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NZ Geomechanics News
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Newsletter of the New Zealand Geotechnical Society Inc.

NEW ZEALAND GEOMECHANICS NEWS

DECEMBER 2001, ISSUE 62

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Cover photo: Tongariro, Ngauruhoe and Ruapehu volcanoes, courtesy of Dr Warwick Prebble

CHAIRMAN'S CORNER

Geotechnical Society 2001 Symposium

Over 3 days from 24 to 26 August, 166 delegates attended a highly successful 2001 Symposium in Christchurch involving 2 days of conference proceedings and a day of field trips. One of the very pleasing aspects of the symposium was the relatively large number of overseas visitors with a total of 17 people representing Australia, Singapore, Malaysia, Korea, and Switzerland. We were very fortunate to receive sponsorship from 7 sponsors and 12 trade exhibitors, and our considerable thanks go to these organisations without whose assistance the financial success of the symposium would not have been possible.

I would also like to take the opportunity of acknowledging the role of the organising committee established by the Geotechnical Society who had ultimate responsibility for the symposium. The symposium committee comprised of Kevin McManus (Chairman), Peter Kingsbury, Marton Sinclair, Bruce Riddolls and Guy Grocott. I would like to thank my colleagues on the organising committee for your efforts and contributions over the last 2.5 years. The Symposium was dedicated to Brian Paterson who was also on the organising committee before his death in 1999.

Life Membership for Les Oborn

A Special General Meeting was held during the 2001 Symposium which unanimously passed a resolution to elect Mr Les Oborn as a Life Member of the Society. Les is well known by older members of the New Zealand Geotechnical Society and is a pioneer of engineering geology in New Zealand. During his time with New Zealand Geological Survey, Les was instrumental in introducing to New Zealand many of the engineering geological standards and techniques that are in current use. In terms of his involvement with the Geotechnical Society, Les was appointed International Vice President for New Zealand/Australia for the International Society for Engineering Geology between 1968 and 1972. Les is the first engineering geologist invited by the Geotechnical Society to present the Geomechanics Lecture, when in 1987 he presented the 5th lecture titled "Thoughts on the evolution of engineering geology in New Zealand". Our warmest congratulations are extended to Les.

Subscriptions

This time last year, I signalled the possibility of increases in our subscriptions due to rising costs from the weakness of the NZ dollar and the impact this has on affiliation fees to international societies. We also have the additional costs to support a new Vice President for the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). While we were able to delay any increase for 12 months, unfortunately there is now a need to increase subscriptions that will be reflected in the current IPENZ dues. Our subs still compare very favourably with other similar organisations, and given the number of activities carried out on behalf of members, I am of the firm opinion that our subs are very good value.

Young Geotechnical Professionals Activities

Chris Bauld has recently been co-opted on to the management committee to promote activities amongst the younger members of the Society. Please contact Chris if you have any ideas for professional, educational and social activities that the Society could be involved with to assist our younger members (telephone (09) 355 6059 email cbauld@tonkin.co.nz).

Website

Phase 1 of the Society's website development is now up and running and proving beneficial to members (www.nzgeotechsoc.org.nz), including the recently published guidelines on the use of the shear vane apparatus that can be down loaded from the web page. Further developments will be incorporated into Phase 2, which is being worked on at the moment. Please contact the Secretary, Debbie Fellows, with any ideas for further development of the website.

Guy Grocott
Chairman

EDITORIAL

This is now the fourth edition of *Geomechanics News* I have had the pleasure of editing. I must admit that, at least from my perspective, the job gets easier. Of course that may have something to do with the excellent work that Debbie and especially Sophie put in to pulling the various articles together. It has now got to the point where I may even have to start calling myself the Executive Editor to reflect the fact that I don't actually do anything.

However, I do enjoy seeing how an edition comes together. With this issue, more than any other, our task has been made more difficult by having to decide what to leave out. There are always promised contributions that fail to materialise but having said that, it is great to be in a position where we are only constrained by what we can afford.

In this issue we publish Warwick Prebble's Geomechanics Lecture in all its glory. Many members will have had the opportunity of hearing his presentation at Canterbury or on tour. For those that were not fortunate enough to attend the Hazardous Terrain Conference there is an excellent writeup courtesy of a coerced Nick Speight and this issue is your opportunity of having a legal copy of Warwick's Keynote Address. To complement the Engineering Geological feel of this issue we have included a review paper by Tara Adhikary on the classification of weathering profiles in the East Coast Bays Formation of the Waitemata Series. Many members will be familiar with this topic but surprisingly, it has rarely been written about.

In our regular features Sergei Terzaghi is back with some further explanations on the mysteries of Numerical Analysis, we only have one book review but Bob Wallace is on form. Laurie's Brain Teaser has a somewhat different flavour in this issue and we're looking forward to next year's Photo Competition on Site Mishaps (inspired by a submission from Northland). In this issue, I am pleased to see the diversity reflected in the Member and Company Profiles. It takes character to work in this business and in my experience any organisation that focuses on this profession tends to be quite colourful. You only need to read the items to see that I'm right.

Talking about colourful characters, Jon Sickling has sent us his second report as the *Geomechanics News* Overseas Correspondent. Ignoring the unforgivable trespass at an International Conference, his light-hearted view of geotechnical work in a foreign field is a timely reminder of one of the attractions of this profession.

There has been some activity in the Industry on Section 36 and the revised Subdivision Standard. The notes on these issues are worth reviewing because the chances are that they will impact on most of the practising Geotechnical Engineers in the country in some way, shape or form over the next few years. There is an initiative under way to establish an Australasian Branch of the International Geosynthetics Society and, because we like to have links between items in the G.News, we also present information on the recently published Geosynthetic Reinforced Soils Guidelines for NZ.

