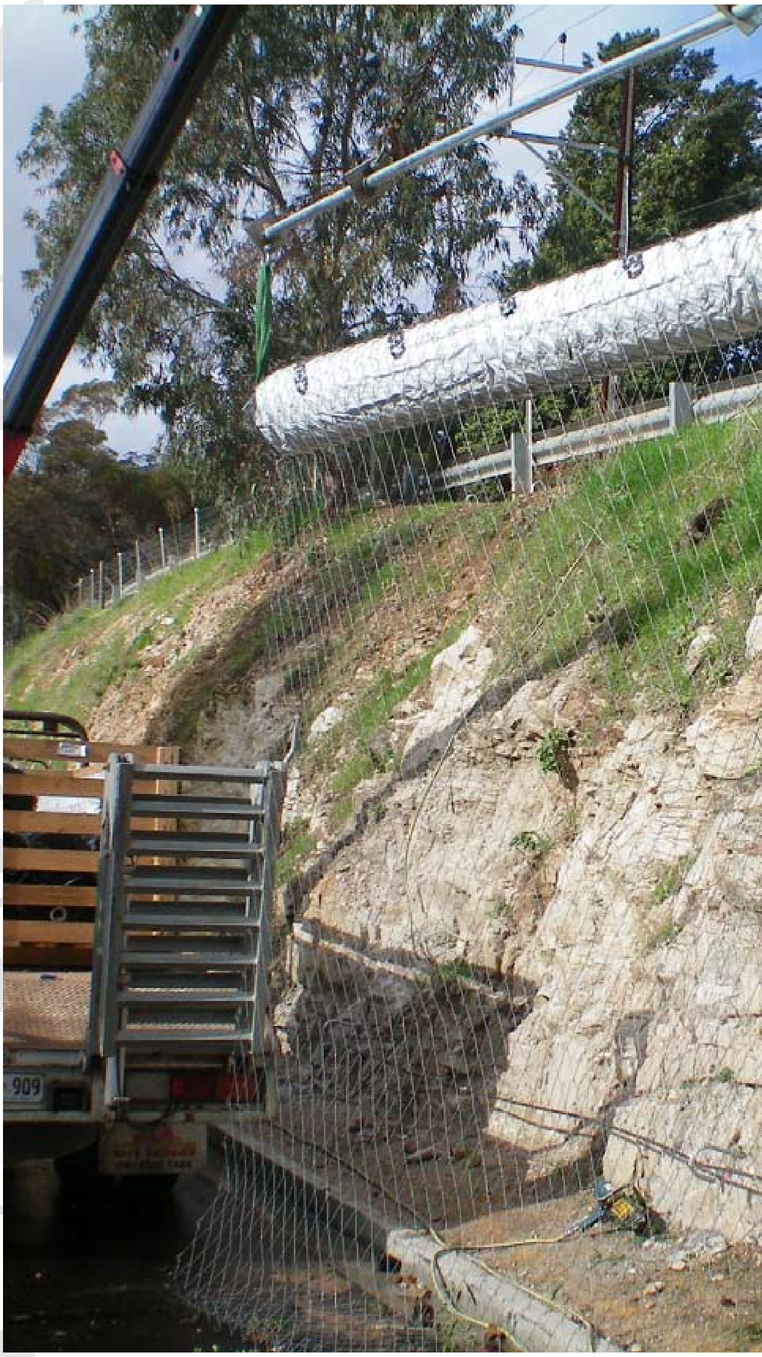
Another case arose when we needed to confirm our clearance from a high-voltage power pylon in the Manukau Harbour. In order to confirm and document the consented distance, we built a 3D model of the piled and raked foundations of the pylon. Our varied sources included a 70 year old archive plan for the pile sizes and heights, coordinates from Transpower for overall location, and 2013 Lidar data from Auckland Council to assist in verification and level checking. As you can see from the image below the resulting elements came together well.



Above: Assessing interactions with existing structures

continued on page 58

DELTAX:
The quantum leap in rockfall protection mesh



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- fewer machine hours

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- Almost invisible on the slope

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STATISTICS

GEOTECHNICAL DATABASE

425 Investigations
150,000+ Data Records
214 AGS Files processed
1 Basalt Archive Database

4,671 Archive Pts
18,300 Data Records

Direct connection to Geotechnical and Civil BIM models

GEOTECHNICAL BIM

425 Investigations equating to 11,009m total drilling depth, plotted in 3D, and then projected in 2D across...

65 Active Geotechnical alignments, or **roughly 25,000m total** lineal 2D section chainage.

Profiles Dynamically Linked to Surfaces
1 x 3D Geotechnical BIM Model!?

GIS ANALYSIS

437 SHP files queried from Auckland Council Data for Existing Ground Level (EGL) Model

200m sqm of spatial data coverage imported for modelling across Auckland.

273 SHP files processed or queried for remainder of project, incl drainage infrasture for Civil modelling
70,000 WW and water Objects

CIVIL BIM

EGL Ground Surfaces modelled across Auckland, with one of the biggest being **34.7M triangles over 62M sqm!**

20 Topographical Site Surveys Models
5 Design Horozonatl & Vertical Alignments
60+ Dynamic Sampled Vertical Profiles
180 Dynamic Sampled Vertical Profiles

22 Pipe Netwoks
3 Pipe Parts Libraries

1 x 3D Civil BIM Model!?

File Statistics (At Oct 2015). 1351 DWG Files, 710 SHP Files, 214 AGS Files, 226 XLS Files, 139 TXT Fles, 41 CSV Files, 1170 PDF Files

CONCLUSIONS

Significant reward always requires prior investment. A great construction project will reap rewards of considered planning and depth of expertise, and so too will the investigation and design process. BIM, or just a modelling approach in general, can often require a reasonable chunk of 'front loading' to the job – both in budget and lead times, to gain downstream benefits such as the "3D modelled, push button and drag and drop" functionality. Still, the benefits once the assets are in place (libraries, databases, models) will very quickly find their way into the daily workflow, and soon after that, hour by hour. They key word is assets. We don't just have some drawings – we have a model asset, BIM, an information packed system, a process, on which to build our next stage of work.

By the time you read this, we will be just beyond the Preliminary Design Stage, and about to head into Detailed Design. This is where the modelling process will be able to really shine; objects will be edited rather than created; databases will be supplemented; new networks will be added but the workflows and configuration is in place. And new data from drilling specifically targeted to areas of focus will be dropped onto the model with a quick 'import and reload'.

FEEDBACK

Ground Investigation lead Ross Roberts reported that the ability to see the ground model developing in real time, and to get geotechnical data back for the design process, gave signifcant benefits. "A ground investigation of this magnitude, lasting over six months with five drill rigs, trial pits, CPTs and geophysics running in parallel for much of the programme, typically for six days a week, would normally require a team of two or three engineering geologists to manage the sites, enter and review logs, and continuously develop the ground model. The process set up for this project enabled most of this work to be undertaken much more efficiently - often by just one person. The effort normally spent on data entry, management and visualisation could instead be spent on ensuring the best outcome from the investigation."

ACKNOWLEDGEMENTS

The author wishes to acknowledge Watercare Services Limited for kindly allowing this work to be published, and for setting an example by making the factual data from this project publicly available on the Auckland Geotechnical Database. Particular thanks go to Stephen Grace and Bojan Jovanovic for their assistance in reviewing the article.

The Opportunities Associated with the Creation of a National Geotechnical Database

ABSTRACT

The Canterbury Geotechnical Database (CGD) is an online database that has been developed for the rebuild of Christchurch following the 2010 - 2011 Canterbury Earthquake Sequence (CES). It was designed as a searchable repository for sharing existing and new geotechnical information along with supporting geotechnical applications for building and resource consents. The data sharing repository has enabled a significant dataset to be developed to the benefit of both the public and private sectors and it is a success story in the recovery of greater Christchurch following the CES. As at September 2015, the database contains over 20,000 cone penetration test records, 4,000 boreholes, 1,000 piezometers with accompanying groundwater monitoring records, 6,000 laboratory test records plus other data. The data is primarily used for geotechnical design of foundations for rebuilding the infrastructure and buildings, but it can also be used for more strategic purposes such as assisting with the recovery for future natural disasters, increasing the resilience of other areas of New Zealand, catastrophe loss modelling and informing regulatory processes. The extensive geotechnical database when combined with other data sets enables close examination and modelling of ground and built infrastructure performance. The lessons learnt from these analyses can be applied to improve resilience and also used to inform regulatory policy decisions in other areas of New Zealand. This article provides an overview of the information held on the database and gives examples of how this extensive dataset can be used. As a result of the success of the CGD, the Ministry of Business Innovation and Employment (MBIE) is in the process of facilitating the development of a nation-wide geotechnical database. It is anticipated that this national database will be operating in early 2016. It is hoped that the geotechnical community and their clients will support the existence of the national database and begin actively contributing data as a step towards improving and achieving long term community resilience.

INTRODUCTION

The Canterbury Geotechnical Database (CGD) is an online database (available via the website: https://canterburygeotechnicaldatabase.projectorbit.com) that has been developed for the rebuild of Christchurch following the 2010 - 2011 Canterbury Earthquake Sequence (CES). This sequence includes four main earthquake events; 4 September 2010; 22 February 2011; 13 June 2011; and 23 December 2011. These events caused widespread liquefaction related land, infrastructure and building damage, affecting approximately 50% of the horizontal infrastructure (roads, electricity, waste water and fresh water), 51,000 of the 140,000 residential properties in Christchurch as well as damage to the commercial land and buildings. The liquefaction related land damage mapped after each of these events is shown in Figure 1 below.

John Scott

John is a CPEng with 30 years national and international geotechnical and project management experience in major civil engineering projects. He has a BE (Civil) degree for the University of Canterbury and a MEngSc degree from the University of New South Wales and is PMP qualified. John is working for MBIE's Facilitating Canterbury Rebuild Team as their Geotechnical Advisor and previously worked for CERA assisting their policy advisors with the Port Hills red zoning policy. John has an interest in CPT testing dating back to 1987 where he helped prepare a design guide for use of CPT for the then Works Consultancy Services (now Opus).

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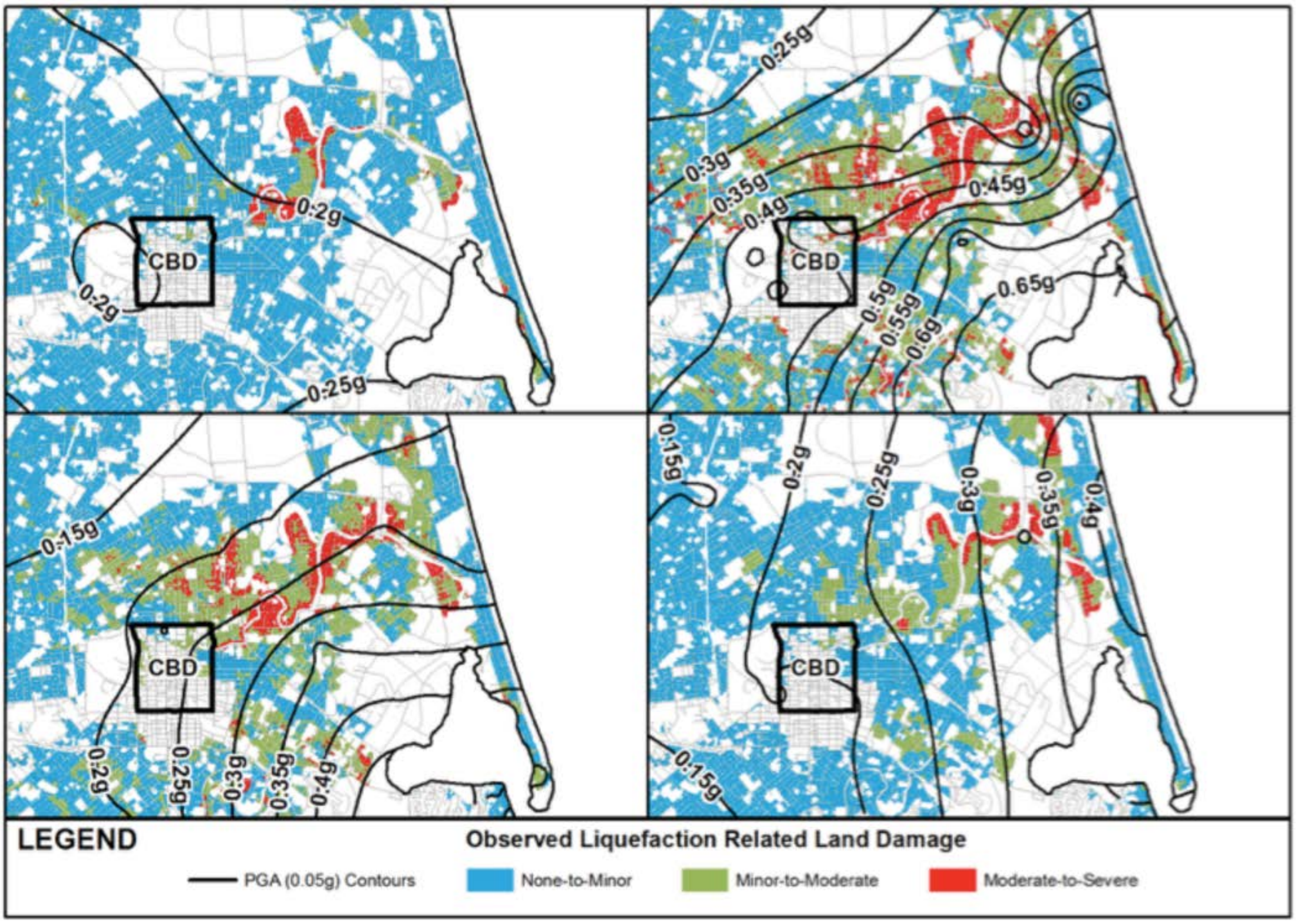

Figure 1: Map showing the observed land damage mapped after the (a) 4 September 2010, (b) 22 February 2011, (c) 13 June 2011 and (d) 23 December 2011 earthquakes.

As a result of the damage, the NZ government classified residential land in Canterbury into red or green zones. The residential Red Zone includes land where the repair and rebuild process was identified by the Canterbury Earthquake Recovery Authority (CERA) to be not practical to implement, because the required land repair and improvement works would be difficult to implement, prolonged, and disruptive for landowners. These property owners were able to sell their properties to the NZ government to manage the withdrawal process. The balance of the residential land on the plains was further categorized by the Ministry of Building, Innovation & Employment (MBIE) into three technical categories (TC1, 2 and 3) to assist with the rebuilding of residential houses. The spatial location of the technical category land areas are shown on Figure 2c and differentiate the levels of specific geotechnical investigation and foundation design options that are required to address the potential liquefaction issues.

The CES also led to the establishment of a Canterbury Earthquake Royal Commission (CERC) of Inquiry into building failure. The CERC produced a report which made 189 recommendations with a number related to geotechnical matters. In particular CERC recommendation number 6 states *"The Christchurch City Council should develop and maintain a publicly available database of information about the sub-surface conditions in the Christchurch CBD .... Other territorial authorities should consider developing and maintaining similar databases of their own."*

As a result of the earthquakes, the realisation of the size of the hazard identification and re-build tasks ahead, and the technical categorisation of the land along with the MBIE geotechnical investigation requirements particularly in the TC3 areas of Christchurch, there was a substantial amount of goodwill generated across the recovery/rebuild community to share geotechnical information. There simply was neither the time nor resources to work in New Zealand in isolation. This led to the Canterbury Geotechnical Database (CGD) being established by CERA to facilitate and increase the confidence of the greater Christchurch recovery process.

