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NZ Geomechanics News

June 2003

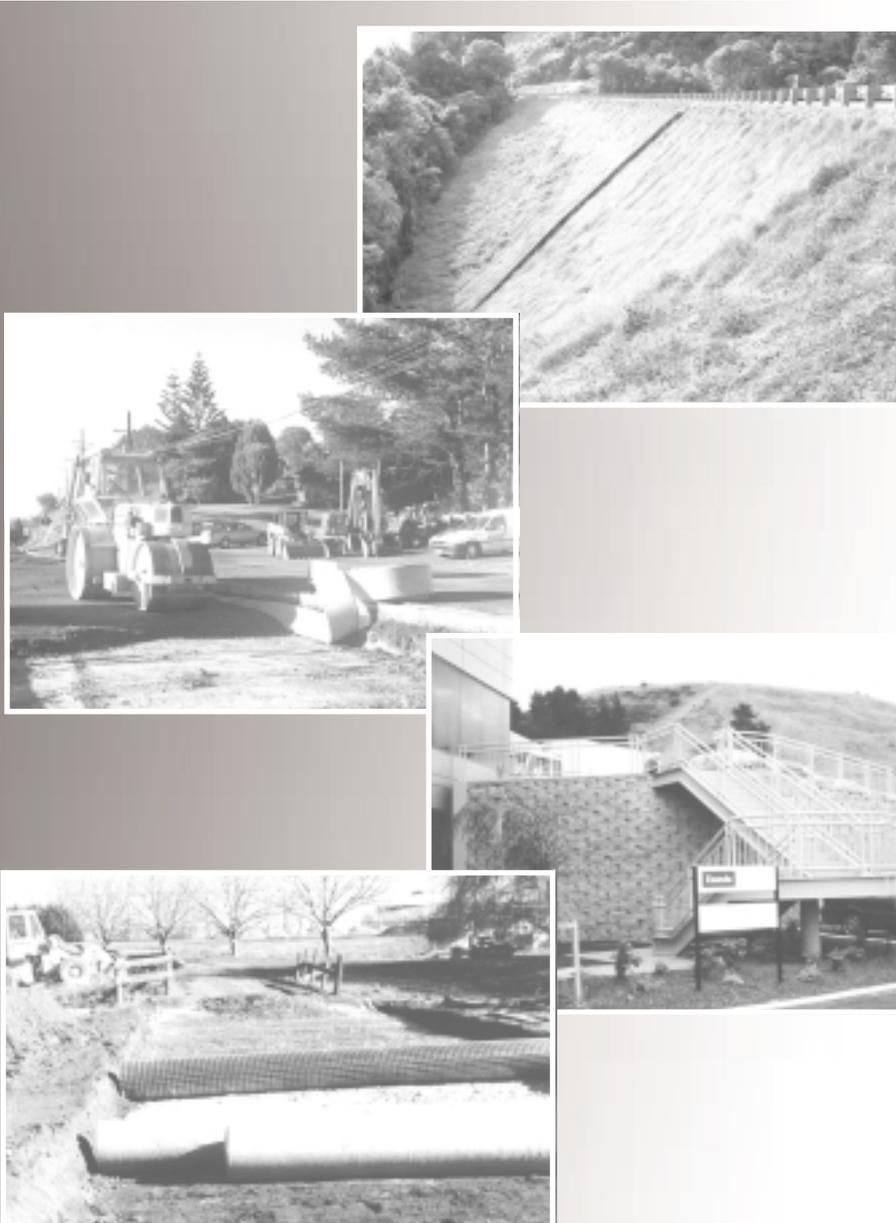


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NEW ZEALAND GEOMECHANICS NEWS

JUNE 2003, ISSUE 65

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Cover photo: The Waihi subsidence of 13 December 2001, resulting from the collapse historical underground gold workings.
Photo Credit: Photo supplied by Keith Penny of Flinders, original source the *Waikato Times*.

CHAIRMAN'S CORNER

Welcome

Welcome to the June issue of the Geomechanics News for 2003, and also a warm welcome from your new Chairman. It is a great honour to take up this position, and I hope I can serve the membership well during my term.

My background for those interested hails from the UK, completing my engineering studies at Oxford and working for Ove Arups in London before travelling out to NZ in search of new experiences and a warmer climate! After completing a PhD at Auckland University I joined the team at Beca in Auckland, where I have remained for the last 11 years and currently lead the geotechnical group there.

Changes to the Management Committee

At the AGM held in Tauranga on 28th March 2003, two new members were welcomed to the management committee, namely Ann Williams (Auckland) and Kevin McManus (Christchurch), together with a new Young Geotechnical Professional rep. Michael Laws (Auckland). It's New Zealand's turn at filling the position of the ISRM Australasian Vice President (VP) with John St. George from Auckland University taking up the position in September 2003. The make up of the committee and their respective roles is now:

| | |
|------------------------------------|-----------------|
| Chairman | John Marsh |
| Secretary | Debbie Fellows |
| Treasurer | Ann Williams |
| <i>NZ Geomechanics News</i> Editor | Phil Glassey |
| Funded Seminars | Kevin McManus |
| Immediate Past Chairman | Steven Crawford |
| Young Professionals Rep | Michael Laws |
| ISSMGE Australasian VP | Grant Murray |
| ISRM Australasian VP | John St. George |

With these new appointments we also have some retirements, and we again thank Steven Crawford for his time on the committee and most recently as Chairman, Ian McPherson for his time on the committee and most recently as long standing Treasurer, Guy Grocott for his time as Chairman and recently as Immediate Past Chairman, and Bruce Riddolls for his term as IAEG Australasian VP.

Conferences

The 2003 Symposium – Geotechnics on the Volcanic Edge, held in March in Tauranga was a huge success, and all thanks to the organising committee for holding such an interesting conference. The proceedings volume will

provide useful reference for many different subject areas. Further reports on the symposium follow later in the newsletter.

We now turn our attentions to the upcoming 9th Australia New Zealand Conference on “Geomechanics – to the eNZ of the Earth”, to be held in Auckland in February 2004. This conference rotates between Australia and New Zealand on a 2:1 ratio, so only comes to NZ approximately every 12 years. So please support and attend what will no doubt be an excellent technical and social event to kick off 2004. In addition our ISSMGE Australasian VP, Grant Murray, has engineered a full meeting of the ISSMGE Board at this conference, so a number of international leaders of the geotechnical community will be present at the conference which will make it a true once in a lifetime experience.

The next ANZ Young Professionals conference is to be held in Brisbane later in 2004, so also start thinking about attendance at that meeting of young minds.

Funded Seminars

Funded seminars are one way the Society provides subsidised training to its members, and we have done well recently with seminars on Serviceability Limit State design and Engineering Geological Practice at the recent NZGS Symposium, and on Ultimate Limit State design before that. Further seminars will be held over the 2003/2004 period, and a number of suggestions have already been received from members. However if you have a hot topic that you think would provide interest to a wide spectrum of the membership, please send us the details and we will attempt to include them in our programme.

Closing

So to close, enjoy this issue of the newsletter, and keep supporting your local branch activities – have you volunteered to organise or give a presentation for your local group yet?

John Marsh
Chairman

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EDITORIAL

The recent Geotechnical Society Symposium, *Geotechnics on the Volcanic Edge* held at Tauranga was a huge success. The conference convenors, Steve Crawford, Sally Hargraves and Paul Baunton can be well pleased and a big thank-you on the behalf of the Society. It was great to see so many people there and I was impressed with the presentations, workshops, field trips and social events. The Sunday field trip to Martha Hill was great and many thanks to the management for getting us down to the mine, and to Keith Penny of Flinders Loss adjustors. Hopefully, Phil Flash will be able to get photos on the website for you all to view. A selection of photos and a review of the symposium are included in this issue.

These symposiums, along with funded seminars, workshops, lecture tours and branch activities are one way for members to continue professional development, which is now a big part of engineering registration under the new legislation. The soil classification debate raged at the symposium, and there are some comments regarding the proposed revisions included in this issue.

We are still going to award a prize to the best letter to the Editor, but alas there were no letters received. We appreciate feedback and have held over the prize until the next issue. Looking forward to hearing from you.

We called for photos regarding the 'habits of the species geotechnicalus' to be published in this issue, but have had little response so will defer that until December 2003. So get your photos in of the weird and wacky things that the geotechnical practitioners get up to in to Debbie Fellows or me as soon as possible and win \$200 for the Christmas office shout.

Talking about bad habits, as editor, it is amazing how many times I have to correct small things like units of measure, or spell out abbreviations, and even then I don't get it right. However with regard to scientific and engineering professional consistency, we need to follow international standards. The convention of units of measure, whether they are spelt out in full or abbreviated, is that there is a space between a number and a unit of measure. You wouldn't write "5metres" so why would you write "5m"? The convention is 5 m, 4 m to 5 m, 3 kPa, 5 kN. There are exceptions when the number is preceded by or immediately followed by a symbol such as dollars and cents. In these cases we can write \$200 or 5c. Latin words such as *et al.* and *in situ* for example, should be italicised. The abbreviations of 'for example' (*exempli gratia*) and 'that is' (*id est*) are not italicised and full stops are used e.g., i.e., etc.

While this may all seem a bit pedantic, these conventions have been set out in the NZ Government Printing Office, Style Book (Third Edition, 1981), for example and go look on the internet at style guides etc. Do not be fooled by the new Microsoft/Word processing way of doing things.

Does this really matter you say? Well, as professionals, and particularly engineers, it is important that we communicate clearly and accurately. We might as well start with getting the small things right, so that the big issues can be concentrated on.

Pedantically yours.

Phil Glassey

Editor

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Word Processing

EDITORIAL POLICY

NZ Geomechanics News is a biannual newsletter issued to members of the NZ Geotechnical Society Inc. It is designed to keep members in touch with matters of interest within the Geo-Professions both locally and internationally. The statements made or opinions expressed do not necessarily reflect the views of the New Zealand Geotechnical Society Inc.

The editorial team is happy to receive submissions of any sort for future editions of *NZ Geomechanics News*. The following comments are offered to assist potential contributors. Technical contributions can include 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
- comments on papers published in *NZ Geomechanics News*
- descriptions of geotechnical projects of special interest.

General articles for publication may include:

- letters to the NZ Geotechnical Society
- letters to the Editor
- articles and news of personalities
- news of current projects
- industry news.

Submission of text material in camera-ready format is not necessary. However, typed copy in Microsoft Word is encouraged, particularly via email to the Editor or on floppy disk or CD. We can receive and handle file types of almost any format. Contact us if you have a query about format or content.

Diagrams and tables should be of a size and quality appropriate for direct reproduction. Photographs should be good contrast black and white gloss prints or high resolution digital images in jpeg format.

NZ Geomechanics News is a newsletter for Society members and articles and papers are not necessarily refereed. 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 submitted by members will be forwarded to the contributing member for a right of reply.

Persons interested in applying for membership of the Society are invited to complete the application form in the back of the newsletter. Members of the Society are required to affiliate to at least one International Society and the rates are included with the membership information details.

REPORT FROM THE SECRETARY

It was nice to meet so many members at the Tauranga Symposium and to be able to put names to faces. Many of you had queries about publications and papers and I hope that we have managed to chase all of these up for you.

I am continuing to up date the web page. The latest developments are to put all the contents pages of *NZ Geomechanics News* onto the web and also the table of contents for the publications that we sell. I hope this will be useful if you are trying to track down a paper. I will continue to send out emails about what is new on the web page. If you have suggestions for additions to the web page or have some membership queries please email me.

New Members

It is a pleasure to welcome the following new members into the Society since the last issue of *NZ Geomechanics News*:

| | | | | | |
|------------|-------------|--------------|---------------|-------------|--------------|
| R J Kaser | B H Norrie | K J Hind | M C George | R M Dawson | S Stojcevski |
| G G Hodder | A F Sleight | A J Holland | S V Hargraves | M Modrich | B Green |
| K Lat | D G Head | J G Berryman | M Jacka | N J Douglas | G Jarvie |
| G J Ander | D E Jacka | D N Ouwejan | J Seale | C Keepa | S Shankar |

Resignations

The following members have tendered their resignations from the Society:

| | | | | |
|----------|------------|---------------|-------------|------------|
| P Yeoman | R O Bullen | W J Henderson | M W McLarin | R J Cooney |
|----------|------------|---------------|-------------|------------|

A Friendly Reminder

Please pay your subscriptions if you haven't already done so. Thank you.

Debbie Fellows

Management Secretary

INTERNATIONAL SOCIETY REPORTS

ISSMGE – Vice President's Report, April 2003

Board Meetings

A Board Meeting was held in South Africa in November and there will be a meeting of the Board in Ghent in early June, ahead of the mid term council meeting in Prague in August. At the November Board meeting an invitation was extended to the Board by the NZGS and organising committee to attend the ANZ regional conference in early 2004. This was accepted by the Board and therefore their next meeting after Prague will be in Auckland.

Technical Committees

The activity of the Technical Committees (TCs) has perhaps not surprisingly been rather slow. Those that were least affected by the re-structuring have continued but it is fair to say that the majority have got off to a faltering start.

Mark Randolph's Offshore TC is considering the possibility of organising a speciality conference in 2005. This would probably be held in WA.

The Joint TC on landslides hosted by the AGS under the Chairmanship of Robin Fell is expected to be involved with the next International Symposium on Landslides that is due to be held in Brazil in 2004. Although I have not confirmed with Prof. Fell I would expect there to be some activity and progress of this JTC later this year at the associated conference to be held in Italy on rapid flow landslides.

Information Technology

The ISSMGE relationship with Webforum that underpins the International Geotechnical Services Directory has not delivered as much income as hoped but this is not surprising given the level of marketing that has been afforded to the initiative so far. There will be a push from the ISSMGE Board to encourage member societies and individual members to look at the advantages sponsorship of this directory will bring to their business.

There has also been a lot of activity by the IT Task Force on the rejuvenation of the ISSMGE Website. This will be launched within the next few weeks and promises to be an exciting development for the society. This will provide a much improved forum for disseminating information to the members and member societies about ISSMGE activity.

All members are encouraged to visit the site at www.webforum.com/issmgeweb.

Industry Ambassadors

At the November Board meeting the proposed role and activity of the Industry Ambassadors (IA's) was discussed. One of the key outcomes that the Board wanted from this initiative was improved feedback from the ordinary

members on their expectations of the society.

To this end, Peter Day the VP for Africa will be coordinating with the IA's nominated from the regions the completion of a membership survey. This has been trialed in South Africa already with some interesting results.

Constitution, Subscriptions and Voting Policy

As reported previously, there has been further discussion on the problems associated with the current method of calculating subscription rates and voting policy at Council. A second proposal is being drafted that will be presented to the Board in May/June and then the Council in Prague next year.

On subscriptions it will be proposed that a new formula be adopted that will effectively result in a uniform, fixed cost per member. There remains some debate on the minimum level of subscription for small societies. At the moment this is set at the equivalent of 30 individual members.

On voting issues it was agreed that a draft proposal will be prepared that provides for a weighting value to be applied on any recently received privilege. This weighting formula will only apply for the selection of international conference venues and council meetings. It will not be applied in voting for a new President.

Role and Format of International/ Regional Conferences

There has been some discussion and movement on the role and format of International and Regional Conferences. A Manual has been prepared that is intended to provide organisers of Conference's undertaken under the auspices of the International Society guidance and suggestions on format. I think this will be presented to the Member Societies as draft in Prague. One of the key features that may raise some debate is the levy on registration fees for organising a conference under the auspices of the ISSMGE.

Cooperation with the ISRM and IAEG

The President has had a further round of meetings with his colleagues at the IAEG and ISRM. I understand that there has been some discussions on establishing working relationships through more joint TCs and perhaps sharing some administrative functions.

J Grant Murray

Vice President for Australasia
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ISRM – Vice President's Report, April 2003

The last ISRM Board and Council meetings were held on 23 and 24 November 2002 in Funchal, Madeira and then followed by EUROCK2002. I was the only Australasian in attendance, which was surprising given the venue and the quality of the EUROCK meetings. As usual the Board and Council meetings had a full agenda and the allocated time was easily filled. Items of discussion included membership issues, electronic communication, budgets, conferences and awards.

The Board of the ISRM has been concerned about falling membership numbers and had previously set up a task force to investigate this issue. The report of the Membership Task Force was presented to the Board and Council meetings. This report included a number of recommendations for addressing the decline in membership numbers. Only some of the recommendations were adopted, most of which centred around improving communication within the ISRM. There was a strong recommendation to move to electronic communication and this was supported by the Board and Councils to the tune of US\$20,000 being allocated in the 2003 budget for initiatives to improve communication. This was to support rebuilding of the ISRM website and provide a basis for electronic distribution of the News Journal.

As a result of falling membership and the above budget allocation, the ISRM budget for 2003 will be in deficit. Despite this, ISRM subscriptions will remain at their present level for 2003.

The Board of the ISRM continues to support increased cooperation between the three sister societies (ISRM, IAEG and ISSMGE) and fully supported the formation of the joint technical committee on Landslides which will be chaired by Professor Robin Fell (University of NSW).

The Muller Award was awarded to Professor Charles Fairhurst who will be well known to most people working in rock mechanics. The Rocha Medal was awarded to Dr Andersen of South Africa for his PhD thesis entitled 'A relative moment tensor inversion technique applied to

seismicity induced by mining'. Dr Andersen will present his thesis at the 10th ISRM Congress to be held in Johannesburg, South Africa from 8 to 12 September 2003.

Fourteen papers have been provisionally accepted from New Zealand and Australia for the 10th ISRM Congress. These papers are in the process of being reviewed with submission of papers (through me) to the organising committee required in electronic format by end of May. The Congress appears to be well organised with strong technical (including keynote lectures, parallel sessions and three workshops) and tourist programmes (including opportunities to visit deep underground and surface mines and game parks). Early bird registration closes 31 May 2003. Full details can be obtained from the conference Web site at <http://www.isrm2003.co.za>. The next ISRM Board and Council meetings will precede the Congress. It is also planned to hold a meeting of the Mining Interest Group during the Congress.

My term as ISRM Australasia finishes with my last Council meeting in Johannesburg. John St George will be taking over as ISRM VP Australasia from September 2003 and I wish him well in his new position. John's contact details are Department of Civil and Environmental Engineering, University of Auckland, Private Bag 92019, Auckland, Phone: +64 9 373 7599 ext 8195, Fax: +64 9 373 7462, Email: j.stgeorge@auckland.ac.nz. The AGS National Committee has invited Dr Tony Meyers to act as a ISRM liaison for AGS members during John's term as ISRM VP.

Associate Professor Chris Haberfield
ISRM Vice President for Australasia

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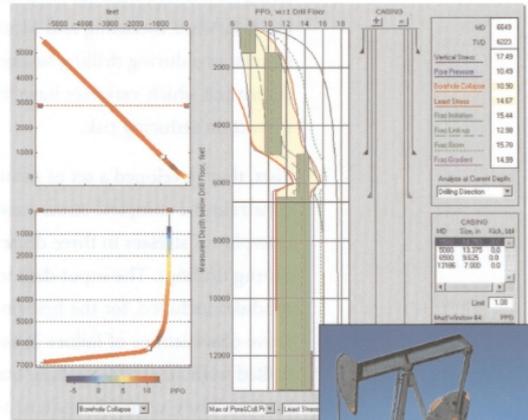
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David Robinson
Geoscience Australia

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MathWorks Products Used:

- MATLAB

MATLAB

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NZGS BRANCH ACTIVITIES

Auckland Branch Activity Report

Attendance at our meetings is very encouraging, ranging between 20 and 60.

The last six months have been busy. In **November 2002**, we held an informative meeting on "Ground Anchors - An Overall Perspective" by Contech. One practical point is that site investigation should cover the extremities of proposed anchors.

Two meetings were held in **December 2002**. On 4 December a report on the 7th International Conference on Geosynthetics at Nice was presented by Gordon Stevens followed by a paper on application of non-woven geotextile for erosion and weed control purposes by Moninder (Witty) Bindra of Permathene. On 11 Dec, the Northern Area Student Prize took place with five participants (including one from Waikato). The eventual winner was Andrew Holland.

This year began with an international speaker, Mike Dobie on "The 2-part Wedge Method Used for Seismic

Design of Reinforced Soil Retaining Walls", held just before the Tauranga Conference. Mike presented a design method for the internal stability of reinforced soil retaining walls.

April will see Peter Riley talk on "Big Dams in South America - Triumphs and Near Tragedies". This is being jointly held with NZSOLD.

In **June**, we are arranging to have Paddy Luxford, Peter Millar and co. to discuss on legal issues and acting as an expert witness.

In **July**, we may have Don MacFarlane discussing on the Manapouri Power Station.

Yan Chan

Auckland Branch Coordinator

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Waikato/Bay of Plenty Branch Activity Report

The Bay of Plenty group last meet prior to the NZGS symposium in March to here from Brabha from Opus about the Western Bay of Plenty Lifelines study that has been completed. This was a successful meeting and was followed by drinks and finger food at the symposium icebreaker.

Stuart Finlan of Montgomery Watson Harza has volunteered to co-ordinate the Hamilton group. Thanks to Mark Mitchell for his previous efforts in Hamilton. Stuart will step into the role as of the first of May. At the time this issue went to press Stuart has not yet had time to put an advance programme together. Hamilton members can expect to see a programme of meetings on the web page in the near future and will be notified by email or mail of any up coming meetings. Please support Stuart by attending the meetings and giving him ideas of your interests.

Paul Burton

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Wellington Branch Activity Report

The Wellington Branch is currently “between” co-ordinators. A big thank you to Ian McPherson of Connell Wagner who has diligently undertaken this role for many years. As of the first of May Grant Dellow of GNS has agreed to take over the co-ordinators role. At the time this issue went to press Grant was out of the country and had not yet had time to put an advance programme together.

Wellington members can expect to see a programme of meetings on the web page in the near future and will be notified by email or mail of any up coming meetings. Please support Grant by attending the meetings and giving him ideas of your interests.

Grant Dellow

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Canterbury Branch Activity Report

The 2002 Southern Area Student Prize presentations in November attracted a good turnout of 20–30 which received a well prepared talk from sole entrant, Caroline Francois, on “Design and Implementation of a dense strong-motion accelerograph array for the Alpine Fault”. Thanks to the judges David Bell from the Geology Dept at the University of Canterbury, Tim McMorrان from URS and Nick Traylen from Geotech Consulting. Caroline is a PhD Student in Civil Engineering at the University of Canterbury and was awarded the Southern Area Student Prize of \$500 book vouchers.

In March, Professor IM Idriss from the University of California, presented a “Review of field-based procedures for evaluating liquefaction potential during earthquakes” to both the geotechnical and structural groups in Christchurch. The meeting attracted an audience of around 40.

In April Professor Kenji Ishihara from the University of Tokyo gave a spectacular slide presentation on “Failure of slopes and soil property characterisation” to an audience of around 30. His examples included 35 million cubic metre debris avalanche off Mt Ontake in Japan, a 20 million cubic metre flow slide in a collapsible loess deposit on relatively flat ground in Tajikistan, and slope instabilities in loose riverbank sand deposits in Bangladesh.

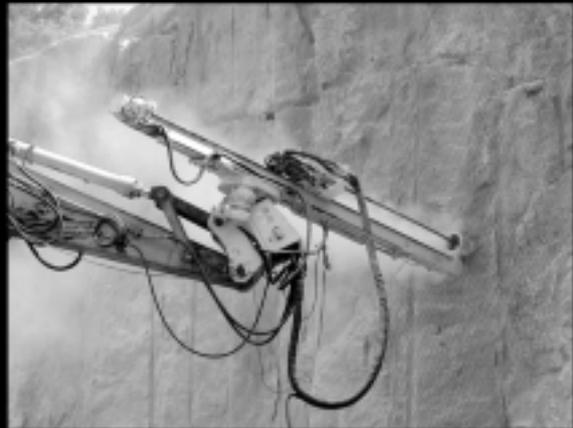
Maccaferri New Zealand Limited have again been kind enough to sponsor drinks and chips before the meetings. The contact for Maccaferri in Christchurch is Adrian Gardner (03 349 5600).