Over the last three issues I have tried to add a little controversial flavour through the Newsletter. The objective is simply to generate debate and flesh out the issues that are all too easily brushed under the carpet in a misplaced desire to keep everyone happy. No matter how hard I try to provoke, we still struggle to get unsolicited contributions. Of course it could be concluded that there is no debate about the questions I raised in my last editorial. In which case we would have to face up to the horrifying possibility that:

- Geotechnical Engineers in Wellington have no understanding of instability mechanisms and the design of anchorages and,
- the Transfund Research Report RR189 was a waste of money and not worth the paper it was printed on.

Unless, of course, you can tell me that it is not true and there is a valid explanation. I suspect that there is a link between the technical merit of these items and the level of local branch activity from where they originated. After all, it's not too difficult to go from an apathetic attitude to the local professional activities to an apathetic attitude about your profession.

Grant Murray
Editor

The Editorial Team:

Grant Murray
Editor
Sinclair Knight Merz
P O Box 9806
Auckland
GMurray@skm.co.nz

Sophie Pezaro
Debbie Fellows
Assistant Editors

Sally Fullam of ArtDesign
Design and typesetting

REPORT FROM THE SECRETARY

Society membership is currently flourishing with a total of 473 members.

New Members

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

G Guy	C Simpson	D Coutts	J Green
N Korte	I Jennings	M Slako	K Anderson
V Pere	L Yang	K Abdulla	S Brindle
G Strayton	J Bush	A McDougall	S Stewart
G Galloway	M Howard	A Teen	

Resignations

P Mohi, T Simpson, A Sprott, A Swain, S Kirkpatrick, D Kettle, and J Harrison have tendered their resignations from the Society.

New Life Member

Congratulations to Les Oborn on being elected our new Life Member.

Debbie Fellows
Management Secretary

EDITORIAL POLICY

NZ Geomechanics News is a newsletter issued to members of the NZ Geotechnical Society. It is designed to keep members in touch with recent developments within the Geo-Professions both locally and internationally.

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.

The editor's 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 the international journals and conferences
- technical notes
- comments on papers published in *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

Submission of text material in camera-ready format is not necessary. However, typed copy is encouraged particularly via email to the editor or on floppy disk. We can receive and handle file types of almost any format. Contact Grant 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 and of a suitable size for mounting to magazine format. *NZ Geomechanics News* is a newsletter for Society members 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

A Tale of Feta and Grout – (non technical article)

From our Foreign Correspondent
Jon Sickling (Mott MacDonald, UK)

"Engineering leads you to some unusual situations", thought the young ANZAC as he sat sipping a nice glass of pomegranate wine with a Turkish Kurd and a nice chap in a silly hat from the Isle of Mann. What's next – a troupe of dancing bears on ice skates? The fact that we were drinking wine at only 10:30am did rather challenge my sense of decency, but one mustn't be rude in such sensitive situations. We had somehow become trapped at the annual wine festival in a town called Sirince, an old Greek mountain village not far from my construction site. Ah, life is tough. It is now about 3 months since I came to Turkey, as a resident Geotechnical Engineer to supervise piling and jet grouting for a moderate sized factory in an earthquake prone area. Since moving to the UK in May and taking a contract position with Mott MacDonald, I have had the good fortune not to work on any jobs actually located in London – olive trees and feta cheese make a very welcome change from rain and the underground.

Always keenly focussed on the job, I somehow managed to find myself in Istanbul for the 15th International Conference on Soil Mechanics and Geotechnical Engineering. Feeling like quite the soil groupie after meeting a certain Mr Ralph Peck on the plane, I strode into the opening session of the conference and took a seat. I suppose I should have felt a little cheap after sneaking in without paying the meagre US$600 enrolment fee, but recent student habits die hard. As I looked around I noticed that the whole place was brimful with academic professor types, and the ubiquitous well dressed female geologists from Italy. It is a strange fact of these events that it is about the only time Professors put their suits on, and consultants take theirs off. This was powerfully evidenced when the six incoming Vice Presidents were asked to stand up and make themselves known, and the representative of the Australasian region was observed to be wearing a rugby shirt and jeans. Not only this, but the said gentleman received a doctoral field commission from Kenji Ishihara to give him some sense of credibility. After two days of meeting people who write expensive textbooks and vain attempts to find free coffee, the conference staff had the nerve to kick me out for not having paid my registration.

Meanwhile back on site things had gone a bit pear-shaped, literally. My beautiful field trial jet grout columns were belling out in diameter in certain zones, resulting in low cement dosages and UCS results that miserably failed the design criteria. Not only that, but the client and contractor had decided that programme was more important than the extravagance of playing scientists with field trials, and that there was no good reason why field trials could not wait until after we had finished production jet grouting. I decided it was my duty as an ethical graduate IPENZ member to inform all parties that, yes, the load tests would be rather useful in assessing the load bearing capacity of the columns. And, yes, wet grab sampling would be a useful way of obtaining samples that we could strength test where the soil-cement was too soft to core. Sigh. In the end, the load tests proved invaluable, as did the wet grab piston samples. I won.

In two weeks it will be back to the office grind in London, with maybe four months site supervision in Ireland coming up. 2001 has been a good year for Geotechnical Engineers in the UK, with demand very high. As in New Zealand, most companies are finding it very hard to recruit engineers from graduate to chartered level, as there seems to have been a big drain of labour to the IT industry over the last five years. There are huge backlogs of rail related geotechnical work in the UK and the short-term employment situation is still looking good. But with the global economic slowdown, it seems that the finance and IT industries are starting to tighten their belts in the UK and it is probably only a matter of time before this filters through to civil engineering. In addition there may soon be an influx of returning expatriates from the Middle East and Asia, given the current political crises. For the moment though, Tauranga Group Alluvium, Scala Penetrometers and Section 36(b) of the building code are thankfully a world away.