The CGD was designed as a searchable repository for existing and new geotechnical information along with supporting geotechnical applications for building and

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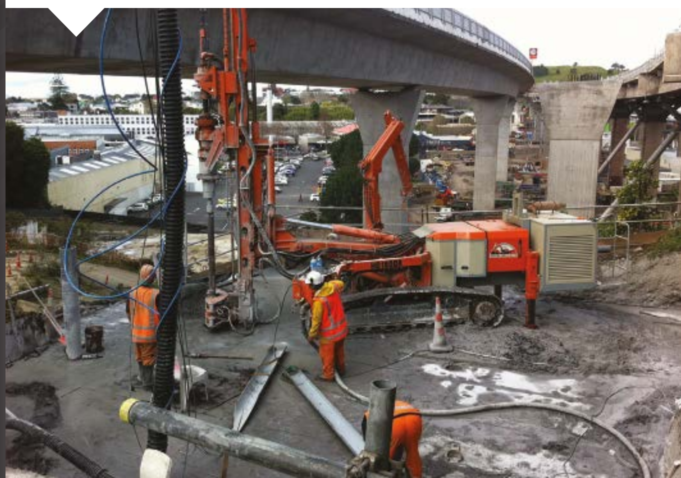


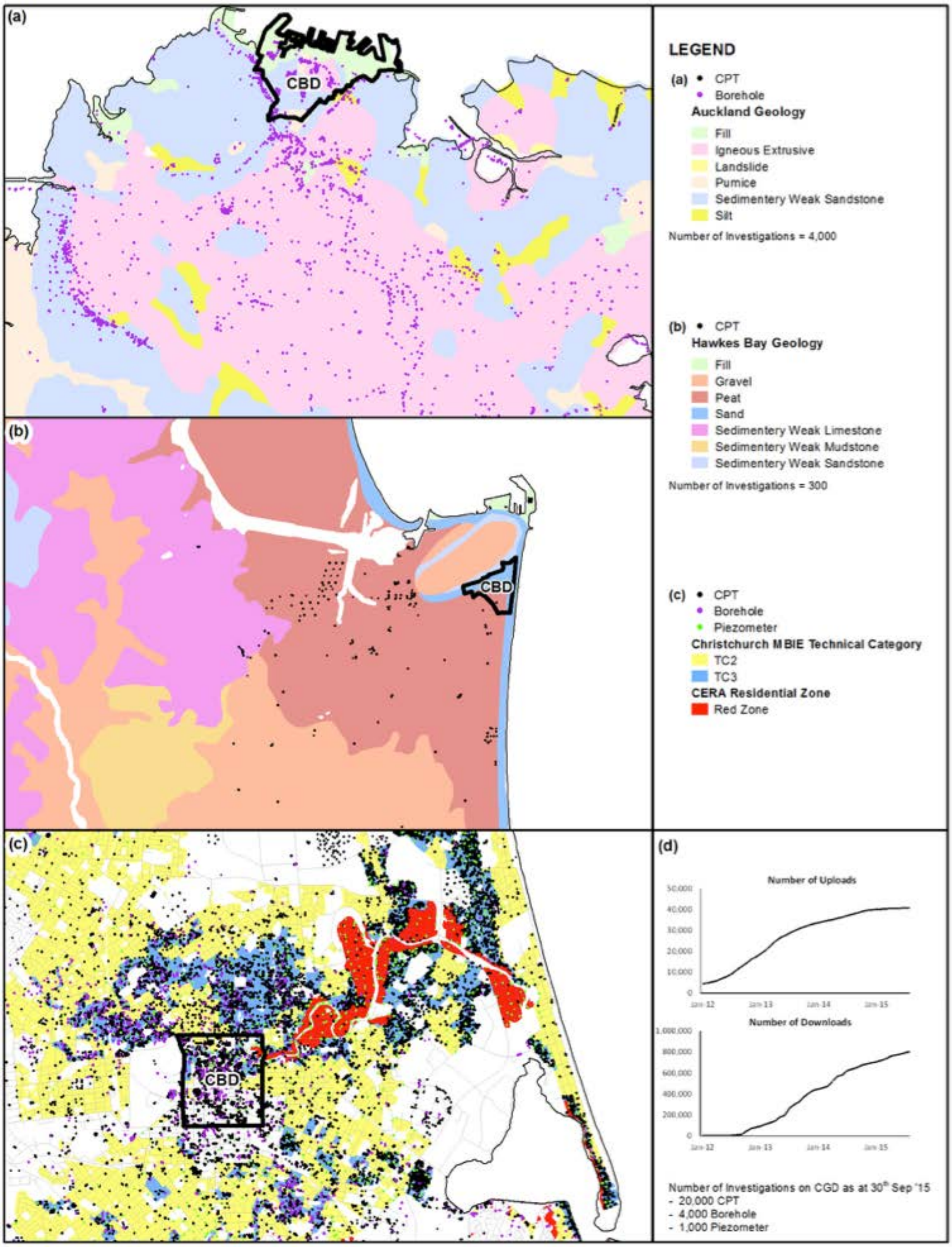


Figure 2: Geotechnical investigation locations available in the database in (a) Auckland, (b) Hawkes Bay and (c) Christchurch.

resource consents. While the data is primarily used for geotechnical design of ground improvement, building foundation repairs, foundations for new buildings and geotechnical design for infrastructure repairs, it can also be used for more strategic purposes such as, assisting with the recovery for future natural disasters, increasing the resilience of other areas of New Zealand, catastrophe loss modelling and informing regulatory processes. Scott et al. (2015a) outlined the benefits of the CGD and this paper further expands on some the advantages of sharing such geotechnical information by providing some additional examples and looks ahead to how a nationwide database could be used not only to benefit the engineering and planning profession but also for the strategic purposes outlined above. This article largely duplicates the paper at the 6th ICEGE conference held in Christchurch in early November 2015 (Scott et al., 2015b).

EXTENT AND DISTRIBUTION OF GEOTECHNICAL DATA

As at September 2015, the CGD holds approximately 20,000 Cone Penetration Test (CPT) traces, 4,000 borehole log records, 1,000 piezometers with accompanying groundwater monitoring records, 6,000 laboratory test records and other information such as the mapped land damage after each main event, LiDAR survey data and groundwater mapping information. The geographic distribution of CPT, borehole logs and piezometers is shown in Figure 2c. It is noted that almost all of the geotechnical investigation data is spatially located on the TC3 land, where MBIE intended for deep geotechnical investigation, site specific assessment and design to be undertaken. This figure illustrates the predominance of CPT in the east of the city reflecting thicker deposits of soft to firm silt and loose to medium dense sand. Interbedded gravels typically occur to the west of the Central Business District (CBD). These gravels are generally unable to be penetrated by CPT and therefore borehole investigations with accompanying standard penetration testing (SPT) are the dominant investigation tool if deep investigations are required.

The CGD has been very successful in a large part due the sharing of geotechnical information between the private and public sectors. Figure 1a shows time plots of uploads and downloads of geotechnical information to the CGD with the uploaded data amounting to 40,000 data files which have subsequently been downloaded approximately 800,000 times. This means that on average data is being re-used 20 times and therefore geotechnical engineers are reviewing more data relating to surrounding ground conditions than what they normally would without a CGD, resulting in more informed specific assessment and design. Also the sharing of geotechnical data has enabled costs savings (resulting from a reduced scope of necessary investigations due to access to neighboring geotechnical data) for the Canterbury recovery of between NZ$50M and NZ$100M. This excludes contract administration, supervision and reporting related costs associated with generating new geotechnical information.

The Auckland Geotechnical Database (the management of which transferred from Watercare to MBIE on 1 September 2015, refer to Figure 2a) also has a lot of geotechnical investigation information available in Auckland courtesy of the DEVORA project, Watercare Services Ltd and Auckland City Council. Data has also been added to Hawkes Bay part of the CGD (refer Figure 2b). Outside of the Christchurch area, the geotechnical database is still in its infancy and is slowly starting to populate.

EXAMPLES OF POTENTIAL DATA ANALYSES

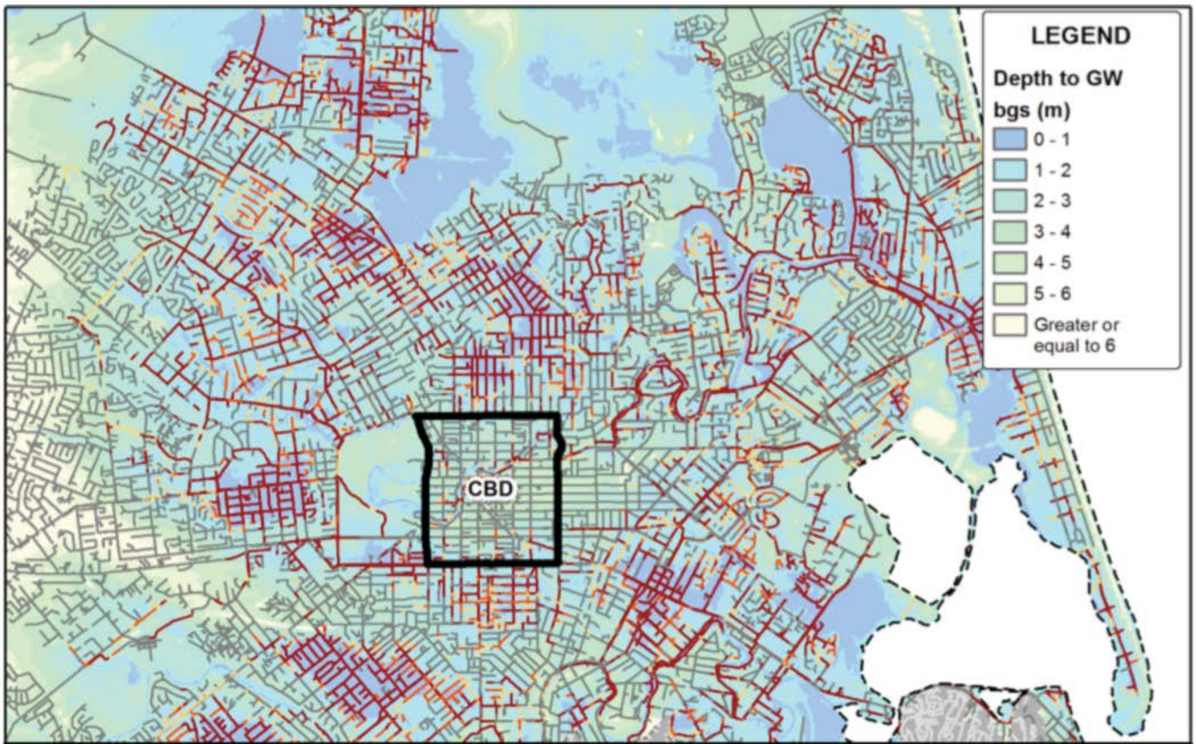
The high density of shared data in Christchurch enables interpolation between points which in turn allows interpretative maps to be generated such as depth to groundwater, soil behaviour type index (I_c) CPT tip resistance, (q_c, which is a measure of soil density), depth to hard / dense soil layers etc. Figures 3 to 7 below present some examples of how the extensive dataset collated in the CGD can be analysed and mapped for more strategic purposes, outlined above, to inform decision makers. Without this extensive dataset these analyses would be difficult to produce.

Horizontal Infrastructure Networks (e.g., roads, electricity, waste water and fresh water)

Figure 3 shows the entire Christchurch City Council (CCC) Wastewater (WW) network overlain on the 15th (lower), 50th (mean) and 85th percentile (higher) groundwater surfaces (van Ballegooy et al., 2014) as well was as the CPT based I_c layers over the portion of the network in the TC3 area. The red pipes (about 30% of the network) represent the part of the network which is likely to be almost always below the groundwater table (below the 15th percentile groundwater level). This part of the network when founded in sandy soils (I_c < 2) would probably require extensive dewatering equipment to repair or replace any pipework irrespective of the time of year the work is undertaken. The orange and yellow pipes represent the part of the network (about 6% and 7%) which is between the 15th and 50th percentile and 50th and 85th percentile groundwater surfaces respectively and is therefore for the majority of the year likely to be either below (the orange pipes) or above (the yellow pipes) the groundwater table. Lastly, the grey pipes (57% of the network) are above the 85th percentile surface and represent the part of the network which is likely to almost always above the groundwater table. This part of the network is therefore much easier to access, repair and replace as it unlikely to require dewatering gear and is less impacted by soil type. This information could be used to improve infrastructure asset management such as operational and capital expenditure budgeting. It could also be used to assess the network vulnerability to various natural hazards, such as the liquefaction hazard (when overlaid on predicted liquefaction vulnerability maps shown in Figure 4), to inform decisions about improving network resilience.

Predicted Ground Behavior for Natural Hazards Planning Purposes

Figures 4a and 4b show the calculated one-dimensional post-liquefaction reconsolidation settlement (S_{V1D}) over the top 10 m of the soil profile using the Boulanger and



WW network pipes	Proportion of the WW network in Christchurch	Proportion of the WW network in the TC3 area of Christchurch	
		$I_c < 2$	$I_c > 2$
Above 85th Percentile Surface	57%	34%	13%
Between Median and 85th Percentile Surface	7%	7%	2%
Between 15th Percentile and Median Surface	6%	5%	2%
Below 15th Percentile Surface	30%	26%	10%
Total	100%	100%	

Figure 3: CCC WW network overlain on the 15th, 50th and 85th percentile groundwater surfaces.

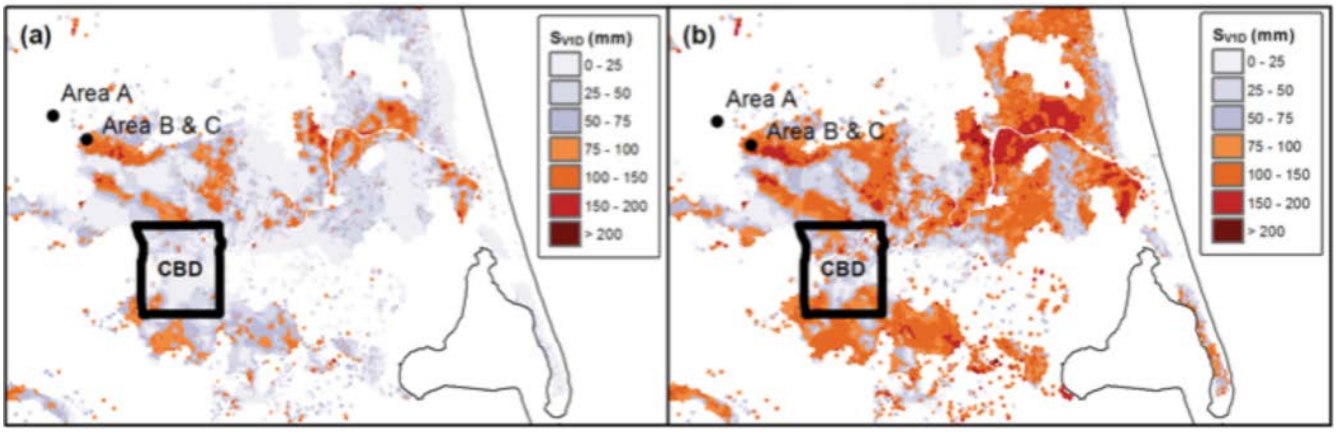


Figure 4: Calculated SV1D at the (a) SLS and (b) ULS ground motions.

Idriss (2014) liquefaction triggering methodology at the Serviceability Limit State (SLS) and Ultimate Limit State (ULS) design motions (representing the 25 and 500 year return period motions) respectively as specified in the MBIE (2014 & 2015) guidelines. These analyses dictate the type of foundation solutions required for residential buildings using the MBIE guidelines.

When comparing Figure 4 with the observed land damage maps shown in van Ballegooy et al. (2015), it can be noted that areas with values of calculated S_{V1D} > 75 mm for the SLS scenario generally experienced minor-to-moderate and moderate-to-severe liquefaction related land damage following the September 2010 event. Similarly, areas with values of calculated S_{V1D} > 75 mm for the ULS scenario generally experienced minor-to-moderate and moderate-to-severe liquefaction related land damage following the February 2011 event. Calibration of liquefaction vulnerability parameters against observed ground performance, allows liquefaction vulnerability mapping to be undertaken for a variety of earthquake scenarios in other areas in New Zealand with similar ground conditions, only if geotechnical data was available through a nationwide database. This would help identify the most vulnerable areas and this information could be used to:

- Eliminate or reduce urban intensification in such areas and therefore result in decreased community vulnerability;
- To better plan critical infrastructure to avoid these areas or to increase their resilience if avoidance is not possible;
- Better understand where affordable housing developments can be undertaken, not requiring significant investment in more expensive foundation and/or ground improvement solutions;
- Enables consenting authorities to undertake a high level review on proposed developments and focus efforts in higher risk areas;
- Enables district plan revision writers to align development rules with predicted land performance; and;
- Enables improved catastrophe loss modelling for insurance and hazard management purposes and for emergency response specialists to undertake appropriate scenario response activities.

Modelling of Appropriate Foundation Solutions

MBIE has progressively developed guidelines on foundation design since 2010. These guidelines where last updated in 2015 to include a series of integrated foundation and/or refined ground improvement solutions to address various levels of predicted ground

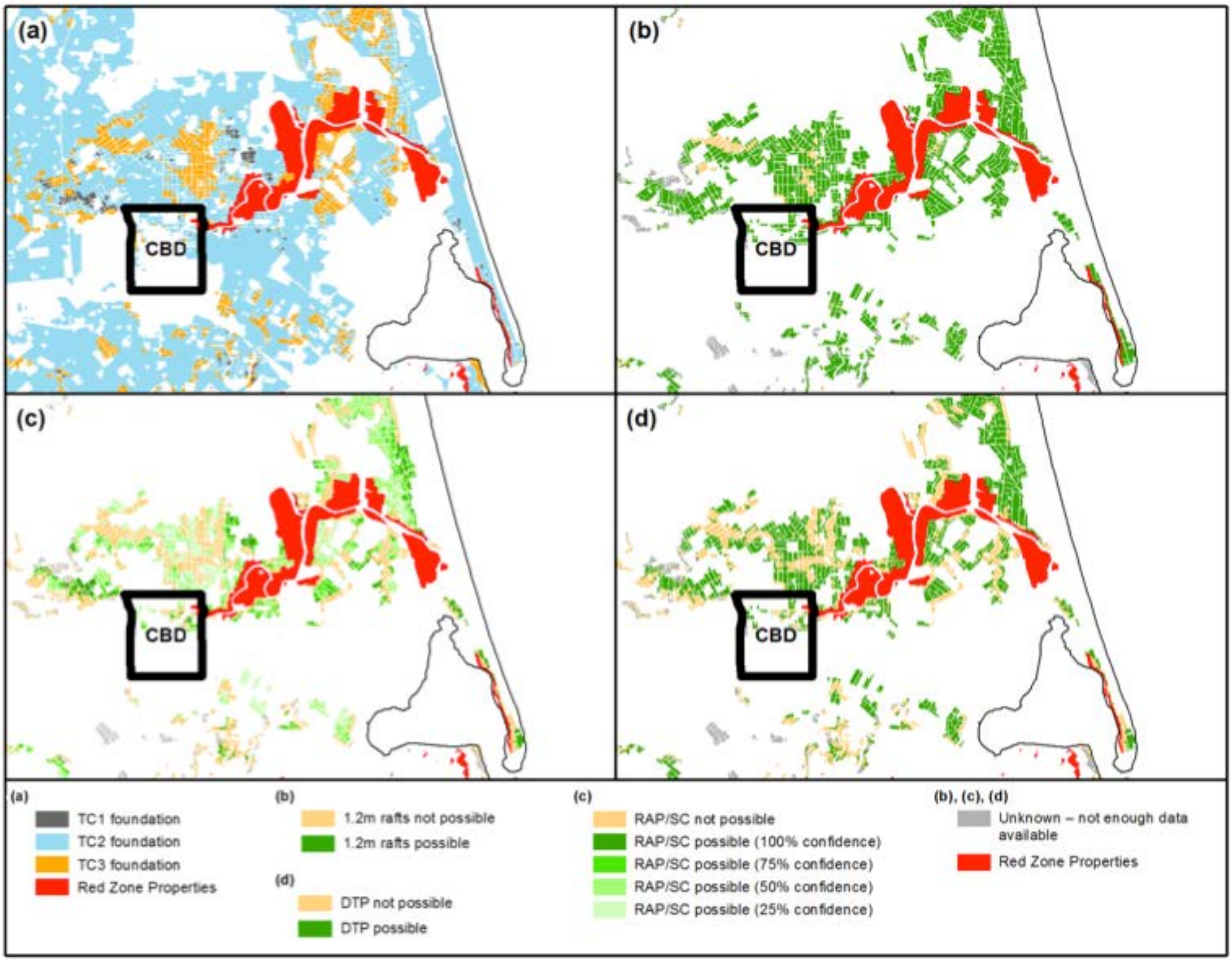


Figure 5: Foundation solutions based on the criteria in the MBIE (2015) guidelines. (a) Map of where TC1, TC2 and TC3 structural foundation systems can generally be used. (b, c and d) Maps of where 1.2 m thick GR or SCR rafts (b), 4 m deep RAP/SC (c), and 4 m deep DTP (d) in conjunction with TC2 foundations can generally be used.

performance. The MBIE guidelines specify a number of criteria based on specific geotechnical assessment to determine which foundation systems are appropriate to be used on various soil profiles. The criteria include calculation of the SV1D parameter at the SLS and ULS scenarios (shown in Figure 4a and 4b respectively) and assessed against thresholds to differentiate between where various foundation and ground improvement solutions can and cannot be used. Models have been developed to illustrate where expected foundation solutions may be utilised geospatially in the rebuild of Christchurch based on the MBIE (2015) guideline criteria. As an example, Figure 5a shows where TC1, TC2 and TC3 structural foundation systems can generally be applied in the TC1, TC2, and TC3 areas of Christchurch. Figure 5b shows where 1.2 m thick Gravel Rafts (GR) and Soil Cement Rafts (SCR) in conjunction with TC2 foundations can generally be applied in the TC3 area, Figure 5c shows where 4 m deep Rammed Aggregate Piers (RAP) and Stone Columns (SC) in conjunction with TC2 foundations can generally be applied in the TC3 area and Figure 5d shows where 4 m deep Driven Timber Poles (DTP) in conjunction with TC2 foundations can generally be applied in the TC3 area. It is noted that RAP/SC ground improvements require construction verification testing to demonstrate that the post-improvement soils achieving the target densities specified in the MBIE guidelines. RAP/SC ground improvements are less effective in silty soils compared to sandy soils and hence a gradation of the level of confidence (or likelihood) that the RAP/SC ground improvement will achieve the target criteria is shown in Figure 5c. The dark green areas indicate a very high likelihood (close to 100%) and the light green shading indicating a very low likelihood (close to 0%) that RAP/SC ground improvement will be successful.