The Canterbury branch attempts to hold regular meetings with a presentation every 4–6 weeks. These are usually held in the School Engineering at the University of Canterbury. The format begins with social drinks and chips at 5.30 p.m. in the Staff Common Room followed by the presentation in a nearby lecture theatre between 6.00 and 7.00 p.m. This is a good time to meet fellow geotechnical practitioners, students and academics. Time at the end of each meeting is allowed for questions and discussion.

Upcoming events are yet to be finalised. See the NZGS Web page for further information. Meetings will be advertised to members in advance by email or post. For up-to-date information on Canterbury Branch Activities, see the NZGS web page or contact the coordinator Brian Adams.

Brian Adams

Canterbury Branch Coordinator
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Email: brian_adams@urscorp.com



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NORTHERN AREA STUDENT PRIZE ABSTRACTS – 2001

Landsliding on the Paeroa Fault at Te Kopia

A. M. Newson, Geology Department, University of Auckland
W. M. Prebble, P. R. L. Browne

Abstract

The Te Kopia geothermal field is bisected by the north-east striking, active Paeroa Fault. Maximum vertical expression of the scarp is 524 m, and has accumulated in less than 300,000 years activity. Three rhyolitic ignimbrites from the Whakamaaru Caldera are exposed, dated at 0.34–0.32 my. These are the source rocks for numerous debris flow deposits within a hummocky, sloping apron at the base of the scarp. Identifiable tephra layers within the apron provide age control for these deposits, and give an indication of a very high recurrence rate for this type of failure.

Thick, ignimbritic clast supported deposits are dominated by zeolite (mordenite) and clay (illite and smectite) alteration. Mordenite alteration is characteristic of warm (<120 °C) near neutral pH heated groundwater, marginal to a geothermal field. Illite alteration is characteristic of hotter (220 °C), acidic waters. Other slope deposits are thinner, matrix supported, and dominated by angular tabular clasts of silicified tuffaceous sediment of the Huka Falls Formation. Nearby circular features suggest that these deposits are hydrothermal eruption breccias.

Geothermal exploration wells drilled in 1965 are used to reveal a slope debris accumulation of 200 ft below the thermally active area. Minimum magnitudes of the larger debris flow deposits have been calculated, and can exceed 700,000 m³. The youngest landslide deposit mantles the modern day soil. It reaches a maximum thickness of 0.9 m, is dominated by kaolin sourced from nearby acid-sulfate pools, and has an aspect ratio of 1/1,333.

Analyses of matrix properties reveal a range of plasticity indices from 9% to 44%. Field moisture content of matrix material from two deposits exceeds the plastic limit. Liquid limits are relatively low. Within the ignimbrite clast dominated debris flow deposits, this may be indicating a low clay influence. Two deposits dominated by kaolin show the highest degree of linear shrinkage.

Debris flow failure within the area can be attributed to several different factors. Acid steam condensate alteration is likely to promote widespread debris flow failures, especially during intense rainfall and earthquakes. To the north of the field area, source areas outlined by rock mass defects are observed, and assumed to also be significant in debris flow failure. Debris flows are also the most widespread type of deposit. Rockfall is a common process. It is controlled by defects within the associated rockmass, and oversteepening along the scarp. Earth flows are observed inside and outside the thermally active area, and area easily identified by barren ground and changes within the vegetation. Infrequent earth flow deposits at the base of the fault scarp indicate a saturated condition when deposited, and a low initial volume. The presence of hydrothermal eruption breccias within landslide deposits may indicate that these events have a direct causal relationship with landsliding. Block slide deposits are rare and occur as isolated hills and benches within the scarp. The presence of hydrothermal eruption breccias amid the landslide deposits may indicate these events have a causal relationship with each other.

Spatial Variation in Auckland Residual Soil

Andrew Holland

Winning Abstract

Thirty CPT soundings were taken in a very small area (8 m by 8 m). The intention was to produce a comprehensive picture of the soil profile in this area and assess its variability. The CPT's were spaced on a 1m by 1m grid with a concentration in the middle and tests extending along the major axes.

The site, located in Albany, Auckland, was considered appropriate for a number of reasons. It was located in an undisturbed area of residual Waitemata group soils, it was easily accessed for testing, a geotechnical site investigation had already been carried out on site and it was flat.

The CPT outputs used in the analysis were end bearing (q_c) and sleeve friction (f_s) as these are the most commonly used parameters in geotechnical design. The data was first analysed using basic statistical techniques. It was decided to use the normal probability distribution model as it is easily applied and makes a good starting point. The mean, standard deviation and confidence limits were calculated and plotted. It was noticed that the confidence limits widened where the mean value was increasing. To test whether there was a correlation between the mean and the standard deviation (the confidence limits are just the standard deviation multiplied by a constant) they were plotted against each other and the correlation coefficient was calculated. The correlation coefficient was 0.733 indicating a strong relationship. (1.0 is a perfect positive correlation).

The data was also tested to determine whether the normal model was appropriate. The tests used were skewness and kurtosis. Skewness is a parameter that measures whether the data is symmetrical about the mean or whether it has weighting to one side. Kurtosis is a measure of how peaked or how flat the data is. Both of these can be compared to the normal distribution. The tests were varied over the depth but on average, the data was more peaked than the normal distribution and was skewed slightly positive compared to the normal distributions

neutral position. These results both suggest that the data could be better modeled by the lognormal distribution.

Representative q_c data from a number of depths, was extracted for all soundings. This data was then input to Variowin, a spatial analysis program. In Variowin a number of plots were created. Variograms, correlograms and variogram surfaces were plotted and analysed for all of the depths. The analysis returned that the data has a range of 5.5 m–6.0 m. The range is the distance over which the parameter being measured has some spatial dependence; i.e. is the point being looked at similar to another point a distance away? The range is important as it indicates whether data collected has some relevance to an area a certain distance away. This parameter is particularly important for engineering design.

The first few metres of the soundings displayed a high degree of variation and a number of spikes or hard layers. I have performed a site investigation in identical geological material only 2 km from the site of my report. In test pits during this investigation a number of hard, indurated (cemented/hardened) clay layers were observed. Induration in clays is a feature of weathering. Some of these layers were difficult to penetrate even with a 20-ton excavator. The indurated layers were not consistent over the whole site. This affected the calculations in the upper parts of some soundings as it created a number of outliers.

On the q_c plots a layer between 3 m and 7 m was noticed that had decidedly more clay like behaviour than the surrounding areas. This layer was significantly different on the CPT soundings but was not differentiated on the visual borelogs created during the original site investigation. This is an aspect of the investigation that needs more research.

There was a high degree of variability found on the site. Coefficients of variation of up to 50% were not uncommon. It was not more variable however, than what is generally taken into account during parameter estimation for an engineering design.

Volcanic Debris Avalanche Deposits from Slope Failure of Tongariro And Kakaramea-Tihia Volcanoes, New Zealand

Andrea Spargo, Warwick Prebble, Phil Shane and Ian Smith, University of Auckland

Abstract

Brecciated deposits containing coarse volcanic clasts are mapped throughout the northern Tongariro Volcanic centre. These deposits displays characteristics typical of debris avalanche deposits commonly found in the ring plains of composite volcanoes. This study examines avalanche deposits in the northern ring plain of Tongariro and Kakaramea to determine their origin, mode of emplacement and time of deposition.

Detailed geological investigations of road cuts along State Highway 47a and the Te Ponanga Saddle Road reveal deposits with large (up to 4 m), angular clasts resting within a coarse-grained matrix. Numerous clast types are observed with some large clasts displaying jig-saw fit fracture patterns. Overall the deposits show a variable degree of alteration and appear chaotic. A key component to understanding the origin and emplacement mechanism of the deposits has been the use of remote sensing and geomorphic analysis of the volcanoes. Aerial photograph interpretation reveals separate origins and modes of emplacement for the sedimentologically comparable deposits.

The ribbed surface morphology of the State Highway 47a deposits is comparable to that of young (<25 ka) lava flows observed in the Oturere Valley, Tongariro. The brecciated deposits occur at the distal margins of the lava flow like lobes. Up to 6 m of brecciated, jig-saw fractured clasts fill valley-like depressions between adjacent flow lobes. The chaotic arrangement of fractured clasts implies that these deposits are the product of failure and/or break up of lava flow margins.

This package of *in-situ* lava and auto-brecciated deposits extend over 20 km² forming the western edge of Lake Rotoaira. The occurrence of the Oruanui Formation above the deposits and their stratigraphic relationships to adjacent units indicate that these flows were emplaced 60–26.5 ka. Therefore these deposits are stratigraphically younger and subsequently separate from the Tongariro

sourced Te Whaiiau Formation – an avalanche induced cohesive debris flow.

By comparison long linear lobes that extend c.4 km outwards across the northern ring plain where they are intercepted by the Turangi Fault, dominate the morphology of the NE Kakaramea volcano. Orientated obliquely to NE–SW trending regional faults, these topographic features can be traced up to the Tihia summit plateau forming part of a broad zone of slope failure. Road cut exposures along the Te Ponanga Saddle Road occur where the road intersects the lobe-like features suggesting that the deposits were emplaced by large-scale slope failure that originated at the edge of the Tihia summit.

With a visible are of c. 9 km² the slope deposits contain a >2 m diameter mega-clast of poorly sorted unconsolidated ash and lapilli indicating that at least in parts the failure was able to raft very weak soil-like clasts. Obliquely oriented fractures dissect the mega-clast and containing coarse Oruanui Formation. These vein-like structures are indicative of shear failure syn or post the Oruanui Eruption of 26.5 ka. The occurrence of the Rotoiara Formation above this deposit further constrains the age to between 26.5 and 13.8 ka. This implies that the Kakaramea-Tihia complex has undergone large-scale collapse events in more recent times. Smaller historic and Holocene debris flows at Tokaanu have been described previously.

This study extends the zone of existing landslides over a much larger area over both volcanoes. A regional approach has been valuable in investigating these volcanoes. Despite the comparable appearance of volcanic ring plain deposits the origin, mode of emplacement and age of deposition can vary greatly. A combination of remote sensing, geomorphologic and geological mapping has been critical to the understanding of debris avalanche deposits.

Geotechnical Hazards Affecting SH 31

C.J. Lauder, V.G. Moon, Earth Sciences Department, University of Waikato

Abstract

The 31 RS (route station) of SH 31 is susceptible to natural hazards, particularly mass movement and flooding induced by extreme weather. The area is sparsely populated, therefore the risk to the population is minimal, however the threat to the infrastructure is high. This study, in association with Transfield Services (NZ) Ltd., aims to assess the effect landsliding has on the road network.

The section of road studied is 11 km long and situated on an east-west trending ridgeline. The road drops to 300 m elevation from 380 m over 3 km, from where it follows the head scarp of a large relict landslide to 180 m elevation over 5.5 km. The road then heads directly west towards Kawhia for another 2.5 km dropping a further 100 m in elevation. The steep gradient helps to induce orographic rainfall, which results in high mean annual rainfall (2500 mm) in the east of the study area. SH 31 is underlain by Kihikihi Sandstone of the Te Kuiti Group, mantled by weathered tephra and breccias of the Alexandra volcanics. The sandstone forms steep (80–90° slopes up to 50 m high) bluffs along the side of the main ridge.

Every winter slips along the highway are observed. The main kinds of failures are shallow translational and washout failures. These failures range in size from 2 m wide and 2 m deep (more common) to 30 m wide to 50 m deep. Commonly, small slips are precursor to larger failures. There are occasional debris flows, which are

narrow (2 m) at the head scarp and up to 80 m long. The shape of the failure scarp is often defined by the edge of seal, failing semi-vertically from the road edge to an average 3 m deep or to the sandstone surface. Larger failures often undercut the pavement by 1–2 m. The volcanically derived soils are the materials that are failing. Failures frequently cut to the sandstone surface, especially to the east where the volcanic deposits are shallower.

Direct shear strength testing on the volcanic-derived soils gives friction angles of 5 to 34 and cohesion values 3 to 51 kNm⁻². The soils have PI values ranging from 10% to 66% and unit weights of 15.2 to 17.8 kNm⁻³. GALENA modelling at one particular site, with a specific slip circle, using the Bishop Simplified method showed a decrease in FoS from 1.27 to 1.01 with a 2 m rise in water table. In saturated conditions FoS dropped to 0.56. This sensitivity to water table variations is a constant through the area, as the material strengths decrease with increased water levels.

Rainfall is interpreted as the most powerful trigger for failures along SH 31. The simplest mitigation strategy is to control the drainage, particularly the surface drainage, reducing run off onto unstable slopes by redirection to lower elevation, where the slope angles are reduced. Preferably, the water should be directed all the way to streams, however logistically this is unlikely. Other options are relocation or lowering of the road.

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Dynamic Response Calculations Using Flac

Vickie Kong, Department of Civil and Environmental Engineering, University of Auckland

Abstract

FLAC (Fast Lagrangian Analysis of Continua) is a two-dimensional explicit finite difference program developed by Itasca Consulting Group for geotechnical numerical modelling. A dynamic analysis option is available to simulate earthquake effects. The purpose of this paper is to present results of work to demonstrate that the dynamic output of FLAC produces valid results and to compare the two types of damping available for dynamic analysis.

The damping types are Rayleigh and local damping. Although Rayleigh damping is dependent on frequency, with appropriate approximation, it can be used as hysteretic damping for geological material. Two input variables are required for the use of Rayleigh damping, one is critical damping ratio and the other is predominant frequency. Predominant frequency is based on the combined effect of the frequency of dynamic loading and the natural frequency of the system.

Local damping is another option. Local damping was

originally designed for static analysis and is a non-viscous damping. The damping force on a node is proportional to the magnitude of the unbalanced force acting on that particular node. However, there is no guarantee to its performance when the input acceleration is in complex waveform. The advantage of local damping over Rayleigh damping is that there is no need to specify the predominant frequency as for Rayleigh damping.

A theoretical solution is available for the steady state response of an elastic layer and this is the basis of the assessment of the performance of the damping options in FLAC. It is found that the results obtained with Rayleigh damping agree with the theoretical solution very closely. However, for local damping the actual damping is found to be larger than the specified critical damping ratio. The amount of over-damping is a function of critical damping ratio and the relationship is nonlinear.

SOUTHERN AREA STUDENT PRIZE ABSTRACTS – 2001

Design and Implementation of a Dense Strong-motion Accelerograph Array for the Alpine Fault

Caroline Francois

Winning Abstract

A dense network of strong motion seismometers is being developed in order to investigate the complexities of the upper crustal rupture process and propagation of major seismic sources such as the Alpine Fault and strands of the Marlborough Fault System defining the South Island sector of the Australia-Pacific plate boundary zone.

The proposed network is designed as a dense array of approximately 20 accelerographs using the University of Canterbury 12-bit CUSP instrument, whose development is now nearing completion. It will be deployed straddling the Alpine Fault in the central West Coast region of the South Island, and coverage will extend across the region at the Alpine-Hope Fault junction also.

The array layout is being designed utilizing the frequency-analysis MUSIC method (Multiple Signal Characterization) developed by Goldstein and Archuleta (1991a&b). The process of finding an optimal configuration is dependent on the geometry of the array

(study of the frequency analysis performance of the modelled earthquake data for various proposed array configurations), and on the instrument site conditions (geology, communications, accessibility, isolation etc).

Goldstein, P. and R. J. Archuleta (1991a). "Deterministic frequency-wavenumber methods and direct measurements of rupture propagation during earthquakes using a dense array; data analysis." *Journal of Geophysical Research*, B, Solid Earth and Planets 96(4): 6187-6198.

Goldstein, P. and R. J. Archuleta (1991b). "Deterministic frequency-wavenumber methods and direct measurements of rupture propagation during earthquakes using a dense array; theory and methods." *Journal of Geophysical Research*, B, Solid Earth and Planets 96(4): 6173-6185.

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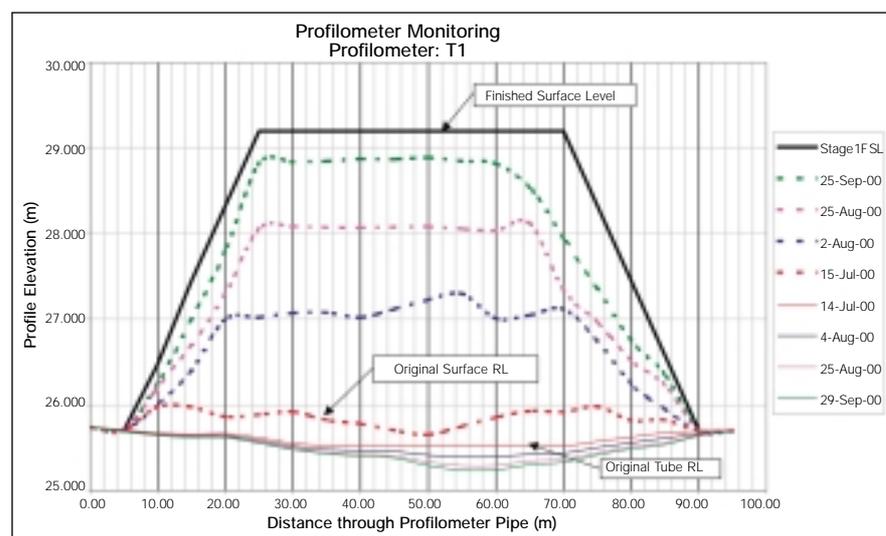
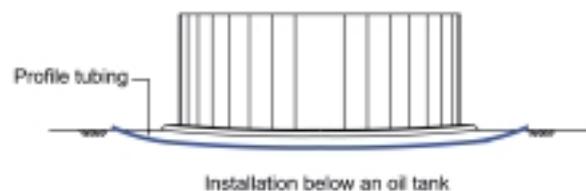
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..and with me in charge Steve, this is how big the society's going to grow.

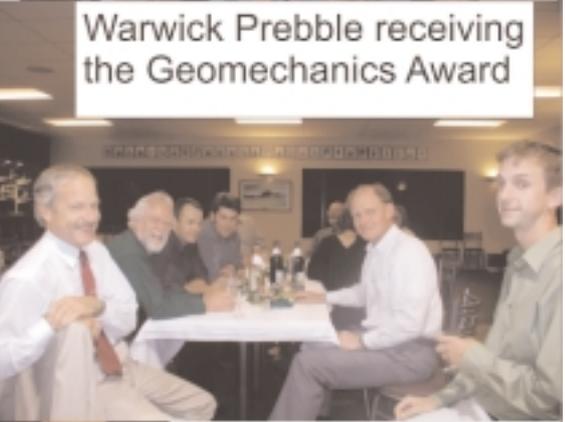
Life membership for John Blakeley



The Conference Dinner



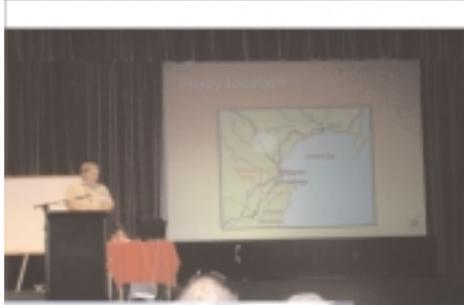
Warwick Prebble receiving the Geomechanics Award



The inverse of being under the table



The Limit State?



Field Trip to Martha Hill



Phil Flash's view of "Geotechnics on the Volcanic Edge"
Tauranga 28 - 30 March 2003



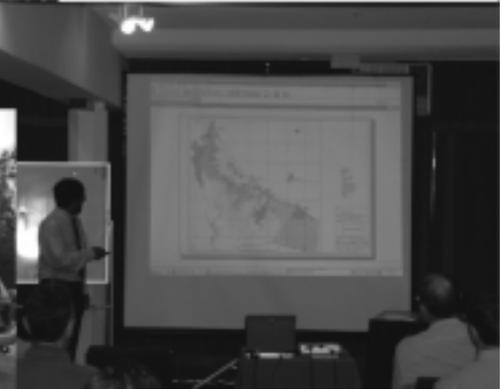
Debating the new soil description...but where's Stuart?



There was plenty of arm waving on the mapping field trip



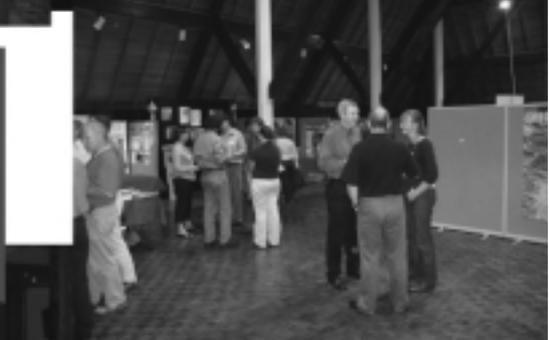
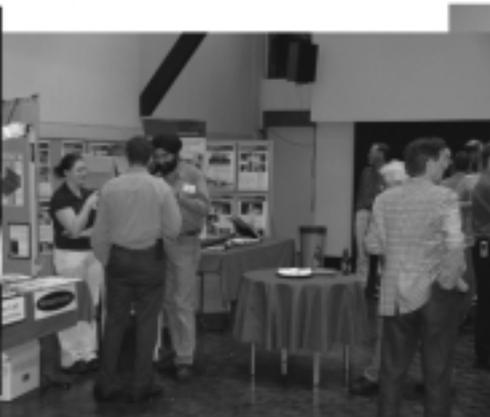
The Icebreaker



WBOP Lifelines



Dinner with Ishihara



The "Stayers"



CONFERENCE REPORTS

'Geotechnics on the Volcanic Edge' New Zealand Geotechnical Society Symposium 2003 28–30 March, Tauranga New Zealand

Reported by: Dick Beetham
Institute of Geological & Nuclear Sciences Ltd

This year we were looking forward to visiting sunny, dynamic Tauranga, New Zealand's fastest growing city, for the bi-annual symposium. It held the promise of an exciting program of technical presentations, workshops, field trips, and of course the opportunity of making new friends and catching up with old ones at a new and interesting venue.

For me it was an absolute relief to arrive in Tauranga from calm, drought stricken Wellington to lashings of rain and battering winds. First up on I attended the Engineering Geological Practice workshop – mainly because the alternative all day session on limit state design seemed a bit daunting and technical. Besides, I was keen to attend the prospective old fashioned dust-up on soil and rock description in the afternoon.

The engineering geology practice workshop capably led by Ann Williams started with most relevant presentations by Phil Glassey, Warwick Prebble and Vicki Moon, followed by a field visit to the Omokoroa cliffs where the rain held off while we observed first hand a strange dodgy white soil along with other materials of dubious properties, as well as the hazards of urban development along the crest of an unstable cliff. On the field trip we heard hair-raising tales about local residents who installed automatic sprinklers to water their favourite plants on the cliffs right up to the point of rapid failure. Perhaps it's an advantage to have no technical knowledge of these matters so that one can enjoy the stunning cliff-top views without any concerns? Also where can a well versed technical expert in natural hazards actually safely live in NZ? The visit to the Apata Coolstore was also an eye opener for me.

We were not disappointed with the soil and rock description workshop. The opposing camps each presented compelling arguments, but like the Middle East conflict there did not seem to be much prospect of a compromise on the day. Discussion from the floor raised some good points, and to me the opposing camps seemed to be centred around the engineers desire to quantify materials to use numbers in analysis versus the geologists who are far more generic and want to describe in detail. I would like to see more rational discussion take place before changes are introduced, so personally I won't be

throwing away my treasured, old, and well-thumbed NZ Geomechanics Society, *Guidelines for the field description of soils and rocks in engineering use* volume just yet. The boxes of samples provided to play with, discuss and describe afterwards were a great idea and provided a good lead into Brabhas microzoning presentation followed by the Ice-breaker drinks, nibbles and even more, but better lubricated discussion!

The Ice-breaker also allowed the rather stunned-looking, limit state workshop group to finally unwind and mix with the other more bellicose group to organise dinners and other evening outings. I dimly recall our party having a great evening reliving the old days over copious beverages and delicious food at a busy Italian restaurant.

Rather early the next morning we were warmly welcomed to the Day 1 of the Symposium proper by the Mayor. Next I rather wished I'd sat closer to the front of the auditorium in order to fully take in Prof Ishiharas excellent keynote address on experience with liquefaction in the Kobe earthquake, Japan. Kevin McManus also got us going with his presentation on foundation design research at Canterbury.