INTERNATIONAL SOCIETY REPORTS

ISSMGE

Istanbul Conference – Council Meeting

The Istanbul conference saw the end of President Ishihara's term of office and the hand-over to a new board.

Presidential Election

The Presidential Election was between Harry Poulos and Belgium's William van Impe. It was a very close vote with Van Impe carrying the day 31–29.

2003 Mid-Term Council Meeting

A series of ballots were held to vote on the venue for the mid-term Council meeting in 2003. A very strong case was made for Boston but in the end the heavy Euro-influence was evident and Prague won the final ballot after New Zealand, Singapore and Morocco were eliminated in the early rounds.

International YGP

The member societies were invited to volunteer to host the next International YGP in 2003. Submissions were heard from Singapore and Romania. A show of hands found in favour of Romania.

Istanbul Conference – Ad-hoc Board Meeting

President-elect (William Van Impe) called an ad-hoc Board meeting on 29 August to introduce and present some thoughts on his planned term of office. The president-elect has identified five priority areas of business that would need to be tackled in this term of office:

ISSMGE Subscription Fee

At the moment the formula used to calculate the subscription rates for individual members within member societies appears to be anomalous. Members from small societies in poorer economic regions or countries can be asked to pay more than the individual members from the larger more affluent member societies.

Constitution on Voting Policy

At the moment each member society has one vote at Council and each vote carries equal weight. There are 73 member societies but at the moment there are 37 societies (a theoretical majority of the council) that represent the interests of less than 7% of the individual members affiliated to the ISSMGE.

Industrial Liaison

The importance of establishing stronger links between the Society and practising engineers within the membership was recognised. One of the concepts proposed was to establish ISSMGE Industrial Ambassadors within each region. This role is yet to be clearly defined.

Information Technology

Council recognise that IT will play an increasingly significant role in the future of the Society.

Technical Committees

An urgent review of the activities and future plans of the TC's was called for with particular focus on possible mergers, termination and modus operandi.

The next Board meeting will be held in Hong Kong in early December.

Grant Murray
ISSMGE Vice-President for Australasia

Sinclair Knight Merz
P O Box 9806
Newmarket
Phone: 09 913 8984
Fax: 09 913 8901
Email: gmurray@skm.co.nz

ISRM

Vice President's Report to NZGS Management Committee October 2001:

Introduction

This report covers ISRM business for the period February 2001 to October 2001. The last Board meeting was held in Beijing, China, on 9th September 2001 followed by a Council meeting on 10th September 2001. Unfortunately due to a prior personal commitment, I was unable to attend. Mr Sukumar Pathmanandavel kindly offered to attend the Council meeting and to act as proxy for the NZGS. As the minutes of the Board and Council meeting are not yet available, this report will be very brief. I will provide a full report once the minutes are available.

Outcomes from Council Meeting

- As the USA nomination for the next ISRM president was received late, Council was required to vote on whether or not to accept the nomination. The nomination was accepted by the Council with a vote of 18 to 8.
- Professor Nielen van der Merwe of South Africa was voted in as the next ISRM President.
- Portugal was voted the host country for the 11th ISRM Congress to be held in Lisbon in 2007.
- The ISRM International Symposium for 2002 will be held on the Island of Madeira, Portugal.
- Mark Diederichs of Canada was awarded the Rocha Medal for his thesis entitled "Instability of Hard Rockmasses: The Role of Tensile Damage and Relaxation".

Associate Professor Chris Haberfield
ISRM Vice-President for Australasia

Golder Associates Pty Ltd
P O Box 6079
Hawthorn West
VIC 3122

IAEG

March – September 2001:

Executive Committee Annual Meeting

Helsinki, 4 August 2001

– It was agreed that the IAEG web site be re-established professionally and items like the Newsletter and Commission activities posted on it.

– The recipient of the Association's premiere award, the Hans Cleos medal, will in future be invited to give a lecture at the IAEG Congress. The 2002 recipient is Sir John Knill and he will receive the medal and give his lecture in Durban.

– An invitation was received from the UK national group to host the 2006 IAEG Congress, in London.

– Regarding recent discussions advocating possible merger with ISSMGE and ISRM, the view of the Executive was that for now, IAEG should maintain its autonomy.

– A proposal was received for the establishment of a new Commission, on Sustainable Development.

Council Annual Meeting

Helsinki, 5 August 2001

– My VP's annual report was tabled, along with those for other regions. There were 31 countries (national groups) represented at the Council meeting. The president, Professor Wang Sijing, emphasised the importance of the work of Commissions as practical support to members, and encouraged increased regional activity of the Association.

– The proposal for the new Commission of Sustainable Development received enthusiastic support.

– The modified statutes and by-laws debated at the 2000 meeting were approved, relating to procedures for organising regional meetings.

– The Bulletin is now available on-line.

Commission Meetings

Helsinki, 7th & 8th August 2001

Meetings of the following Commissions were held:

- C-10 Building stones and ornamental rocks
- C-14 Waste disposal
- C-16 Ancient monuments and archaeological sites
- C-17 Aggregates

All Commissions are keen to receive ideas from members on what activities will be of most use to them. Workshops attached to IAEG-sponsored meetings are increasingly seen as a way of improving communication.

IAEG-Sponsored Symposium "Aggregate 2001 – Environment and Economy"

Helsinki, 6th – 10th August 2001

I was invited to chair a session of the symposium on behalf of the IAEG. Papers presented covered a wide range of topics, from exploration to production, with considerable emphasis on environmental issues.

A notable trend in many countries is a change from production of aggregate from alluvial to hard rock sources, for environmental reasons associated with extraction.