If a similar density of geotechnical data sets exist elsewhere, or were to be established through a nationwide database, then similar geospatial foundation system models could be prepared for other areas of New Zealand. This information could be used to:

- Allow the regulatory authorities to test criteria for reasonableness of outcome and avoid unintended outcomes of proposed design solutions;
- Guide building design and urban growth strategies of territorial authorities;
- Give planners, developers and engineers, a big picture view of what is possible and where;
- Undertake cost benefit analyses of investing in robust foundation solutions as opposed to implementing more routine but more vulnerable foundation systems and accepting the risk of significant building damage during a significant seismic event;
- Help quantity surveyors and estimators to estimate appropriate foundation rebuild costs so that property owners can specify appropriate sum insured values for their insurance policies; and;
- Enable specialist contractors to assess opportunities for investment in specialist equipment and ground improvement construction techniques.

Subsurface Geological Features

As discussed previously, a shared geotechnical database like the CGD enables industrywide easy access to a high density of geotechnical data. This data can be used to better inform the development of a geological model for a given area which in turn can be used to better predict future performance enabling geotechnical engineers to provide more informed design recommendations (potentially resulting in more appropriate and economic foundation solutions). To demonstrate this, three areas of Christchurch (areas A, B & C in Figure 4) which experienced similar levels of ground shaking are compared in Figure 6. Despite their close proximity to each other, these three areas performed differently as demonstrated by the land damage observations and liquefaction related ground surface subsidence as presented in Figure 6. The land damage observations show area A performed worse than areas B & C during the September 2010 event. However the land damage observations over the CES are comparable for all three areas. The liquefaction related ground surface subsidence over the CES shows that areas A & B subsided by similar amounts, typically in the order of 300 to 400 mm. Comparatively the ground surface subsidence in area C is less than areas A & B with typically recorded settlement in the order of 100 mm to 300 mm. The land damage and subsidence observations indicates that area A is vulnerable to liquefaction related land damage at lower Peak Ground Accelerations (PGA). While area B appears to subside due to liquefaction related effects it does not appear to be vulnerable to liquefaction related land damage at lower PGA. Area C has not significantly subsided and does not appear to be vulnerable to liquefaction related land damage at lower PGA.

Figure 6 also shows the calculated SLS S_{V1D}[6] at each CPT location for each of the three areas. This liquefaction vulnerability parameter predicts similar performance for areas A & B with predicted SLS S_{V1D} typically between 100 to 150 mm, whereas for area C the S_{V1D} parameter is predicting considerably better performance with predicted SLS S_{V1D} typically between 0 to 50 mm. The contrast in calculated SLS S_{V1D} values between the adjacent B & C areas indicate a sharp geological boundary change between these two areas and reveal the location of a potential historic infilled river channel. The identification of this feature would not have been possible without the density of CPT data available in the CGD. With reference to the September 2010 land damage observations, while the S_{V1D} parameter is doing a good job of predicting performance for an SLS event in areas A & C, it appears that it is not capturing an important element which is influencing liquefaction related performance in area B. Based on the MBIE (2015) guideline criteria, shallow ground improvements in conjunction with TC2 foundations cannot be used in areas A & B because the SLS S_{V1D} is greater than 100 mm. However, the guidelines recommend that engineering judgement should be applied supported by detailed examination of the geotechnical data and observed land performance throughout the CES rather than strict observance to the criteria.

Figure 7 shows plots of q_c, I_c and the calculated liquefaction triggering factor of safety (FS) vs depth over the upper 10 m for the CPT traces within each of the areas indicated in Figure 6. The liquefaction triggering FS values are calculated using the Boulanger and Idriss (2014) liquefaction triggering methodology at the design SLS ground motions. Sensitivity plots of calculated SV1D vs PGA over the top 10 m of the CPT traces for a magnitude 6 earthquake are also shown in Figure 7. Examination of the CPT traces in these three areas help to explain why

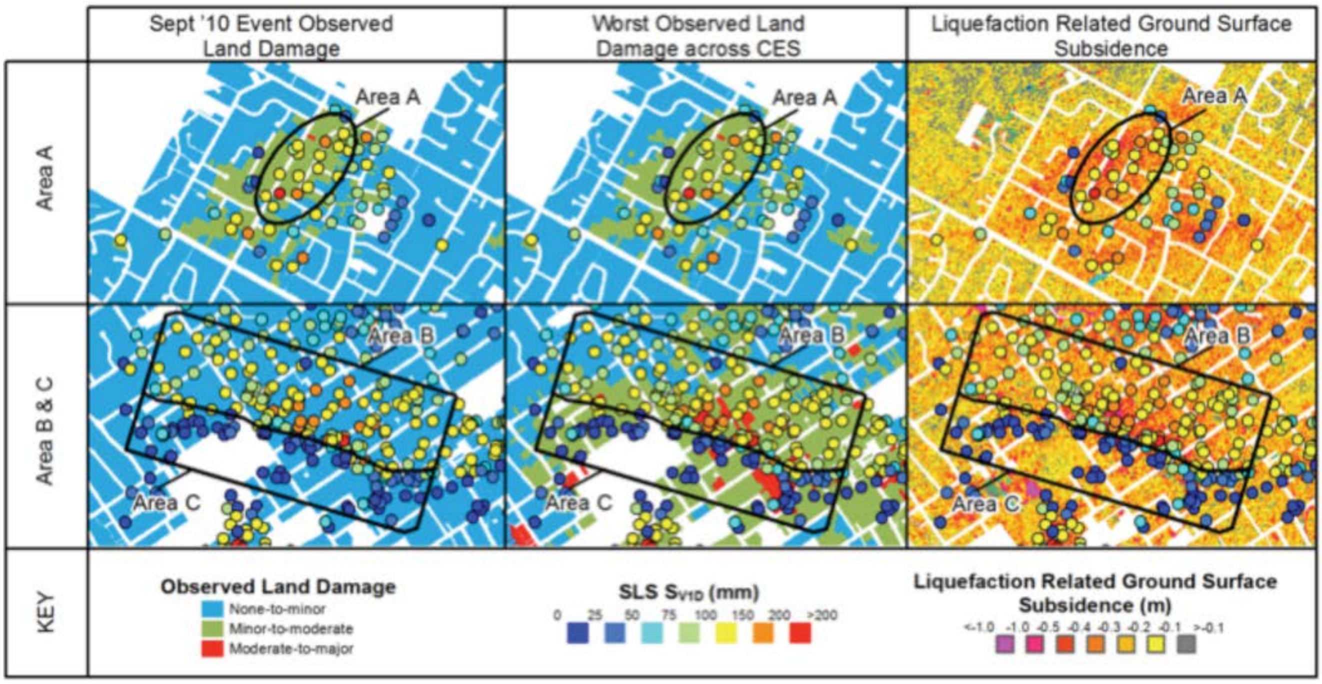


Figure 6: Land damage observations for the September 2010 event (left column) and the CES (middle column) and liquefaction related ground surface subsidence (right column) for areas A, B & C. The calculated SLS S_{V1D} values at each CPT location are shown on each of the maps.

[6] It is important to note that any of the existing liquefaction vulnerability parameters, such as LPI, LPI_{ISH} or LSN, (described in van Ballegooy et al., 2015) could also be used to demonstrate this point. The Sv_{1D} parameter is used in this case because it is the parameter used in the MBIE (2015) guidelines.

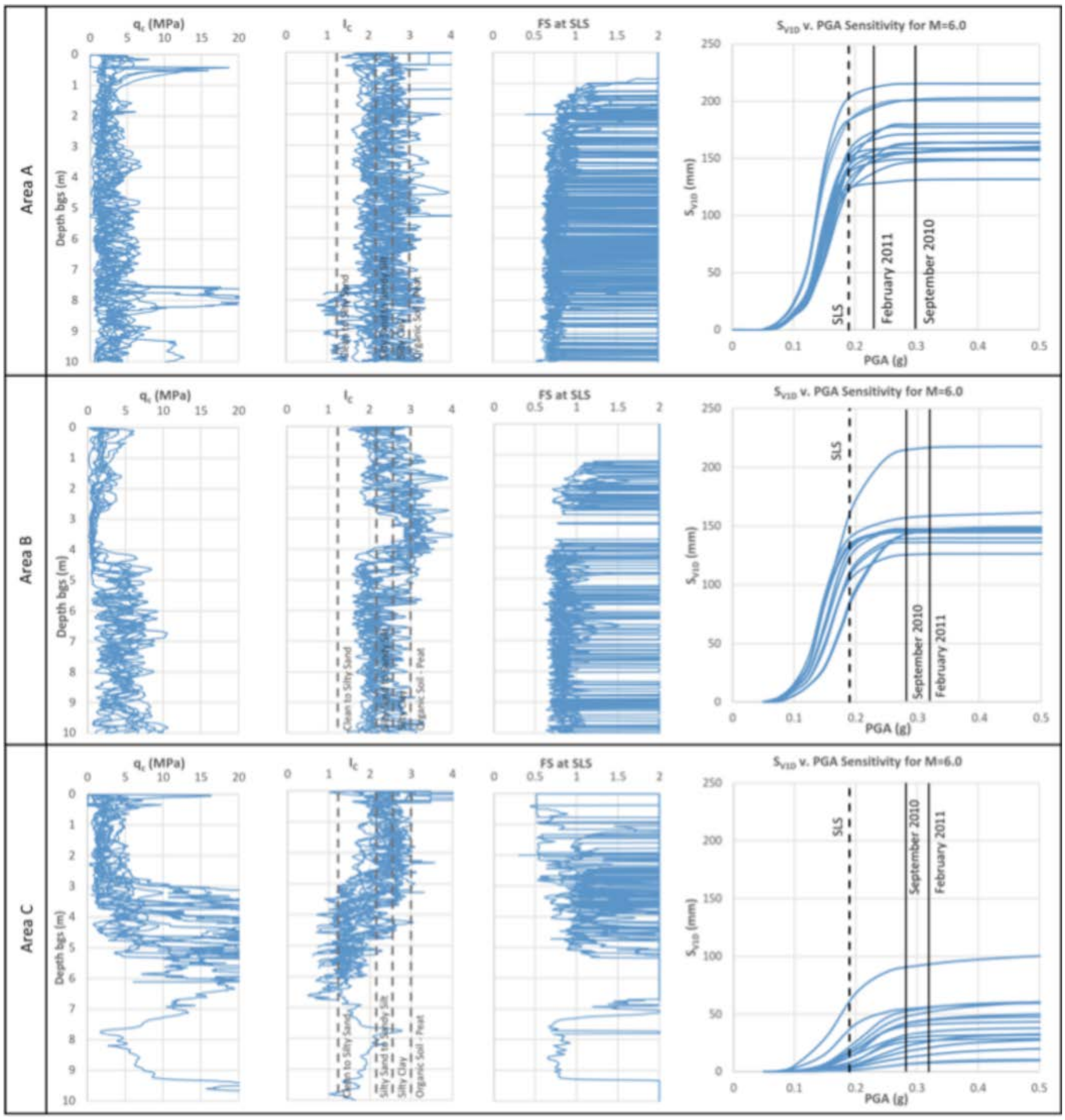


Figure 7:. Plots of q_c, I_c, and SLS S_{V1D} vs depth over the upper 10 m and plots of SV1D vs PGA for a magnitude 6 earthquake for the CPT within areas A, B & C as shown in Figure 6.

the SV1D liquefaction vulnerability parameter is over-predicting the liquefaction related damage at SLS levels of earthquake shaking when compared to the observed September 2010 performance.

For area A the CPT Ic traces indicate a highly interlayered soil profile with I_c values rapidly fluctuating between 1.8 and 3 all the way down the CPT trace. The qc traces indicate a relatively loose soil profile typically less than 5 MPa over the full length. For area B the CPT q_c and I_c traces are similar to area A except between approximately 3 and 4 m below the ground surface (bgs) where a zone of very soft material is encountered with measured q_c typically less than 1 MPa and the Ic values typically above 2.6. Similar to areas A & B, area C also shows relatively loose material over the upper 3 to 4 m. Below this level the measured q_c values increase to 10 to 20 MPa with the majority of the CPT traces terminating by 6 m because they were unable to penetrate the denser soils. The I_c values typically range between 1 to 2 below 4 m indicating the presence of sand and gravel layers.

Based on the q_c and I_c plots it is possible to infer typical ground models for each of the three areas. Area A could be described as a relatively loose silty sand to sandy silt to a depth of 10 m. Area B could be described as a relatively loose silty sand for the upper 3 m underlain by a 1 m thick soft silty clay / organic soil between 3 and 4 m bgs underlain by a relatively loose silty sand for the remainder of the ground profile. Area C could be described as relatively loose silty sand to sandy silt for the upper 3 to 4 m bgs which is underlain by dense sand and gravel layers.

The FS vs depth plots shown in Figure 7 can be used to interpret the thickness of any liquefying and non-liquefying layers within the ground profile at the SLS ground motions. The soil profile in area A is characterized by the presence of a non-liquefying crust for the upper 1.5 m underlain by a thick deposit of liquefying soil layers for the remainder of the ground profile. Similar to area A, area B is characterized by the presence of a non-liquefying crust for the upper 1.5 m which is underlain by a 1.5 m thick liquefying layer. The soft silty clay to organic soil between 3 and 4 m bgs is a non-liquefiable layer which is then underlain by liquefying material for the remainder of the ground profile. For area C the FS periodically dips below 1 in the upper 3 to 4 m indicating the presence of a few interbedded layers of liquefying soils sandwiched between non-liquefying layers. Below 4 m no liquefaction triggering is generally predicted.

Combining each of these information sources together an interpretation of the predicted liquefaction vulnerability of the three areas can be made that reconciles with the land damage observations. Area A is vulnerable to liquefaction related damaged at SLS levels of shaking. This vulnerability is demonstrated by the presence of a thin non-liquefying crust underlain by a thick liquefying layer. The high calculated S_{V1D} values appropriately capture this vulnerability. Area B is not vulnerable to liquefaction related damage at SLS levels of shaking. However this is not captured by the S_{V1D} liquefaction vulnerability parameter as it is predicting relatively high S_{V1D} values at a similar range to those calculated in area A. From the CPT traces it can be seen that the non-liquefiable silty clay to organic material soil layer at 3 to 4 m bgs is probably suppressing the damaging effects of the liquefaction occurring below this depth. The SV1D parameter is not adequately able to account for the presence of this layer and hence based on observed land damage and engineering judgement shallow ground improvements (such as GR and SCR rafts) in conjunction with TC2 foundations could likely be used in this area even though the MBIE (2015) guideline criteria of SLS $S_{V1D} < 100$ mm would not be achieved. Finally area C is not vulnerable to liquefaction related damage at the ground surface at SLS levels of shaking due to the presence of the dense sand and gravel layers encountered from about 4 m bgs. The SV1D parameter is able to capture this vulnerability by predicting relatively low values. As shown by this example, engineering recommendation with respect to area B have been better informed and improved as a result of the collated geotechnical data available in the CGD.

The CGD geotechnical dataset in conjunction with the land damage mapping after each of the main CES earthquakes is an extremely valuable reference point for predicting ground performance in other areas of New Zealand with soil deposits susceptible to liquefaction. If soil profiles with CPT traces similar to the CPT profiles of areas A, B or C (shown in Figure 7) are obtained for another area of New Zealand with similar depth to groundwater, then at similar levels of earthquake shaking, similar land performance could be expected.

The lessons to be gleaned from this particular case study are:

- Confirmation that the fluvial geological environments are highly variable over short distances;
- Geological models should be developed and used to inform the interpretation of site specific CPT data;
- Access to area wide data more easily enables a geological model to be formulated which in turn can be used to better scope geotechnical investigations and improve prediction of future performance. This enables geotechnical engineers to provide more informed design recommendations (potentially resulting in more appropriate foundation solutions); and;
- Calculated liquefaction vulnerability parameters, such as the MBIE (2015) SV1D parameter, should not be solely relied on to predict future performance. Engineering judgement is required underpinned by detailed examination of all geotechnical data not only from the specific site but also from the surrounding area.