The symposium days (Friday and Saturday) were organised into four theme sessions of 1 hour 40 minutes each separated by morning tea, lunch and afternoon tea. Equipment and product displays and advertising stands provided interest to the tea and lunch area, and a probe rig at the front entrance immediately showed new arrivals that they had reached the right place. Each theme session had format of six 15 minutes presentations followed by 10 minutes of questions from the floor to all presenters, with the session chairperson briefly introducing presenters, keeping track of timing and taking the questions. The themes neatly encompassed the wide variety of topics covered by the presentations. As well, presenters used a variety of presentation techniques, from older overheads or slides to slick powerpoint methods. The clarity of the slides improved dramatically when someone discovered that the projector brightness could be switched from half to full power. Also we discovered after some trials and tribulations that a good laser pointer that everyone can use is an essential tool in a large auditorium. I was delighted to see that most speakers had

put effort into ensuring their presentations were both entertaining and educational. It is a long day to sit through listening to dry technology, so skillful insertion of some entertainment in a presentation is essential to grab and maintain audience attention.

Generally the standard of presentations was good, but in order to encourage presenters to try hard, I recommend that prizes are awarded at future symposia for the best in different categories of presentations – the best student, general and powerpoint presentations are examples of a few awards that spring to mind. Over the two days there were some outstanding presentations that I still remember clearly: Prof Ishihara, Kevin McManus, Bernie Hegan's blast from the past, Georg Winklers enterprising use of humour with powerpoint images certainly livened up Northland Allochthon, Mauri McSaveney's wry humour overcoming tragedy in the mountains, Joy Hoverd on the risk and consequences of tephra in Auckland, an excellent powerpoint presentation on tie-back retaining walls and their stability under earthquake loading by a speaker whose identity escapes me, and EL Giles eloquence on mining at Waihi. This list is not comprehensive and I apologise if I have caused offence by not mentioning someone – there were other good presentations.

The Symposium dinner after the first day was great fun. We dashed from our bus through sheets of rain into the golf clubhouse, while the more gentlemanly tried to protect the ladies using their jackets and other means. The company was excellent, the food and drinks were fine, the speeches entertaining, and it was a great opportunity to recognise the contributions of John Blakeley. I was grateful to be delivered home to my motel door by an obliging bus driver.

Weather had improved for our Sunday field trip, the first leg of which had some of our older society members puffing and sweating as they clambered down to and back from the new motorway cutting. What amazing long anchors are being used to support the cutting! The second leg to Martha mine was also most worthwhile. I managed to get on the trip into the open pit and was impressed by the scale and order of the operation. We then bussed around the remainder of the project. One would hardly know that beneath the fenced and grazed sloping grassy slopes there was a tailings impoundment structure. Thanks Sally, our tour leader.

Well, to all those who helped organise the symposium, lead field trips and workshops, to our colleagues who gave presentations, to those who provided stands and sponsorship, and all those attending, we owe a vote of thanks! Without you and your support we would be stuffed. I have many enduring memories of the Symposium, but one of importance that I would like to mention is the continuing support of our old stalwarts, such as Mick Pender, Warwick, Tim, Geoff, the Society Committee, *et al.*, and in parallel I was delighted to see many younger members of the Society coming along, taking part and enjoying themselves. I look forward to meeting more of you in the future – at symposia. With your support I can't help feeling that our Society is in good shape and heart! Of course a lasting memento of the symposium is the distinctive, attractively covered volume of proceedings. For those Society members who were unable to attend – get your copies now. The volume contains all the papers presented – a wealth of useful information and case histories.



Left: Keynote speaker, Prof. Kenji Ishihara (second from left) with the Sinclair Knight Merz contingent at the "Geotechnics on the Volcanic Edge" Symposium.

EUROCK 2002 – ISRM International Symposium on Rock Engineering for Mountainous Regions

Funchal, Madeira, 25–28 November 2002

Reported by: Chris Haberfield
Golder Associates PTY Ltd and Monash University

The island of Madeira of the north-west coast of Africa is well known to Europeans as a holiday destination. To us, it is home of Madeira wine, which we all enjoyed(?) as a cheap, alcoholic alternative during our student days. Well the island richly deserves its popularity as a holiday destination, and the Madeira wine is still cheap.

The island is of volcanic origin, measures about 60 km long and 20 km across and rises to a height of 1860 m above sea level. It was an ideal location for a symposium on rock engineering in mountainous regions. The huge rock engineering problems encountered in this region are clearly illustrated by the difficulty in just finding a suitably flat site to locate their airport. In the end they placed their airport runway on the side of the mountain, with half the structure supported on columns and piles.

The 20 km trip from the airport to Funchal takes you through numerous tunnels drilled through hard rock and many elevated structures crossing deep ravines. My hotel is perched on top of a cliff with fantastic views of the atlantic ocean. The swimming pool abuts the cliff top with no safety fencing preventing thrill seekers taking a dive into the Atlantic ocean many metres below.

Enough of the travel log.

As indicated by the name, the symposium concentrated

on rock engineering in mountainous regions. About 200 delegates enjoyed not only the beauty of Madeira, but also a good and varied technical program which included two workshops, four keynote lectures, technical tours and two parallel sessions covering 4 themes.

The four keynote lectures covered topics of slope stability classification systems, rock fall protection and tunnelling. The presentation of the keynote lecture on rockfall protection by Prof. Mazars was a highlight with impressive computer generated video clips of the results of numerical modelling of rocks impacting rock fall netting. The accuracy of the numerical predictions were as impressive as the visual effects.

The conference proceedings contain 106 papers across the four themes of slope stability, underground works, environmental protection and case studies. The papers dealing with landslip stability issues on Madeira are particularly interesting.

Overall the conference was an enjoyable and worthwhile educational experience and I would encourage New Zealand Geotechnical Society (NZGS) and Australian Geotechnical Society (AGS) members to consider attending the 2003 ISRM Congress in Johannesburg (September 2003) which promises more of the same.



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GeoCart'2003

12–24th February 2003, Wairakei, New Zealand

Reported by: Phil Glassey

Institute of Geological & Nuclear Sciences Ltd

Having recently taken on a new role of managing the Mapping section of the Institute, it was more than appropriate that I attend this National Cartography Conference, held at the Wairakei Resort, Taupo. The theme of the conference was 'Accessible New Zealand; Capitalizing on Contemporary Technologies'. The conference was jointly organised by the New Zealand Cartographic Society, Land Information New Zealand (LINZ), Spatial Analysis Facility, University of Auckland and the University of Waikato.

The conference was attended by about 80 delegates with 12 commercial exhibitors, mostly dealing in GIS and production of maps. The National Cartographic Exhibition featured a number of maps and other products presented by participants.

The social calendar included a BBQ, an Ice Breaker and a Dinner, which included a cracker little 3-piece jazz band. There was a half-day visit to the Institute of Geological & Nuclear Sciences Ltd, Wairakei Research Centre, where participants were shown the GeoNet Monitoring systems, the Chemistry labs and some spatial modeling. This was well received.

There were 4 plenary sessions and four parallel sessions. There was a strong education theme throughout the conference, especially on teaching cartographic skills in this new technological age, but also sessions on 'Mapping the Imagined', Mapping Technologies, Visualisation, Data, Data Libraries and Services, and Mapping Natural Environments.

There was a strong representation from LINZ presenting on metadata, Accessible NZ and the New Digital Topographic Database. There was also a strong contingent from The University of Auckland and University of Waikato, and although I missed the first session on 'Mapping the Imagined' it included papers from these schools on 'Middle Earth on Location', 'The geomorphology and toponymy(?) of imagined landscapes',

and 'Augmented Reality and Imagined Landscapes'. Wow! A far cry from your bog-standard topographic map. Along a similar theme was a paper presented by Gregory More from Royal Melbourne Institute of Technology on 'Dynamic Visual and Acoustic Presentations of City Information' which I found particularly interesting.

The highlight of the presentations for me was the plenary paper presented by Steve Erskine of the Ordnance Survey, United Kingdom, entitled 'Ordnance Survey – Providing the Geographic Framework for Great Britain'. The British have spent considerable time and money in building database structures and producing digital maps including National scale maps, the famous London Underground map, detailed infrastructure and cadastre. Many of these maps, particularly road and route maps can be printed from map kiosks.

Of the commercial exhibitors, the Geographix site interested me. Roger Smith and K2Vi have put together a 3DNZ – virtual New Zealand browser, which is a 3-D Terrain Browser, using textured land surfaces derived from the topographic map series (you may have seen the book). While this isn't ground breaking technology, they have done it first, and in such a way that it appears seamless, relative fast and the texturing and colouring is great. It wasn't easy to fly around the landscape using the six button mouse, though. They need a joystick.

The conference for me was inspiring, and exciting in the realisation that we are not bound by conventional 2-dimensional maps but can now produce information using a whole suite of graphic visualisation tools. However, while there were strong graphic, visualisation and GIS themes throughout the conference it was disappointing that many of the presentations weren't more graphic and didn't use the technology more fully. Perhaps we aren't quite there yet. But I'm sure it won't be long before we are presenting information as 3-D holograms.

THE 9TH AUSTRALIA NEW ZEALAND CONFERENCE ON GEOMECHANICS



8-11 February 2004
Auckland

Plan now to participate in the conference. While held every 4 years, it is held in New Zealand only every 12 years, bringing together geotechnical practitioners involved in soil mechanics, rock mechanics and engineering geology. The conference is promoted by the Australian Geomechanics Society and the New Zealand Geotechnical Society

Theme

"to the eNZ of the earth"

The conference theme aims to generate discussion on what makes geotechnical practice within New Zealand and Australia different to other parts of the world. This uniqueness is in part historic due to both countries being young nations and in part location as a result of their position on or adjacent to a tectonic plate boundary. The theme also encourages contributions to consider the influences of the "Electronic Age" on geotechnical practice.

Subject areas

- Slope instability and remedial measures
- Foundation performance and assessment
- Roads, dams, tunnels, mines
- Laboratory testing
- Earthquake engineering
- Contractual and risk issues
- Case histories and failures
- Engineering Geology
- Numerical modelling
- Environmental geotechnics

Keynote speakers

- Conference Keynote Address by Professor Geoff Martin, University of Southern California.
- The John Jaegar Memorial Address by the recipient of the award given by the Australian Geomechanics Society.
- The New Zealand Geotechnical Society Geomechanics Lecture.

Post-conference tours

These are likely to include trips to sites of geotechnical and geological interest in the upper North Island.

Exhibition facilities

An area will be available for displays over the three days of the conference. Corporate sponsorship opportunities are also being offered. Contact the Conference Manager for details.

Enquiries

All enquiries should be addressed to the:

Conference Manager
Barry Williams
Centre for Continuing Education
University of Auckland
Private Bag 92019, Auckland, New Zealand
Phone: +64 9 373 7599 ext 88903
Fax: +64 9 373 3419
Email: b.williams@auckland.ac.nz

Conference convenors

Geoffrey Farquhar, Meritec
Philip Kelsey, Earthtech Consulting
John Marsh, Beca Carter Hollings & Ferner

Internet home page

www.cce.auckland.ac.nz/geomech04

STANDARDS, LAW & INDUSTRY NEWS

Guidelines for Classification and Description of Soils and Rocks – Some Comments on Responses to the Draft of the Revised Document

The draft of this document was made available to Society members in March of this year. Since that time, a number of responses have been received, and a discussion session was held in conjunction with the recent Tauranga symposium.

It seems appropriate for the committee to make a few comments in this edition of Geomechanics News, while the matter is still fresh in members' minds. These comments do not cover all responses; they are an attempt to cover some of the more important issues the responses and discussion have brought to light.

The framework and intent of the proposed Classification and Description document

Quite a number of comments have been received which appear to misunderstand the framework within which the committee revising the document has been working. The committee is not creating a document "out of the air", or putting together a collection of its individual ideas. The committee's starting point was the existing document, which states:

"The guidelines for the soil description method are largely based on the method originally given in the USBR 'Earth Manual' which was primarily designed for the classification of construction (i.e. remoulded or excavated) materials."

This method became better known as the Unified Soil Classification System, and is undoubtedly the most widely used system worldwide, so this was the starting point for the original document, and for its revision. In addition to this starting point, the committee set the following criteria:

- the guidelines should be as clear and uncomplicated as possible,
- the guidelines should conform to international practice as closely as possible, (and any departures from this should be identified and explained),
- changes to the existing document should be made only when clearly justified i.e. only when they clearly improve the document,
- emphasis to be given to describing those properties which are of engineering significance, and
- the guidelines should cover both field and laboratory description (the present document more or less does this).

Some comments show that many of our members are not familiar with the Unified System, as they are raising issues

or making suggestions that are clearly contrary to that System. Geotechnical engineers do not work in isolation from the rest of the world, so there is nothing to be gained by devising our own private system out of kilter with the rest of the world.

The silt and clay 'particle size' versus 'behaviour' issue

This was a major source of controversy and dissension when the original document was prepared, and judging from comments received it is still an issue. It is an example of lack of knowledge of the Unified System. There has never been any ambiguity on this issue in the Unified Classification System – behavioural characteristics were adopted back in the 1940s when the system was first proposed by Casagrande. If anyone is in any doubt about this matter, a quick reference to the Unified System will show that if a material belongs in the fine grained category, then there is no further need of particle size data. In other words, particle size measurement is needed only down to the silt/sand boundary, i.e. the 0.06 mm dimension. An extract from Terzaghi and Peck's book *Soil Mechanics in Engineering Practice*, is particularly pertinent in this respect. In considering the classification of fine grained soils the book states:

"Any system of classification based on grain size alone is likely to be misleading, because the physical properties of the finest soil fractions depend on many factors other than grain size. For example according to any of the commonly used conventions [in use at that time, 1948, based on particle size] a soil consisting of quartz grains of colloidal size should be called a clay, whereas in reality it does not possess even a remote resemblance to clay. Hence if the words 'silt' or 'clay' are used to express grain size, they should be combined with the word 'size' as in the expression 'clay sized particles'."

The point is that the distinctive properties of clay do not arise primarily because of its particle size, but because it consists of clay minerals. Grinding up a rock till all particles are finer than 0.002 mm will not create a clay, whereas the weathering process which converts rock minerals to clay minerals will, even if many particles are not finer than 0.002 mm. In the commentary in the revised document, the terms 'clay fraction' or 'silt fraction' are suggested to designate the proportion of the material consisting of particles of clay or silt size. This usage appears to be in keeping with international practice.

The terms 'classification' and 'description'

Some criticism has been expressed about the usage of the terms 'classification' and 'description' in the new draft. There is no wish to be dogmatic about the meaning of these terms. Their usage in the document is clearly explained, and appears to be in keeping with international practice. For example the Australian soil document on soil classification/description (Australian Standard AS 1726, 1993), contains the following statement:

"In a soil description, the terms used should be presented in a logical, consistent order, which:

Distinguishes between composition, condition, and structure of the soil, describes firstly, the information which may be obtained from a disturbed sample, [and] secondly, describes the additional condition and structure properties which may only be observed in an undisturbed soil.

Order of description:

- Classification – symbol or soil name,
- Condition of soil – moisture condition and consistency (S_u or R_D).
- Structure of soil – zoning, defects etc,
- Additional observations."

The revised document follows the Australian procedure. The British Code of Practice on soil description is slightly different, and seems to use the term 'classification' to refer to rigorous laboratory classification as a completely separate exercise to field classification and description.

The table of soil consistency – the undrained strength boundaries

Some UK readers have rightly noted that the scale of undrained shear strength used for categorising clay consistency is different from British practice. The table in the revised document is the same as in the original document, and the same as in the Australian standard. It is also essentially the same as that given in Terzaghi and Peck's book *Soil Mechanics in Engineering Practice*. However, this may well be an issue which the committee will want to reconsider.

The Scala penetrometer values in the density index (relative density) table

Several people have questioned the origin of the Scala values used in this table. There is an odd comment below the table

in the original document disclaiming any correlation between Scala values and SPT or CPT values. The Scala values have simply been transferred from the original document, and the committee does not know the origin of the table. If any readers know any more about this, the committee would be delighted to hear from you. Unless some sound supporting evidence is forthcoming for the Scala scale, the committee is likely to remove it altogether.

Rock description versus soil description

Some comments have been received suggesting that the basic approach for the soil description section and the rock description of the document should be the same. While this may appear sensible at first sight, there are very fundamental differences between the materials, which make a uniform approach impossible. These differences include:

- Describing/classifying soil involves physically remoulding and manipulating the material – not possible with rock. The Unified System starts with the remoulded soil – no parallel exists with rocks.
- Soils are given specific names because of their engineering properties.
- Rocks are named because of their geological origin, which may bear little or no relationship to engineering properties.
- A soil name like 'Clayey Gravel' is immediately informative to an engineer; a rock name like 'Porphyritic Dacite' is not. (This is not to suggest that such names should not be used – if that is the correct name of the rock it should be used).
- Soil classification/description methods were devised by soil engineers, whereas rock methods were devised by mining and tunnelling engineers etc.

Particular geological formations

Some readers have suggested that sections be included covering particular geological groups, such as the Auckland Waitemata group materials, the Northland Allochthon group, volcanic soils and organic soils. Current thinking of the committee is that systems specific to such groups are very useful, but would probably best be included as appendices, rather than in the main text of the document.

NZGS Soil & Rock Description 'Revision' Committee

Geoff Farquhar, David Burns, Doug Johnson, and Laurie Wesley

Are the Foundations on 'Good Ground'?

From the BIA News

Why new-home builders need to consider the condition of the soil on their site

Key concerns of people building a new home are usually the building itself, the landscaping and other environmental factors. The importance of the engineering properties of the soil on the building site, however, is a matter of significance that is often overlooked by the homeowner.

Many new homes are designed and built to NZS 3604 *Timber Framed Buildings*, which is part of Acceptable Solution B1/AS1 but is specifically limited to buildings that, amongst other things are founded on 'good ground'.

The term 'good ground' is defined in NZS 3604 as "any soil or rock capable of permanently withstanding an ultimate bearing capacity of 300 kPa" and excludes:

- potentially compressible ground such as top soil, soft clay and uncompacted gravel;
- expansive soils with a high liquid limit and that contract or expand excessively with changes in moisture content;
- ground that is likely to move as a result of subsidence, slippage, seasonal changes, the effects of tree roots, or other site conditions.

A building constructed on poor ground could suffer major damage to the extent of having to be demolished, but in most cases the damage is less spectacular. However, that damage could still be a basis for the territorial authority deeming the building dangerous or unsanitary, and requiring the necessary repairs to be done. Those repairs can be very expensive.

Establishing that the site has 'good ground'

It is the responsibility of building owners to establish that 'good ground' exists at the building site, and to confirm this when applying for the building consent. That responsibility is frequently delegated to the designer, who might also be the builder engaged by the owner. In many situations as detailed in NZS 3604, it will be reasonable to base the determination at least in part, on the fact that similar

buildings on adjacent sites have performed satisfactorily.

The territorial authority will often be able to supply information on ground conditions. It should have information on sites that are subject to unsatisfactory conditions recorded on the project information memorandum (PIM). The PIM however, only records information known to the territorial authority, which cannot be expected to have detailed geotechnical data for its entire district. Where there is any doubt as to the ground conditions, the owner should seek the necessary expert advice, which may include soil testing on site.

What if the site does not have 'good ground'

If a building site does not meet the requirements of 'good ground', the owner has two basic choices. Firstly, it might be possible, with suitable earth-works, to improve site conditions and provide 'good ground', allowing the building to be constructed in accordance with NZ 3604. Alternatively, it will be necessary to have the building specifically designed, either in accordance with B1/VM1 or some 'alternative solution' that the territorial authority is satisfied complies with the Building Code. Regardless of the approach adopted, the building consent application must be supported with sufficient technical information to satisfy the territorial authority that the completed work will satisfy Building Code requirements.

Summary

- the quality of soil on a building site is a matter of significance often overlooked by the consent applicant;
- buildings constructed on poor ground could suffer damage;
- building owners who base their design on NZ3604 are responsible for establishing the building will be on 'good ground' when applying for building consent;
- if 'good ground' does not exist specific engineering design will be required.



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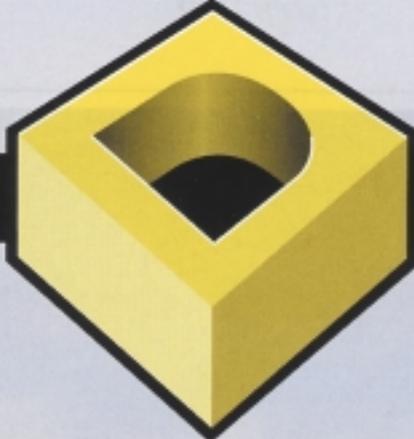
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BOOK REVIEW

Problem Solving in Soil Mechanics

This text is a relatively short book at 175 pages long. In the preface it states that the book is intended as a supplement to a larger book by the same author and its main aim is to stimulate problem solving and aid in self-teaching.

There are ten chapters in the book as follows:

- Nature of Soils, Plasticity and Compaction.
- Effective Stress and Pore Pressure in Saturated Soils.
- Movement of water through soil.
- Shear strength of soils and failure criteria.
- Stress distribution and settlement in soils.
- One-dimensional consolidation.
- Application of Limit Analysis to Stability Problems in Soil Mechanics.
- Lateral Earth Pressure and Retaining Walls.
- Stability Earth Slopes.
- Bearing Capacity of Shallow Foundations and Piles.

Each chapter of the book has a short introductory section, typically one page or less, 15 to 20 pages of worked examples and about a page of references and follow up readings. In total there are 114 examples.

This book is not for someone looking for a deep theoretical understanding of soil mechanics. It would be extremely useful however to help work through problems that come up at irregular intervals and you are not too sure how to solve. Certainly the impressive range of worked examples in this book cover most basic, and not so basic, engineering problems.

If you are looking for a well-balanced, basic soil mechanics text book through which presents both theory and examples, I think that I would probably stay with my copy of Soil Mechanics by Craig.

Reviewed By: Ian McPherson,
Connell Wagner Ltd, Wellington

Problem Solving in Soil Mechanics

| | |
|------------------|---|
| Author: | A. Aysen |
| Publisher: | A.A. Balkema |
| Date published: | February 2003 |
| Page extent: | 175 pages |
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| Web shopping at: | http://balkema.jcn.nl/ima/balkema/index.html |
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PROJECT NEWS

Amelioration of Liquefaction Risk at the Tuaropaki Geothermal Power Station, Mokai, New Zealand

Evan Giles, Principal, URS New Zealand Limited

Anthony Fairclough, Senior Geotechnical Engineer, T & T Konsult

Dedication: This paper is dedicated to the memory of John Norrie, who, as Principal of Cheal Hindess Battersby and Norrie Ltd, lead the consulting and design team from concept to inauguration. John contributed to the earlier drafts of this paper but tragically lost his life in a skiing accident prior to its completion. His dynamism, in our view, played no small part in the fast track achievement of a most successful project.

Summary

The new Tuaropaki 58 MW Geothermal Power Station has been operational at Mokai for some 24 months. The site lies approximately 30 km north-east of Taupo, within the Taupo Volcanic Zone. Preliminary geotechnical investigations identified that the soils underlying the proposed power plant were susceptible to liquefaction when subjected to seismic loading.

Alternative power plant sites were sought and when no suitable alternative could be identified, a number of foundation options were assessed including piles, stone columns, and deep excavation coupled with dewatering. Stone columns were identified as the optimum foundation solution. Project prices and timeframes were fixed so there was considerable pressure for a speedy and economical resolution.

The geotechnical work completed included a seismic assessment, liquefaction assessment, assessment of lateral spread, slope stability analysis, and detailed foundation design. This paper summarises the design and construction aspects associated with improving the foundation soil conditions for the Tuaropaki Geothermal Power Station.

Project Description

The Tuaropaki geothermal project is the largest privately developed project of its type in New Zealand and is the most modern and advanced of its kind. The plant was developed and is owned by the Tuaropaki Power Company Ltd, wholly owned by the Tuaropaki Trust. Ormat Pacific Inc, a subsidiary of Ormat Industries Ltd of Israel as the EPC (Engineer Procure Construct) contractor, were responsible for all design, equipment and materials supply, and construction from the wellheads at Mokai to the national grid connection point at

Whakamaru. Cheal Hindess Battersby and Norrie were the civil and structural consulting engineers for the project and were assisted by URS New Zealand (formerly Woodward-Clyde New Zealand Ltd) for the geotechnical and some structural elements of the work. The construction cost of the project was approximately NZD\$130 million.