A recurring theme was that laboratory testing alone to predict aggregate suitability was unreliable, and that geological assessment methods were often more appropriate, together with performance monitoring.

Australasian Regional Group

At the NZGS symposium in Christchurch in August, an IAEG workshop was held, entitled "Engineering Geology in the Computer Age – Back to Basics". Emphasis was on the need to routinely prepare engineering geological plans of uniform standard as the core task of every geotechnical assessment. There were 42 registrants. It is planned to hold practitioner workshops with future symposiums.

Some registrants also met informally to discuss professional issues, and it was agreed that position papers should be prepared on registration and education.

9th IAEG Congress

Durban, 16th – 20th September 2002

The organisers have advised that abstracts may still be submitted via the web site: http://stanfield.ac.za./durban 2002

Bruce Riddolls
IAEG Vice-President for Australasia

Golder Associates Ltd
P O Box 2281
Christchurch
Phone: 03 377 5696
Fax: 03 377 9944
Email: briddolls@golder.co.nz

NZGS BRANCH ACTIVITIES

Auckland Branch Activity Report

The middle part of the year has been filled with a number of excellent presentations to the Society in Auckland. All of these have been very well attended showing a pleasing support for the programme of talks by the Society. The topics are summarised briefly below for those who missed the meetings.

Fundamental Factors Affecting Liquefaction Susceptibility of Granular Soils – Professor Yoginder Vaid
Professor Vaid has spent many years working in the laboratory testing of granular soils and investigating liquefaction and flow of sand. He gave an enlightening talk covering many of the fundamentals of liquefaction and the importance of fabric and deposition environment to liquefaction potential.

Transit Pilot Specification F7 – Geosynthetics – Gordon Stevens
Gordon Stevens presented an informational talk covering the background behind the new geosynthetics specification. He also covered the basic aspects of specification and testing involved with the proposed standard.

Project PJK – Tim Sinclair and Tony Cowbourne
The Routes P, J and K, Tauranga Expressways currently under construction make up the largest ever single roading contract in NZ. The project involves construction of embankments as high as 9m on soft foundations, cuts up to 30m high and a total of 7 bridges.

Tony gave an outline of the project and the geotechnical conditions that have challenged the design team. He also detailed some of the design and testing work involved with constructing the embankments on soft ground, including the use of a trial embankment to prove the design.

Tim covered specific design problems on the project including surcharging of embankments and embankment stiffness and cracking. In addition he described negative skin friction design, including pointing out the high actual FOS on negative skin friction due to cumulative load factors.

Seismic Performance of the Bolu Viaduct on Ankara Motorway, Turkey – Professor Ezio Faccioli
Professor Ezio Faccioli gave a presentation on liquefaction and the performance of a significant viaduct structure during the major earthquake in Turkey. Professor Faccioli was one of Jamiolkowski's partners in Studia Italia until he accepted a full-time chair at Milan some three years ago. He has been involved in many of the main recent geotechnical projects in Europe.

Future Talks

We have two presentations to round out the year with Warwick Prebble presenting his Geomechanics Lecture and the Geotechnical Society Student Prize. A brief summary of the proposed talks is given below.

If you have a potential topic or wish to present something to the Society in Auckland please contact Chris Bauld on phone 355 6000.

Chris Bauld
Auckland Branch Co-ordinator

Auckland Meeting Schedule – Spring 2001

November Geomechanics Lecture – Warwick Prebble "Hazardous Terrain – An engineering geological perspective"

New Zealand is well endowed with hazardous terrain. Warwick draws on a wealth of experience from working in various parts of NZ. He presents a brilliantly illustrated lecture that looks at hazards in active volcanic terrain, East Coast topples and weak rock in his tour of the identification and application of engineering geology.

Date: 22 November 2001
Time: 5:30pm Refreshments – 6:00pm talk
Location: School of Engineering – Room 1.401

December Student Prize

Students from the northern region will present results from their latest research in a competition for this prize.

Please attend to support the future of our industry.

Date: 12 December 2001
Time: 5:30pm Refreshments – 6:00pm talk
Location: School of Engineering – Room 1.401

Waikato/Bay of Plenty Branch Activity Report

Tauranga hosted Colin Viska from Slope Indicator Australia on 21st August. The talk on geotechnical instrumentation was very informative, particularly regarding the SINCO website (www.slopeindicator.com). This site hosts a large amount of useful information relating to the practical aspects of geotechnical instrumentation. Unfortunately though, total attendance was only 5, including the speaker and sponsor, so a lot of the sponsor's products went unopened.

Dr Warwick Prebble presented the NZ Geomechanics Lecture "Hazardous Terrain – an Engineering Geological Perspective" in Hamilton on 11th October and on 21st November in Tauranga. The Hamilton venue was the University of Waikato and while the timing coincided with University exams, Warwick was greeted with an enthusiastic audience of some 30 active and retired practitioners, lecturers and students. All of whom are now suitably inspired to tramp the Tongariro Crossing to check out some of Warwick's theories on the likely location of the next central volcanic plateau eruption.

Paul Burton, Mark Mitchell
Waikato/BoP Branch Co-ordinators

Wellington Branch Activity Report

Wellington Branch has had a mixed year compared with the goal of a speaker at about six weekly intervals. We started off well but two speakers dropped out in the middle of the year due to work commitments.
Our speakers to date have been:

- Greg Saul from Opus on the Candy's Bend project in March
- Peter Yttrup from Piletech on screw-in piles also in March
- Simon Nathan on building (or not building) across fault lines in May
- Gordon Stevens from Maccaferri on geotextiles in June
- Dick Beetham from IGNS on the Sisqually earthquake in July
- Tony Hurst from IGNS on the Mt Umu volcano in Japan in September
- Ezio Faccioli on earthquake effects on a Turkish Viaduct.