DISCUSSION AND CONCLUSIONS

It is estimated that the total site investigation savings in TC3 land for residential property due to access to adjacent residential site investigation information are in the NZ$50 - 100 million range. This figure does not account for infrastructure and commercial development savings and other qualitative benefits such as improved confidence in the level of risk exposure and faster rebuild times due to more efficient use of resources etc. The CDG has changed how the geotechnical professionals now work and it has become integral to their business practices in Canterbury. The consultants now have the ability to put more attention into analysing existing data rather than collecting new geotechnical data. Access to more geotechnical information than would normally be the case enables more focussed designs as a site is able to be evaluated in the context of both its immediate and also surrounding geological environment. This in turn lowers costs to clients both in the investigation and building components of a project. This data model is a very cost effective way to store and share information which reduces the significant inefficiencies in retrieving archived files and relying on corporate knowledge etc. when planning new projects.

In addition to these benefits of data sharing, this article presents examples are presented of how an extensive geotechnical dataset can be used to:

- Undertake a high level assessment of a specific project with regard to information from the surrounding area to better inform the geotechnical risks;
- Provide ground strength and seismic ground performance data that could be used in other locations in New Zealand as a benchmark for expected ground performance in similar geological settings, particularly areas with complex subsurface geological models;
- Enable infrastructure providers to be more informed in their asset management (such as operational and capital expenditure budgeting) and to better target more vulnerable areas for strengthening and also, post an event, to optimize the repair/replacement effort;
- Provide sub-surface data to regulatory authorities and decisions makers so as to enable them to make well informed land planning decisions and determine the appropriateness of investment strategies and solutions;
- Enable regulatory guidance to be prepared and assess the likely impact of guidelines and building codes;
- Enable specialist contractors to assess opportunities for investment in specialist equipment and ground improvement construction techniques;
- Help quantity surveyors and estimators to estimate appropriate foundation rebuild costs so that property owners can specify appropriate sum insured values for their insurance policies; and;
- Enable improved catastrophe loss modelling for insurance and hazard management purposes and for emergency response specialists to undertake appropriate scenario response activities.

In addition to the benefits outlined above, access to extensive geotechnical datasets enables the research community to undertake research projects that would normally not be possible as a result of budget constraints.

The data sharing model in Canterbury has enabled a significant dataset to be developed to the benefit of both

the private and public sectors and it is a quiet success story in the recovery of greater Christchurch following the CES. As a result of the success of the CGD , MBIE is in the process of facilitating the development a nationwide geotechnical database which will incorporate the Hawkes Bay and Auckland regions as a starting point and build from there. This paper presents a compelling argument that a nationwide geotechnical database populated by geotechnical data together with an associated collaborative data sharing model will provide significant benefits to other areas of the country. It is anticipated this national database will be operating in early 2016. It is hoped that the geotechnical community and their clients will support the existence of a national database and begin actively contributing data as a step towards improving and achieving long term resilience.

ACKNOWLEDGEMENTS

The site investigation data initially put into the geotechnical database was provided courtesy of the NZ Earthquake Commission (EQC). The public and private sectors and utility companies subsequently have added significantly more data to this database. The dataset was initially accessed through the Canterbury Earthquake Recovery Authority (CERA) and is now accessed via MBIE. The wastewater infrastructure information has been provided by the Christchurch City Council. The support of all these parties is gratefully acknowledged. This extensive post disaster geotechnical dataset is understood to be a first of its kind in the world and would not have been possible without buy-in from both the public and private sectors to the collaborative data sharing model for the Canterbury recovery. The graphics in this paper have been generated by Tonkin & Taylor Ltd's natural hazards group and their development was only possible with the support of EQC.

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Comparison of Single Anchored Retaining Wall Design Methods Used in the Christchurch Rebuild

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Bas Suckling is an Engineering Geologist from Aurecon with two years of experience working in Christchurch. He completed this work under the supervision of Ian Froggatt, to satisfy the requirements of his Post Graduate Diploma in Engineering Geology at the University of Canterbury.

Ian Froggatt

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BACKGROUND

In the wake of the Canterbury Earthquake Sequence, many residential and council owned retaining walls required repair or total rebuild. There are currently two retaining wall design guideline documents for use in Christchurch. In 2012, the Ministry of Business, Innovation and Employment (MBIE) released design guidelines for residential walls entitled *Seismic Design of Retaining Structures Guidance* (Ministry of Business Innovation and Employment, 2014). This was revised and version two was issued in November 2014. The Christchurch City Council (CCC) have a retaining wall design guideline entitled *Christchurch City Council: 2010/2011 Earthquake Damages – Retaining Walls Repairs Works Design Brief Document* (Beca Infrastructure Ltd, 2011).

This paper investigates how the anchor and socket loads can vary on a standard single anchored timber post retaining wall if the Wood and Elms Flexible (Wood & Elms, 1990) or the Sabatini load distribution method (Sabatini, Pass, & Bachus, 1999) is used, and also investigates the effect of applying the Wall Displacement Factor (W_d), described by MBIE as applicable for various residential settings.

To investigate this, we have developed a standardised

PARAMETER	DISCUSSION AND JUSTIFICATION	VALUE CHOSEN
Height of wall	Reasonable height for an anchored wall.	4 m
Anchor height	Chosen for ease of modelling.	1.5 m
Design Life	Residential wall supporting only a private driveway or garden.	50 Years
Unit Weight	Well graded granular backfill.	γ = 22 kN/m^3
Retained Material Angle of Friction	Well graded granular backfill.	ϕ'= 36°
Retained Material Cohesion	Well graded granular backfill.	c' = 0 kPa
Socket Material Angle of Friction	Loess	ϕ' = 30
Socket Material Cohesion	Loess	c' = 5 kPa
Wall Friction	Taken to be 50% of the angle of friction of the backfill	δ/ϕ' = 18
Depth to Groundwater	Groundwater not included in this model.	N/A
Vertical Surcharge	Assume zero for this investigation.	0
Horizontal Surcharge	Assume zero for this investigation.	0
Slope Angle of Retained Material	Assume zero for this investigation.	β= 0°
Angle of Wall	Christchurch City Council Retaining Wall Design Guide requires the back slope for all walls to be minimum 1H:20V.	α= -3°
Coefficient of vertical acceleration	Seed & Whitman (1970), "Vertical accelerations can be ignored when the Mononobe-Okabe method is used to estimate PAE."	K_v = 0

Table 1: Model Parameters

site model and analysed the different ULS loads acting on the model using the structural modelling software Microstran.

MODEL PARAMETERS

We have undertaken an investigative design of a hypothetical timber pole wall with a 4m retained height. The wall has a single anchor installed at 1.5m from the top. The parameters used in the model are listed in Table 1.

SEISMIC DESIGN PARAMETERS

As outlined in both the CCC and MBIE guidelines, the pseudo static design acceleration should be derived from the elastic site hazard spectrum in accordance with NZS 1170.5 2004: Structural Design Actions Part 5: Earthquake actions. For our study it was calculated as follows:

$$C(T) = C_h(T) * Z * R_u * N(T,D) \qquad (1)$$

In which:
$C_h(T)$ (Spherical Shape Factor) = 1.33 (Class C Soil)
Z (Hazard Factor) = 0.3 for Christchurch for ULS
R_u (Return Factor) = 1.0 (Walls assumed to be IL2 in this analysis though will not always be the case)
N(T,D) (Near Fault Factor) = 1 (>20km from nearest fault)

$$C(T) = 0.4$$

Topographic Amplification Factor

No topographic amplification factor has been used in this assessment.

Wall Displacement Factor

Section 6.2 of the MBIE Guidelines details the use of the Wall Displacement Factor (W_d) in residential retaining wall design. It recommends that the ULS horizontal acceleration coefficient can be reduced for most residential walls, as they are flexible enough to absorb high transient ground acceleration without damage, as the inertia and damping of the retained soil limits deformation. The MBIE Guidelines list six typical situations where retaining walls are used for residential development, which range from retaining walls integral to the dwelling (W_d= 0.7) to retaining walls for landscaping purposes (W_d= 0.3). The coefficient of horizontal acceleration is multiplied by the Wd factor prior to calculation of the active earth pressure. The CCC guidelines do not specify the need for a Wd factor. We have undertaken our analysis using three values of W_d, 1, 0.7 and 0.3.

Active Earth Pressure (Earthquake)

The active earth pressure coefficient Kae has been calculated using the Mononobe-Okabe method (Mononobe & Matsuo, 1929). Using the values outlined the model parameters section and the K_h values with W_d applied, the K_{ae} values have been calculated. The results are shown in Table 2.

W_d	K_h*	K_{ae}
1	0.4	0.548
0.7	0.28	0.413
0.3	0.12	0.286

Table 2: Active earth pressure coefficients with different values of W_d *K_h = C(T) x W_d

WOOD & ELMS FLEXIBLE METHOD

The Wood and Elms Flexible Method is outlined in Wood & Elms, (1990). The selection of the flexible method over the stiff method was based on the projected wall deflection. The flexible method uses a straight forward triangular shaped loading diagram, where the pressure acting at any point on the wall is given by:

$$P = K_{ae} \ \gamma H \qquad (2)$$

Where γ is the unit weight of the retained soil, and H is the height above ground. An excerpt from Wood & Elms, (1990) is shown in Figure 1. Using this method, we have anticipated that the socket load will be larger than the anchor load. We have modelled three walls using this method, using the three Kae values listed in Table 2.

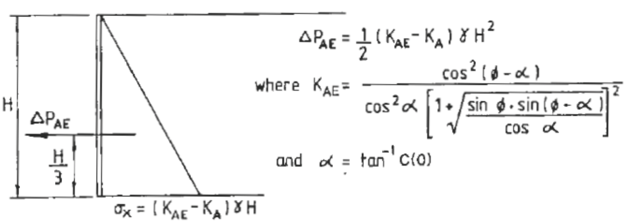

Figure 1: Wood and Elms 'Flexible' Loading Diagram (taken from Seismic Design of Bridge Abutments and Retaining Walls, 1990)

SABATINI METHOD

The MBIE (2014) guidance document recommends that tied back retaining walls are designed using the method outlined in Sabatini et al. (1999). This method models a trapezoidal shaped load on the wall with areas of low pressure at the top and base of the wall, resulting in a high anchor load and low socket load. Figure 2 indicates the shape and the relative dimensions of the load distribution. We have modelled three walls using this method, using the three K_{ae} values listed in Table 2.

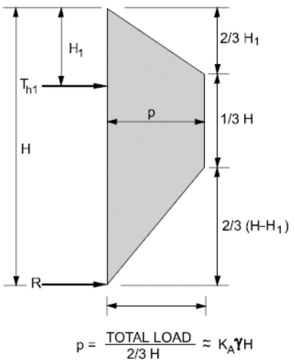

Figure 2: Sabatini Loading Diagram (Taken from Ground Anchors and Anchored Systems, 1998)

MICROSTRAN MODELLING

Models of the wall were built using Microstran V9.2 (Bently Systems Incorporated, 2014), a structural modelling software package. Using this software it is possible to derive the maximum bending moments and anchor and socket loads. Annotated examples of the models and their outputs are shown in Figures 3 and 4. The base sockets have been modelled by making the base of the member fixed against rotation and deflection in three dimensions rather than using Winkler Springs to model soil behaviour. This was done for simplicity of modelling.

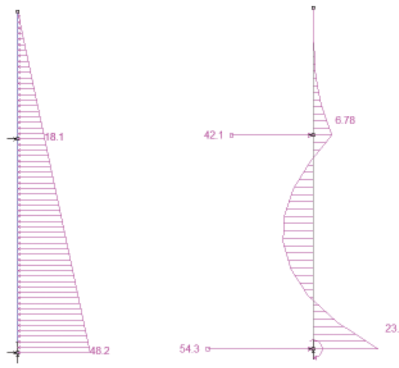

Figure 3: Microstran model of 4m high anchored wall using the Wood and Elms Flexible method, Wd of 1. The applied load is shown on the left and the bending moment and reactions on the right.

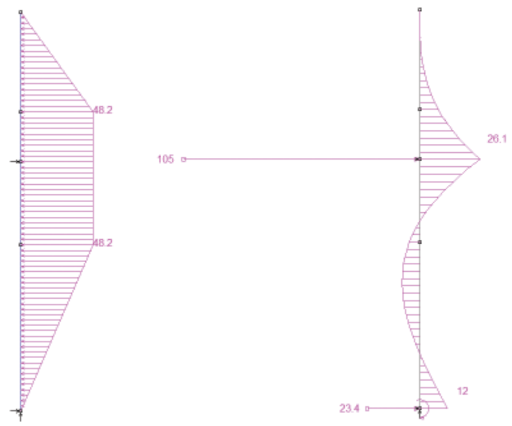

Figure 4: Microstran model of 4m high anchored wall using the Sabatini et al method, Wd of 1. The applied load is shown on the left and the bending moment and reactions on the right.

Variable	Sabatini Method			Wood and Elms Flexible		
	No WD	WD = 0.7	WD = 0.3	No WD	WD = 0.7	WD = 0.3
Horizontal Acceleration (g)	0.4	0.28	0.12	0.4	0.28	0.12
Mononobe Okabe Coefficient	0.548	0.413	0.286	0.548	0.413	0.286
K_{ae} γ H (kPa)	48.224	36.344	25.168	48.224	36.344	25.168
Moment at Anchor (kNm)	26.1	19.7	13.6	6.78	5.11	3.54
Moment at Socket (kNm)	12	9.01	6.24	23.3	17.6	12.2
Anchor Load (kN)	105	79.3	54.9	42.1	31.7	22
Socket Load (kN)	23.4	17.6	12.2	54.3	40.9	28.4

Table 3: Results of Microstran Modelling

RESULTS

The results of our modelling including the active earth pressure, the maximum bending moment and the load at the anchor and socket are shown in Table 3.

Variable	Sabatini Method			Wood and Elms Flexible		
	No WD	WD = 0.7	WD = 0.3	No WD	WD = 0.7	WD = 0.3
Derived Pole Diameter	225mm	200mm	175mm	225mm	200mm	200mm
Derived Anchor Diameter	20mm	16mm	16mm	16mm	16mm	16mm

Table 4: Derived Wall Parameters
Note pole and anchor diameters were derived for the loads only and do not allow for corrosion etc.

DISCUSSION

As predicted, the anchor loads are higher using the Sabatini method, and more than double the anchor loads using the Wood and Elms Flexible method. Conversely, the Wood and Elms Flexible method results in socket loads which are more than double the loads derived using the Sabatini Method. These relationships hold true using the three W_d factors.

This begs the question, if a geotechnical professional was asked to design two anchored walls using the parameters in this model, how different would the specifications be? We have derived typical diameters for anchors and timber sections and these are shown in Table 4 (the full details of the design are beyond the scope of this investigation). One could consider a potential case where the new wall will retain landscaping on a residential section above a road. At one end of the spectrum the new wall may be designed based on loads derived using the Sabatini Method, with a WD=0.3 applied. Alternatively, the wall may be designed based on loads derived using the Wood and Elms Flexible method, with no WD applied. The two walls could have a vastly different pole diameter, yet both be valid designs using an accepted method.

FURTHER INVESTIGATION

This was a simple assessment into the different methods of anchored timber post retaining wall design. For someone else who shares a passion for retaining wall design, this investigation could be expanded to include springs in the analysis to better model the socket behaviour. Further investigation could also be undertaken into the design and economic implications of other commonly used retaining walls in Christchurch, such as gravity and multi-anchored walls.

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Plate Load Testing – Two Different Approaches

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Alan is a geotechnical engineer working for ENGEO (formerly Geoscience) in Wellington. Alan has eleven years' experience as a Geotechnical Engineer in New Zealand and Australia and has considerable experience in site investigations and geotechnical design of building foundations, subdivisions, retaining structures, cell phone towers, wind farms and dams.

Neil Charters

Neil is a geotechnical engineer working for ENGEO (formerly Geoscience) in Christchurch. Neil has worked on a variety of projects over the last 10 years, involving hydro-electric schemes, motorways, railways, general infrastructure, as well as residential development. Neil has been involved with these projects from the feasibility stage, through investigations and detailed design and into construction monitoring. Neil has worked on projects in a wide variety of geological settings around both islands of New Zealand, and Canada.

ABSTRACT

For many foundation designs it is insufficient to consider only the bearing capacity of the foundation soils – the stiffness must also be considered. To assess foundation stiffness, ENGEO (formerly Geoscience) has recently been involved in specifying and observing plate load tests at two sites with markedly different geologies and with substantially different equipment. One test was on non-engineered fill derived from Port Hills loess and colluvium, the other on weathered Wellington Greywacke. One test site used the dead weight of an excavator to apply the load, the other test site used production ground anchors as reaction. The subgrade reaction and bearing capacity values measured are presented, with comparisons to published values. The challenges met during the testing are discussed.

Keywords: foundation stiffness, foundation testing, bearing capacity, plate load test.

1. INTRODUCTION

In many relatively simple foundation designs, consideration of the soil or rock's bearing capacity is the most important consideration. In such cases, simple theoretical or empirical formulae are used to calculate the soil's bearing capacity, and the settlement at bearing capacity "failure" is assumed to be 25mm, a somewhat arbitrary value. Depending on the sensitivity of the structure, it is often important to more carefully consider the stiffness of the foundation. Examples of situations where foundation stiffness is an important consideration include:

- Upgrading an old building that contains under-strength or brittle elements that are sensitive to foundation movement;
- Design of structures with tight displacement tolerances for serviceability requirements (such as telecommunications towers);
- Design of structures with a heavy load on a strong soil or rock, where bearing capacity failure may not be reached, but where moderate or high settlements may still occur.

In 2014, the authors designed and observed two markedly different load testing arrangements to assess the stiffness behaviour of the subgrade, both of enough technical interest to be considered worthy of dissemination.

The first load testing arrangement took place in Lyttelton on non-engineered fill derived from Port Hills loess and/or colluvium, and used the dead weight of an excavator to apply the load. The second load testing arrangement took place in weathered Wellington Greywacke, and used production ground anchors as reaction.

2. PORT HILLS LOESS AND COLLUVIUM FILL TESTING

2.1 Building

An existing two-storey building in Lyttelton, Canterbury, required seismic strengthening as part of its earthquake repair. The building is supported on strip foundations approximately 300 mm wide and 500 mm deep, which bear on uncontrolled fill, likely placed before 1965. Test pits and boreholes had been previously completed at the site to assess the ground conditions below the uncontrolled fill. A geological cross section through the site is shown in Figure 1.