The power plant comprises one 30 MW GE back pressure turbine and generator, and six binary ORMAT® Energy Converters, four utilising LP steam at 1.2 bar and two utilising separated brine. The transfer fluid is isopentane. There are 156 Ormat designed aircooled condensers. The generated electricity is delivered via a 22 km connection to the Transpower Whakamaru substation. This first stage development of the geothermal fields in the Tuaropaki Trust lands harnesses 25% of the resource and is delivering 58 MW at the grid link.

Site Description

The geothermal wells and the Power Station site are located on land collectively known as Tuaropaki E. This parcel of land is the result of a 1952 amalgamation of lands owned by members of the seven Mokai hapu – Parekaawa, Te Kohera, Wairangi, Whaita, Moekino, Haa, and Tarakaiahi. These hapu have affiliation to both Ngati Tuwharetoa and Ngati Raukawa. Figure 1 shows the locality of the site within the Taupo region.

Site Geology

Published geological maps (DSIR 1960) and unpublished geological reports (Kingston Morrison and Works Geothermal) indicate the site is underlain by a complex series of alluvium, ignimbrite, rhyolite and other volcanic deposits. The geologic units that lie within the influence zone of the proposed foundations are Taupo Pumice Alluvium, Mokai Sand and Mokai Ignimbrite. Several active faults have been identified within a 5 km radius of the power station site. Two faults run within 1 km of the power station site.

Engineering Geology

A walkover survey of the site and a study of aerial photographs showed evidence of active soil creep and surficial sloughing, the latter presenting as shallow scarps. Several small tomos (erosion piping) and two springs were

also identified. As the work progressed, rigorous studies of stereo-pair aerial photographs suggested possible liquefaction flows across the Mokai region that probably occurred during the last major seismic event.

Seismic Activity

Mokai lies within the Taupo Volcanic Zone, which is an area of high seismo-tectonic activity. Many potentially active fault traces have been identified in the region.

In the period 1942 to 1989 there have been thirty

earthquakes of Modified Mercalli Intensity V (MM V) or greater in this zone. In the period 1840 to 1989 there has been one earthquake of MM VI or greater. Smith and Berryman (1983, 1992) indicate that the Serviceability Earthquake for Mokai is a MM VII earthquake with a return period of 50 years. The Maximum Credible Earthquake for Mokai is a MM IX earthquake with a return period of approximately 1000 years.

Based on the above earthquakes, the criteria in Table 1 below were used for design purposes:

Table 1 Earthquake Design Criteria

| Earthquake Scenario | Estimated MM Intensity at the Mokai Power Station Site | Estimated Richter Magnitude at the Earthquake Source | Estimated Peak Horizontal Ground Acceleration |
|-----------------------------|--|--|---|
| Serviceability Earthquake | VII | 5.0 | 0.35 g |
| Maximum Credible Earthquake | IX | 7.5 | 0.70 g |

The values tabled were based on soft soil conditions with the structural ductility factor taken as unity. The values have been inferred from charts, tables and formula from Smith and Berryman (1983, 1992), NZS 4203 (1992), Das (1993), Kramer (1996) and Yeats et al (1997).

Volcanic Activity

The Taupo Volcanic Zone has the highest volcanic hazard risk in New Zealand. Over the last 150 years there have been several volcanic events in the zone. These ranged from light ash showers such as those erupted from Mount Ruapehu in 1996 and 1997 through to the violent and destructive eruption of Mount Tarawera in 1886, which resulted in the loss of 150 lives.

Mokai is sited approximately 160 km northeast of Mount Ruapehu and approximately 60 km southwest of the Okataina Volcanic Center and Mount Tarawera. Although the immediate volcanic hazard is limited to the area immediately adjacent to the eruptive source, it can be expected that Mokai will be subjected to ash fallout sometime in the future.

Potential sources of ash fallout within a 200 km radius of Mokai include Ruapehu/Tongariro, Maroa, Taupo, Okataina and Rotorua. The Ministry of Civil Defense (1991) indicates Mokai may be covered in a layer of ash between 50 and 150 mm thick after a moderate sized eruption from the Okataina Volcanic Center.

Geothermal Activity

The geothermal power station is sited in an area of geothermal activity. There are two natural hot water springs sited near Mokai approximately 2.5 and 5.0 km from the proposed power station site. To date, five productive

geothermal bores have been sunk within 2 km of the proposed power station. These bores penetrate to a depth of between 1200 and 1800 m below the ground surface and supply heat energy for the power station.

Subsurface Investigations

Ten backhoe testpits, seven investigation drillholes and 45 Cone Penetrometer Tests (CPT's) were completed in a staged investigation process on and adjacent to, the site of the geothermal power station site.

Taupo Pumice Alluvium

Taupo Pumice Alluvium was encountered in approximately two thirds of the drillholes and testpits. When present, this unit was found to extend to a maximum depth of 3.8 m. It comprised fine to medium sized pumice gravel in a fine to coarse-grained pumice and quartz sand matrix. The pumice gravel was typically sub-rounded to sub-angular, of low density and with a high void ratio. Uncorrected Standard Penetration Test (SPT) N values ranged between 0.5 and 6; average 4. These results indicate that the Taupo Pumice Alluvium at the site has a very loose to loose consistency. CPT tests performed within the Taupo Pumice Alluvium showed the cone resistance of the material to be variable and to range between 0.5 and 10 MPa. The average cone resistance was approximately 6 MPa.

Mokai Sand

Mokai Sand was encountered in all of the drillholes and testpits and was found to comprise a silty fine to medium grained pumice sand. It is an unwelded deposit and was found to generally extend from the ground surface, or to underlie the Taupo Pumice Alluvium.

At the power station site, the Mokai Sand layer can be sub-divided geotechnically, on the basis of strength, into an upper and lower unit. The upper unit extends to a depth of between 5 and 12 m below the ground surface and overlies the lower Mokai Sand unit

Field observations, analysis of CPT results and laboratory test results indicated that the upper Mokai Sand unit is susceptible to liquefaction when saturated and subjected to cyclic loading. Cyclic loading can result from rotating or oscillating machinery and from seismo-tectonic activity. Uncorrected SPT N values in the upper Mokai Sand unit ranged between 3 and 12 with an average of about 6, indicating a very loose to medium dense consistency. Uncorrected SPT N values in the lower Mokai Sand unit ranged between 15 and refusal, with an average $N > 30$, indicating a medium dense to very dense consistency.

CPT tests performed within the upper Mokai Sand indicated that the cone resistance of this material is variable (between 0.2 and 14 MPa) with an average cone resistance of approximately 5 MPa. CPT tests performed within the lower Mokai Sand unit indicated a cone resistance of between 10 and in excess of 30 MPa with an average cone resistance of approximately 20 MPa.

Mokai Ignimbrite

Mokai Ignimbrite was encountered in drillholes BH2, BH3, BH4 and BH7 at between 7.7 m and 19.25 m depth. The thickness of ignimbrite encountered was variable and ranged between 0.35 m to in excess of 4.6 m thick. Mokai Sand was found to underlie a thin layer of Mokai Ignimbrite in drillholes BH3 and BH4. Logs of geothermal wells near the site (Kingston Morrison) indicate that the Mokai Ignimbrite can be over 200 m thick.

The Mokai Ignimbrite is highly variable and was found to comprise interbedded layers of slightly weathered or hydrothermally altered, unwelded to moderately welded, silty sand, silty clay, sandy silt and sand.

Uncorrected SPT test results in the Mokai Ignimbrite ranged from 21 to refusal with an average of approximately 30, indicating a medium dense to dense consistency.

Groundwater Conditions

Pore pressure measurements taken during CPT indicate that there is a complex groundwater regime present. Analysis of the CPT results indicates that there are two or three perched groundwater tables present within the upper Mokai Sand unit. These groundwater levels appear to be discontinuous across the site and recharge is controlled by direct rainfall.

Shallow piezometers on the site indicate that the surface of the uppermost perched groundwater table, beneath the power station, is between 2 m and 4 m below the natural ground surface. Evidence of two springs was identified on the aerial photographs and during the site walkover. These springs are located beyond the proposed building

platform sites on the north-eastern slope. At the time of the field investigations, both of these spring areas were observed to be wet.

Geotechnical Analysis

It was found that the upper Mokai sands were susceptible to liquefaction. The extent of the liquefaction susceptible material was estimated at the drillhole and CPT locations using the SPT and CPT results and a combination of empirical and numerical methods developed in the United States (Woodward Clyde 1996 and NCEER 1997).

The results of the liquefaction calculations were used to construct a contour plan of the base of the liquefaction susceptible material. The base of the liquefaction zone under the building platforms, during a MM IX earthquake, was found to be between R.L.447.7 m and R.L.468.3 m. It was found that the extent of liquefaction during a MM VII earthquake is similar to that during a MM IX earthquake.

The upper 0 to 2 m of natural ground above the groundwater table is unlikely to liquefy during seismic loading, however, this firm "crust" is likely to move in sympathy with underlying liquefied material during a sufficiently large earthquake.

Foundation Options

The power station required the construction of a level building platform with plan dimensions of approximately 210 x 135 m. The identification of a potential liquefaction hazard led to various building platform and foundation options being assessed at the preferred power station site. Three foundation options were selected for more detailed assessment. The first option placed key structures onto piled foundations. The second removed the liquefaction risk by creating a platform totally within a cut taken down to dense sands. This option requires extensive dewatering works. The third option relied on stone columns for rapid pore pressure dissipation as well as overall densification. These options are described below. In addition, several alternative locations were identified, and a preliminary site assessment conducted for each. All the alternative sites were found to be unsuitable for a variety of geotechnical, topographical or economic reasons.

Settlement and Displacement.

A preliminary estimate of settlement and lateral displacement due to static and seismic loading was made for the three options, using the CPT results and a combination of empirical and numerical methods (Kramer 1996, Ambraseys and Menu 1988, Bartlett and Yould 1995, Fang 1991, Flemming et al 1986, Xanthakos 1994 and Paulos and Davis 1980). Preliminary estimates of the foundation movements are summarised in Table 2. For preliminary geotechnical design purposes, the piles were assumed to be 300 mm diameter hollow steel tube sections.

Table 2: Preliminary Estimate of Foundation Settlement and Lateral Displacement

| Foundation Option | Estimated Settlement Due to Normal Service Loads (mm) | Estimated Settlement Due to a MM VII Earthquake (mm) | Estimated Lateral Displacement Due to a MM VII Earthquake (mm) | Estimated Settlement Due to a MM IX Earthquake (mm) | Estimated Lateral Displacement Due to a MM IX Earthquake (mm) |
|-----------------------------|---|--|--|---|---|
| Option 1* Piles | ≤ 5 | ≤ 10 | 300 to 600 | ≤ 10 | >2000 |
| Option 2** Cut Platform | ≤ 5 (2 Average) | 0 to 10 (4 Average) | 0 | 0 to 20 (8 Average) | 0 to 20 |
| Option 3** Stone Columns | 0 to 20 (8 Average) | 0 to 40 (15 Average) | 0 | 0 to 70 (30 Average) | 0 to 20 |

* Settlements and lateral displacements calculated assuming 300 mm diameter steel piles.

** Settlements and lateral displacements calculated using typical foundation dimensions.

Driven Piled Foundations

This option required the construction of a cut and fill building platform between R.L.465.00 m and R.L.463.65 m, and the installation of driven pile foundations under key structures. It was anticipated that the piles would be embedded 2 m into the dense Mokai Sand layer resulting in an average pile length of approximately 9.2 m.

While the calculated static load movements were acceptable, the response to seismic loading was unacceptable. The estimated displacements are of such a magnitude that yielding and failure of the piles can be expected during a serviceability earthquake.

The use of raked piles to provide additional lateral support and reduce pile deflections was assessed as part of the preliminary design, but it was concluded that raked piles are an inappropriate mechanism for resisting seismic lateral loads. Observations in the United States show that raked piles do not perform satisfactorily during seismic loading. This is because during an earthquake the lateral loads are concentrated at the pile connections resulting in severe damage, or failure, of the pile caps.

Permanent Lowering of the Groundwater Table

This alternative required a creating a building platform fully in cut between R.L.457 m and R.L.455.65 m. The surface of this building platform was expected to comprise dense sand suitable for the construction of reinforced concrete strip and pad type foundations.

To enable this option to be constructed, the groundwater level under the building platform had to be temporarily lowered. In addition, a network of subsoil and horizontal drains would be required to permanently lower the groundwater table within and immediately adjacent to the building platform. A 12-hour pump test was performed to determine the geohydrological characteristics of the site. Watertable draw-down was observed at the three monitoring wells closest to the production well. The test data was analysed using methods described by Kruseman and de Ridder. The

hydraulic conductivities (K) calculated from the pump test ranged from 3×10^{-6} to 6×10^{-5} m/sec with a geometric mean of 1×10^{-5} m/sec (Table 3). The hydraulic conductivities presented were in the range expected for silty sands to fine sands.

Table 3: Estimates of Hydraulic Conductivity* (m/s)

| ANALYTICAL METHOD | OW1M | OW8 | OW10 |
|----------------------------|--------------------|--------------------|--------------------|
| Theis Curve Fitting Method | 6×10^{-6} | 5×10^{-5} | 3×10^{-6} |
| Theis Recovery Method | 3×10^{-6} | 4×10^{-5} | 6×10^{-5} |
| Cooper Jacob Method | 7×10^{-6} | 5×10^{-5} | 5×10^{-5} |
| Nueman Method | 3×10^{-6} | 4×10^{-5} | 4×10^{-5} |

* Data may be effected by aquifer heterogeneity

Based on the maximum flow of 20 l/min obtained from the production well and the hydraulic conductivity data presented above, well points were considered to be the most efficient way of dewatering the soils during construction. However, since wellpoint drawdown is limited to 4 to 5 m depending on the permeability and soil structure, to lower the watertable by around 11 m up to three levels of well points would be needed. Based on the fine sandy nature of the soils and the depth of dewatering required, a close spacing of well points was required and dewatering was estimated to require several weeks.

Stone Columns

The third option required the construction of a cut and fill building platform between R.L.465.00 m and R.L.463.65 m, and the installation of stone columns under the building footprint to improve subsoil conditions. Reinforced concrete strip and pad type foundations would be placed on the area improved by stone columns.

The stone column design ameliorates the risk of liquefaction by increasing the permeability and excess

Table 4: Preliminary Stone Column Design

| | |
|--|---|
| Proposed Building Platform Level: | R.L.465.00 m falling at 1:100 to R.L.463.65 m |
| Stone Column Material: | Durable medium to coarse sized gravel (40 to 100 mm size) |
| Estimated Total Number of Stone Columns: | 2700 |
| Stone Column Diameter: | 1.0 m |
| Stone Column Spacing: | 3.0 m spacing directly under, and up to 6 m beyond key buildings and structures |
| Estimated Length of the Stone Columns: | 3.0 to 10.3 m |

pore-water dissipation characteristics of the site and by increasing the ultimate strength of the ground through an increase in the insitu confining stress. The vertical stiffness and lateral shear resistance of the soil is also improved through the ground densification. The stone column design completed for the Taupaki Power Station is summarised below in Table 4.

Selection of the Foundation Option

A feature of Ormat power stations is that a short construction period is possible because of modular design and the use of many proprietary off-the-shelf components. The configuration of Ormat power stations results in many relatively small foundations. At Taupaki there are about 600 individual foundations. Individual foundation loads are generally small.

The centre of mass of many components is relatively high above ground level. The net result is that for almost all foundations, overturning under seismic or temperature loads is the critical design case. There are many items of rotating equipment: one 30 MW turbine generator (TG), six nominal 5 MW TG's, 156 fourteen meter diameter condenser fans, and many pumps. There are many hundreds of meters of steam pipe, some up to 1650 diameter and therefore stiff, and several pressure vessels. Control of settlement is therefore important.

Table 5 sets out the advantages and disadvantages of the options, from which the reason for the choice of stone columns as an amelioration method can be deduced.

Construction of the Stone Columns

Layout of the many foundations in the power plant was determined by plant design and could not be adjusted to suit stone columns. The layout of the stone columns therefore varied across the site to best-fit the foundation layout and dimensions. For example, a footing 4 m square would have one stone column under each corner, at 3.4 m x 3.4 m centres. The turbine generator is supported on four rows of stone columns at 2.1 m x 2.2 m centres. Air cooler footings, at 5.56 m x 5.8 m, have stone columns at 2.78 m x 2.9 m. The area between the structures was augmented with uniformly spaced stone columns. A minimum of two rows of stone columns was provided outside the foundation footprint, to provide edge protection. Under the 50 tonne pentane tank, spacing was closed up by placing additional stone columns at the centres of the square pattern used, on the basis that failure would have the worst consequence at this site and because the depth of liquefiable sand was a maximum (11 m). Stone column placement included the main gate area to protect access in the event of fire after an earthquake.

The Vibroflot process used to create the stone column consists of a vibrating tool of 600 mm diameter, some 10 m long, suspended from a mobile crane. Vibration is developed by a rotating eccentric weight driven by a 75 kW electric motor inside the unit. High pressure water jets in the tip assist in penetration. While not dissimilar to a large concrete vibrator, technical fabrication details are closely guarded by the manufacturers.

The Vibroflot unit is lowered into the ground and effectively liquifies a ring of ground around it. The water

Table 5: Comparison of Options

| Option | Piles | Deep Cut | Stone Columns |
|---------------|--|--|---|
| Advantages | <ul style="list-style-type: none"> NZ plant available Fast installation Early start to superstructure | <ul style="list-style-type: none"> Use standard foundations Use NZ plant Small lateral displacements | <ul style="list-style-type: none"> Place strategically under standard foundations Pore pressure dissipation Low lateral displacement |
| Disadvantages | <ul style="list-style-type: none"> CAVEAT: Large lateral displacement | <ul style="list-style-type: none"> Concern regarding long term drain functionality Slope stability issues 300,000 m³ spoil | <ul style="list-style-type: none"> No NZ plant |

jets assist in penetration and flush out fine materials. Once the full column has been liquefied, coarse stone is mechanically force-fed into the hole, and the Vibroflot is worked up and down to compact the stone and drive it into the surrounding ground. The process continues until no more stone can be introduced.

Subsequent excavation for foundations showed the stone columns to be distinctly formed, about 1.2 m diameter with dense packing of the stone and a clear cut transition to natural ground.

Water Supply

About 1200 m³ of water per day was required. Resource Consent (RC) applications to take and discharge were lodged as soon as the stone column option was confirmed. No time delays arose from the RC application.

Return water from the operation of the Vibroflots has a high silt load. At times the whole site was awash with muddy water. This dirty water was treated by extending retention on site through the use of settling ponds in series. The Resource Consent required water leaving the site to have a suspended solids concentration not exceeding 100 gm/m³. This was exceeded on only one occasion, four days after work started.

Contract Details

A contract was negotiated with Brian Perry Ltd and Keller Grundhau Gmb. The Vibroflot units, belonging to Keller Grundhau Gmb, were shipped from Australia. Three Vibroflot units were provided, two for use and one in reserve. The contract was signed on 22 October 1998, the first stone column was installed on 31 October, the last on 6 January 1999. Construction statistics were:

| | |
|---------------------------------------|----------------------|
| No. of stone columns | 2686 |
| Length of stone columns | 22304 m |
| Volume of stone used (paid) | 27210 m ³ |

Construction Monitoring

Control was effected during construction as it is not practical to check stone columns after completion. The total amount of stone used was determined from quarry records, less an allowance for wastage.

The Contractor provided staff dedicated to recording stone column construction, and provided written records of the following for each column constructed:

- Stone Column ID
- Time start and finish
- Depth
- Volume of stone placed

The maximum stone consumption was 24 m³ for 10 m, i.e. 2.4 m³/m, and the least (very common), 1m³/m. The average was 1.22 m³/m. Stone columns varied in depth from 6 m to 11 m and averaged 8.3 m.

Verification

An attempt was made to verify the improvement in density of the natural ground by repeating CPT at some original locations. There was no discernable difference between the “before” and “after” CPT plots. This is consistent with the Wesley et al (1998) findings regarding the lack of sensitivity of pumice soils to CPT probing.

A large test pit, intersecting 3 stone columns, was excavated in the centre of the site where original investigation test pits were unstable (depth about 3 m, some 2 m into the Upper Mokai Sand). The test pit was completely stable and the *in situ* soil was assessed as medium dense. The stone columns were found to be densely packed and the effectiveness of the stone columns to freely discharge water was also confirmed.

Conclusion

The geotechnical team went on to a green field site to undertake the first round of geotechnical investigations on 1 July 1998. The power station was supplying power at its rated capacity in December 1999, 17 months later.

Identification of the liquefaction susceptibility of the site had the potential to cause serious delays. It is a tribute to all concerned, engineers, contractors, client, and owner's engineer, that the issues were identified and resolved expediently with no delay to the overall construction programme.

Stone columns are a ground improvement technique. Structural foundations are still required to support the plant and buildings and to provide resistance to overturning under earthquake and thermal loads. Conversely there is no foundation system that could be made to work on the site without ground improvement. Stone columns fulfilled all of the requirements – geotechnical, structural, programme and cost.

The construction contract was a conventional measurement contract under NZS 3910.

Acknowledgement

Cheal Hindess Battersby and Norrie Limited, and URS New Zealand Limited would like to thank Ormat Pacific Inc and the Tuaropaki Power Company Limited for their support and permission to publish this paper.

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Figure 1. View of completed power station.