Attendances have been poor to mediocre, which I find very depressing. Typically we are getting 10 to 15 people but only four people turned up for Tony Hurst (three from my company). Given that Branch meetings are one of the few ways that members get some feedback for their subs, this level of support is very disappointing. The $100 cost for a powerpoint projector works out at a pretty heavy cost when this few people turn up.

Coming up we have two more talks. Warwick Prebble will deliver the Geomechanics Lecture on 6 November and we have a talk from John Hutchinson lined up in late November/early December. This gives a total of nine talks for the year which is what I normally aim for.

I have been doing the Branch speaker role for some time now and am not particularly happy to keep organising talks when so few people turn up. Therefore, any other people, or person, who want to take up a new and challenging task are more than welcome to take over. In the meantime, any offers of talks/assistance etc are most welcome.

Ian McPherson
Wellington Branch Co-ordinator

Canterbury Branch Activity Report

The branch has offered the following technical seminars in the second half of this year, and helped organise the NZGS 2001 Symposium, which was held at the University of Canterbury on August 24th and 25th.

On Wednesday July 25th, Mr Matthew Howard presented the results of his MSc thesis research on the Porters Pass Fault, one of the principal contributors to seismic hazard in North Canterbury. This well illustrated talk, the only South Island entry for this region's NZGS Student Prize, was attended by about 40 people and generated lively discussion. The high quality of the research and of the presentation made this a worthy award winner. The abstract is presented below.

The next activity was the 2001 NZGS Symposium, which included presentation of the 2001 Geomechanics Lecture, entitled "Hazardous Terrain – An Engineering Geological Perspective" by Dr Warwick Prebble. The Symposium assembled a programme of interesting and well-presented papers, and brought together the NZ geotechnical community for informal discussions and the renewal of old friendships. Thanks should be given to Kevin McManus and his committee for organising an excellent event.

Next, on Wednesday September 26th, Professor Ezio Faccioli, Professor of Engineering Seismology at the Politecnico di Milano, Italy, presented a paper entitled "Hazard Evaluation of the Bolu Viaduct Site, on the Istanbul – Ankara Motorway, After the M 7.1 November 1999 Earthquake". This was a joint meeting with the Canterbury Structures Group, who provided most of the audience. Professor Faccioli gave a nice talk about the long base-isolated freeway structure that suffered severe damage, but did not fall down, during the second earthquake in Turkey in 1999. His seminar described the damage, and then focused on the estimation of design ground motion for repairs to the structure.

The presentation scheduled for Wednesday November 28th by Dr Kevin McManus entitled "Some Strengths and Pitfalls of In-Situ Testing in Geotechnical Engineering" has been postponed until January 2002 to allow Professor John Hutchinson, who will be in Christchurch at that time, to give a seminar on slope stability the following evening, November 29th 2001.

John Berrill
Christchurch Branch Co-ordinator

Holocene Surface-Rupturing Earthquakes Along Porters Pass Fault

Matt Howard

Abstract

The Porters Pass fault (PPF) is a prominent element of the Porters Pass-Amberley Fault Zone (PPAFZ) which forms a broad zone of active earth deformation ca 100km long, 60-90km west and north of Christchurch. For a distance of ca 40km the PPF is defined by a series of discontinuous Holocene active traces between the Rakaia and Waimakariri Rivers.

The amount of slip/event and the timing of paleoearthquakes are crucial components needed to estimate the earthquake potential of a fault. Movement was assumed to be coseismic and was quantified by measuring displaced geomorphic features using either tape measure or surveying equipment. Clustering of offset data suggest that four to five earthquakes occurred on the PPF during the Holocene and these range between ca 5-7 m/event.

Timing information was obtained from four trenches excavated across the fault and an auger adjacent to the fault. Organic samples from these sites were radiocarbon dated and used in conjunction with data from previous studies to identify the occurrence of at least four earthquakes at 8500 ± 200, 5300 ± 700, 2500 ± 200 and 1000 ± 100 years B.P. Evidence suggests that an additional event is also possible at 6200 ± 500 years B.P. The ~1000, 5300 and 6200 years B.P. paleoearthquakes were previously unrecognised, while the 500 year event previously inferred from rock-avalanche data has been discarded. The present data set produces recurrence intervals of ~2000-2500 years for the Holocene.

The identification of only one Holocene PPF rupture to the west of Red Lakes indicates the presence of a segment boundary that prevents the propagation of rupture beyond this point. This is consistent with displacement data and results in slip rates of 0.5-0.7mm/yr and 2.5-3.4mm/yr to the west and east of Red Lakes respectively. It is possible that the nearby extensional Red Hill Fault influences PPF rupture propagation.

The combination of geometric, slip rate and timing data has enabled the magnitude of prehistoric earthquakes on the PPF to be estimated. These magnitudes range from an average of between 6.9 for a fault rupture from Waimakariri River to Red Lakes, to a maximum of 7.4 that ruptures the entire length of the PPAFZ, including the full length of the PPF. These estimates are approximately consistent with previous magnitude estimates along the full length of the PPAFZ of between 7.0 and 7.5.

CONFERENCE REPORTS

Engineering & Development in Hazardous Terrain

Christchurch, 24 – 25 August 2001

Reported by: Nick Speight
Tonkin & Taylor Ltd, Auckland

The Geotechnical Society symposium on 'Engineering and Development in Hazardous Terrain' held in Christchurch during August 2001 featured presentations on a number of recent projects in New Zealand and included the investigations, design, and risk management and mitigation for major projects undertaken in some of this country's most hazardous terrain. Also included were papers on slope failures, risk assessment and seismic and volcanic hazards.