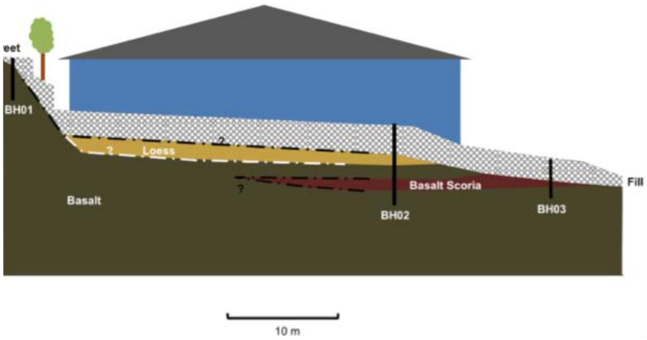

Figure 1: Geological Cross Section, Port Hills Site

The building foundations performed relatively well during the Canterbury earthquake sequence, with a maximum differential settlement of approximately 40 mm measured.

An understanding of both the strength and stiffness of the fill below the existing and proposed new strip foundations was considered important in understanding the likely behaviour of the foundations in the future. Geotechnical testing indicated that the fill was typically firm to stiff with Dynamic Cone Penetrometer (DCP) blow counts between 1 and 6 per 100 mm (typically 3 blows/100 mm).

2.3 Testing Arrangement

Two plate load tests were carried out in general accordance with ASTM test method D1194. The test locations were prepared by excavating a small pit (approximately 2 m long x 0.7 m wide x 0.6 m deep) with a narrow excavator bucket and hand tools to create a smooth and level pit base. The excavated material consisted of fill with a matrix of loess and basalt cobbles (up to 200 mm diameter), brick fragments and gravel.

A 300 mm diameter by 25 mm thick steel bearing plate was placed on the test surface, using sand as needed to provide a uniform seat between the plate and subgrade. A jack stand (rated to 12 tons), two steel plates and an Enerpac RC102 hydraulic lifting jack were then centred on top of the bearing plate. Dial indicators on a magnetic stand were attached to a 2.75 m long datum bar and positioned over the lowest steel packing plate. An excavator was moved such that the undercarriage would lie directly over the test apparatus. Wood blocks were used as cribbing to allow the jacking force to be transferred to the underside of the excavator carriage (Figure 2).

Set back photo of test 1

View of in-pit set up in test 1

Close up view of dial gauges and hydraulic jack in test 1

Close up view of dial gauges in test 1

Figure 2: Port Hills Site Photographs

Prior to loading with the hydraulic jack, the dial indicators were zeroed. The applied load was measured as a calibrated hydraulic pressure applied to an effective cylinder area specific to the equipment used, measured to 2.5 bar (approximately 5 kPa) tolerance. Loading consisted of up to seven increments. Each increment was held for a minimum of 10 minutes before loading to the next successive value until reaching a final bearing stress of between 470 and 570 kPa. Deformation was recorded to 0.025 mm tolerance on two dial indicators and reported as the average measurement recorded on the two dial indicators.

2.3 Test Results

Test 1 had a relatively linear response of approximately 85 kPa/mm until a load of 300 kPa was reached, after which the stiffness reduced to approximately 52 kPa/mm. This test was terminated at a load of 570 kPa due to the applied load approaching the mass of the excavator used as reaction force. Test 2 had an essentially linear response with a stiffness value of approximately 40 kPa/mm until it was terminated due to eccentric loading of the plate at a maximum applied pressure of 470 kPa and a deflection of 12 mm (Figure 3).

The two tests had stiffness values within approximately 25% of each other, which we consider to be relatively consistent for uncontrolled fill material.

An ultimate bearing capacity of 300 kPa was selected for this project subject to geotechnical inspection of all foundation excavations.

While the measured bearing capacity and stiffness seem high for uncontrolled fill, this testing program supported the observations of good performance (40 mm differential settlement) during the Canterbury Earthquake sequence.

3. WELLINGTON GREYWACKE TESTING

3.1 Building

An existing multi-storey building on The Terrace, Wellington is intended to be seismically strengthened. The building contains a basement with a 12 m high retaining wall, which is partly supported by buttress walls that extend into the basement perpendicular to the retaining wall. The foundations of the existing buttress walls are 1.8 m wide and 0.6 m deep, with foundations for new buttress walls expected to be 1.0 m wide and 0.8 m deep. The performance of the retaining wall under seismic loading is dependent on the rotational stiffness of the buttress wall, which is, in turn, dependant on the stiffness of the buttress wall foundations. In addition, some of the building columns are founded on shallow pads, up to 2.8 m wide and up to 2.2 m deep. An understanding of the stiffness of both the foundations of the buttress walls and the foundations of the building was considered important in understanding, respectively, the behaviour of the retaining wall and the superstructure.

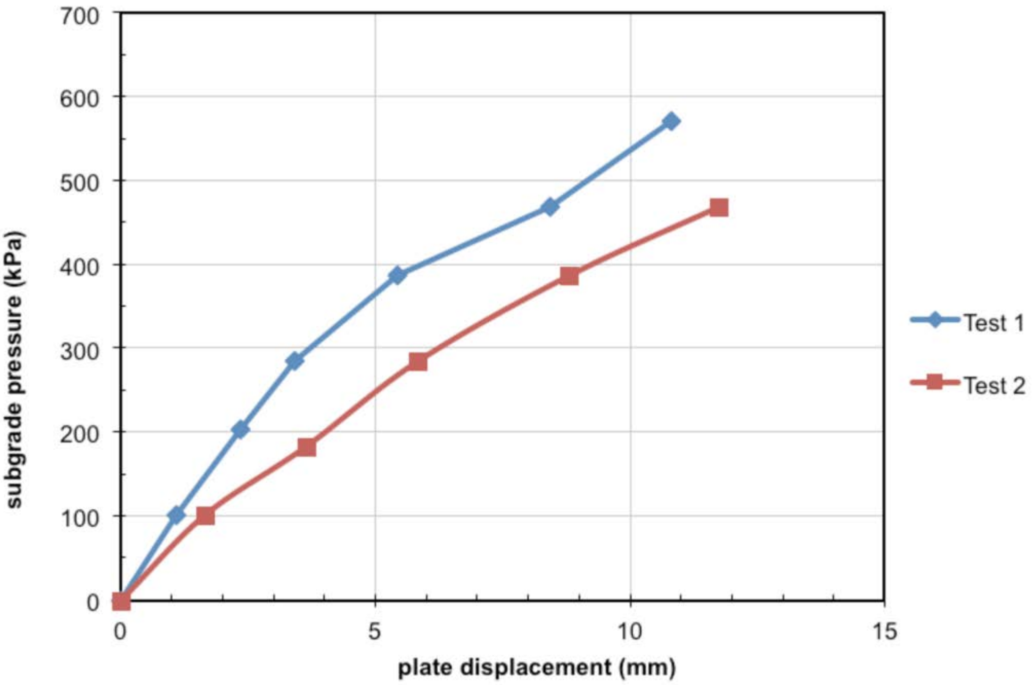

Figure 3: First Compression Curve, Port Hills Site

Figure 4: Structural frame and vertical anchors supporting Test 2. Plate is located within the pit below the cut floor slab in the centre of the photograph.

3.2 Testing Arrangement

A higher importance was placed on understanding the buttress wall foundations and hence the two test locations were placed near the base of the retaining walls, between buttress wall foundations. Three tests were carried out, one between Gridlines E and F (Test 1) and two between Gridlines K and L (Tests 2 and 3). Tests 1 and 2 were intended to approximate as closely as practicable the foundations of the new buttress walls, with Test 3 intended to provide the maximum credible bearing pressure. All tests were carried out on a smooth and level rock surface at 0.9 m to 0.95 m depth below the basement floor; Tests 1 and 2 used 650 mm by 700 mm steel plates to load the rock, while Test 3 used a 350 mm square plate. Test 3 was carried out within the same pit, and hence tested much of the same rock, as had been previously loaded in Test 2. Reaction was provided to both tests by a structural steel frame attached to vertical rock anchors. Due to the limited space below the frame and within the pit, it was not practicable to use dial gauges to record movement of the plate. Instead, measurements were made by tape measure from the underside of the beam to the top of the plate, taking into account the movement of the beam relative to the floor slab. Due to the relative crudity of this method, the deflection of the plate was measured at several locations on the plate. The difference between the highest and lowest deflections measured was typically less than 20%, which may reflect error in the measurements and/or rotation of the plate. The arrangement of Test 2 is shown in Figure 4.

Test 1 was completed on fractured highly weathered Greywacke, with SPT "N" values recorded as 42-50 in a nearby borehole. Tests 2 and 3 were completed on moderately weathered Greywacke with SPT N values well in excess of 50. The difference between the rock weathering is due to the depth of cut at the test locations: Test 1 was located approximately 7m below the original ground surface whereas Tests 2 and 3 were located approximately 10m below the original ground surface.

3.3 Test Results

Testing was carried out in cycles, similar to those specified in BS8081, with a maximum sustained load 1574 kN. Maximum loads for each cycle were held for 15 minutes for Tests 1 and 2 and for five minutes for Test 3. Up to eight cycles were planned, with Tests 1 and 2 discontinued after six cycles and Test 3 after four cycles. Figure 5 shows the pressure/deflection plots for the tests, based on the first compression (i.e. the load cycles are not shown, for clarity).

Tests 1 and 2 were both discontinued at between 3383 kPa and 3458 kPa. At these pressures, the testing jack was unable to sustain further load. As these two values were so similar, the reason for discontinuation was likely a problem with the jack or the kentledge, rather than a bearing failure in the rock. Test 3 was therefore completed with a smaller plate to allow higher pressures to be achieved with similar force. Test 3 extended to an applied pressure of 10,072 kPa, at which pressure the

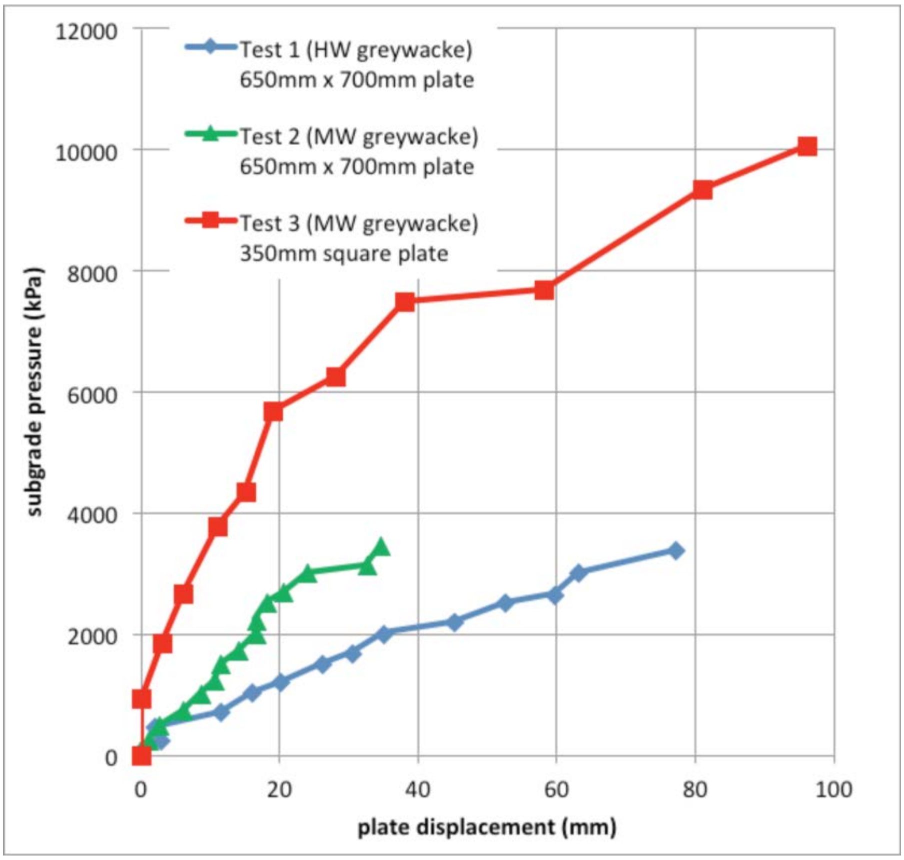

Table 1: Comparison of test data with published values

deflection of the rock was so high (99mm) that further testing may have ruptured the jacking cables.

Tests 1 and 2 had essentially linear responses with stiffness values of approximately 50 kPa/mm for Test 1 and 130 kPa/mm for Test 2. Test 1 thus had a substantially softer response than Test 2, which was attributed to the rock being more weathered at the Test 1 location. Test 3 had an essentially linear response up to 6000 kPa with a stiffness value over the linear portion of approximately 300 kPa/mm. The stiffness of Test 3 is of dubious significance as the area had previously been loaded by Test 2.

An ultimate bearing capacity of 3000 kPa was conservatively selected for this project.

4. COMPARISONS WITH PUBLISHED VALUES

A comparison of the stiffness and strength parameters obtained from the testing with published values is presented in Table 1. To calculate the apparent Young's modulus (E), a re-arrangement of the classical equation $D = 2q(1-\nu^2)B / E$ was used (after Bell (1978) equation 5.9), where D=settlement, q=pressure, ν=Poisson's ratio (taken to be 0.3) and B=footing width. This formula assumes that stress extends to 2B below the footing and that E is a constant within that depth range. Only the linear part of the first compression line was considered in calculating E from the tests.

The referenced bearing capacities for rocks fom the literature that are broadly similar to weathered Greywacke give substantially different bearing capacities (range 300 kPa to 6000 kPa). The testing carried out supports the use of the Navfac and Peck values for this weathering grade of greywacke. The testing suggested that the bearing capacity for the fill material was somewhat higher than may be assumed for uncontrolled fill based on nearby DCP testing.

Published information on the likely settlement behaviour of shallow foundations in rock was available only if the unconfined compressive strength or deformation modulus of intact rock were known, which they were not in this case. Published information on the likely settlement behaviour of silty soils suggested somewhat lower values than those that were demonstrated by the testing.

5. CHALLENGES MET DURING TESTING

Port Hills

The main challenges at the Port Hills Site were related to site access and the presence of uncontrolled fill. Testing was completed in a flat area adjacent to the building as this was the closest location that could be reached with the excavator. The assessed foundations were relatively narrow and the soil weak so the applied loads were relatively easily achieved.

SITE	PARAMETER	VALUE FROM TESTING	VALUE FROM LITERATURE	REFERENCE
Wellington Greywacke	Young's modulus	70 MPa (Test 1); 130 MPa (Test 2);	-	-
	Stiffness	50 – 130 kPa/mm	-	-
	Ultimate Bearing Capacity	> 3000 kPa	300 kPa	Look (2007) Table 22.5, assuming low strength rock with 50° friction angle.
			2300 to 3450 kPa	Navfac (1986) Table 1. Allowable bearing capacity 765 – 1149 kPa (8 to 12 tons/ft²) for "weathered or broken bed rock", multiplied by 3.
			6000 kPa	CP 2004, listed in Bell Table 5.1. Allowable bearing capacity 2 MPa for "soft sandstones", multiplied by 3.
			3000 kPa	Peck, listed in Bell Table 5.2. Allowable bearing capacity 1 MPa for "soft or broken bedrock", multiplied by 3.
Port Hills loess / colluvium fill	Young's modulus	16 MPa (Test 1); 12 MPa (Test 2);	2-20 MPa; 10-20 MPa	Bowles (1996) typical value for Silty Sand; Look (2007) typical value for Stiff Silt
	Stiffness	40 - 52 kPa/mm	24-48 kPa/mm	Bowles (1996) typical value for Silty Sand
	Ultimate Bearing Capacity	>300 kPa		

Figure 5: First Compression Curve, Wellington site

One of the principal challenges of this site was the potential heterogeneity of the uncontrolled fill and the possibility that our two test locations may not be representative of the fill across the site. However, the observed foundation performance during the Canterbury Earthquakes (less than 50 mm differential settlement) with the relative consistency between the results suggested that the likelihood of heterogeneous fill was relatively low.

Wellington

- The Wellington site was significantly more complex than the Port Hills site due to the stronger ground and wider foundations meaning that the test loads were significantly higher (approximately 1600 kN compared to 50 kN)
- In order to replicate existing foundations as closely as possible, the width of the plate was made as large as possible in Tests 1 and 2 (650mm x 700mm). This necessitated the application of high forces to get the desired bearing stresses (maximum applied force 1574 kN, although up to 2000 kN was allowed for). In order to minimise the overall cost to the project, reaction was provided by ground anchors located such that they could be used in the final design. The spacing between anchors was 3.1m, resulting in high bending moments in the reaction frame (up to 1220 kNm applied in the testing, with up to 1550 kNm allowed for). A heavy reaction frame, comprising twin 400WC328 steel beams was required to carry this bending demand.
- The unusual nature of the test, the heavy structural steel requirements, and the low head room resulted in a slow assembly time.
- A failure of unknown origin, but probably in the jacking system or kentledge arrangement, limited the applied load to 1539 – 1573 kN, below the 2000 kN that the system was designed for.
- Excessive deformation (99mm) in Test 3 caused the engineer to stop the test to prevent rupture of the jacking cables which were sitting on the adjacent ground due to the settlement of the rock.

6. CONCLUSIONS

Testing of the subgrades of shallow foundations was carried out for highly to moderately weathered Greywacke and loess/colluvium fill. In Greywacke, testing supported the use of an ultimate bearing capacity for shallow foundations of at least 3000 kPa. The testing indicated that foundation stiffness values of 50 to 130 kPa/mm may be expected for foundation widths in the order of 650mm to 700mm. In fill derived from Port Hills loess, testing supported assuming an ultimate bearing capacity of 300 kPa and a stiffness of 40-50 kPa for 300 mm wide foundations.

Care would be required to extrapolate the stiffness values to foundations significantly larger than those tested (see Bell equation 5.12).

At both sites, the testing provided design parameters that were valuable in the detailed design process.

At the Port Hills site, the testing suggested that the soil stiffness was at the upper end of published values, which is somewhat higher than may be assumed based on the geotechnical testing. This indicates that the soil is fill and therefore typically weaker than may be expected for native soils.

7. ACKNOWLEDGEMENTS

We would like to thank our colleagues Joe Gray, Jacob Cornall, Tomasz Krawczynski and Victoria Anderson for their valuable assistance with procuring equipment, completing the testing and research.