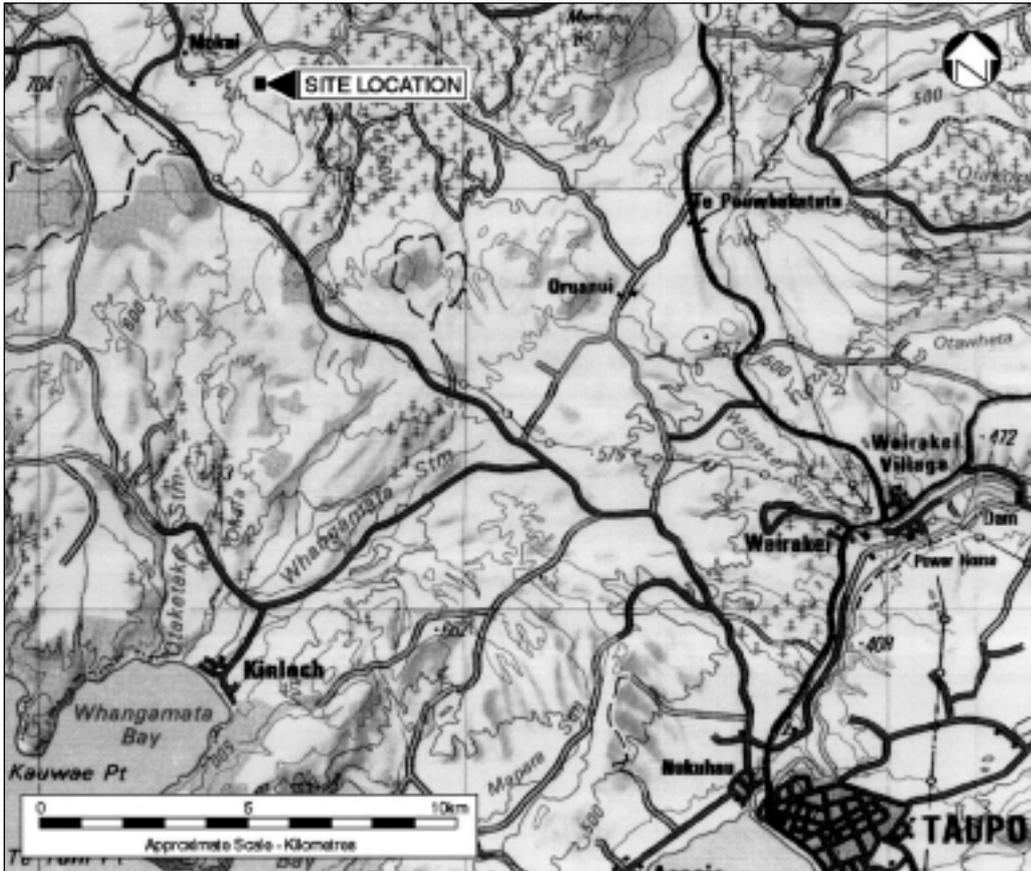
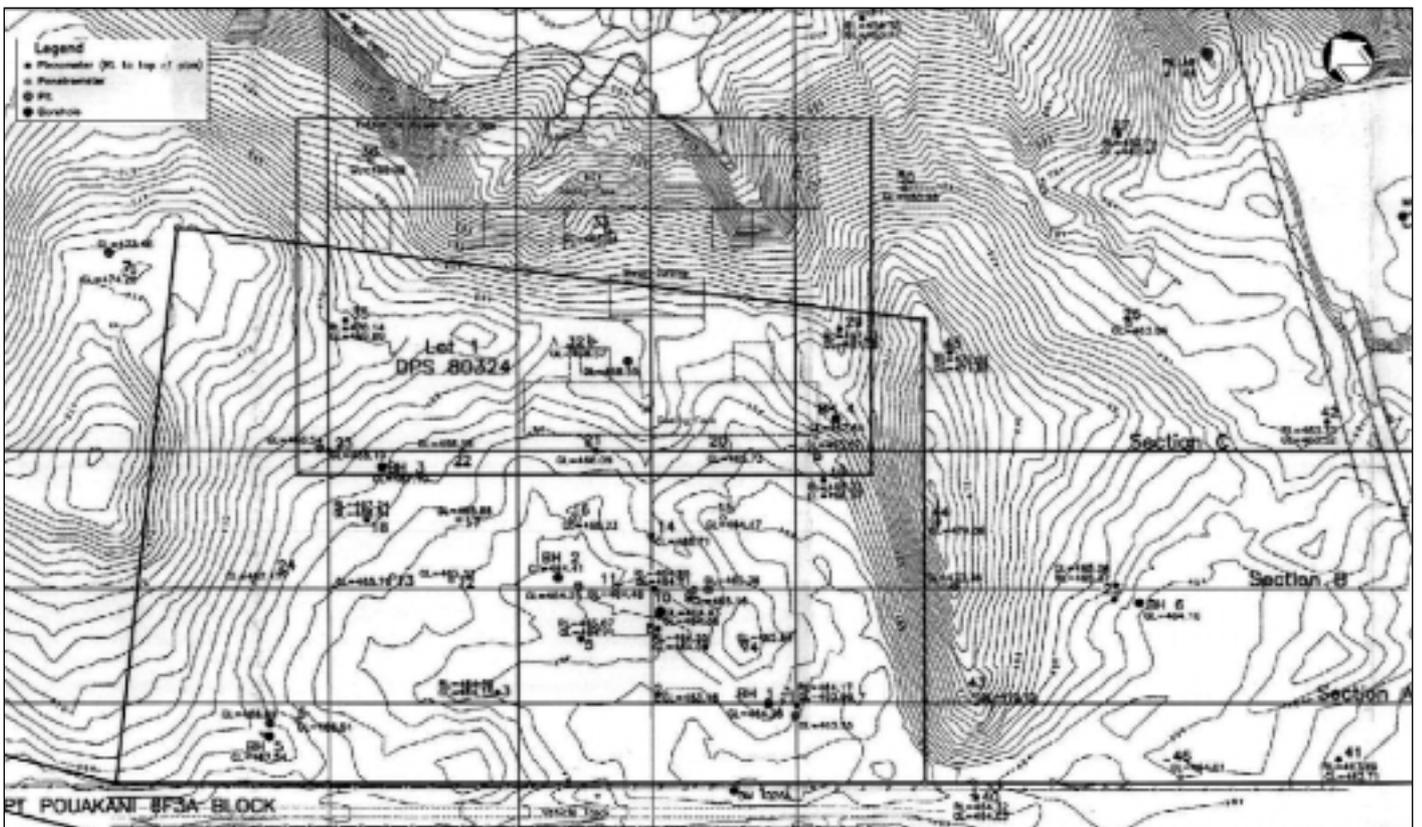


Figure 2. Locality plan

Figure 3. Contour plans



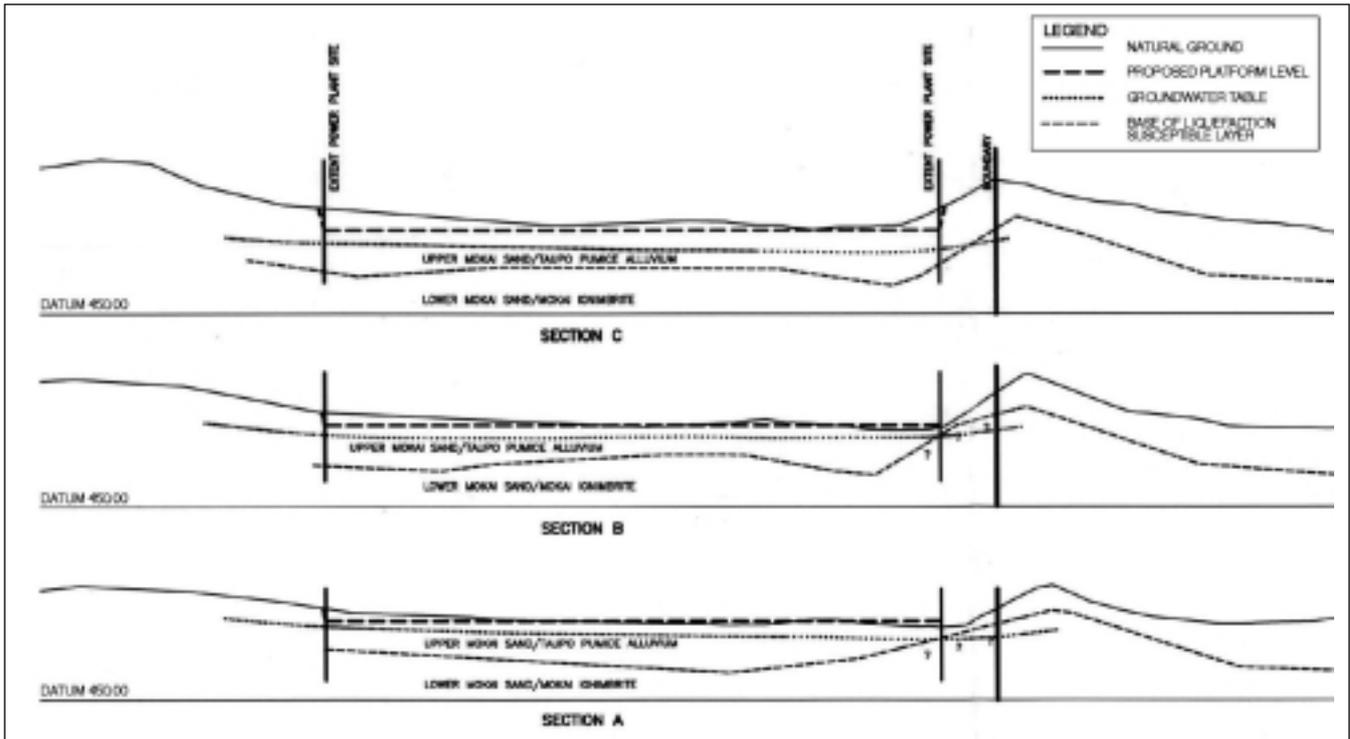


Figure 4. Cross sections.

Check it out – we are online!

- New NZ Geotechnical Society website
- Regularly updated
- Has a comprehensive list of what is on
- Includes the Shear Vane Guidelines



www.nzgeotechsoc.org.nz

Etsong Geogrids for Sub Grade Improvement Works

Moninder Bindra, Permathene



Above: SH 2 Kaitoke To Te Marua Realignment, Upper Hutt

Transit New Zealand is constructing a new \$14.2 million, 5.5 km long section of SH2 between Kaitoke and Te Marua, just north of Upper Hutt. Higgins Contractors are the main contractors with Rick Goodman and Sons Ltd the bulk earthwork sub-contractor. The process of clearing and preparing the route of the road is well underway. This includes installing drainage, clearing topsoil and shifting ground material from hilly areas into hollows to provide a consistent new road in the naturally hilly terrain. In some areas the contractors are excavating down to 25 meters below the existing surface and moving this ground material into low troughs to build up the land. In total there is 500,000 cubic meters of soil to move.

Permathene supplied approx. 21,000 m² of Etsong Geogrids for sub grade improvements works. The geogrids were laid in layers on the weak sub grade and

covered with good soil before putting the new road on it. Permathene also supplied approx. 60,000 m² of Syntex Nonwoven geotextile for sub grade improvement and drainage applications.

Etsong and Syntex are distributed exclusively by Permathene Ltd in New Zealand and manufactured at an ISO 9000 facility. These products are tested and inspected in quality control laboratories accredited by the Geosynthetic Accreditation Institute's Laboratory Accreditation Program before shipment.

For further information, contact

Permathene Ltd – Civil Engineering Division

Phone: 09 820 7231

Email: info@permathene.com

Website: www.permathene.com

Functional Longevity for the Ages!

Moninder Bindra, Permathene

In keeping with the Auckland City's strict focus on sediment reduction and environmentally friendly products, the Auckland City Council is moving from the conventional hard armor channel lining systems such as concrete or rip-rap to a more environmentally conscious, cost-effective and aesthetically pleasing alternative such as Erosion Control Blankets (ECBs) and Turf Reinforcement Mats (TRMs) for channel lining works.

Jackson Clapperton, a registered engineer specified Pyramat high performance TRM manufactured by SI Corporation, USA to line storm water drainage channel for Turner Trust Ltd's project in West Auckland. Pyramat is a patented, three-dimensional woven geotextile matrix composed of UV stabilized polypropylene monofilament yarns. This environmentally superior soft armor solution combines long-term strength, durability, dimensional stability and the functional longevity of a high performance geotextile. The unique three-dimensional geometry of Pyramat, in conjunction with vegetation, reduces the velocity of waters, thereby controlling erosion and reducing pollution. Pyramat is designed to withstand prolonged exposure in the challenging conditions of demanding jobsites or inhospitable climates. Ultraviolet stabilisers assure functional longevity when vegetative establishment is delayed or the matrix is otherwise exposed to extended periods of sunlight.

After applying the seed to the soil surface, Pyramat was installed on the channel sides. The excess soil and vegetation was stripped off from the slopes. Pyramat installation eliminated the need for significant excavation and site disturbance associated with the traditional rip-rap design. Once emerging roots of the developing vegetation reached the zone of reinforcement, the resulting

Figure 1: Pyramat has just been installed in the storm water channel



“revegetation platform” provided increased slope stability and erosion control on this critical sites. The contractor had to build a temporary dam to redirect the flow of water during construction. This material proved worthy of their selection and presented a cost effective stable solution that is working well and has satisfied the Council's engineers, clients and the contractor.

Benefits of Pyramat TRM versus Hard Armor Systems:

- Sediment and Pollutant Capture
- Safety
- Habitat Protection
- Ease of Installation
- Less expensive
- Facilitation of Groundwater Recharge
- Improved Appearance
- Flexible Lining System (more resistant to thermo-separation and contraction)

Figure 2: Vegetation is firmly established after a month



Permathene is a proactive leader in the area of stormwater management practices and has been recognized by the various councils in New Zealand for its innovation, assertiveness and progressively outstanding contributions. Permathene is the exclusive distributor of Pyramat in New Zealand and the Pacific Islands. For additional information regarding the use of Pyramat, contact Moninder (Witty) Bindra, Civil Engineering Division, phone 09 829 0741 or email info@permathene.com.

SPECIAL INTERESTS

Total Geological History – A Model Approach to the Anticipation, Observation and Understanding of Site Conditions

Phil Glassey, Institute of Geological & Nuclear Sciences Ltd

At the recent Geotechnical Symposium, “Geotechnics on the Volcanic Edge”, held in Tauranga, 28–30 March 2003, I was asked, at short notice, to put together a presentation for the Engineering Geological Mapping pre-symposium workshop. I was given a very broad scope and decided that I should re-emphasise the need for good engineering geological maps that put engineering sites into appropriate geological context. Although preaching to the converted, there is always new content to bring to this topic. Such material includes Sir John Knill’s inaugural Hans Cloos lecture “Core Values” presented at the 9th IAEG Congress in September 2002, and published in the latest issue of the “Bulletin of Engineering Geology and the Environment” (Volume 62, Number 1, February 2003). Another relatively recent tool for engineering geologists is the Total Geological Model, based on the paper presented at GeoEng2000 in Melbourne in November 2000 by Peter G. Fookes, Frederick J. Baynes and John N. Hutchinson.

It was the later that I presented at the workshop and then demonstrated, using examples, how sometimes we forget to go back to first principals in our mapping. The Total Geological Model is one model that can be used to get back to first principals in a site investigation and should be used by any geotechnical practitioner venturing into new and unknown terrain. The model can be found at <http://fbe.uwe.ac.uk/public/geocal/scripts/totalgeology/home.plx>.

A model approach to total geology

The Total Geological Model advocates that the ground conditions at any site are a product of its total geological and geomorphological history. The authors call this **total geological history**; it includes stratigraphy, the structure, the former and current geomorphological processes and the past and present climatic conditions. Geological models provide a way to conceptualise ground conditions and make predictions. They impose structure on data, identify patterns, allow us to draw on experience and published case histories. A site specific geological model is essential to make sense of the total geological history and predict how this will influence the engineering performance of the site during and after construction.

This site specific geological model is based on consideration of the regional and local geological and geomorphological history and of the current ground surface conditions. The approach is this:

- At the Desk Study stage one or more of the initial global scale Tectonic and site scale Geological and Geomorphological models are identified. They form a simple, related series to help develop the questions about the site that should be asked. It thus becomes the first task to identify the relevant initial models for the project area and the second to develop a check list of questions to be answered during the investigations. These will be the responsibility of the engineering geologist. The geologist may need assistance with the geomorphology.
- Combination of the initial site scale models and the site check list(s) will form the preliminary site engineering geology environment model to enable the earliest planning to take the potential broad geology and geomorphology of the area into account. The initial models and their check lists will need to be investigated thoroughly and developed by the subsequent studies.
- Development of the subsequent specific site engineering geology environment model as the investigation progresses is discussed by Fookes 1997. Initial models help plan the site investigation: subsequent development of these models to form the specific models in the walkover and ground investigation stages help engineering design and construction.

Check list questions are not new in engineering geology but to date have generally been developed for selected terrain types, e.g. extrusive volcanic, valley glacier. The approach described by the authors is based on the concept that global end members representing the entire spectrum of possibilities can be identified and presented. An initial check list for each Geological and Geomorphological model is embodied in both the annotation on the figure and in the text under the figure with the heading ‘anticipate’. The more detailed site specific check list and site specific model then needs to be made, once the clear outlines of the geology at the location are identified beyond the desk study stage.

The essence of the approach involves understanding the geology and geomorphology to be able to evaluate the anticipated conditions. To do this and to understand the models there must be some appreciation of the history of the world.

Types of Models

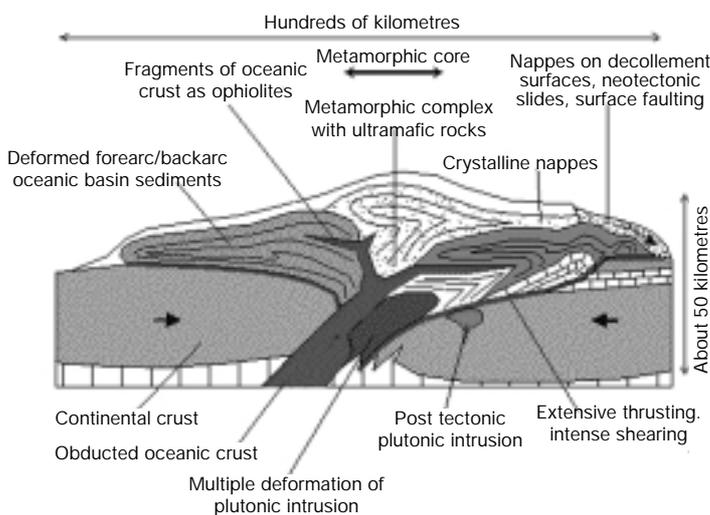
Even when no local geological information or imagery is

available a very preliminary desk study can be made, by identifying the local stratigraphic, lithologic, structural, and geomorphologic controls for the site. Knowledge of these controls is used to give a very broad picture of the possible engineering geological conditions and spatial relationships at that location, and initial, i.e. wide-ranging and not rigorous, geological model(s) can be assigned to predict geological features that might reasonably be expected in the site area. Three series of models are provided.

Global-scale Tectonic models based on plate tectonics

There are ten of these models, presented two-dimensionally, i.e. as sketch sections. They cover large areas of terrain, typically many tens to many hundreds of kilometres and set the scene for anticipating the regional structure and rocks of the area.

Below: Example of a Tectonic Model:
Convergent plate boundary – collision complexes



Lithologies:

The system forms when two masses of continental crust collide and continue to converge and hence the entire range of crustal igneous, sedimentary and metamorphic rocks may be entrained, or formed, in the collision complex, together with ophiolite sequences from pieces of oceanic crust that may be caught up in the collision.

Structure:

Major crustal thickening due to underthrusting of thick crustal slices and relatively shallow seismic events associated with the thrusting are characteristic, but considerable strike-slip faulting is also common and can form patterns suggestive of indentation of one continental mass by another. Ophiolites may be emplaced by obduction at the tectonic suture that forms between crustal masses and involves detachment of pieces of oceanic crust from the downgoing oceanic plate and thrusting onto the continental plate. Sutures are usually

intensely sheared and often separate markedly different stratigraphic or tectonic regimes. Crustal shortening of many hundreds of kilometres can result from an ongoing collision and the immense compression causes deep crustal rocks to be thrust to the surface. This results in intense ductile folding and multiple deformation episodes, intense shearing along regional thrusts, and the development of nappes as the crustal rocks are extruded from the collision complex and flow out close to the surface as huge recumbent fold systems. The rapid uplift and youthful topography combined with the neotectonic movements of nappes and sheets of tectonised crustal rocks can result in surface instability in the form of massive landslides.

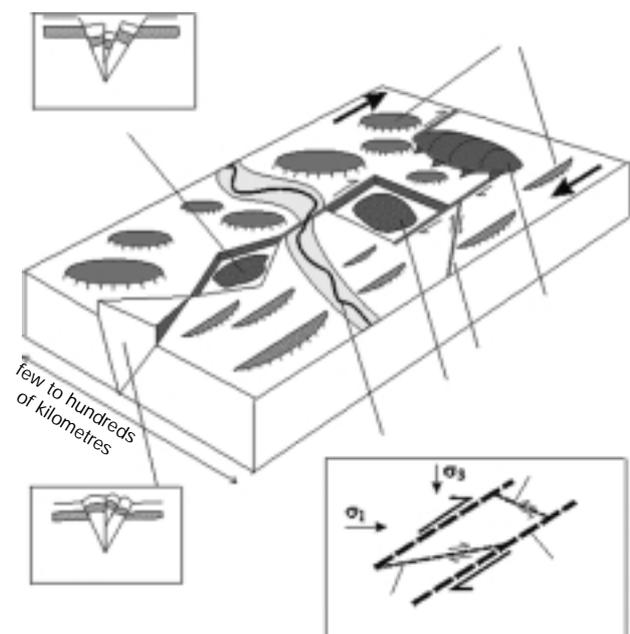
Related Models:

- entire range of igneous and sedimentary models
- plastic folds with cleavage
- multiple folds and shears
- tectonised melange
- sheared schists
- gneiss and migmatite

Local- or site-scale initial Geological models

There are seventeen of these models, presented three-dimensionally, i.e. as sketch block models, which typically cover areas from kilometres to tens of kilometres. They relate to the rock-forming environments – igneous, sedimentary, structural and metamorphic and to the initial stratigraphy, and to tectonic and diagenetic changes modifying the stratigraphy. Such models form a part of the relevant global Tectonic model(s) and are locally modified by the processes involved in the Geomorphological models.

Below: Example of Geological Model:
Structure – strike slip faults (NB: annotations missing)

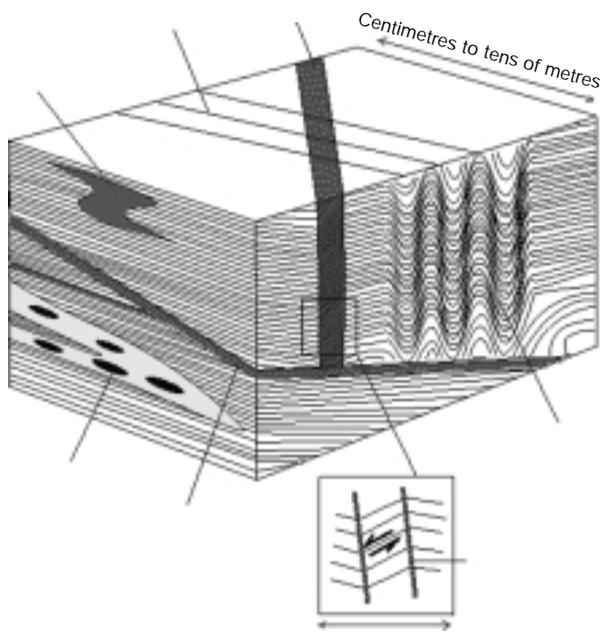


Anticipate:

Associations: movement is dominantly horizontal, may be local or may represent regional or continental shears where developed at plate boundaries i.e. major tectonic shears, sinistral displaces to the left, dextral to the right, secondary structures (rhomb shaped pull apart basins, en echelon folds, splay faults, reidel shears) develop in cover rocks or surficial materials depending upon the scale of the shear.

Below: Example of Geological Model:

Metamorphic – schists and phyllites (NB: annotations missing)

**Anticipate:**

Lithologies: rock types dominated by micas, schists, phyllites. Interbedded marbles, quartzites and deformed pebble beds form if rocks were originally sediments, greenstones form if originally volcanics etc. Differentiated layering and segregation of quartzo-feldspathic material develops with more intense metamorphism, injection or partial melting to form igneous rock types is possible.

Setting: metamorphic rocks, shear zones, mobile belts, extensive belts of flat lying schistose rocks associated with the sole of major thrusts and recumbent folds, "schistes lustres" in the cores of nappes.

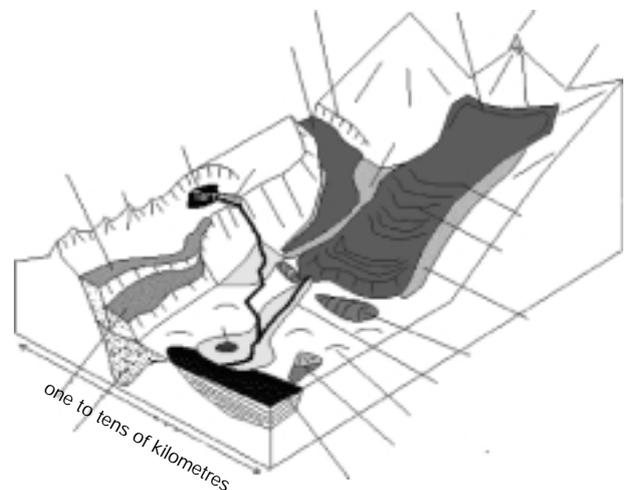
General: platy clasts, anisotropic and low shear strengths, high mica contents, low durability, schists exhibit reduced shear and compressive strength when wet, schist formations show a tendency to attract regional tectonic strain during orogenesis because they are weak and this generally manifests itself in the form of numerous conjugate kink bands and shears throughout the formation. Landslides are common, schists can be poor aggregates, rockfill etc. due to shape and low strength.

Local- or site-scale initial Geomorphological models which characterise the landforms

There are eight of these models, presented three-dimensionally, i.e. as sketch block models, which also typically cover areas from kilometres to tens of kilometres. They relate directly to the local geomorphology, i.e. the earth's surface landforms, and to the earth surface processes which have modified or are modifying the local geology. These processes are related to current climates and the relatively recent past climates, i.e. they are essentially a product of the later Tertiary and the Quaternary Ages. Such models also help to portray conditions of deposition in ancient equivalents to the models.