A total of 37 papers were submitted, providing broad-spectrum coverage of the symposium's theme. Twenty-three papers were presented orally to delegates while the remaining 14 were displayed as posters. A trade display featuring some of the latest geotechnical innovations and services ran concurrently with the symposium.

From the outset, it was clear that a great deal of effort had been put into the presentation of data. Delegates were treated to an informative and visually appealing display of Powerpoint slides on a variety of recent projects, ranging from the design and construction of the Otira Viaduct to the engineering geology of an embankment dam on karst foundation.

Dr Warwick Prebble of Auckland University commenced the symposium with the 2001 Geomechanics Lecture. From an engineering geology perspective, Warwick discussed the range of hazardous terrain that geotechnical professionals in New Zealand often have to contend with. Some of the areas he covered were the Taupo Volcanic Zone, the East Coast Deformed Belt, the Southern Alps, and North Island weak rock. The importance of engineering geology in site investigations was highlighted, as were 'total mapping' as a recommended first step for field investigations and consideration of the regional picture in understanding and assessing site features on a localised scale. Warwick's lecture was well received and set a high standard for the remaining presentations.

The first of the two sessions on slope failures featured a series of case studies on recent projects involving instability. Of particular note was *George Winkler's* presentation on the engineering geology of the Golden Cross landslide, a 2100m long, 500 – 1000m wide, and up to 145m deep landslide, occupying approximately 135 hectares of land. Remedial works for stabilisation of the landslide were impressive, including 35km of horizontal drainage, 25 pumping wells to achieve deep-level drainage, and a 763m long 5m x 5m drainage drive.

Topics at the two afternoon sessions included risk assessment and seismic hazards. *Dr Robin Dunlop*, Chief Executive of Transit New Zealand, presented an informative non-technically oriented paper which was co-authored by *Ian Cox*, also of Transit New Zealand. Robin's presentation highlighted the importance of risk assessment for Transit New Zealand in the development, maintenance and operation of New Zealand's state highways. Recognising the need for effective risk management systems, Transit New Zealand has adopted the Australasian risk management standard AS/NZ 4360 which includes a definition of 'risk' in terms of the assessed consequence and likelihood of a postulated event, and 'risk management' as the process of risk. Case studies on roading projects such as the Otira Viaduct and the seismic retrofit of the Auckland Harbour and Thorndon overbridges were provided as examples of the implementation of such systems.

The conference was not all didactic presentations, however, and at the end of the first day delegates welcomed the opportunity to discuss what had been learned over light refreshments. In the evening, the conference dinner was held at the Centra Hotel at which delegates had the opportunity to meet people within the profession and to network. The guest speaker's topic at the dinner was, refreshingly, not hazardous terrain but rather his kayaking tour of the Antarctic. A fascinating talk, with accompanying slides illustrating the beautiful but harsh scenery of Antarctica was enjoyed by all.

The second day of the conference began with a panel discussion/debate on Section 36(2) of the Building Act. A series of presentations by numerous speakers from different backgrounds including consulting engineers, lawyers, and representatives from territorial local authorities, local government authorities and the EQC, covered a broad range of subjects. *Paddy Luxford*, chairing a subgroup of the NZGS, proposed amendments to the Act suggesting that property titles should identify and define the apparent risk of the hazards on a site and reference any relevant engineering reports. This would allow existing and/or future landowners to review the reports and evaluate the risk themselves, which they can then either accept or reject. Once the panel had spoken, the microphone was passed round the floor and delegates were given the opportunity to voice their opinions and ask questions.

The remainder of the morning was set aside for viewing the 14 poster presentations on display. Delegates were invited to informally discuss the content of the papers with the authors.

The final afternoon session on the second day focused on volcanic hazards and other issues, including construction of an embankment dam on karst topography and geothermally-initiated landslide movement near Waihi Village at the southern end of Lake Taupo. Presentations on mitigation of dam-break lahar hazards from Mt Ruapehu and flood/debris flow from Mount Cook Village provided delegates with useful practical information. Another interesting presentation was that of *Dr Tam Larkin* of Auckland University who presented a paper on natural hazards to Auckland engineering lifelines, in which he suggested that the next volcanic episode in the Auckland region may well emerge very near the CBD!

For those who had recovered sufficiently from Saturday evening's activities, optional field trips to Mount Cook Village and Arthur's Pass left Christchurch at 7.00am the following day. Both venues were the subjects of papers that had been presented at the symposium. Delegates on the Mt Cook field trip were taken to Mount Cook Village which is located on alluvial fans at the base of the mountains. Here, a commentary was provided on the hazard investigations and subsequent mitigation work undertaken to protect the village from flooding and debris flows.

The Arthur's Pass field trip featured a trip to the recently completed Otira Viaduct and widening of Candy's Bend, an 850m long section of State Highway 73. Delegates on this field trip were treated to a display of roading engineering, constructed in arguably some of the most rugged terrain in the country. Presentations during the symposium by *Dr Robin Dunlop* and *Ian Cox* of Transit New Zealand and *Greg Saul* of Opus Consultants highlighted the extreme conditions designers had to contend with in the design of the Otira Viaduct and the widening of Candy's Bend.

Overall, the symposium was a well organised and informative event as well as a great opportunity to catch up with others working within the wider geotechnical community.

Editor's Note: The Conference Proceedings are available for purchase through the Geotechnical Society, refer to NZGS Publications page.

15th International Conference on Soil Mechanics and Geotechnical Engineering

Istanbul, Turkey, 27 – 31 August 2001

Reported by: Grant Murray
Sinclair Knight Merz

You have to be a little bit concerned about a conference where the opening ceremony is an hour and a half behind schedule and at the end of the opening address the chairman asks if anyone has questions! I don't mind missing afternoon tea to try and get things back on schedule but delaying the delegates from hitting the bars after a long dry day in an air-conditioned auditorium is unforgivable.