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11th Australia and New Zealand Young Geotechnical Professionals Conference

11YGPC
Queenstown New Zealand
October 2016

> Call for Abstracts & Nominations

The New Zealand Geotechnical Society and the Australian Geomechanics Society invite you to attend the 11th ANZ Young Geotechnical Professionals Conference (11YGPC).

The 11YGPC is for geotechnical professionals from New Zealand and Australia 35 years old and younger. It is designed for all attendees to present a technical paper on any topic of interest / experience relating to the field of geomechanics or geotechnical engineering.

Nominations

Please complete the nomination form available on NZGS website to this call for abstracts. Nominations of delegates must also be supported by a senior mentor and include an abstract of 200 words on a topic that is related to geotechnical practice or research. Successful nominations will be selected based on the quality and relevance of the abstract.

Positions are limited to approximately 50 attendees and all successful nominations will be expected to present their technical paper at the conference.

Cost

The cost of this three day event is anticipated to be approximately NZ$1000 (incl. GST). The exact cost will be confirmed at the time of nomination acceptance.

This cost includes conference venue and dinner, three nights' accommodation, an arrival drinks reception and field trip to discover the regional geology of the Queenstown region.

IMPORTANT DATES

(dates given below are approximate only)

- **4 March 2016** - Nominations and abstracts due
- **4 April 2016** - Nominations accepted
- **1 July 2016** - Full Paper due
- **25-28 October 2016** - 11YGPC

NEW ZEALAND GEOTECHNICAL SOCIETY INC

FURTHER INFORMATION will be available shortly on the New Zealand Geotechnical website www.nzgs.org. For any urgent queries or return of nomination forms / abstracts, please contact Frances Neeson (Organising Committee Chair) 11YGPC@gmail.com

Geomodels in Engineering Geology – an introduction

– Peter Fookes, Geoff Pettifer and Tony Waltham

Review by:
Ross Roberts

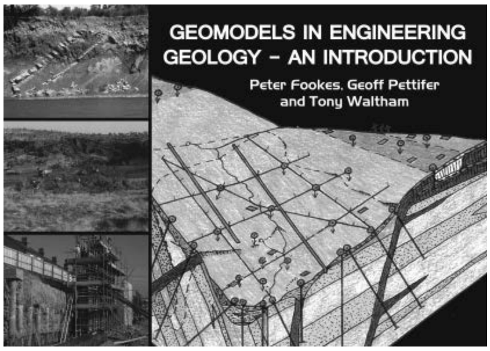
Ross is an Engineering Geologist with Jacobs in Auckland. He trained in the UK at Edinburgh and Newcastle, and has since worked on projects ranging from motorways and railways to geothermal power stations and wharf structures. He has a particular interest in geohazard assessment, investigation and remediation. He has worked in the UK, Ireland, Australia, Java, Sumatra and New Zealand.

NZ Geomechanics News co-editor

IF KARL TERZAGHI is the father of modern geotechnical engineering, then Fookes must be his equivalent in the world of engineering geology. In the 1950s engineering geology did not exist except as a loosely defined 'geology for engineers'. Fookes established the subject and played a defining role in the first Engineering Geology MSc course at Imperial College. He has published over 180 papers and been involved in topics as diverse as geomorphology and concrete technology. He is a past recipient of the William Smith medal (in 1985) and the Glossop Medal (in 1997). His core speciality – if such a broadly experienced generalist can be said to have one – is in geomodels. It is only natural therefore that when an Engineering Geologist sees a new book published by Peter Fookes on this topic there is a quiver of excitement.

The stated aim of the book is 'to provide an introduction to geomodels in which the drawings and photographs largely speak for themselves', and it is clear throughout that a graphical approach has been preferred. Almost every page is dominated by beautiful hand-drawn block models or stunning photographs of some of the world's best geology. In this respect the book most certainly achieves its aim. Each model neatly summarises a 'typical' condition and geology, and the photographs do an excellent job of showing how these look in real life. It provides a guide to worldwide ground conditions, with

Title	Geomodels in Engineering Geology: An Introduction
Authors	Peter Fookes, Geoff Pettifer, Tony Waltham
Publisher	Whittles Publishing
Year Published	2015
Length	208 pages
ISBN	9781849951395
Web shopping	http://www.whittlespublishing.com/Geomodels_in_ Engineering_Geology
Price	Paperback £35



basic text explanations and information on each principal block diagram and its annotated photographs.

The book is split into five sections:

- **Underlying factors** deals with climate and geology
- **Near surface ground changes** focusses on weathering
- **Basic geological environments for engineering** describes each of the main climatic environments and the impacts on the surface geological conditions
- **Ground investigation** describes the phases of investigations and gives tips about layout
- **Case histories** provides a few pages each on a range of very different projects showing how each was characterised.

Unexpectedly this book only really glances on the production of geomodels. The main focus is on presenting existing 'generic' models for a range of climatic and geological zones as an introduction to the key geological hazards. At 208 pages, this book covers the majority of conditions in enough detail to give a succinct introduction.

The introductory pages are kept very basic (down to the level of defining in some detail the difference between igneous and sedimentary rocks, for example); all geologists and most engineers will simply skip much of this as it is more appropriate for high school level.

review continued ›

60 Countries have come to Edinburgh to decide the future of Geotechnical Engineering

Grant Murray

Grant Murray is an independent consulting engineer practising in geotechnical and dam safety engineering. Grant was trained in Scotland and has based the last 20 years of his professional life in NZ. He has been fortunate enough to have project experience throughout the UK, NZ, Australia, the Pacific Islands, SE Asia, Asia and Africa.

THE XVI EUROPEAN CONFERENCE on Soil Mechanics and Geotechnical Engineering was held in September 2015 in Edinburgh. I was fortunate enough to be able to attend the conference in this beautiful city where I first studied geotechnical engineering so it's fair to say I enjoyed a week catching up with some former colleagues and reminiscing over those halcyon days as a carefree student.

The conference was organized by the British Geotechnical Association (BGA) and the ISSMGE with the conference theme, Geotechnical Engineering for Infrastructure and Development. The conference was very well attended with nearly 1000 delegates making it the largest European geotechnical conference in the history of the event.

At the official opening and welcome reception the Minister for Transport & Islands of Scotland, Derek Mackay MSP, emphasized the importance of geotechnical engineering in sustainable development of the modern world.

The first keynote lecture was delivered by Kenichi Soga from the University of Cambridge, United Kingdom, and was entitled "The Role of Distributed Sensing in Understanding the Engineering Performance of Geotechnical Structures". Messrs Rankine and Hutton would not have had a clue what he was talking about – and neither did I having become reacquainted with the delights of 80/- beer the night before.

Prof. Gomes Correia, from Portugal, gave the second keynote lecture entitled "Geotechnical Engineering for Sustainable Transportation Infrastructure". The lecture highlighted yet again one of the fundamental doctrines of geotechnical engineering that I have espoused for many years; a little bit of common sense can contribute to safe, reliable and resilient infrastructure solutions and contribute to preserving natural resources. What we do is not rocket science.

The third keynote lecture was delivered by Prof. Giulia Viggiani from Italy with the title "Artificial Ground Freezing: from applications and case studies to fundamental research". Having spent my first winter as a graduate civil engineer on a dam at the top of the North Yorkshire Moors I have had actual, rather than artificial, experience of freezing more sensitive extremities than just some natural ground - so I gave this lecture a miss.

From a technical perspective the conference published 686 papers, including three keynote lectures and six invited lectures, in 4,784 pages and seven volumes of proceedings. Interestingly, ninety of the papers were from outside Europe including one from NZ concerning the conversion of a CPT cone resistance to a Coefficient of Subgrade Reaction – I kid you not, but suspect the Pope will have more luck with Richard Dawkins.

One particular highlight for me was the entire session devoted to technical papers on the Queensferry Crossing – the spectacular third bridge currently under> construction across the Firth of Forth.

The conference closed with ringing endorsements and enthusiastic encouragement for delegates to attend the 19th ICSMGE in Seoul, Korea in September 2017 and the next ECSMGE in Reykjavik, Iceland in 2019. To whet your appetite the conference themes for these events will be "Unearth the future, connect beyond" and "Geotechnical Engineering, foundation of the future".

Later on, somewhat bizarrely lumped in with the case studies, typical engineering properties of many soils and rocks are given which would provide a useful desk-study level reference if the sources of the information were given. It feels as if this book does not know who the target audience is, so tries to please everyone.

Who should buy this book? I would suggest that for inexperienced engineering graduates this book would provide a useful introduction, and for engineering geologists working in a new climate zone or geology this would be a valuable check that the key likely hazards have been addressed. Most practitioners would very rapidly move beyond the high-level generic models in this book, so if you already have a basic understanding of the geology in your area of work this book probably isn't for you.

13th International Society for Rock Mechanics (ISRM) Congress

THE CONGRESS, HELD over three days (11 – 13 May) in Montreal, Canada, was attended by 640 registrants. The innovations in applied and theoretical rock mechanics theme was intended for the application of rock mechanics and rock engineering in civil, mining, and petroleum engineering. Technically, each day consisted of plenary and/or keynote lectures followed by paper presentation and poster sessions. A more specialised Shale Symposium was also held over the three days. The Congress was also held in conjunction with the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Annual Convention. The accompanying trade expo with 470 exhibiting companies was CIM dominated, with 11 ISRM related booths.

Two plenary lectures (the Müller and Rocha awards) and the seven keynote addresses were presented. Most presented stimulating updates in their topic area, in particular those that gave a historical review, current status and thoughts for the future. We were given reminders of the benefits of the observational approach (fostered by Ralph Peck) to the formulation and calibration of numerical models and display of a wide array of numerical techniques applied to both surface works and underground.

The 450 papers (from 650 abstracts) were presented in eight parallel sessions, with 15 minutes per paper. They included warnings of the greater likelihood of earthquakes with moon phases (in all sincerity), and that good looking models may not be realistic or may possess fatal flaws. Although topic areas (e.g. numerical modelling, laboratory testing) were reasonably streamed, there were inevitable clashes for those with wider interests, compounded at times by non-appearance of authors or less than strict timekeeping.

Posters had a lower profile. There were fewer in number and displayed in a slightly removed (difficult to find) location, though they did have a long exposure time once found. An interesting feature was a quiz for teams of students from individual countries on technical and nontechnical topics related to rock mechanics (rockbowl). Social events, which included the induction of a further 10 ISRM fellows, included an exhibition of local folklore/culture, a display from local company Cirque du Soleil plus some rather dazzling slight-of-hand card tricks. All of this within walking distance of Old Town Montreal with its historic buildings and delightful bistros.

From the Australasian perspective (29 papers from Australia, 3 from NZ) highlights included:

- Keynote address by Chris Massey on the stability of the Port Hills rock slopes during the 2010/11 Canterbury earthquakes.
- Recognition of the paper on Riskgate (risk management approaches for underground coal mining design, operations and accident investigations) by Bruce Hebblewhite, Rudi Mitra and Philip Kirsch as one of the ten best Congress papers.

Stuart Read
Stuart Read is an engineering geologist with GNS Science. He obtained his degree, in engineering geology from the University of Canterbury, in 1971. His 43 years of engineering geological consulting and research experience has been in the evaluation, investigation, construction and refurbishment of engineering and mining projects. He has taken a leading role in the development of the rock and soil mechanics laboratory for GNS Science and has research interests in the strength and deformation properties of rock and soil masses.

Overall the congress was a successful event that provided a worthwhile update on a wide range of rock mechanics topic areas. It did however suffer from the topic broadness, something naturally associated with an international society flagship 4-yearly gathering; there would have been benefits from having fewer parallel paper presentation sessions and more emphasis on the posters.

NZGS Awards Diary

TO ADVANCE THE aims of the Society we regularly present awards to outstanding members. We encourage all members to consider applying for, or supporting others to apply for the awards summarised below. More details are available on our website."

YOUNG GEOTECHNICAL PROFESSIONALS CONFERENCE AWARDS

The Earthquake Commission Research Foundation and the NZGS have awards available for New Zealanders attending the Young Geotechnical Professionals Conference. If you are 35 years of age or younger and hope to present at the Conference this financial award is designed to help with your expenses.

THE NEW ZEALAND GEOTECHNICAL SOCIETY STUDENT PRESENTATION AWARDS

These awards are presented to recognise and encourage student participation in the profession. Students of a recognised tertiary institution in New Zealand submit an abstract for their poster to register for the award and then prepare an A1 size poster that clearly and concisely presents their work on any aspect or topic in the fields of Geotechnical Engineering or Engineering Geology.

The posters are judged and ranked by a panel of three judges nominated by the management committee of the NZGS, and displayed at a local branch meeting. Posters are judged on technical content, layout, and overall poster appeal. The winner of the best poster will receive $1000 prize, with second and third place receiving $500 and $300 respectively.

YOUNG GEOTECHNICAL PROFESSIONALS FELLOWSHIP

This fellowship, worth up to $4,000, is awarded to the author of the best paper by a New Zealand representative at each Australia-New Zealand Young Geotechnical Professionals conference. A judging committee consisting of two members of the conference organising committee and two senior geotechnical professionals will judge the award. The award is to be used for the reimbursement of expenses incurred in attending the next International Young Geotechnical Professional Conference.

NEW ZEALAND GEOTECHNICAL SOCIETY SCHOLARSHIP

The NZGS provides 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 (e.g., PhD, Masters by research) or undertake independent research (e.g., post-doctoral research) which would not otherwise be possible for them.

ANNUAL				
YGP Conference Award	**Advertised December 2015**	**Nominations and Abstracts due 4 March, 2016**	**Nominations accepted 4 April, 2016**	**Full paper due 1 July, 2016**
YGP Fellowship	**Awarded at ANZ YGP Conference. 25-28 October, 2016**			
NZGS Scholarship	**Advertised in June**	**Close 31 October, 2016**	**Winner 30 November, 2016**	
NZGS Student Presentation Award	**Advertised in June issue**	**Close 16 October, 2016**	**Winner 31 October, 2016**	**Present Nov/Dec 2016**

NZGS Scholarship

The NZGS provides funding for a scholarship to enable a member of the Society to undertake postgraduate research in New Zealand to advance the objectives of the Society. Through this scholarship, the Society aims to encourage members to enroll for post-graduate research (e.g., PhD, Masters by research) or undertake independent research (e.g., post-doctoral research) which would not otherwise be possible for them in the fields of Engineering Geology or Geotechnical Engineering.

NZGS Scholarship 2011

Jawad Arefi
jawad.arefi@beca.com

My name is Jawad Arefi and I came from Italy to New Zealand in 2008 as an exchange student to write my Master's dissertation and then decided to stay longer and to complete a PhD. I received my doctorate from the University of Canterbury in 2014 and I am now working as a geotechnical engineer at Beca in Christchurch. I enjoy the diversity of projects that I am working on but I have a particular interest in geotechnical earthquake engineering stemming from my research background.

My research study involved an experimental and computational investigation into the deformational properties of sands containing fines content (particle diameter 0·75mm) in the context of site response analysis. These properties, in terms of modulus and damping, exert a great influence on seismic response of soil sites, so simultaneous modeling of the modulus and damping behavior of soils during cyclic loading was desirable.

The experimental investigation was carried on sandy soils sourced from Christchurch using a dynamic triaxial apparatus, while the computational aspect was based on the framework of total-stress one-dimensional (1D) cyclic behavior of soil. Measurements of linear and nonlinear deformational properties of the soil specimens were undertaken. The testing program was designed to quantify the effects of fines content on the low-strain stiffness of the silty sand, as well as on the nonlinear stress-strain relationship.

In addition, modeling of the cyclic stress-strain behavior based on this experimental program was also investigated. The modeling effort focused on developing a simple constitutive model which simultaneously models the soil modulus and damping relationships with shear strains observed in laboratory tests. The model was verified through element test simulations under different cyclic loadings. It was shown that the model could accurately simulate the modulus and the damping simultaneously.

The model was then incorporated within the OpenSees computational platform and was used to scrutinize the effects of damping on one-dimensional seismic site response analysis. For this purpose, several strong motion stations which recorded the Canterbury earthquake sequence were selected. The soil profiles were modeled as semi-infinite horizontally layered deposits overlying a uniform half-space subjected to vertically propagating shear waves. The advantages and limitations of the nonlinear model in terms of simulating soil nonlinearity and associated material damping were further scrutinized.

In 2011, I noticed that in order to complete my PhD studies I would need to extend it for a few months but I was wondering how to fund the home stretch phase of my studies. The NZGS scholarship was a fantastic funding opportunity for undertaking research at a postgraduate level in the field of geotechnical engineering. I was short listed and was invited to fly to Auckland to present my research. The relaxed and informal environment for presentations was a great chance to introduce my research to the NZGS selection committee and I learned a lot from the QA part of the assessment. The highlight of the NZGS scholarship for me was to cover my tuition fees and living expenses for the last few months of my studies which allowed me to focus on writing the thesis. In this period, I was fortunate enough to write two conference papers for 11th ANZ and 15th WCEE conferences in Australia and Portugal, respectively. I attended both overseas conferences and presented my research.

Last but not least, I extend my gratitude to NZGS for this financial assistance which allowed me to finish my studies stress-free.

NEW ZEALAND GEOTECHNICAL SOCIETY SCHOLARSHIP Check the website for full details here http://www.nzgs.org/awards/new-zealand-geotechnical-society-scholarship.htm

NZGS Young Geotechnical Professionals

THE YOUNG GEOTECHNICAL PROFESSIONALS (YGP) group has been formed to represent, support and provide a voice for the young professionals in the NZGS. We represent a lively, increasingly influential and rapidly growing section of Geotechnical Engineers and Engineering Geologists nationwide. Through a social culture of innovation, integrity, networking and the pursuit of excellence, we anticipate facilitating in the professional and personal development of the young professionals. Remember, if you are a NZGS member under 35 years of age, you are automatically a YGP!

LATEST ACTIVITIES:

Student Awards

The 2015 student poster awards have been submitted and posters will be on display and winners announced at the December Auckland Branch Meeting. Winning posters will be shown in the next issue of Geomechanics News.

11th ANZ YGP Conference

The 11th Australia New Zealand YGP Conference is to be held in Queenstown, in October 2016. The YGP conference has been held over the past 20 years for geotechnical professionals from Australia and New Zealand who are 35 years and younger with a maximum of 10 years' experience. The aims of the conference are to:

- Promote the professional development of delegates through sharing experience and ideas, and by presenting a paper to senior professionals and peers.
- Expand and strengthen the lines of communications between young professionals within the field of geomechanics.
- Promote an enhanced perspective of the varied roles, responsibilities and opportunities encompassed by the geotechnical profession.