Below: Example of Geomorphological Model:

Valley glaciation (NB: annotations missing)

**Anticipate:**

Superficial deposits: tills or boulder clays (formation: comminution, deformation, transport: supraglacial, englacial, basal, depositional: ablation, meltout, lodgement, flow, waterlain), rock flour, varved silts with low shear strengths, glacial erratics with boulders up to many metres in size, outwash sands and gravels, chaotic and often unpredictable distribution of different superficial deposits, innate heterogeneity.

Processes: powerful erosion and swift transport and deposition of bedrock fragments, deformation and shear in superficial deposits and bedrock at the base of the glacier, striation of bedrock, deep subglacial erosion (overdeepening) and later infill leads to irregular rockhead, overconsolidation of boulder clays, transport of debris results in terminal moraines many kilometres away from existing glaciers that have been deposited before glacial retreat, numerous phases of advance and retreat including the "Little Ice Age" during the 16th Century, stress release phenomena in swiftly eroded bedrock. Proglacial lakes dammed by ice cored moraines may present a hazard.

Finite Elements in Soil Mechanics, Part VI

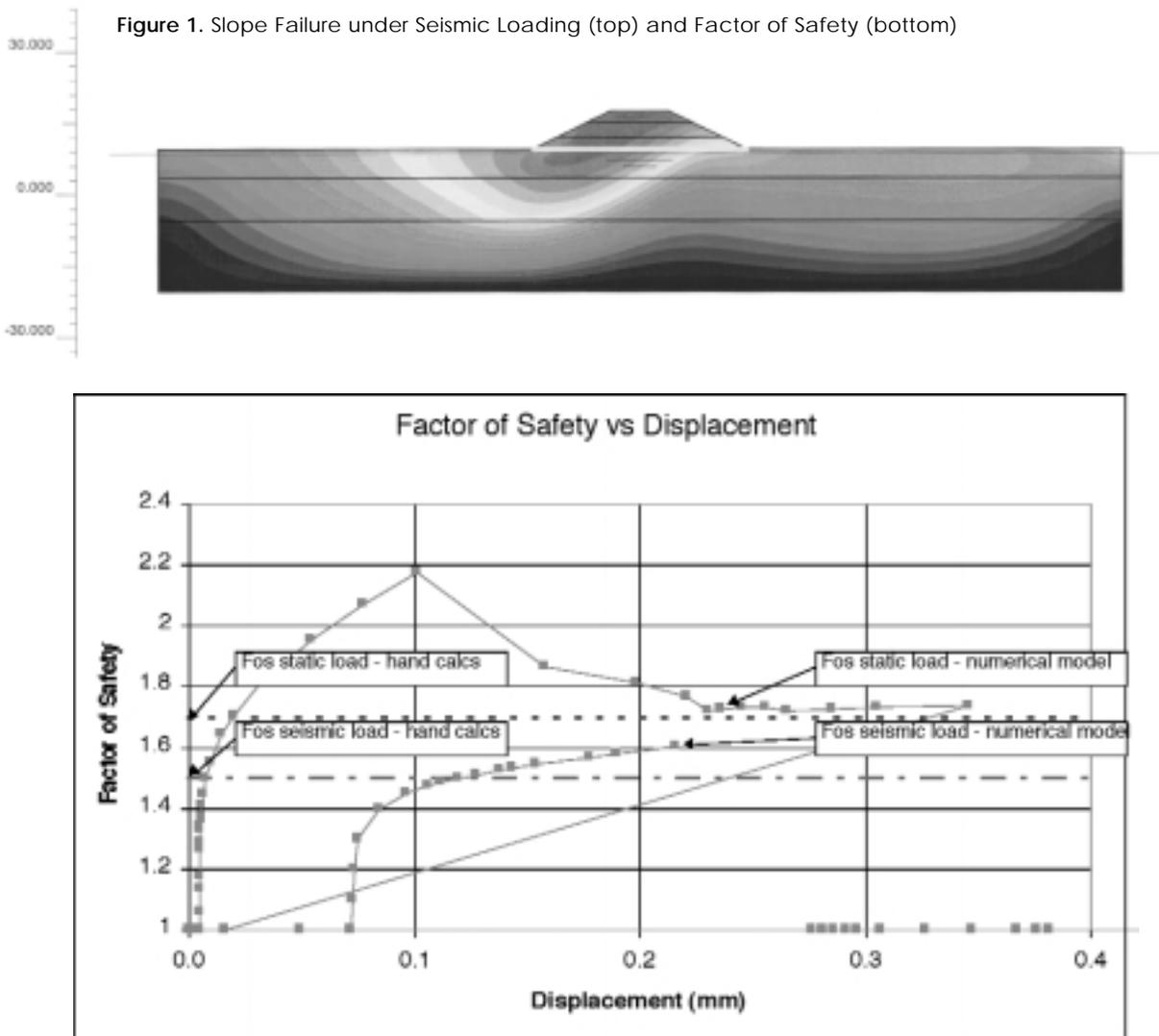
Sergei Terzaghi, Sinclair Knight Merz

Many geotechnical engineers wonder why they even need to know anything about numerical analysis, without realising that everyday that is exactly what they are doing. Every time they do a consolidation calculation, slope stability calculation or bearing capacity, or any other kind of calculation, they are doing a numerical analysis. Of course, in my column, I have been talking about more sophisticated varieties of numerical analysis with the focus being on finite elements, but nonetheless, the lessons learned are equally applicable to simple hand calculations. In fact I find that I can often more effectively do simple hand calculation because of the understanding of the processes involved through the more sophisticated analysis.

The tools that I normally talk about should be in every geotechnical engineer's tool box, simply because there are a number of programs available which are comparatively inexpensive, easy to use, relatively accurate and effective,

provided one understands the basis that they operate on. Also, as the land to develop becomes scarcer, greater demands and constraints will be placed on the engineers. Already in many parts of the world, design is governed by deformations rather than strength. Deformations do not lend easily to analytic solutions. Recently I came across an example where a sophisticated analysis did not give good answers in a situation where it should have. There were perhaps more lessons to be learned in understanding why it did not give good expected answers than in the rest of the paper. I hope the answers are forthcoming.

Enough on philosophy – lets get on with the real topic. In This issue I will talk about slope stability, which is maybe more day-to-day for most people. It is a pity that tools such as Slope-W, Stabl, and others are so apparently user-friendly these days, because one forgets that there is a hierarchy of analysis that should always be considered.





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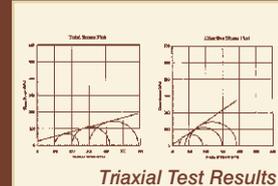
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A slope problem, assuming an analysis is appropriate, should always start with some form of hand calculation be it an infinite slope analysis, or based on an appropriate form of charts. Only then is it appropriate to go to a more sophisticated analysis such as a slope stability program. Whilst the results are often satisfactory, there are many cases requiring a higher level of analysis. These are cases related to where progressive failure is occurring, creep or other time dependent deformation, or simply where the deformation or geometrical characteristics of the problem govern. Most of the modern finite element/finite difference/boundary element programs have routines that enable calculation of factor of safety. How do these work and how good are they? After all, even ten years ago, this was almost heresy (my, haven't we progressed!).

For a limit equilibrium analysis, the fundamental factor of safety is defined as:

$$Fos = \text{Shear strength available} / \text{Shear strength mobilised}$$

Unfortunately, the actual application of the factor of safety varies from usage to usage, as is evidenced by the

differences in bearing capacity, some of the slope stability charts and so on. There are also problems in how to work out both quantities, which is why the various forms of methods of slices have come into being, though it should be noted that these methods are indeterminate (that is, there is not a unique solution as there are more variables than there are constraints). However, the method of slices is basically a re-statement of the above equation in the context of slope stability.

Assuming that one's finite element model is based on a realistic set of parameters, then the stresses/strains/deformations that one obtains represents a set of working stresses/loads/deformations, such as would be obtained from the prototype. Assuming that one has reached convergence ($Fos > 1$), then it is easy to program a routine to systematically reduce all material strengths by an increment until the program is unable to converge or the model goes into large plastic deformation.. This represents a failure mechanism. A way of monitoring this is to select a point and monitor the movement of the point with the incremental reduction in strength. The amount of reduction of strength is measure of the factor of safety.

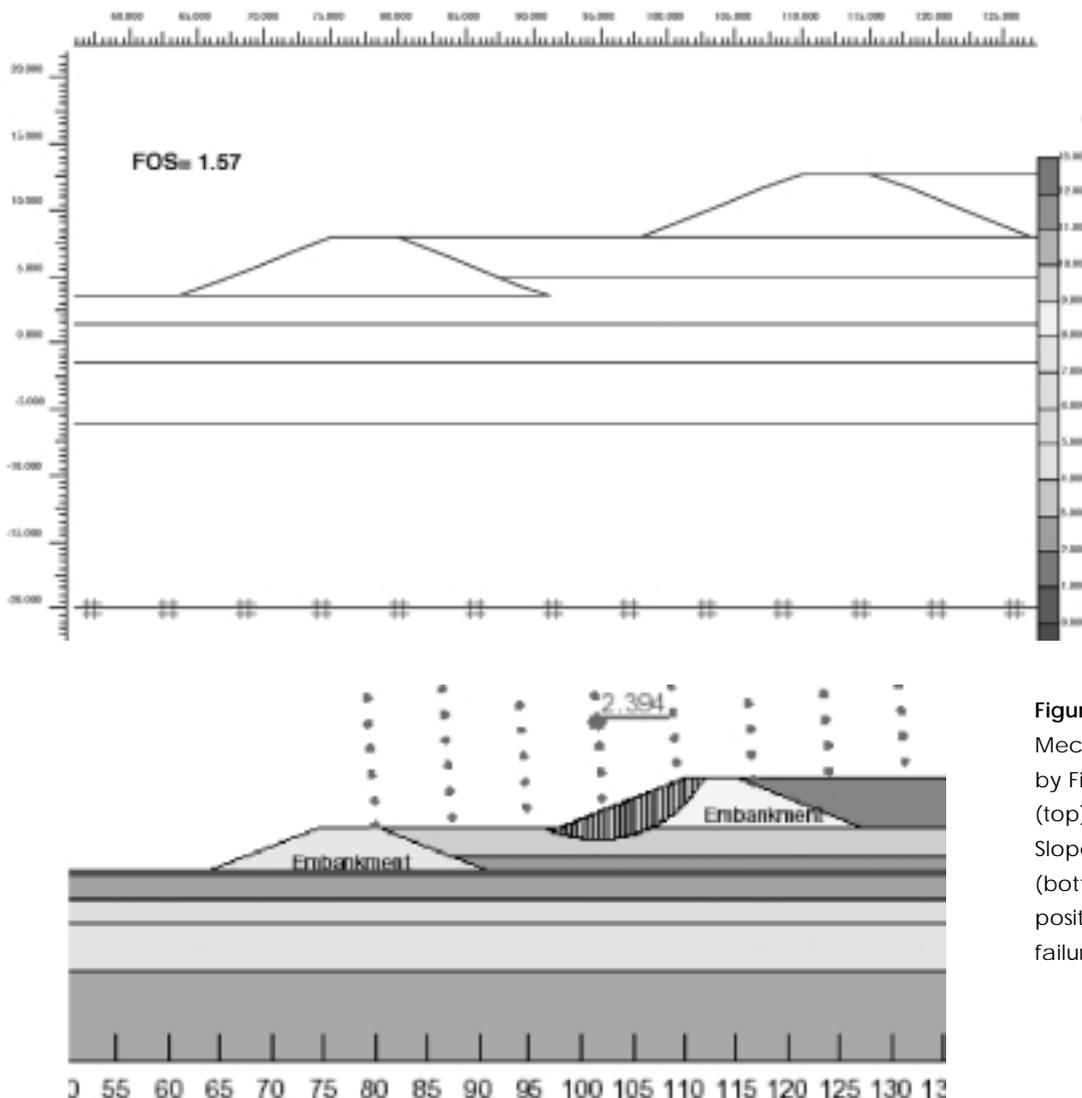


Figure 2. Failure Mechanisms Predicted by Finite Element Model (top) and Conventional Slope Stability Program (bottom). Note that the position of predicted failure is different.

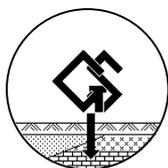
It is fairly easy to demonstrate that for a simple slope, this gives a similar answer to a conventional slope stability analysis. This is shown on Figure 1 along with a graph of movement with factor of safety.

How does this perform in more complex settings? Usually very well in my experience for the simple reason that the method will find the surface of lowest factor of safety without any pre-conceptions about the shape or position of the failure surface. If the failure surface is different to what is anticipated, it is telling you something about either one's expectations or about the reliability of the model. It has been found that for many of the more complex failures that such a method can give one more reliable answers than a conventional slope stability calculation, but only provided that the model is realistic.

One such example is shown in Figure 2.

However, there are also pitfalls with this as well. For example, if one includes an elastic element, you may never get a true failure mechanism develop. Also, if one is not looking at the right points, one may not find the right factor of safety. There can be problems in interpretation exactly when a failure mechanism has developed if for example the soil problem deforms into a more stable configuration, yet, technically a failure has occurred.

For all of this, slope stability by finite elements is now a viable method of analysis in that one can combine effects of staged construction, consolidation, deformation, and stability at different stages into one analysis. This becomes a very effective tool for the geotechnical engineer.



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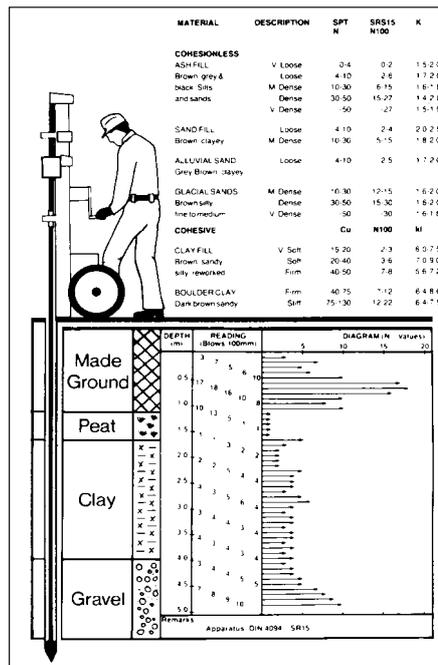
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TECHNICAL ARTICLES

The Window Sampler

Andrew Beeching, Geotechnics

Introduction

The window sampler tool is new to New Zealand, but has been used for about 20 years in Europe. The Geotechnics Ltd. window sampler equipment is a combination of the Nordmeyer Percussion Coring System and locally supplied hydraulic breaker and power pack. Geotechnics has operated the window sampler since August 2002 with a steadily increasing workload.

Geotechnical

The advantages a window sampler holds over a hand auger are in the areas of depth, speed, and quality of sample. The window sampler can operate to depths of 10 metres, usually taking around 2.5 hours to do so. The sample recovered is continuous and relatively undisturbed when compared to that of an auger, and contacts, slip surfaces, bedding, laminations etc. are all preserved in the sampling tube.

The advantages a window sampler holds over a drilling rig are in the areas of cost-effectiveness and portability. The window sampler is much cheaper than a drill rig for shallow investigations, and can be used anywhere a wheelbarrow could go, including inside buildings.

Environmental

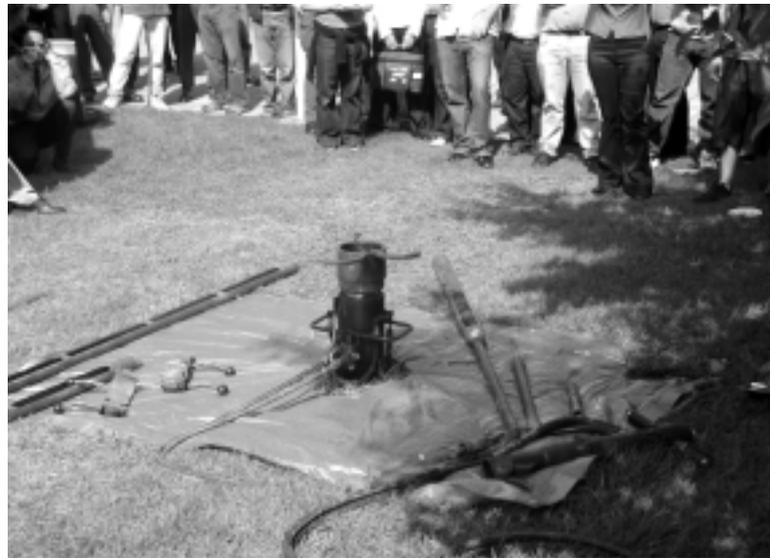
The window sampler system can be used to obtain environmental samples at depth using the standard sampling tubes or the enclosed environmental sampling tube. This tube obtains a continuous sample within a PVC cylinder, which can then be sent away for testing. Vegetable oil and silicon lubricant are used with the system to prevent samples being contaminated, and the equipment is cleaned thoroughly between each use.

Instrumentation and Testing

The window sampler can create a borehole up to 84 mm diameter, making it ideal for the installation of any shallow instrumentation, such as standpipes and piezometers. Water levels can be obtained following sampling by using a dipmeter, and shear vane and scala tests can be performed downhole at any interval by removing the sampling tube and testing at the bottom of the hole.

Method

The window sampler uses the hydraulic breaker to hammer sampling tubes into the ground, one metre at a time, and then a hydraulic ram is used to extract the tubes and rods. The tube containing sample is taken away to be logged, and



Above: The window sampler on display at the Tauranga, "Geotechnics on the Volcanic Edge" Symposium held in March 2003

the next size down is used to continue the sampling. The sampling tubes come in 80, 60, 50 and 36 mm outer diameters, and can have reinforced cutting shoes attached to increase their diameter by 4 mm each.

Capabilities

The window sampler was designed to penetrate soils and some soft rock. Geotechnics has used the equipment primarily within the shallow formations of Auckland city, including weathered East Coast Bays Formation (interbedded siltstone and sandstone), the Cornwallis Formation (volcanogenic flysch), and the Tauranga Group (alluvium). It has also been used in Waikato and Tauranga in sands and peat. Various types of fill material have been sampled, from clean clays and silts to fills containing porcelain, scoria, brick, polystyrene and gravel up to about 80 mm diameter.

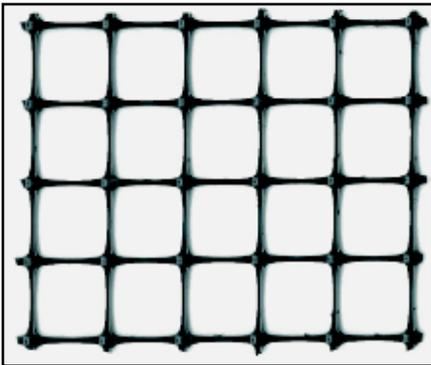
So far, Geotechnics has used the window sampler equipment on a number of Auckland residential sites, as well as on numerous roadside sites and industrial sites (including a petrol station), for investigations including foundation and retaining wall design, identification of slip surfaces, environmental sampling and standpipe installation.

For more information on the window sampler service, call Andrew Beeching, Geotechnics, Auckland. Phone (09) 356 3513 or 021 683 034.

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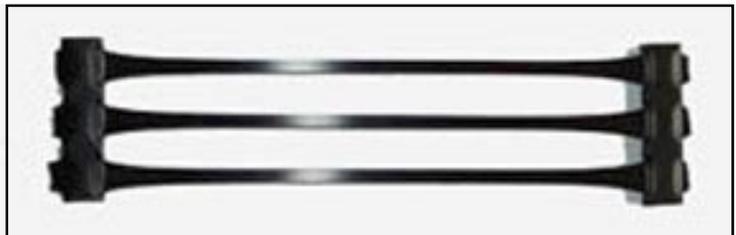
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Slope Stability Analysis – Variation or Validation?

Rodney Hutchison, Keith Gillespie and Associates Ltd

Terry McCarthy, Soil and Rock Consultants Ltd

Introduction

As practising geotechnical engineers, one of our fundamental analytical tools is our slope stability calculating package. Hopefully, we all give due and careful thought to the selection of soil parameters but, eventually, we tend to key the data in, look at the result and then trust it implicitly. But should we?

Both of us were involved recently in an exercise where a Territorial Authority called for a stability analysis of a small slope in connection with flood control works. For various reasons, the analysis was carried out by four independent parties and we were surprised at the scatter of the results.

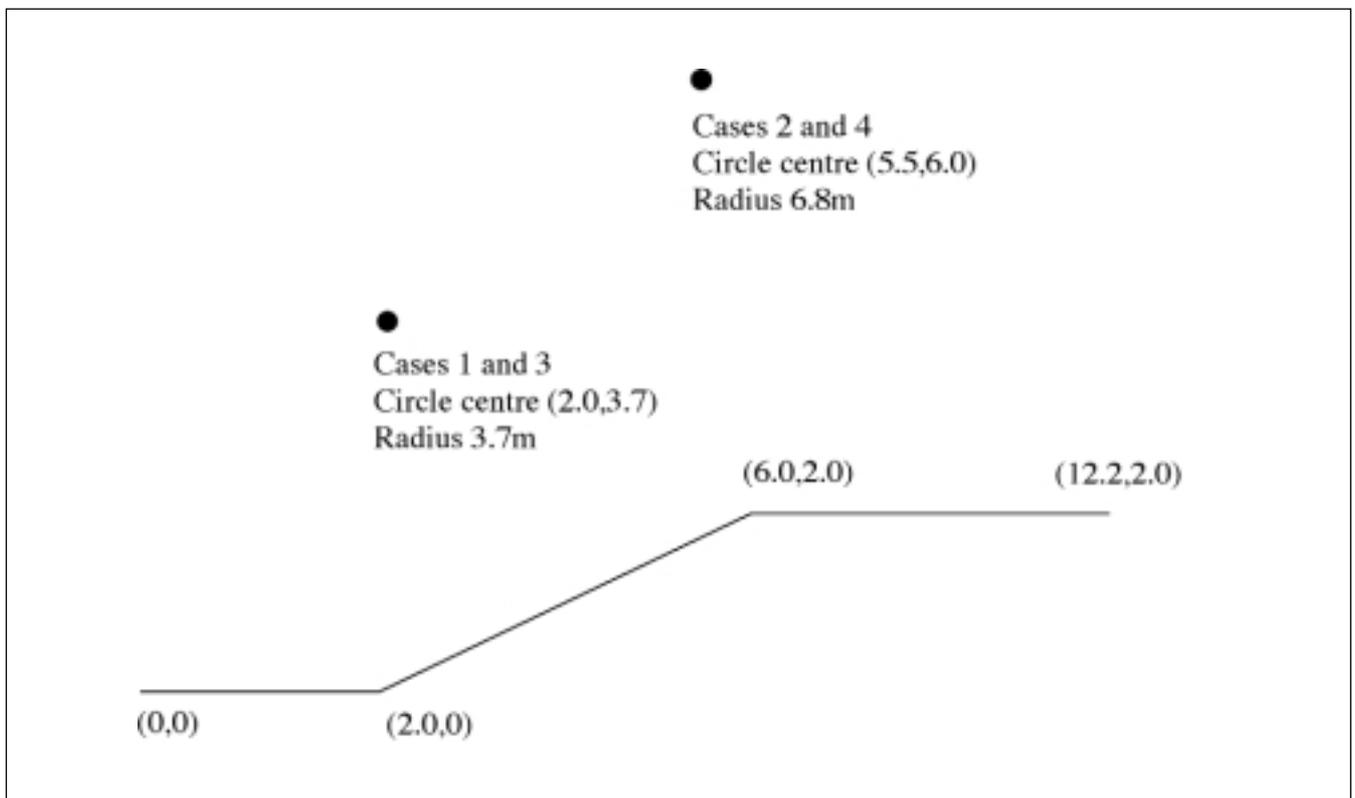
This raised the question as to whether we, as a specialist profession, need to validate the way in which we use our slope stability packages. A similar concern arose in Hong Kong in the early 1980s and the then Geotechnical Control Office (GCO) carried out a similar, but more extensive survey. The scatter of results was horrifying. Hopefully our software, and our understanding of how to use it, has improved since then.

Based on our recent experience, we believe that it would be useful to the profession to either validate or confirm our confidence in the slope stability software that we each use.