This was the 15th International Conference of the ISSMGE held in the marvellously exotic city of Istanbul – spanning two continents and goodness how many cultures, in all its dilapidated splendour it was a marvellous venue. I was one of two NZ representatives at the event (there was a third Kiwi there but the less said about his illegal presence the better). Fortunately, the rest of the week was not spent gagging for a beer but at the conclusion I was still left wondering if the falling attendances at these events was due to a burgeoning feeling amongst the delegates that this was just some more of the same-old same-old.

Once I got over my schoolboyish enthusiasm for rubbing shoulders with the Jamiolkowski's and Peck's, the di Mello's and the Ishihara's, I had the impression this was neither a celebration of the profession's achievements over the last four years or a demonstration of the latest technological advances. Perhaps GeoEng 2000 was too hard an act to follow. I suspect Melbourne's success will never be matched and I think it represented the end of an era. In my opinion these events should now look forward.

It is always hard at these big conferences with multiple sessions going in different venues to choose what is going to be the most interesting. Murphy's Rule never fails – if there is an exciting and innovative session where the debate is heated and informative then it won't be the one I am in. It's also a mistake to pick the sessions where you think you have some interest and experience. One of two things will happen; you will either be bored because it's all old hat and routine stuff that you already know or you will be horrified to find out that what you have been doing for years is hopelessly wrong and inadequate.

I managed to find myself listening to Norwegians advocating the adoption of standards for the determination of characteristic engineering properties for soils. I heard a speaker from India claiming professional standards can only be upheld by having an International Register of approved practitioners. I got into a debate with some colleagues from the USA who have got so nervous of litigation they can no longer apply sound engineering judgement. But worst of all I was trapped in a session chaired by Germans with the arrogance to ignore the rules of the society and the official conference languages.

Perhaps one of the most positive aspects of attending international events such as these is to come back with the realisation that everywhere else in the world Geotechnical Engineers are struggling with exactly the same problems we face. It is also refreshing to see that underneath the gloss and the bluff and the bluster, they also make the same mistakes.

The highlights for me were the keynote addresses of Harry Poulos and David Hight. Both are so articulate and manage to make the most complex concept sound so obvious and straightforward. Then there were historical lectures on the Suez and Panama Canals. Fantastic feats of engineering, the like of which we shall never see again.

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STANDARDS, LAW & INDUSTRY NEWS

Submission on Review of the Building Act

Legislative Submission
NZGS Working Party on Section 36
A Discussion Document August 2001
Section 36 Building on Hazard-Prone Sites

1.0 Introduction

1.1 The following submission should be read in conjunction with our prior submission dated 18 December 2000 and is based on the results of feedback from our full membership, a number of Territorial Authorities, and presentations to the Local Authority Institute of Surveyors and a Speciality Conference of the New Zealand Geotechnical Society held in Christchurch in August this year.

1.2 We enclose a full transcript from the latter conference speciality section on s36 issues for your reference. [Not reproduced in *NZ Geomechanics News*]

1.3 This supplementary submission has been prepared by the working party of the New Zealand Geotechnical Society (NZGS) which was set up to provide comment on suggested changes to s36 of the Building Act.

2.0 New Zealand Geotechnical Society Position

2.1 The current section 36 of the Building Act is causing significant difficulties with interpretation such that few if any Territorial Authorities are or can implement this section of the Building Act within the literal interpretation. All Territorial Authorities in New Zealand are therefore potentially exposed to litigation under this section of the Act.

2.2 It is our experience that although most Territorial Authorities are endeavouring to be fair in their use of this section of the Act, wide discrepancies exist throughout the country on the form of interpretation. In addition significant hardship is resulting to members of the public affected by s36(2) impositions, not only because of these various interpretations and inconsistencies within a given Territorial Authority but also due to flow on effects with financial institutions, insurance companies and subsequent loss of property value.

2.3 It is the position of the NZGS that s36(2) in its present form and s36(4) should be abolished and the bulk of this submission elaborates on the reasons for this and the alternative approach we recommend.

2.4 However, should our recommendations not be adopted, it is our submission that the current s36 should undergo a significant rewrite and the NZGS then would generally support the proposed changes being promulgated by the Building Industry Authority provided the modifications identified in this submission are included as part of the changes.

3.0 New Zealand Geotechnical Society Proposal

3.1 Where a Building Certifier recommends to a Territorial Authority the granting of a consent in which it has relied on the assessment of a hazard or a Territorial Authority in issuing a building consent relies on a report that identifies and assesses the effect of a land hazard on a building, and the means of mitigation of the hazard, then the existence of the report shall be identified on the property title by means of a hazard notice, and a copy of the report shall be held by the appropriate Territorial Authority for future reference.

3.2 The society considers that it is very important that hazards are identified and <u>the effects</u> of those hazards on a building are adequately considered. It is fundamental to our submission that all land hazards assessed as impacting on a building are recorded i.e. even reports associated with consent approvals under s36(1). It is our submission that all consents can be approved under s36(1) provided adequate mitigation of the hazard to avoid material damage to a building occurs or is to be provided for at the time of issuance of a building consent. It may however under some circumstances be appropriate to approve such consents with a waiver.

3.3 The society believes it is very important that the identified risks associated with a hazard that potentially impacts on a building are transferred with the ownership of a parcel of land and its buildings. As the law stands at present only those hazards considered to be of sufficient risk that they are likely to cause material damage to the land when they occur are noted on a property title as a 36(2) notice. In practice many hazards identified by competent professionals are judged by them to be of sufficiently low risk that it is unlikely that they will cause material damage to a building or the land. These often remain oblivious to future property owners. It is our submission that this is not acceptable in today's society.