The conference is also a lot of fun and I encourage all YGPs to start thinking about preparing a paper for the conference. Abstracts and nonmination forms are due on the 4th March 2016. Further information and nomination forms can be found on the NZGS website.

Regional Events

We are still keen to hear from YGPs about ideas for regional events so if you have any suggestions please get in contact! We've got with the times and now have a dedicated Facebook page so please visit and like the page https://www.facebook.com/nzgsygp. And don't forget to keep an eye out for, and support events in your area!

Frances Neeson

Frances is an Engineering Geologist with Opus in Christchurch. She holds a Bachelor of Science (Geology) and Post Graduate Diploma in Engineering Geology. Over the last five years Frances has enjoyed working on small and large projects in the North and South Islands including numerous infrastructure projects, earthquake remediation and the Ferrymead Bridge Replacement. Frances is excited to be able to represent the growing numbers of YGP members of NZGS and promote YGP orientated activities!

ygp@nzgs.org

11YGPC
Queenstown
New Zealand
October
2016

IMPORTANT DATES

(dates given below are approximate only)

- **4 March 2016** - Nominations and abstracts due
- **4 April 2016** - Nominations accepted
- **1 July 2016** - Full Paper due
- **25-28 October 2016** - 11YGPC

International Association for Engineering Geology Environment

IAEG EXECUTIVE & COUNCIL MEETINGS, 25-26 OCTOBER 2015

The first Executive Committee and Council meetings of the new term under President Prof Scott Burns were held in New Delhi at the end of October. The meetings were organised in conjunction with a conference organised by the Indian Society of Engineering Geology on the occasion of their 50th anniversary. Following are items of interest arising from these meetings.

FEE STRUCTURE & BULLETIN

The sub-committee headed by Martin Culshaw (Bulletin Editor) assessing the membership fee structure reported to the Executive and Council with a series of recommendations. Outcomes include the reduced fee option for low income countries will be retained and the Bulletin will likely go to an on-line version only in the next 2 or 3 years.

There was discussion around whether the current fee option without the Bulletin be retained once the on-line only version commences. Given close to half IAEG members currently choose the no bulletin option it is likely this membership category will be maintained in the immediate period.

WEBSITE

The IAEG web site (http://www.iaeg.info/) has undergone an upgrade in the last 12 months or so. There is now a blog page and if you wish to contribute items to the blog please contact the Web Editor, Giorgio Lollino. There is also an Events page to keep members informed of upcoming conferences and meetings and an Education and Training page which includes the on-line video lecture series.

YOUNG PROFESSIONALS

A Young Professionals group has started within IAEG, originally instigated at the 2010 IAEG Congress in Auckland and reinvigorated at the 2014 IAEG Congress in Turin. The YoPro's intend to be active on the IAEG website blog and also the IAEG LinkedIn page. If you would like to get in contact with this group please email Louise Vick (louise.vick@gmail.com) and/or Pedro Martins (Pedro.Martins@beca.com).

COMMISSIONS

There are 10 active IAEG commissions which can be accessed via the website (http://www.iaeg.info/commissions/). Several Commission meetings were held in New Delhi including Commission C4 on Education and Training, C25 on Use of Engineering Geological Models and C34 on Marine Engineering Geology. A new Commission on Landslide Nomenclature was agreed at the Council meeting which will interface with JTC1 on Landslides and some recent work on a landslide glossary currently being undertaken in Europe.

IAEG INTERNATIONAL RESEARCH PROGRAM & SCIENCE AND TECHNOLOGY AWARDS

In order to promote development of Engineering Geology the IAEG has established the "International Research Programme of IAEG" (IRP-IAEG). IRP projects will largely be conducted through the IAEG Commissions. The new Science and Technology Awards (STA-IAEG) have been approved by Council which includes two separate prizes: the Academic Achievement Award (AAA) and the Technology Progress Award (TPA). Further information on the IRP and STA's can be obtained from the Secretary General, Faquan WU (iaegsg@163.com).

NEWSLETTER, FEDIGS, CONFERENCES

A new bimonthly electronic newsletter is to be commenced in 2016. In addition to current activities of the IAEG, the newsletter will carry interesting news and information from the geological and engineering world.

The cooperation agreement between IAEG, ISRM and ISSMGE as part of the Federation of International Geo-engineering Societies was modified at the last FedIGS meeting in Shenyang, China on 4 July 2015. This modified agreement was endorsed by the IAEG Council in New Delhi.

The next IAEG Asia regional conference will be held in Kathmandu, Nepal in 2017 as voted by Council. Planning is well underway for the next IAEG Congress to be held in San Francisco in 2018.

Mark Eggers

Mark is is a Principal and Director at Pells Sullivan Meynink where he consults on large civil and mining projects across Australia, New Zealand and SE Asia. Mark has a keen interest in education and research through close associations with University of New South Wales and University of Canterbury. He also co-teaches field courses in engineering geology for the Australian Geomechanics Society.

International Society of Soil Mechanics and Geotechnical Engineering

ISSMGE BOARD MEETING, 12 SEPTEMBER 2015

The fourth Board meeting of the term of the new President, Prof. Roger Frank, was held in Edinburgh with the 16th European Conference on Soil Mechanics and Geotechnical Engineering. We discussed advertising in the ISSMGE Bulletin, advertising webinars to ISSMGE members, the method to calculate the Member Society Annual Subscription (MSAS), the difficulties in the Ukraine, improved IT support and features, enhancing the International Journal of Geoengineering Case Studies, and modifications to the cycle for electing the ISSMGE President.

ISSMGE MID-TERM COUNCIL MEETING, 13 SEPTEMBER 2015

The VPs presented reports on the activities in their regions. My VP (Australasia) report focused on the Sydney 2021 bid and was well received. Presentations were also given by the Chairs of the following Board Level Committees: Innovation and Development Committee, Technical Oversight Committee, Young Members' Presidential Group, Corporate Associates' Presidential Group, Award Committee and the Professional Image Committee. Further reports were presented on: Webinars, International Seminars, the International Journal of Geo-Engineering Case Histories, The ISSMGE Bulletin and FedIGS. The Audited Accounts for 2013, 2014, as well as the ISSMGE Foundation, were presented by the Secretary General, Prof. Neil Taylor. I, as Treasurer, presented the budget for 2015 – 2019. Finally, an update on the IXX Int. Conf. on Soil Mechanics and Geotechnical Engineering, in Seoul, Korea, in September 2017, was presented.

TECHNICAL COMMITTEES (TCS)

The ISSMGE currently has 32 TCs examining a wide range of geotechnical topics.

TCS WITH NZGS REPRESENTATION:

TC203 – Earthquake; TC206 – Interactive Design; TC207 – Soil-Structure; TC211 – Ground Improvement; TC212 – Deep Foundations; TC217 – Land Reclamation; TC302 – Forensic.

TCS WITH NO NZGS REPRESENTATION:

TC101 – Laboratory Testing; TC102 – In-Situ Testing; TC103 – Numerical Methods; TC104 – Physical Modelling; TC105 – Geo-Mechanics from Micro to Macro; TC106 – Unsaturated Soils; TC107 – Laterites and Lateritic Soils; TC201 – Dykes and Levees; TC202 – Transportation; TC204 – Underground Construction; TC205 – Safety and Serviceability; TC209 – Offshore; TC210 – Dams; TC213 – Scour and Erosion;TC214 – Soft Soils; TC215 – Geo-Environmental; TC216 – Frost; TC301 – Historic Sites; TC303 – Floods; TC304 – Risk; TC305 – Geotechnical Infrastructure for Megacities and New Capitals; TC306 – Geo Education; TC307 – Sustainability; TC308 – Energy Geotechnics.

Details of each TC are given at: www.issmge.org/en/committees/technical-committees.

If you are interested in representing the NZGS on a TCs, contact Prof. Mick Pender (m.pender@auckland.ac.nz), the NZGS's ISSMGE Liaison, with your CV.

WEBINARS

The ISSMGE offers bi-monthly webinars by international experts in their fields. Past webinars are an excellent resource and are available from the ISSMGE website: www.issmge.org/en/resources/recorded-webinars. Of particular relevance to NZ geotechnical engineers are the webinars by Prof. Misko Cubrinovski and Prof. George Gazetas.

CORPORATE ASSOCIATES

Major geotechnical companies around the world support the ISSMGE by becoming a Corporate Associate (CA). Contributing to the ISSMGE provides visibility. The Australasian region has only the one CA, Coffey. Aecom, Arup, GHD and Golder Associates are also CAs from other regions.

It would be very helpful if readers could encourage their companies to become a CA. Further information is available at: www.issmge.org/en/corporate-associates.

Mark Jaksa

Mark is Head of the School of Civil, Environmental and Mining Engineering at the University of Adelaide.
Over the last 25 years Prof Jaksa's research at the University of Adelaide has concentrated on probabilistic methods, geostatistics, artificial intelligence, ground improvement, expansive soils and geo-engineering education. He has published over 125 journal and conference papers on these topics.

International Society for Rock Mechanics

ISRM COUNCIL MEETING – 10 MAY

Currently ISRM has 7,800 individual members:160 from New Zealand plus 146 corporate members.

Regional Vice Presidents for 2015 – 2019 are:

Africa Mr William Joughin, South Africa
Asia Dr Seokwon Jeon, Korea
Australasia Mr Stuart Read, New Zealand
Europe Prof. Charlie Chunlin Li, Norway
North America Dr Doug Stead, Canada
South America Prof Sergio A.B. da Fontoura, Brazil

The 2015 – 2019 president, Dr Eda Freitas de Quadros from Brasil, had been elected during 2011 – 2015 Board term. Dr Luis Lama from Portugal will continue as Secretary General. Three Vice Presidents At Large have been included with the Board:

- Prof. Manchao He, China
- Prof. Petr Konicek, Czech Republic

Prof Norikazu Shimizu, Japan

ISRM COMMISSIONS

During the 2011 – 2015 term there were 18 ISRM Commissions. Of these 16 will continue into the 2015 – 2019 term plus one new application had been received. Details of the Commissions are on the ISRM website (links on https://www.isrm.net/gca/?id=153).

Several of the Commissions are very active, with Testing Methods having published two books. The 2007 blue book in of suggested methods of rock characterisation, testing and monitoring has been updated (expansion) in 2014 - the orange book. A reduced price for the orange book is available for ISRM members (see https://www.isrm.net/gca/?id=177).

COMMUNICATION:

The ISRM website (www.isrm.net) has information on the society's intent, structure and activities, including conferences, commissions, awards, products and publications. For those NZGS members affiliated to ISRM as individual members there is a members area with access to further products. There is also Linked in, Twitter or RSS access.

The ISRM Digital Library, launched in October 2010 (https://www.isrm.net/gca/?id=992), is intended to make rock mechanics material available to the rock mechanics community, in particular papers published from ISRM Congresses and sponsored Symposia. It is part of OnePetro (https://www.onepetro.org). ISRM individual members are allowed to download, at no cost, up to 100 papers per year from the ISRM conferences.

Regular means of communication are:

- ISRM newsletter, published quarterly since March 2008 and
- ISRM News Journal, published annually since 2007 (three times per year since 1992 prior to formation of the Newsletter).

ISRM ON-LINE LECTURES

Twelve ISRM On-line lectures have been presented since February 2013, covering a range of topics including tunnelling, slope stability, case histories and risk – see ISRM website **http://www.isrm.net/gca/?id=1104.**

FEDIGS (FEDERATION OF INTERNATIONAL GEO-ENGINEERING SOCIETIES)

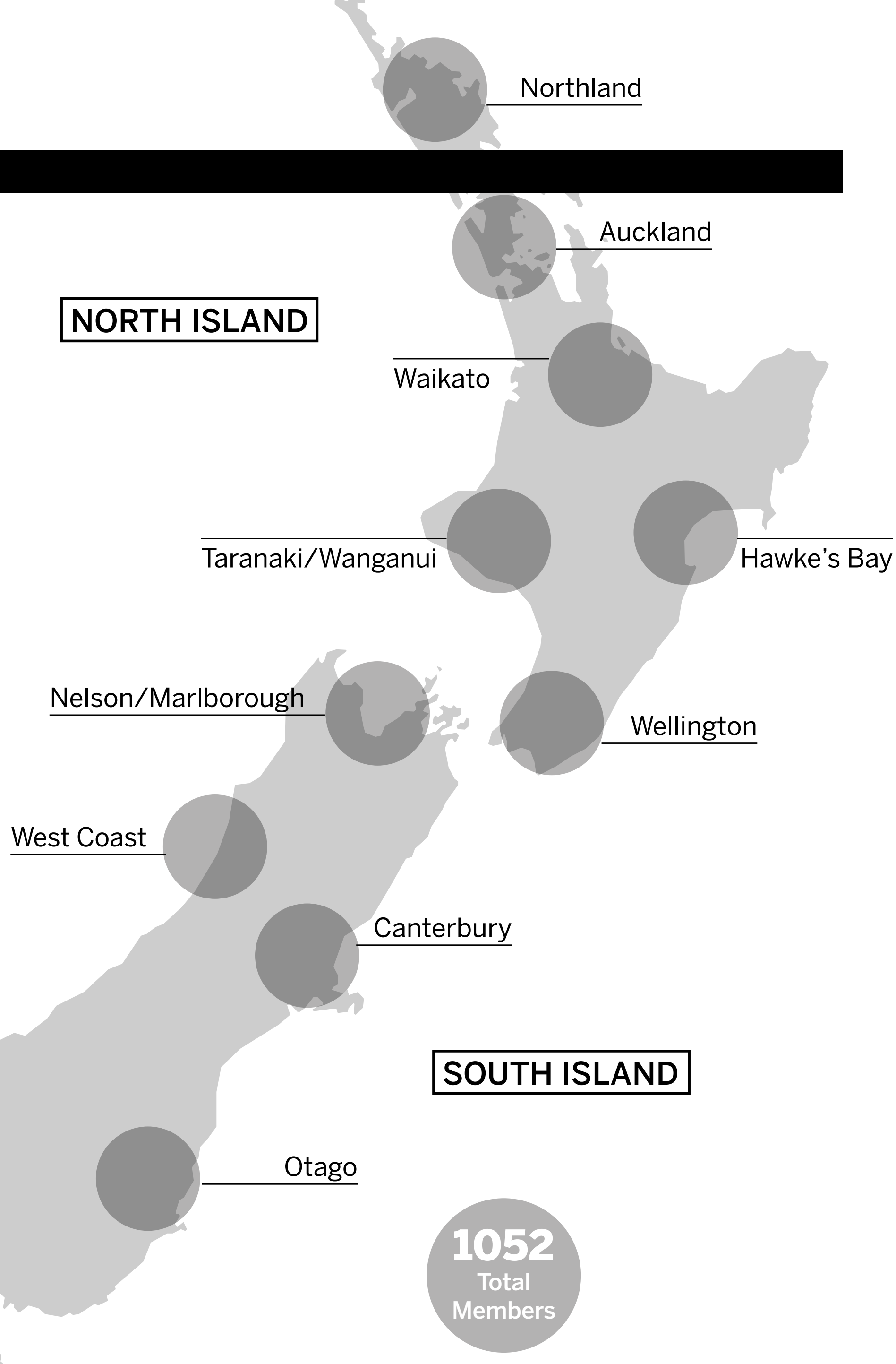
FedIGS was created in 2006 by the sister societies IAEG, the ISRM and the ISSMGE, and the IGS joined at a later stage. The intention of such a Federation is the exchange of experiences of member Societies and the promotion of common initiatives. The Board of the Federation meets once a year, with the next meeting in September 2015.

Three Joint Technical Committees (JTCs) operate under the umbrella of FedIGS, currently:

- JTC 1 - Joint Technical Committee on Natural Slopes and Landslides
- JTC 2 - Representation of Geo-engineering Data in Electronic Form
- JTC 3 - Education and Training

Stuart Read
Stuart Read is an engineering geologist with GNS Science. He obtained his degree, in engineering geology from the University of Canterbury, in 1971. His 43 years of engineering geological consulting and research experience has been in the evaluation, investigation, construction and refurbishment of engineering and mining projects. He has taken a leading role in the development of the rock and soil mechanics laboratory for GNS Science and has research interests in the strength and deformation properties of rock and soil masses.

Branch reports



AUCKLAND

Heading into the second half of the year, co-author Dr Tam Larkin, Senior Lecturer at the University of Auckland, presented his 2014 Geomechanics Award winning paper "Determination of site period for NZS1170.5:2004", in June. The University of Waikato duo of Dr Willem de Lange and Dr Vicki Moon presented on "Liquefaction, LIDAR and hot springs: Joining the dots through Kirikiriroa (Hamilton)". It was great to see this very interesting work around paleo liquefaction and faulting in the Waikato region. Thanks to Vicki and Willem for travelling up from Hamilton.

The team from Waterview, Hamish McLean, Stu Cartwright and Wataru Okada followed in August, presenting on the all-important cross passages between the twin tunnels. Our colleagues at the Australasian Tunnelling Society (ATS) held a very interesting talk on the design and construction of the Underground Transit in Seattle: Extending the "Link", which was presented by Isabelle Lamb from McMillen Jacobs Associates, in September. It is well worth watching out for further interesting presentations from ATS.

Martin Williams, of Cameron Gibson Wells in Nelson, travelled to share his wealth of knowledge on AGS4 and Web Based Borehole Logging Systems in October. Many thanks to Ground Investigations, Geotechnics, Brian Perry Civil and GeoLogs for their support of these events in the second half of the year, it is greatly appreciated.

For November we have Andy Dodds from ARUP speaking on the Gerald Desmond Bridge (GDB) at the Port of Long Beach in California on the geo-structural challenges faced in designing this new 600m long, 6-lane signature cable-stayed bridge. To round out 2015, in December we are looking to have a varied session drawing from the great 6ICEGE presentations and exhibition of the Posters for the Annual NZGS Student Presentation Award.

WAIKATO BRANCH REPORT

Welcome back to Kori Lentfer as co-coordinator who has been away from Hamilton for 6 months.