The Problem

We have simplified (only slightly) the original problem referred to above and invite readers to carry out an analysis of it. We will then review, collate and publish the results. Depending on the responses received, we may subsequently set up a more complex set of analyses as a future survey.

The slope to be analysed is a single, two metre high slope, with a grade of 1V:2H. Two slip circles are defined, together with a request to determine the critical slip surface and its associated minimum factor of safety. To keep groundwater simple, only two variants are included; the 'dry case' and a fully saturated (phreatic surface coincident with ground surface) case. This is detailed in the sketch below.



Soil parameters to be applied are:

- effective stress $c' = 3 \text{ kPa}$, $\Phi' = 24 \text{ deg}$
- total stress $c_u = 50 \text{ kPa}$
- bulk density $\gamma_b = 18 \text{ kN/m}^3$

Results

The results of the analyses should be returned to either:

- Rodney Hutchison
Email: Rhutchison@kga.co.nz
Fax: 09 478 6169)

or

- Terry McCarthy
Email: terry@soilandrock.co.nz
Fax: 09 414 1556)

To help us collate the data, please return it in the form of the table below.

We will collate the results and publish them in the next issue. If you wish, results may be sent to us anonymously or accredited. Irrespective, the detailed results will remain confidential and no names will be published with the results.

Next Stage

Depending upon the responses received, or if the scatter in the results suggests it, we will broaden the scope of the survey to look at the effects of more complex geometries and water tables (perched, piezometric heads etc).

Which brings us to the final question. Does anyone out there still have a copy of the original GCO survey and results? We would like to obtain a copy as, to our knowledge, it has been one of a few widespread validation surveys carried out.

| | Circular/ Non circ. | Circle centre | Radius (m) | Calculated FoS Eff. Stress Total stress | Method used | Software used |
|--|------------------------|------------------|------------|--|-------------|---------------|
| Case 1 (dry) | C | x=2.0 y=3.7 | r=3.7 | | | |
| Case 2 (dry) | C | x=5.5 y=6.0 | r=6.8 | | | |
| Case 3 (saturated) | C | x=2.0 y=3.7 | r=3.7 | | | |
| Case 4 (saturated) | C | x=5.5 y=6.0 | r=6.8 | | | |
| Case 5 Critical slip Surface (dry) | | | | | | |
| Case 6 Critical slip Surface (saturated) | | | | | | |
| Do you want us to repeat the exercise with more complex geometries and groundwater conditions? | | | | | Y/N | |

COMPANY PROFILES

Foundation Engineering

Established in 1972, Foundation Engineering is an independent consultancy, providing a wide range of professional, specialist Geotechnical and Engineering Geology services to developers, contractors, local government, corporate, and private clients. We also operate an IANZ accredited soils testing laboratory, operating under ISO 17025 - 'General requirements for the competence of testing and calibration laboratories', which has been registered since 1977 for more than 30 tests. In addition to a full range of standard testing equipment, we have computerised electronic monitoring and data recording equipment for use in "high technology" soil parameter determination, as required for some of our larger and/or more complex projects.

Based in Auckland and Orewa, we have built our reputation serving our local communities, but we are also actively involved in geotechnical projects throughout the rest of the country. Our experience over the past 30 years has led us to the position of being one of the leading land development consultants in the upper North Island. During this period we have been involved in the development of many hundreds of residential, commercial

and industrial subdivisions. Our role in these projects is to undertake investigations for suitability of land use, including earthfills, settlement, stability, roading, sanitary and stormwater drainage, etc, followed by earthworks quality control, *in situ* testing and construction inspections. We also design retaining walls, gabions, stabilised slopes, groundwater control systems, earth dams, road subgrades etc. Many hundreds of kilometres of roading (rural/commercial/industrial) have been constructed with our input including lime/cement stabilisation, CBR and Benkleman Beam testing. Certification of developed land for building purposes is one of our major responsibilities.

On the building scene, a large proportion of our work involves foundation investigations for institutional clients and for inner city and city fringe commercial and industrial building developers. We also undertake site investigations for residential developments, roading and bridge projects, schools, rest homes, marina and canal housing projects, golf courses, heavy industrial developments, landslip and coastal protection works, cliff top assessments, retaining walls and reinforced earth applications.

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Opus is New Zealand's largest engineering consultancy offering multi-disciplinary engineering, environmental, planning and architectural services, through its 28 offices spread around New Zealand, and overseas offices in Malaysia, London, Nottingham, Brisbane and Western Australia. Opus works in partnership with a widening range of clients, helping them visualise and achieve their goals, and delighting them with innovative solutions of quality and value.

The Opus geotechnical professionals, together with its laboratories, provide comprehensive geotechnical engineering, engineering geological, geophysical and testing services to clients through its nationwide network of offices and laboratories offering a full range of laboratory and field testing. These capabilities are supplemented by leading edge applied research and specialist services at Central Laboratories in Wellington.

The team of geotechnical specialists provide a broad range of services to a variety of clients from government and local authorities to private sector organisations. Key services include procurement and management of geotechnical investigations, slope stabilisation, design of earthworks, retaining systems, foundations, dams, canals, tunnel rehabilitation, highway and heavy duty industrial pavement design, landfills and assessments of contaminated sites.

Recent projects that required significant input from the Opus geotechnical team include the Alpuerto motorway, Auckland Central Remand Prison, Route PJK Expressway (Tauranga), Horotiu and Gisborne Landfills, Wellington Wastewater Project, Wellington Inner City Bypass, Widening Pukerua Bay to Paekakariki Railway

tunnels, Stockton Mine Coal Handling Facilities (Westport), the Candy's Bend to Starvation Point (Arthur's Pass), Clyde Dam Landslide Stabilisation and Malampaya onshore gas plant (Philippines).

In addition to the new development, the Opus geotechnical team plays a key role in helping manage existing infrastructural assets. This involves emergency response as well as long-term innovative solutions to stability problems that affect lifelines such as roads. An example is the stabilisation works for the Nevis Bluff rockslide (Central Otago).

A broad range of risk management services supplement the core geotechnical services offered by the team. These include natural hazard and earthquake hazard assessment and mapping, assessment of risk to infrastructure and lifelines, and development and implementation of risk management measures. Also the team has pioneered the application of project and financial risk management.

Typical risk management studies undertaken are earthquake hazard studies for Wellington Region and the Western Bay of Plenty, all-hazards risk management study for Queenstown-Lakes District, water supply risk assessment for the Greater Wellington Region, and road network risk management studies for Wellington City.

Research to target key engineering sector issues is undertaken at Opus Central Laboratories, where specialist skills, instrumentation and testing facilities provide the means to investigate a wide range of unusual problems from seismic site response to the impact of soil and backfill types on heat dissipation from underground high-voltage power cables.

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MEMBER PROFILE



Jeff Bryant

Occupation
Principal, Geoconsulting Ltd

From the beginning

A keen interest in tramping and mountaineering in my younger days led me towards a career path with a strong outdoors focus. However, I can trace certain key attributes such as knowing the benefits of a strong precedent argument, empirical design considerations and the perils of natural hazards to my sand castle building days as a toddler.

A fellow trumper encouraged me to consider majoring in geology and I took to this with gusto. When I started in the early 70's, graduate students were gaining holiday work across the Tasman with Broken Hill or Mt Isa mines who would pay their airfares and send them back with around \$2000 – a very good return in those days. By the time I graduated, the Australian minerals boom was over and geologists with 10–20 years experience were coming to New Zealand looking for work.

Another fortuitous piece of advice saw me gain holiday work on the Tongariro Power Project with the NZGS. This introduction to engineering geology and, in particular, the applied aspects of geology convinced me to enrol in Canterbury University's new MSc course.

Career summary

My first four years in employment were with the Ministry of Works' Central Laboratories in Gracefield. These were heady days when the MoW did everything and it was my privilege to meet and work alongside some very knowledgeable and experienced people. This was followed by another four years in Hong Kong working for the Geotechnical Control Office. Again I was privileged to work alongside a broad range of geotechnical professionals from a wide variety of backgrounds and interests. I still correspond or have professional interaction with some of the friends I made during that time. Returning to New Zealand and employment with the MWD, I was posted to Dunedin then Alexandra where the Clutha Valley Development Roading project was in full swing as the Clyde Dam was being built. The roading project wound down around the same time as concerns over lake shore stability started to mount. I subsequently became part of a somewhat boisterous and irreverent team of geologists,

numbering 27 at the peak, who assisted with the lake shore investigations and remedial works programme.

The last ten years has seen me employed as a consultant trading under the name Geoconsulting Ltd, initially in Alexandra but now based in Queenstown. Although Central Otago is one of the country's driest areas, the terrain has a challenging array of geotechnical problems particularly those associated with the numerous very large and very old landslides in schist bedrock. Supplementing the local work is the odd assignment in Asia where the scale of projects and the nature of problems are often totally different from what one can expect back home. One lasting impression of working overseas that I am constantly reminded of is how infinitely more desirable New Zealand is for doing field work (amongst other things). Heat stroke, dehydration, sunburn and gastrointestinal diseases are not the only hazards one has to face in a tropical country. Mosquitoes bearing dengue fever, spiders, scorpions, hornets, snakes, poisonous and prickly plants, packs of wild dogs, bears, tigers, armed illegal immigrants and lightning strikes have all had to be avoided at some stage!

Typical week

No such thing really. There are always the usual phone calls, preparing fee estimates, meeting with clients on site, field work including follow-up visits and reporting. It would be a lousy week that didn't contain some field work. On top of that is keeping up with what is going on in the geotechnical world and the dreaded office administration tasks.

Highs and lows

I enjoy the personal aspect of dealing with clients and also meeting and dealing with new people and their cultures whilst overseas. Most people have a genuine interest in what you are doing and I get particular satisfaction from explaining that to them in their terms whether it be a corporate boss or the digger driver. Most common question from the latter – "Found any gold yet?" The many major projects I have worked on over the years have all been challenging and stimulating, each one resulting in

a significant gain in knowledge and experience.

Lows would have to be dealing with wannabe entrepreneurial developers who never do anything right and often leave you in the position of rectifying their problems at short notice and under all sorts of constraints. They are the worst at paying too. The only regret is not finding any gold in all those test pits.

Ambitions

Educate the populace at large of the need to think of the ground they own or are thinking of owning or administer as an asset that has to be understood and cared for.

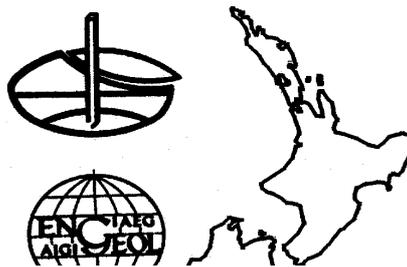
Catch more of the wily brown trout that cruise up and down the shoreline in front of my house (I can just about cast a dry fly to them off my balcony).

Advice

- To clients: You can pay for a site investigation whether you do one or not.
- To prospective purchasers: Would you buy a second hand car without getting specialist advice as to whether it is roadworthy or a sound buy?
- To me: Spend more time fishing.

Contact Details:

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PO Box 374
Queenstown
Phone/Fax: 03 4423777
email: jeffbryant@ihug.co.nz



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FOREIGN CORRESPONDENT

My Malaysian Rollercoaster Ride

Anthony Fairclough, T&T Konsult Sdn Bhd, Kuala Lumpur

I have been working in Kuala Lumpur, at T&T Konsult Sdn Bhd (T&TK), for well over two years now. T&TK is a civil, structural, geotechnical and highway consultancy firm with strong affiliations to Tonkin and Taylor (NZ) Limited. On the whole I have really enjoyed working in Malaysia as I have made some good friends, worked on some extremely interesting projects, and learnt a lot about Malaysian culture and how things work in Asia.

Malaysia is a progressive Islamic nation, however, the country has an extremely diverse ethnic mix. The general population comprises a mix of Malay, Chinese, Indian and Eurasian people who generally tolerate and respect each other's traditions and beliefs.

One outstanding side effect of Malaysia's ethnic diversity is the wonderful variety of cuisine, especially if you are partial to spicy food. Chinese, Indian, Indonesian, Malay, Thai and Portuguese influences have been blended and fused with local ingredients to produce a never-ending list of unique and delicious local dishes.

To date I have not experienced any anti-western sentiments, and I have found the Malaysian people to be friendly and helpful. On several occasions' people here have given me a big beaming smile, a thumbs up, and a rousing "All Black Number 1 - Weeery powerful" when they discover that I come from New Zealand. It appears that a certain Mr Jonah Lomu made his usual impression during the 1998 Commonwealth Games Rugby Sevens.

Living and working in Malaysia can be a bit of a roller coaster ride. One day can leave you feeling completely frustrated, while the next can bring you an extremely exciting and challenging project.

Issues such as language can add an additional layer of frustrations for an expat project manager. English is widely spoken in Malaysia, however, communication difficulties occur on occasion. The other day I phoned my office to speak to one of my work colleges. This conversation could have been taken straight from a Monty Python sketch as it went something like this:

Ring Ring, Ring Ring.....

Reception: Hello?

Tony: Hello, it this T&T Konsult?

Reception: Excuse me?

Tony: Is this T&T Konsult?

Reception: Yes.

Tony: Hi, it's Tony here, could I please speak to Low.

Reception: Who?

Tony: It's Tony Fairclough speaking, could I please talk to Low.

Reception: Mr Fairclough is out-station.

Tony: O.K. is Low available?

Reception: Yes, one moment.....

Low: Hello.

Tony: Hi it's Tony Fairclough here, did you manage to get the information from Pacific and Orient that I need today?

Low: One moment.

The line goes quiet for a few minutes.....

Low: Mr Anthony is not here.

Tony: Mr Anthony is speaking.

Low: Oh, I have a call for you, I will just.....

Tony: No, No, No, I want to speak to Low!

Low: Oh, O.K., Low speaking.

Tony: Did you manage to get the information from Pacific and Orient that I need today?

Low: Yes.

Tony: Where is the information?

Low: They have sent it by post; you should receive it in about one week.

Tony: Sigh, Thanks... I will talk to you when I get back to the office, Bye.

On the positive side, I have worked on some extremely interesting and challenging projects up here in Malaysia. Two of my favourite Malaysian projects so far have been the Kuala Lumpur Monorail Project and a BASF-Petronas Petro-chemical plant in Kuantan on the east coast of Malaysia.

The Kuala Lumpur Monorail is a new public transport system that serves the central business, hotel and shopping district of Kuala Lumpur. The monorail system comprises 8.6 kilometres of dual-track monorail and 11 elevated stations. On this project I was responsible for the foundation design on three of the stations and the depot. The foundations for these structures principally comprised large-diameter bored or driven piles.

The Petronas-BASF BDO Plant is a petro-chemical facility that was constructed near Kuantan on the east coast of Malaysia during 2001/2002. One of the most interesting aspects of this project, that I was involved in, was the design of some temporary foundations for a heavy-lift crane. The heavy-lift crane that was used on



Left: Photograph of a typical K.L. Monorail Station.

BDO Plant project was a Manitowoc M1200R. This crane has a boom that can tower almost 160 metres above the ground and can lift a 1,433 ton load from a location 77 metres from the centre of rotation.

The ground conditions at the BDO site comprised a veneer of engineered fill overlying alluvium, marine deposits and residual soil. Needless to say the geotechnical conditions on site were not ideal for a beast such as the Manitowoc M1200R. I am pleased to report that all of the heavy lifts at the BDO site were completed safely, and that the performance of the temporary foundations was within predicted and tolerable limits – an achievement that gave me much personal satisfaction.

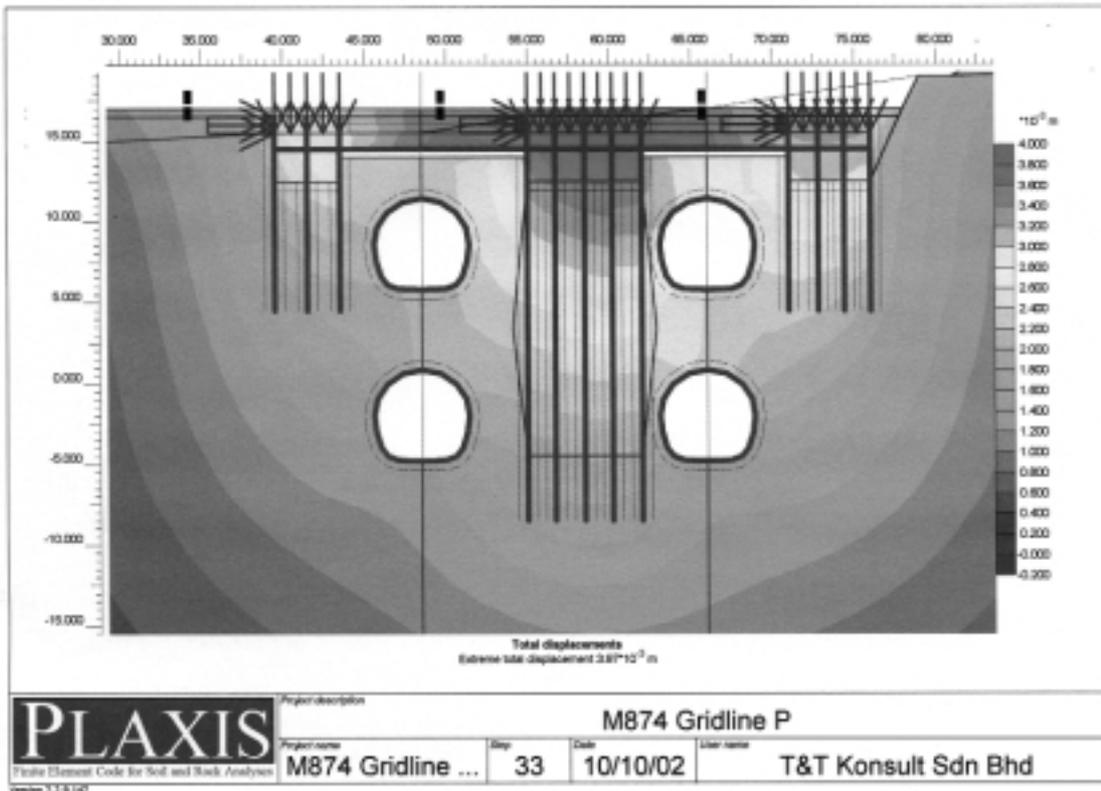
Another interesting project that I have worked on in Malaysia was the Yau Tong Phase 4 Apartment Building in Hong Kong. The pile foundations for this multi-story building were to be located in-between and immediately adjacent to four Mass Transit Railway Tunnels. T&TK was engaged by the foundation contractor to complete detailed design of the building foundations.

As part of the Yau Tong project T&TK completed a detailed finite element analysis of the proposed foundations using the PLAXIS software package. The objective of this work was to model soil-structure interaction, predict stresses and deflection of the tunnel lining, and optimise the foundation design.

Tonkin and Taylor (NZ) Limited assisted T&TK on the Yau Tong project by analysing several key cross-sections using the FLAC software package. Comparison of these results showed that PLAXIS and FLAC finite

Below: Photograph of a Manitowoc M1200R.





Above: Typical Plaxis output for the Yau Tong project.

element models gave very similar predictions of the tunnel stress and deflection.

The Asian economic crisis has significantly reduced the number of large civil engineering projects that are currently ongoing in Asia. This issue, coupled with an increase in the number of competent, well-trained local engineers, has drastically reduced the number of positions that are available in the region for expat engineers. I expect the Asian regional economy will make a slow but steady

return to prosperity over the next 2 to 5 years. Hopefully this will mean increased opportunities in Asia for New Zealand engineers.

I have gained much from my "Asian adventures" on both a professional and personal level. I recommend that you take any opportunity to work in Asia as it will teach you to think outside the box, help you to become a well-rounded engineer, and to you will learn to become more patient grasshopper.....

THE BOB WALLACE COLUMN

I am unashamedly quoting from a brilliant article presented by Professor John Atkinson in the July 2002 issue of Geotechnical Engineering (Volume 155 Issue 3 Proc's of the ICE). When running workshops for practising civil engineers Professor Atkinson asks them to agree or disagree with the following propositions:

- Sands are frictional; clays are cohesive.
- Landslides occur after rainfall, so water lubricates soil.

The title of Professor Atkinson's article is "What is the matter with geotechnical engineering?" I think these propositions go right to the heart of the problem. If you were to ask a group of self professed Geotechnical Engineers to debate these propositions I am sure you would get some confused and erroneous arguments. There is a fundamental lack of understanding of basic soil mechanics theory and in our daily professional activities we perpetuate the problem.

I have had a post-graduate with a PhD in a Geotechnical Engineering subject ask me when a slope stability analysis should be undertaken assuming effective or total stress conditions. I have seen a MSc thesis suggest that given two materials with similar stiffness, more settlement would be expected for the material that was more cohesive.

In both these instances the student was clearly an intelligent individual that had received some excellent tuition and guidance through their formal education. But somewhere along the way the fundamentals became corrupted and a flawed understanding of our discipline became established in an individual who could be operating under the supervision of someone that may not know any better.

How often do we confuse compression and consolidation? Even worse, how often do we couple strength and stiffness by measuring these two independent properties with one test? And when we perform an SPT or a Shear Vane measurement – what are we actually determining?

There was a fantastic follow-up article by Nick Langdon in the January 2003 issue where he describes even more incredulous events of geomechanical stupidity. I particularly liked the account of an undrained analysis being unnecessary because land drains were present on the

site. Langdon's premise was that undergraduate engineering education should be aimed at producing future practitioners.

I have great sympathy for the academics that I meet because I can see the pressure they are under to ensure that their Civil Engineering graduates are equipped with the all the necessary skills to operate as effective practitioners when they enter the work place. There is an increasing demand to cover important new topics that are vital for a Practising Engineer such as Sustainable Development, Planning and the Environment, Geographic Information Systems (GIS) and Information technology (IT), Project Management, Contracts and Law.

This is putting so much pressure on the teaching of traditional Civil Engineering subjects that it is easy to understand why the students are not readily absorbing basic soil mechanics. There is simply not enough time in the University to calendar to cover effectively the classification and identification of soil properties, permeability, seepage, strength, stability, soil pressures, bearing capacity and settlement never mind the relative sophistication of partial saturation and critical state theory.

This problem has been recognised in the UK and there have been recent moves to drop maths from the curriculum of a Civil Engineering undergraduate that have led to some interesting debates. For myself, I will be interested to see how future Post-Graduates of Geotechnical Engineering will cope with the rigours of advanced geotechnical analysis without a thorough understanding of the basics of soil mechanics and the basics mathematics to drive the analytical tools.

From my perspective there are two solutions. The first would be to lengthen the duration of undergraduate study to facilitate the teaching of Civil Engineering and all its relevant topics to a reasonable level of rigour. I believe this is encouraged in the US where advocates of a seven year undergraduate program are gaining ground.

The second, and less politically correct, solution would be to fail students who don't grasp the fundamentals. I believe failing a student has become quite a radical philosophy amongst tertiary education establishments but it could have some beneficial effects for the industry in the future. We may end up with practitioners that can answer John Atkinson's propositions correctly.

EVENTS DIARY

2003

JUNE 9–10 2003, Edmonton, Canada

3rd Canadian Conference on Geotechnique and Natural Hazards

Conference themes:

- Slope movements
- Snow and rock avalanches
- Seismic
- Flood and natural dams
- Emerging
- Risk reduction and hazard mitigation
- New techniques
- Climatic triggers

<http://www.geohazards2003.eba.ca>

JUNE 22–26 2003, Cambridge, USA

12th Pan American Conference on Soil Mechanics and Geotechnical Engineering

Conference themes:

- Ground characterisation and exploration
- Geo-materials and mechanics
- Geo-construction
- Lessons learned from failures
- Future challenges
- Fluids in the subsurface environment

<http://www.soilrock.mit.edu>

JULY 2–4 2003, Sarawak, Malaysia

2nd International Conference on Soft Soil Engineering and Technology

Conference themes:

- Characteristics, testing and fundamental behaviour of soft mineral and organic soils
- Engineering analysis and design methods particularly for peat and organic soils
- Construction procedures and appropriate technology
- Land use and environmental issues
- Land use recognition using remote sensing
- Potential commercial exploitation of peat land
- Engineering aspects of other problematic soils, soft artificial soils, sanitary landfill

Abstracts due: 31 January 2003

JULY 28–30 2003, Nottingham, UK

Problematic Soils

Session themes:

- Peat and organic soils
- Volcanic Soils
- Expansive soils
- Collapsible soils

- Decomposed Soils
- Contaminated Soils
- Fills
- Unsaturated soils

Abstracts due: 1 November 2002

For more information contact:

The Conference Director

Ci Premier Pte Ltd

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AUGUST 11–12 2003, Malaysia

Geo-Environmental Engineering

For more information contact:

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AUGUST 25–28 2003, Prague, The Czech Republic

13th European Conference on Soil Mechanics and Geotechnical Engineering

Geotechnical Problems with man-made and man influenced grounds.