Andrew Holland attended the 6th Annual Conference on Earthquake Geotechnical Engineering and is chasing up some key delegates to re-present some key papers for the Waikato Branch before Christmas if possible. Stand by for more details.

Earlier this year there was some exciting work on identifying and tracing the recently discovered Hamilton Fault (fault zone). Waikato University were quite exciting about taking an initial look into this **http://www.stuff.co.nz/waikato-times/news/68159250/scientists-discover-potential-fault-line-under-hamilton.html** If any site developments in the Hamilton area have any interesting cuts, trenches or excavations then NZGS would be very interested in taking a look. Please contact **Kori Lentfer Ph: 0277222540**

SEE THE EVENTS DIARY OR WWW.NZGS.ORG FOR FUTURE EVENTS

Future Prospects for Branch Events in planning include:

- "Tomos" in Hamilton Ashes? Evidence of piping failures in Hamilton hill soils
- Huntly Section of the Waikato Expressway
- Hamilton Section of the Waikato Expressway

BOP BRANCH

Nothing to report

HAWKES BAY

The Hawkes Bay NZGS Branch held two technical presentations on the findings of the Christchurch Ground Improvement Trials.

The first presentation was held on 13 August and was presented by Dr Sjoerd van Ballegooy, who discussed the details of the ground improvement trials, the different ground improvement method trialled, and the extensive in-situ testing via the T-Rex machine and blasting. He finished the presentation by discussing the findings and evaluating the efficacy of the different improvement methods. The presentation was held at the GHD offices in Hastings, with refreshments proudly provided by GHD. The presentation was very well attended, and attendees discussed the presentation at length with Dr Sjoerd van Ballegooy after the meeting.

The second presentation was held on 8 October and was presented by Mr Rick Wentz. This presentation followed on from Dr Sjoerd van Ballegooy's presentation, and Mr Wentz discussed the impacts of the ground improvement trials on the Christchurch rebuild and on the building industry in Hawkes Bay. Specifically, Mr Wentz discussed how the findings of the ground improvement trials might fit into a national guidance frameworks and how they could be applied within the geological setting of the Hawkes Bay. Again, the presentation was well attended, with geotechnical engineers, structural engineers and land development professionals in attendance. The presentation was hosted at the Opus offices in Ahuriri, Napier.

WELLINGTON

The Wellington Branch has recently enjoyed a number of evening presentations and information evenings including:

- Introduction to AGS4(NZ) and demo of Geologs borehole database system – presented on Wednesday 23 September, presentation outline available on NZGS website.
- NZGS/IPENZ PEngGeol information evening – held on Wednesday 14th October.

The above events were well received and attended and we would like to thank our presenters, sponsors and members for their ongoing support. It is much appreciated. To help us continue we kindly ask for members to get in touch with any ideas they may have for presentations.

We've got a couple of upcoming presentation topics planned for which the date are still to be confirmed. These include:

Screw Piles: Guidelines for Design, Construction and Installation presented by Piletech – date to be confirmed.

Upcoming events:

We are planning a meeting to discuss "limitations" and "use of report" wording in geotechnical report with an aim to better understand how we need to establish the purpose and limitations of our reports for the particular project studied. We hope to hold this presentation in the autumn, with the discussion planned to be facilitated by William Gray of Opus, who had presented a series of workshops on Geotechnical Assessments in Support of Land Development courses for IPENZ.

We are also planning to co-sponsor a professional development event with the local IPENZ Engenerate branch in autumn or winter 2016. This event, similar to the event held last year, would see young geo-professionals and engineers presenting to a group about a current project they are working on. The presentations would be brief, with an award(s) given to the best presentation(s). The aim would be to help young geo-professionals and engineers to develop their professional public speaking skills and to network with other like-minded professionals. Members of the IPENZ Branch would be sitting on a panel to help judge the presentations.

Lastly, we are thinking of holding a social event to get the local geo-professionals together and get to know each other a bit more. The event may be held in late 2015 or as a 'welcome back' event in February/March 2016.

NELSON

The Nelson Branch of NZGS held two meetings during August, which were both well received. Local geotechnical engineer Martin Williams gave a presentation of a web-based borehole logging system (Holeweb) and an explanation of AGS4(NZ) data format. Liam Wotherspoon of University of Auckland gave a presentation entitled "Application of Geotechnical and Geophysical Site Characterisation Methods in Canterbury" and explained how the techniques could be applied to the local Nelson-Tasman region. Liam is leading a new 2 year project to study the dynamic site characterisation of the Nelson-Tasman region and to map the site soil subclass categories of the urban areas which are transected by the active Waimea-Flaxmore Fault System. Any members who are able to provide local borelogs or site specific shear wave velocity data for the Nelson-Tasman urban areas to assist this study please forward this data to Liam at his email: l.wotherspoon@auckland.ac.nz.

CANTERBURY

We have had a presentation on Tuesday 17 November by Kelly Robinson at the University of Canterbury who received a scholarship from NZGS to help fund her PhD research on liquefaction-induced lateral spreading in the 2010-2011 Canterbury earthquakes. We have a number of presentations lined up for the new year including presentations on the AGS4 logging standards with Geologs software and screw pile investigation, design and construction by Piletech.

OTAGO

Nothing to report sorry

Charlie Price presenting Gavin Alexander with a hand-made gavel which Peter Robinson, the Secretary of the Australian Geomechanics Society had made to mark Gavin's two years as Chair and in appreciation of the growing cooperation between our two societies.

★ GEO-NEWS WEEKLY E-NEWSLETTER ★
Our new weekly email lists all notices and Branch announcements normally sent to members, but in one email. Please send items to include to **secretary@nzgs.org**

Do you have an idea for your local branch meeting? Your local coordinators are keen to hear your ideas and are always oen to offers of assistance! See the folowing pages for a list of friendly contacts

AUCKLAND

Luke Storie

Luke is undertaking a PhD at the University of Auckland on earthquake resistant design of foundations. He is investigating the response of buildings in Christchurch CBD following the earthquakes following on from research undertaken under the supervision of Professor Michael Pender. Previously, with a BE(hons) and BA, Luke was a Geotechnical Engineer at Coffey Geotechnics

luke.storie@gmail.com

Kim Rait

Kim is a Geotechnical Engineer with Beca Ltd. She completed a BSc(Hons) in Mathematics and Statistics at the University of Canterbury before working in accountancy for several years. Kim then returned to UC to complete a PhD in Geotechnical Engineering and has been working at Beca on various small projects over the last year while completing her thesis.

Kim.Rait@beca.com

Eric Torvelainen

Eric is passionate about soil stiffness, SSI and liquefaction. A Canterbury graduate, he works in T&T using numerical methods to solve complex problems, such as wind turbine foundations, bridges, multi-storey and in-ground structures.

ETorvelainen@tonkin.co.nz

SEE THE EVENTS DIARY OR WWW.NZGS.ORG FOR FUTURE EVENTS

WAIKATO

Kori Lentfer

Kori is a Engineering Geologist. He graduated in 1998 with a BSc(Tech) in Geology, followed by Masters study at Waikato University and an MSc thesis in Engineering Geology from Auckland University in 2007. Kori has worked for consultants based in the UK, Europe and the Middle East.

koril@cmwgeosciences.com

Andrew Holland

Andrew is a Director of HD Geotechnical. He studied engineering at the University of Auckland, graduating in 2002.

Andrew's experience includes geotechnical investigation, assessment and design for infrastructure, buildings and development. Andrew is a Chartered Professional Engineer (CPEng).

Andrew@hdc.net.nz

BAY OF PLENTY

Matthew Packard

Matthew is a Senior Geotechnical Engineer with Coffey. He has completed a BSc degree in Earth Sciences at Waikato University and a University of New South Wales Masters of Engineering Science. His main areas of interest are soft ground conditions, liquefaction and settlement analysis, soil-structure interaction and complex retaining structures.

matthew.packard@coffey.com

HAWKE'S BAY

Riley Gerbrandt

Riley, a Geotechnical Engineer with Opus in Napier, immigrated to New Zealand from California with his family in late October 2011. Whilst it took him several months to get up to speed with the local geology, different codes/standards and some innovative Kiwi designs, he has come to thoroughly enjoy the New Zealand engineering consultancy space.

Riley.Gerbrandt@opus.co.nz

WELLINGTON

David Molnar

David is an engineering geologist at Aurecon Wellington. He has 6 years of experience in projects throughout New Zealand, notably NZTA's SH16 Causeway Upgrade and SH2 Muldoon's Corner Improvements, also KiwiRail's North to South Junction which won the 2012 Railway Technical Society of Australia (RTSA) Biennial Railway Project Award.

david.molnar@aurecongroup.com

Aouyb Riman

Ayoub is a senior geotechnical engineer with more than 10 years of experience gained in several countries in the Middle East, Africa, Australasia and Europe. He has experience in the analysis and design of foundations, soil improvement and treatment, deep excavations, cut and cover tunnels, land reclamation, slope stability, seismic assessments

ARiman@tonkin.co.nz

Dolan Hewitt

Dolan is an engineering geologist with five years of experience. Dolan has worked in Western Australia in mine resource geology and planning. He now works for Opus and has been involved in geotechnical investigations and risk assessments for infrastructure and land development throughout New Zealand.

Dolan.Hewitt@opus.co.nz

NELSON

Grant Maxwell

Grant manages technical development for the MWH geotechnical team across the Asia Pacific region. He grew up in Nelson and has now returned home with a young family. Grant is especially interested in emergency responses and encouraging asset and community resilience to natural disasters. He has 16 years' experience working across NZ, Australia, Pacific nations and the UK.

Grant.J.Maxwell@nz.mwhglobal.com

CANTERBURY

Tim Farrant

Tim is a Geotechnical Engineer with Riley in Christchurch. As a Christchurch local, Tim studied Civil Engineering at the University of Canterbury, graduating with a BE (Civil) in 2011. Since then Tim has been actively engaged with the Canterbury earthquake recovery, gaining 4 years of geotechnical earthquake engineering experience in Christchurch.

tfarrant@riley.co.nz

Sam Glue

Sam is a Geotechnical Engineer working for Tonkin & Taylor in Christchurch with 9 years experience working throughout New Zealand and Australia. Sam graduated from Canterbury with a BE (Civil) in 2006 and is passionate about being involved in the construction of major infrastructure projects that will withstand the test of time and earthquakes.

SGlue@tonkin.co.nz

OTAGO

David Barrell

David is a geologist and geomorphologist at GNS Science in Dunedin. South Island born and bred. Since joining GNS Science, he has specialised in Quaternary geology, landform evolution and landscape processes. David very much enjoys the mix of scientific research and applied geoscience that his work entails.

d.barrell@gns.cri.nz

Teresa Roetman
I live up in the Waitakere Ranges in Auckland, far from the rush of traffic and noise. Sitting at my desk, looking out to the bush clad hills full of birds happily chirping in the sun I feel blessed to be part of this wonderful environment. I love these hills, hiking the tracks with my son and daughter, paddling in the rivers and streams, seeing weta's and glowworms, hearing the wildlife, not to mention the fantastic views of the surrounding city. We love the west coast beaches, the black sand, the wild surf. When I am not working for the NZGS I enjoy all the "wild west" has to offer.

Please remember to contact the Secretary (Teresa) if you wish to update any membership, address or contact details. If you would like to assist your Branch, as a presenter or sponsor, or to provide a venue, refreshments, or an idea, please drop a line to your Branch Co-ordinator or Teresa. If you require any information about other events or conferences, the NZGS Committee and NZGS projects, or the International Societies (IAEG, ISRM and ISSMGE) please contact the Secretary on secretary@nzgs.org You may also check the Society's website for Branch and Conference listings, and other Society news: www.nzgs.org

Management committee

POSITION	NAME	Email
Chair	Charlie Price	chair@nzgs.org
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Elected Member	Guy Cassidy	GCassidy@engeo.co.nz
Elected Member	Sally Hargraves	sally@tfel.co.nz
Elected Member	Ken Read	Ken.Read@opus.co.nz
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ISSMGE NZ Representative	Mick Pender	M.Pender@auckland.ac.nz
ISRM Australasian Vice President	Stuart Read	S.Read@gns.cri.nz

EDITORIAL POLICY

***NZ Geomechanics News* is a biannual bulletin issued to members of the NZ Geotechnical Society Inc.**

Readers are encouraged to submit articles for future editions of NZ Geomechanics News. Contributions typically comprise any of the following:

- **technical papers which may, but need not necessarily be, of a standard which would be required by international journals and conferences**
- **technical notes of any length**
- **feedback on papers and articles published in NZ Geomechanics News**
- **news or technical descriptions of geotechnical projects**
- **letters to the NZ Geotechnical Society or the Editor**
- **reports of events and personalities**
- **industry news**
- **opinion pieces**

Please contact the editors (editor@nzgs.org) if you need any advice about the format or suitability of your material.

Articles and papers are not normally refereed, although constructive post-publication feedback is welcomed. Authors and other contributors must be responsible for the integrity of their material and for permission to publish. Letters to the Editor about articles and papers will be forwarded to the author for a right of reply. The editors reserve the right to amend or abridge articles as required.

The statements made or opinions expressed do not necessarily reflect the views of the New Zealand Geotechnical Society Inc.

NEW ZEALAND GEOTECHNICAL SOCIETY INC

NZGS Membership SUBSCRIPTIONS

Annual subscriptions cost $105 per member. First time members will receive a 50% discount for their first year of membership; and student membership is free. Membership application forms can be found on the website http://www.nzgs.org/membership.htm or contact the NZGS Secretary on secretary@nzgs.org for more information.

NEW ZEALAND GEOTECHNICAL SOCIETY INC

The New Zealand Geotechnical Society (NZGS) is the affiliated organization in New Zealand of the International Societies representing practitioners in Soil mechanics, Rock mechanics and Engineering geology. NZGS is also affiliated to the Institution of Professional Engineers NZ as one of its collaborating technical societies.

The aims of the Society are:

a) To advance the education and application of soil mechanics, rock mechanics and engineering geology among engineers and scientists.
b) To advance the practice and application of these disciplines in engineering.
c) To implement the statutes of the respective international societies in so far as they are applicable in New Zealand.
d) To ensure that the learning achieved through the above objectives is passed on to the public as is appropriate.

All society correspondence should be addressed to the Management Secretary (email: secretary@nzgs.org).

The postal address is
NZ Geotechnical Society Inc,
P O Box 12 241,
WELLINGTON 6144.

Letters or articles for NZ Geomechanics News should be sent to editor@nzgs.org.

MEMBERSHIP

Engineers, scientists, technicians, contractors, students and others who are interested in the practice and application of soil mechanics, rock mechanics and engineering geology are encouraged to join.

Full details of how to join are provided on the NZGS website http://www.nzgs.org/about/

ADVERTISING

NZ Geomechanics News is published twice a year and distributed to the Society's 1000 plus members throughout New Zealand and overseas. The magazine is issued to society members who comprise professional geotechnical and civil engineers and engineering geologists from a wide range of consulting, contracting and university organisations, as well as those involved in laboratory and instrumentation services. NZGS aims to break even on publication, and is grateful for the support of advertisers in making the publication possible.

TYPE	BLACK AND WHITE	COLOUR	SPECIAL PLACEMENTS		SIZE
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Quarter page	$150	$175	-		90mm wide x 130mm high

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National and International Events

LINKS ARE AVAILABLE FROM THE NZ GEOTECHNICAL SOCIETY WEBSITE WWW.NZGS.ORG

2016

28-29 APRIL, 2016
Leuven, Belgium
Design of piles in Europe - How did EC7 change daily practice?

10-12 MAY, 2016
Tampere, Finland
7th International Symposium on In-Situ Rock Stress

25 MAY, 2016
Xi'an, China
GEOSAFE: 1st International Symposium on Reducing Risks in Site Investigation, Modelling and Construction for Rock Engineering

25-28 MAY, 2016
Reykjavík, Iceland
The 17th Nordic Geotechnical Meeting

30 MAY-3 JUNE, 2016
Petaling jaya, Selangor, Malaysia
19Seagc – 2Agsseac Young Geotechnical Engineers Conference

31 MAY-3 JUNE, 2016
Subang Jaya, Malaysia
19Th Southeast Asian Geotechnical Conference & 2Nd Agssea Conference

2-4 JUNE, 2016
North Cyprus
Fourth International Conference on New Developments in Soil Mechanics and Geotechnical Engineering

12-19 JUNE, 2016
Napoli, Italy
12th International Symposium on Landslides

20-23 JUNE, 2016
Sofia, Bulgaria
International Symposium - Challenges For Engineering Geology And Geotechnics After Natural Disasters

25-27 JULY, 2016
Shandong, China
4th GeoChina International Conference 2016

1-6 AUGUST, 2016
New Delhi (NCR), INDIA
6th International Conference on Recent Advances In Geotechnical Earthquake Engineering and Soil Dynamics

24 AUGUST-4 SEPTEMBER2016
Cape Town, South Africa
35th International Geological Congress

29-31 AUGUST, 2016
Ürgüp-Nevşehir, Turkey
EUROCK 2016 – ISRM European Regional Symposium

4-7 SEPTEMBER, 2016
Guimarães, Portugal
3rd International Conference on Transportation Geotechnics

5-9 SEPTEMBER, 2016
Queensland, Australia
5th International Conference on Geotechnical and Geophysical Site Characterisation

1 OCTOBER, 2016
Bali, Indonesia
ARMS 9 – the 9th Asian Rock Mechanics Symposium

19-22 OCTOBER, 2016
Brazil
COBRAMSEG / SBMR 2016

2017

12-17 FEBRUARY, 2017
Cape Town, South Africa
AfriRock 2017 - International Symposium

13-15 JUNE, 2017
Ostrava, Czech Republic
International Symposium EUROCK 2017

17-22 SEPTEMBER, 2017
Seoul, Korea
19th ICSMGE-Seoul 2017 - Unearth the Future Connect Beyond

11YGPC
Queenstown New Zealand October 2016

IMPORTANT DATES
(dates given below are approximate only)

4 March 2016 - Nominations and abstracts due

4 April 2016 - Nominations accepted

1 July 2016 - Full Paper due

25-28 October 2016 - 11YGPC

STABILITY ANALYSIS
Detail A
Reinforced Soil
Foundation Soil
Typical DuraMesh Wall
CIRTEX
DURAMESH SOLUTIONS
BAY OF PLENTY
11/11/15