Conference themes:

- Man made deposits – recent and ancient
- Contaminated ground – remediation and preparation for new construction
- Construction on man made and remediated brownfield sites
- Foundations in urban areas
- Networking of Geo-Engineers between East and West Europe

<http://www.escmge2003.cz>

SEPTEMBER 8–12 2003, Gauteng, South Africa

10th ISRM International Congress

<http://www.isrm2003.co.za>

AUGUST 26, 2003, Wellington, New Zealand
New Zealand Society on Large Dams (NZSOLD)

- Dams - Consents and Current Practice

Symposium themes:

- Ecological impacts of dams and flow regulation
- The consenting process and legislation
- Dam technology practice (incl tailings dams)
- Recent case histories and experiences

<http://www.ipenz.org.nz/nzsold/symposiums.htm>

email: derek.wilshere@extra.co.nz

Ph (04) 562-7920 or (0274) 303-596

SEPTEMBER 15-18 2003, Istanbul, Turkey

International Symposium on Industrial Minerals and Building Stones

SEPTEMBER 17-18 2003, Saint Petersburg, Russia

International Geotechnical Conference - Reconstruction of Historical Cities and Geotechnical Engineering

Conference themes:

- Reconstruction of historical cities
- Geotechnical calculations in reconstruction
- Geo-ecology

Papers due: March 1, 2003.

Contact: Mikhail Lisjuk

Tel: +7-812-251-04-62 Tel/Fax: +(7)-(812)-316-61-18

<http://www.georec.spb.ru/conference.htm>

SEPTEMBER 22-26 2003, Bled, Slovenia

1st International Conference on Groundwater in Geological Engineering

Themes:

- Groundwater as a risk factor and/or a technical constraint
- Groundwater as an environmental constraint
- Groundwater as a socio-economic constraint

Deadline for submission of abstracts: 1st December 2002

<http://www.pivo-union.si/ICGGE-2003/>

<http://www.drustvo-skiah.si>

<http://www.iah.org/>

<http://www.bled.si/>

SEPTEMBER 22-24 2003, Lyon, France

3rd International Symposium on Deformation Characteristics of Geomaterials

Conference themes:

- Soils and soft rock
- Experimental investigations into deformation properties from very small strains to beyond failure
- Time effects (ageing and viscous effects)
- The interpretation of laboratory, in situ and field observations of deformation behaviour
- Characterizing and modelling behaviour
- Case studies

Abstracts due: 01/01/02

<http://islyon03.entpe.fr>

OCTOBER 13-15 2003, Stockholm, Sweden

Geoproc 2003 - International Conference on Coupled T-H-M-C Processes in Geosystems

Conference themes:

- Fundamentals
- Modelling
- Experiments
- Applications

<http://www.geoproc.org>

2004

JANUARY 21-23 2004, Singapore

6th International Conference on Deep Foundation Practice (PILETALK 2004)

For more information contact:

The Conference Director

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Orchard Plaza, Singapore 238841

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FEBRUARY 9-11 2004, Auckland, NZ

To the eNZ of the Earth - 9th ANZ Conference on Geomechanics

Conference theme aims to generate discussion on what makes geotechnical practice within NZ and Australia

difference to other parts of the world.

Topics include:

- Slope instability and remedial measures
- Foundation performance and assessment
- Dams, Roads, tunnels and mines
- Laboratory testing
- Earthquake Engineering
- Contractural and risk issues
- Case histories and failures
- Environmental Geotechnics
- Engineering Geology
- Numerical modelling

Abstracts due: 31 March 2003

Acceptance notification: 18 April 2003

Submission of papers: 30 June 2003

Acceptance of papers: 29 August 2003

<http://www.cce.auckland.ac.nz/geomech04>

MARCH 22–23 2004, Kuala Lumpur, Malaysia
5th International Conference on Ground Improvement Techniques

Conference themes:

- Mechanical and chemical stabilisation of soils
- Accelerating the consolidation of clayey soils and electro osmosis
- Soil reinforcement and earth reinforcement
- Modification of marine soils and related topics
- Grouting techniques and thermal stabilisation of soils
- Evaluation of ground improvement and theoretical methods
- Densification of granular soils
- Dynamic compaction and micropiles
- Deep compaction, blasting heavy compaction, vibroflotation
- Innovative techniques in ground improvement
- Environmental aspects
- Deep soil mixing
- Soil improvement by precompression

Important dates:

Submission of abstracts: 26 Sept 2003
Notification of acceptance: 26 Oct 2003
Submission of paper: 26 Jan 2004

For more information contact:

The Conference Director
Ci Premier Pte Ltd
150 Orchard Road #07-14
Orchard Plaza
Singapore 238841
Tel: 065 6733 2922
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MARCH 24–25 2004, Kuala Lumpur, Malaysia
4th International Conference on Landslides, Slope Sustainability and the Safety of Infra-structures

Conference Themes:

- Geological and geotechnical site investigations
- Design shear strength parameters and their measurements limit
- Equilibrium and deformation slope stability analysis
- Modification of marine soils and related topics
- Back analysis of slope failures
- Landslide hazard and risk assessment
- Landslide inventory and hazard zonation
- Landslide Stabilisation and remedial measures
- Observational methods: instrumentation and monitoring
- Effects of rainfall and groundwater
- Effects of seismicity
- Slope instability of landfills and waste materials
- Slope instability in coastal areas

- Slope instability in urban area
- Slope instability in special materials: residual soils, shales, loess, soft sensitive clays

Important dates:

Submission of abstracts: 10 August 2003
Notification of acceptance: 15 Sept 2003
Submission of paper: 15 Jan 2004

For more information contact:

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Ci Premier Pte Ltd
150 Orchard Road #07-14
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Email: CIPREMIERE@SINGNET.COM.SG
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MARCH 29–30 2004, London, UK

A.W. Skempton Memorial Conference

Topics Include:

- Influence of Geology on Civil Engineering
 - Soil Behaviour, Characterisation and Modelling
 - Slopes and Embankments
 - Foundations
 - Ground Performance and Building Response
- Web: www.skemptonconference.com

APRIL 13–17 2004, New York, USA

5th International Conference on Case Histories on Geotechnical Engineering

Topics Include:

- Geotechnical Aspects of Italy 2002 and Alaska, 2002, Earthquakes including: Liquefaction, Ground Motion and Amplification, Comparison with other recent Earthquakes, Failure of Ground, Damage to Geotechnical Structures and similar topics
- Mitigation and Design for Liquefaction including: Analysis and Design of Laterally Loaded Large Diameter Piles and Pile Groups using Advanced Calibrated Computer Models in As-IS and Liquefied Conditions, Earthquake drains for Mitigation of Liquefaction, Load tests for piles for Liquefied and Improved Soil Ground Conditions, Lateral Load Testing of Pile Groups, Calibration Studies of the DSSI problem from Recent Earthquakes in Seismological-geotechnical-structural hand shake in the performance based design conditions of Ground Deformations Related to Soil Liquefaction and similar topics.

Abstracts: April 1, 2003

Full manuscripts: August 1, 2003

<http://www.umn.edu/~eqconf/5thCHConf>

MAY 3–5, 2004, Hong Kong

4th Asian Symposium on Engineering Geology and the Environment

“Engineering Geology for Sustainable Development in Mountainous Areas”

Sub-themes:

- Natural and man-made geo-engineering/environmental hazards: regional perspectives
- Mechanisms of instabilities in mountainous terrains
- Remote sensing and GIS in land-use planning and hazard prediction
- Origin, measurement and analysis of in-situ stresses
- Engineering geology for infra-structural development: case histories
- Geo-environmental impacts of natural resource exploitation and engineering projects

Submission of abstracts: May 1, 2003

Acceptance of abstracts: July 1, 2003

Submission of full papers: October 1, 2003

<http://www.hku.hk/earthsci>

MAY 4–7, 2004, Liege, Belgium

EurEnGeo 2004 – First European Regional Conference of the IAEG

Conference themes:

- Professional Practices,
- Engineering Geological Methods
- Case Studies of Infrastructure Projects
- Workshops on “Hazardous Geological Processes in Civil Engineering” and on “New developments in Risk Evaluation”

Submission of abstracts

<http://www.EurEnGeo2004.org>

MAY 19–22, 2004, Beirut, Lebanon

International Conference of Geotechnical Engineering – Beirut 2004

JUNE 22–26, 2004, Calgary, Alberta, Canada

Geo-Engineering for Resource Development

Conference themes:

- Hydrogeology and Geo-engineering practise
- Risk analysis in geotechnical design and construction
- Advances in engineering geophysics
- Advances in geo-engineering application of satellite technology
- Advances in data integration and numerical modelling

Call for Abstracts: Jan. 30, 2003

Submission of Abstracts: April 30, 2003

Submission of Paper for Review: October 30, 2003

Submission of Final Paper: Jan. 31, 2004

<http://www.geoerd.com>

AUGUST 2004, Santiago, Chile

MASSMIN 2004

Conference themes:

They reflect the main concerns and issues affecting the future of the world mining industry

- Mine Design Fundamentals
- Mine Planning
- Mine Operation
- Applied Geomechanics in mining
- Mass Mining Methods – Case Stories
- Research and Technological Innovation
- Transition from Open Pit to Underground Mining

Deadlines:

Submission of abstracts in English, not exceeding 200 words: August 30th, 2003

Letters of acceptance or regret: October 31st, 2003

Submission of papers: April 30th, 2004

Contact person:

Chairman: Dr. Antonio Karzulovic

Email: akarzulovic@akl.cl

SEPTEMBER 13–17, 2004, Thessaloniki, Greece

International conference on Eco-Engineering:

“the use of vegetation to improve slope stability”

Conference Themes:

- Vegetation and eco-engineering
- Interactions of vegetation and structures
- Soil reinforcement by roots
- Hydrology and land use
- Soil erosion
- Geotechnical methods and applications
- Slope degradation and forest dynamics
- Applications of land restoration
- Modelling of slope stability
- Decision support systems
- Riverbank and coastline protection measures
- Plant growth versus engineering stability
- Benefits and liabilities in slope protection and erosion control

Call for Abstracts: 1 January 2004

For further information, please contact:

Sanna Dupuy (conference administration)

Laboratoire de Rhéologie du Bois de Bordeaux
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Pacific Events Centre, Manukau – Investigation and design of pre-load beneath stadium footprint overlying buried valley system

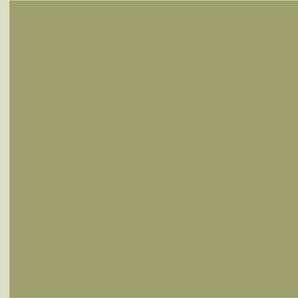
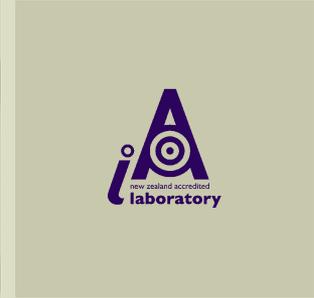
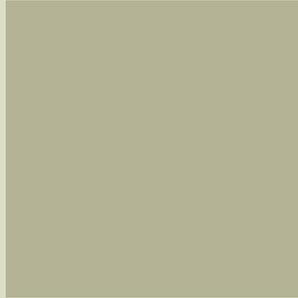


Ohinau Drive, Opito Bay – Investigation and detailed back analysis of landslide in volcanics affecting existing multi-lot residential subdivision



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SEPTEMBER 20–22, 2004, Porto, Portugal

2nd International Conference on
Geotechnical Site Characterization

– Sponsored by ISSMGE and endorsed by the ASCE
Geo-Institute and the ISRM, and will be scientifically
led by the members of Technical Committees of the
ISSMGE TC16 – for In Situ Testing – and TC10 – for
Geophysical Methods.

– We are inviting all those that work in the broad area of
Site Characterisation to send contributions as abstracts.

<http://www.fe.up.pt/ISC-2>

OCTOBER 18–20 2004, Nanjing, China

4th International Conference on Dam
Engineering

For more information contact:

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Ci Premier Pte Ltd
150 Orchard Road #07-14
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OCTOBER 21–23 2004, Nanjing, China

International Conference on Soil Nailing
and Slope Stability

For more information contact:

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National Network of Technological Societies (NNTS)

NNTS exists for the following purposes:

- Facilitating the presentation of the informed views of New Zealand's technological 'community of expertise' on issues of the day (by creating mechanisms for endorsement of non-aligned and learned contributions on technological issues affecting the wider community when they are presented to Government, the media, community leaders and the general public).
- Development of wide-ranging expertise listings as a resource for those in the community seeking informed comment on technological issues.
- Sharing of best practice and cooperation amongst Chief Executives/Executive Officers of member organisations e.g. development and operation of codes of ethics, shared publishing possibilities, wider advertising of meetings/seminars/conferences etc.
- Possibly developing a national Technology Events calendar, sharing administrative service experiences e.g. database developments.

**NZGS is now a member – so check out the website
www.nnts.org.nz**

NEW ZEALAND GEOTECHNICAL SOCIETY INC.

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| Murray, JG (Grant) | ISSMGE Australasian Vice President | Sinclair Knight Merz Ltd P O Box 9806 Auckland Gmurray@skm.co.nz | 09 913 8984 Work 09 913 8901 Fax 09 524 5078 Home 021 271 1992 Mobile |
| Baynes, FJ (Fred) | IAEG Australasian Vice President | 9 Chester St Subiaco WA 6008, Australia fredb@iinet.net.au | +61 8 9382 1259 Work +61 8 9382 1564 Fax |
| Haberfield, CM (Chris) | ISRM Australasian Vice President | Golder Associates Pty Ltd P O Box 6079 Hawthorn West VIC 3122, Australia chaberfield@golder.com.au | +61 3 8862 3500 Work +61 3 8862 3501 Fax +61 3 9754 5452 Home |

* Elected members of committee

+ Appointed position

NEW ZEALAND GEOTECHNICAL SOCIETY INC.

Objectives

- a) To advance the study 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.

Membership

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

Members are required to affiliate to at least one of the International Societies.

Students are encouraged to affiliate to at least one of the International Societies.

Annual Subscription

Subscriptions are paid on an annual basis with the start of the Society's financial year being 1st October. A **50% discount is offered to members joining the Society for the first time**. This offer excludes the IAEG bulletin option and student membership. No reduction of the first year's subscription is made for joining the Society part way through the financial year.

A \$30 per year service centre will apply to all non IPENZ members.

Basic membership subscriptions (inclusive of GST)
which include the magazine *NZ Geomechanics News*, are:

| | |
|----------|---------|
| Members | \$67.50 |
| Students | \$28.10 |

Affiliation fees for International Societies

are in addition to the basic membership fee:

| | |
|--|---------|
| International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) | \$24.00 |
| International Society for Rock Mechanics (ISRM) | \$33.00 |
| International Association of Engineering Geology & the Environment (IAEG) | \$21.00 |
| (with bulletin) | \$70.00 |

All correspondence should be addressed to the Secretary. The postal address is:

NZ Geotechnical Society Inc.

P O Box 12 241

WELLINGTON

The Secretary
NZ Geotechnical Society Inc.
The Institution of Professional Engineers New Zealand (Inc)
P O Box 12 241
WELLINGTON

NEW ZEALAND GEOTECHNICAL SOCIETY INC.
APPLICATION FOR MEMBERSHIP
(A Technical Group of the Institution of Professional Engineers New Zealand (Inc))

Full Name (Underline Family Name) _____
Postal Address _____
Phone No: _____ Fax No: _____ Email: _____
Date of Birth _____
Academic Qualifications _____
Professional Memberships _____ Year Elected _____
Present Employer _____
Occupation _____
Experience in Geomechanics _____

Student Members:

Tertiary Institution _____
Supervisor _____ Supervisor's signature _____

Note that the Society's rules require that in the case of student members "the application must also be countersigned by the student's Supervisor of Studies who thereby certifies that the applicant is indeed a bona-fide full time student of that Tertiary Institution"; Applications will not be considered without this information.

AFFILIATION TO INTERNATIONAL SOCIETIES:

All full members are required to be affiliated to at least one Society, and student members are encouraged to affiliate to at least one Society. Applicants are to indicate below the Society/ies to which they wish to affiliate.

I wish to affiliate to:

| | |
|--|--------|
| International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) | Yes/No |
| International Society for Rock Mechanics (ISRM) | Yes/No |
| International Association of Engineering Geology & the Environment (IAEG) | Yes/No |
| (with Bulletin) | Yes/No |

DECLARATION:

If admitted to membership, I agree to abide by the rules of the New Zealand Geotechnical Society Inc.

Signed _____ Date _____

ANNUAL SUBSCRIPTION:

Due on notification of acceptance for membership, thereafter on 1st of October. Please do not send subscriptions with this application form. You will be notified and invoiced on acceptance into the Society.

PRIVACY CONDITIONS:

Under the provisions of the Privacy Act 1993, an applicant's authorisation is required for use of their personal information for Society administrative purposes and membership lists. I agree to the above use of this information:

Signed _____ Date _____

(FOR OFFICE USE ONLY)

Received by the Society _____
Recommended by the Management Committee of the Society _____

NEW ZEALAND GEOTECHNICAL SOCIETY INC. PUBLICATIONS

| Publication Name | List Price Members | List Price Non-Members |
|---|-----------------------|---------------------------|
| New Zealand Geomechanics Society Conferences: Proceedings of the New Zealand Geotechnical Society Symposium – <i>Engineering and Development in Hazardous Terrain</i> Christchurch 2001 | \$50 | \$70 |
| Proceedings of the New Zealand Geotechnical Society Symposium – <i>Roading Geotechnics 98</i> Auckland 1998 | \$40 | \$70 |
| Proceedings of Technical Groups, Vol 22, Issue 1G <i>Geotechnical Issues in Land Development</i> Hamilton 1996 | \$20 | \$35 |
| Proceedings of the Auckland Symposium – <i>Groundwater and Seepage</i> May 1990 | \$10 | \$45 |
| Australia – New Zealand Conferences on Geomechanics: <i>Proceedings of the 6th Australia – NZ Conference on Geomechanics</i> Christchurch, February 1992 | \$50 | \$100 |
| <i>Proceedings of the 3rd Australia – NZ Conference on Geomechanics</i> Wellington, May 1980 | \$10 | \$30 |
| Other Publications: <i>Proceedings of the 2nd Australia – NZ Young Geotechnical Professionals</i> <i>Conference, Auckland, December 1995</i> | \$25 | \$40 |
| <i>Shear Vane Guidelines</i> | \$15 | \$20 |
| <i>Guidelines for the Field Description of Soils and Rocks in Engineering Use</i> | \$10 | \$13 |
| <i>Stability of House Sites and Foundations – Advice to Prospective House</i> <i>and Section Owners</i> | \$1 | \$1 |
| Back Issues of NZ Geomechanics News (depending on availability) | 50c | 50c |

Prices do not include GST or postage & handling

Orders to:

Debbie Fellows
 Management Secretary
 PO Box 60-213
 Titirangi, Auckland
 Email: dfellows@xtra.co.nz

ADVERTISING

NZ Geomechanics News is published twice a year and distributed to the Society's 500 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.

| Advertisement Location | Single Issue | Advert. Size (mm) |
|--|--------------|---|
| Black & White | | |
| Back Cover | \$300 | 210 wide x 297 high |
| Inside Cover (Front or Back) | \$250 | 210 wide x 297 high |
| Full Page Internal | \$225 | 185 wide x 265 high |
| Half Page Internal | \$175 | 90 wide x 265 high |
| Quarter Page Internal | \$150 | 185 wide x 130 high 90 wide x 130 high |
| Colour | | |
| Full Page Internal | \$400 | 210 wide x 297 high |
| A3 Centrefold | \$750 | 420 wide x 297 high |
| Inserts Insert to be posted with magazine – \$200/flyer Maximum size single A4 page Special price given on request for other types and sizes | | |
| Note 1. All rates exclude GST 2. Space is subject to availability 3. 3 mm bleed 4. Advertiser to provide all flyers | | |

If you are interested in advertising in the next issue of *NZ Geomechanics News* please contact:

Management Secretary

Debbie Fellows
 PO Box 60-213
 Titirangi
 Auckland
 Tel: 09 813 0012
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 Email: dfellows@xtra.co.nz



GEOTECHNICS LTD ROAD TESTING UNIT

Geotechnics offers a comprehensive road testing service which incorporates a wide range of testing applications from single lane unsealed rural accessways to multi-lane highways and motorways. The Road Testing Unit is purpose built for a range of IANZ registered services including:

DEFLECTION TESTING (BENKLEMAN BEAM)

This service utilises a standard Benkleman Beam where pavement deflections are measured and recorded with preliminary results issued on site, followed up by a formal test report.

DEFLECTION TESTING (GEOBEAM)

Using our patented Geobeam, deflection measurements are made via an electromagnetic proximity transducer located at the point of test. This system provides for both standard deflection information and detailed bowl shape at every test point if required. The information is automatically recorded and stored on a hand held site computer and can be used to determine subgrade moduli and analysis of pavement component performance.

This service has particular application on existing pavements where subsurface information is required for design purposes.

Standard test loads of 7.3 tonnes and 8.2 tonnes are available for deflection testing.



FIELD CBR AND PLATE BEARING TESTING

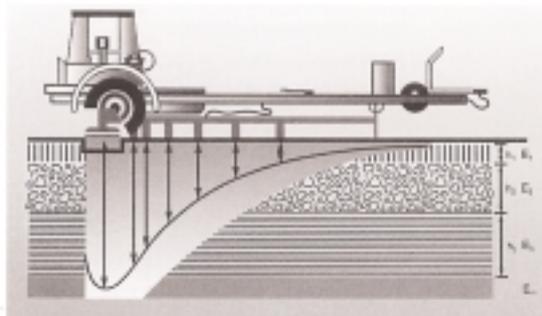
The unit has also been designed to perform Californian Bearing Ratio and Plate Bearing Tests and has built in facilities and equipment for the performance of these tests.

FULL TIME TEAM

The Road Testing Unit is operated by a two man team who are committed full time to its operation and maintenance. We aim to provide a timely, cost competitive service which meets the demands of the civil engineering and construction industries.

THE FALLING WEIGHT DEFLECTOMETER

Using the Falling Weight Deflectometer (FWD) Systems and associated analysis software, it is possible to quickly and accurately determine the structural condition of the pavement system. The required overlay or other rehabilitation alternatives are calculated from analytically based structural design methods, at a cost which is negligible compared to the cost of an incorrect rehabilitation strategy.



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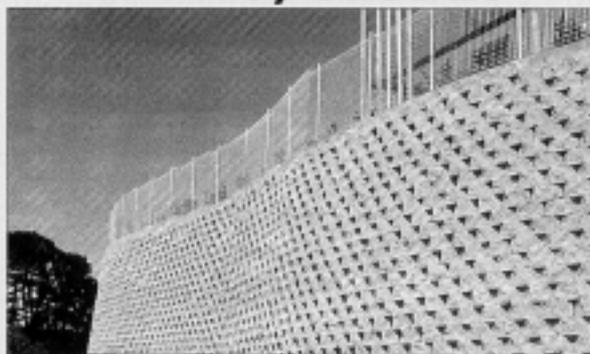
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We have numerous products to achieve ground holding and erosion control - from biodegradable protection blankets and permanent grass reinforcement systems, to the rugged, heavy duty gabions.

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We specialise in a broad range of sophisticated drainage products which are economical and easy to install. The emphasis of these products is to be user friendly with features such as minimum excavation and backfill requirements in addition to high flow rates.

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Our roading products are at the forefront of geosynthetic technology. These technically proven products are designed to extend the life of the road and increase the load bearing capacity.

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