3.4 It is the opinion of this committee that the only effective means of transferring the knowledge of the probable natural hazard risks associated with buildings on a property is if the existence of an assessment is identified on a property title. (There have been some submissions made suggesting that the LIM is sufficient to provide notice of potential hazards but the NZGS does not agree. A recent study by a major Territorial Authority found that only 38% of property transactions in the past year sought out a LIM. It is the NZGS position that knowledge of these hazards is extremely important in any property transaction and the only effective means of transferring this knowledge is notation of a property title just as easements are noted on a title).

3.5 While this approach will result in many hazard notations on titles, as both acceptable and high risk hazards will be identified within the reports, such notations should reduce the current stigma which exist with s36(2) notices. However the owner, a future owner, the financial institution, and the insurer, by reference to the identified report can make a properly informed decision on the actual risk associated with the building or property. Our proposal should also render the current provision within the EQC Act allowing them to decline cover for such a hazard to be redundant.

3.6 Properties which currently have s36(2) notices or section 641(A) notices relating to the Local Government Act would of course remain but it is recommended these titles be progressively amended to identify the hazard which created the requirement for the notice and the report which identified the hazard. This could either occur on application for a further building consent or by specific application of the property owner.

3.7 While the EQC Act does not come within the auspices of this review it is the position of the NZGS that this Act should be amended to allow the EQC to vary its premiums in accordance with the risk their actuaries perceive to exist based on the hazard assessment, rather than the current position which allows a claim to be declined if the property has a 36(2) notice registered. The NZGS considers that any high risk properties must be able to obtain insurance even if they have to pay a premium for the benefit.

3.8 Consideration of removal of hazard notices from a title would not be necessary as further reports on the hazard and its effects could be subsequently registered where changes in conditions occur. Thus the actual sequence of hazard assessments could be reliably tracked.

4.0 Automatic Registration of Hazard Reports

4.1 In order to overcome the practical issues associated with registration of such hazard notices on titles it is proposed that the hazard notice be automatic on issuance of a building consent and it would occur when the Territorial Authority notifies the District Land Register (DLR) of the existence of a report on which it has relied.

4.2 We propose a code system for such purpose such as: {s36(1) NZBA 91 (coastal erosion, subsidence (settlement) ref 12345 Christchurch City Council}

This would mean report no. 12345 held by Christchurch City Council exists and provides a hazard assessment on (coastal erosion and subsidence associated with settlement). Each Territorial Authority could use its own report numbering system providing it could retrieve the report when required. The Territorial Authority would provide the reference on a prescribed form so that the DLR could automatically enter the notice.

5.0 Specific Issues to be Addressed in Legislation

The following specific issues should be addressed in s36 legislation to meet the submission of the society.

5.1 _Natural Hazards_

5.1.1 Although several parties have expressed an interest in widening the number of natural hazards to be considered under s36, the society is of the opinion that the following hazards are sufficient: Erosion; Falling Debris; Subsidence; Slippage; Inundation. With the exception of earthquakes which are adequately addressed by existing codes, other known natural hazards have a probability of occurrence which is beyond the time scale suggested by the society (see 5.4 below) as being appropriate for the assessment of natural hazards.

5.1.2 The NZGS has given considerable thought to the addition of active faulting, and are unanimous that building development within close proximity of an active fault should be controlled. We have however been unable to adequately define the term “active” for the purposes of this legislation nor to adequately define the proximity building development can take place to an active fault and have thus decided against its inclusion at this time. Within the time scale suggested under 5.4 below, active faults would in our opinion need to be defined as faults which have undergone measurable displacement in the past 100-200 years. However, such a definition does not appear to meet the currently suggested criteria of the NZ Geological Society who appear to define ‘active’ in geological time.

5.1.3 It is our opinion that it is essential the legislation provides definitions for each of these natural hazards and we propose the following:

a) Erosion – *Is the wearing away of soil and rock particles by water, wind, ice or gravity*. This would include consideration of coastal erosion by the sea or lake and bank erosion by rivers and streams along with surface sheet erosion of the land by wind or water. (Erosion by ice generally does not need consideration and erosion by gravitational effects is defined as a separate category under this Act).

b) Falling Debris – *This is material that is moving or falling under the action of gravity to the base of a slope*. It can be soil, rock, snow or ice. It includes all forms of debris arising from landslip whether it be rotational slumping or avalanche type flows.

c) Subsidence – *Is a general term associated with the vertical movement downwards of the land with little or no horizontal component.* It is usually associated with the removal of support to the land due to subsurface erosion or prior underground works such as tunnelling or mining. However, in this Act it also is applied to settlement due to consolidation, compression, compaction, or decay of material, or liquefaction of the ground or due to shrinkage from drying of the ground. (Ground which shrinks also swells and thus shrinkage/swell movements are captured under this requirement).

d) Slippage – *Is the lateral and vertical movement of the ground due to gravitational effects.* It will result in the undermining and loss of support of the land and may involve both vertical and horizontal movement. It is intended this definition cover all forms of slope movement from events which occur rapidly over a few seconds to those which involve long slow creeping effects.

e) Inundation – *Is the flooding with water of an area.* In the broadest sense this covers not only flooding due to the slow build up of water from a river flood, but also includes short term flooding due to overland flow paths. It could also extend to flood damage due to a rise in the groundwater level, storm surge and tidal effects or temporary ponding of water on flat ground during prolonged rainfall.

5.1.4 Comment: The bolded items in 5.1.3 are sufficient key words to apply to the coded form defining the hazard suggested in 4.2 above. We note that the design approach for each of the above hazards is often quite different.

For example with inundation it is a requirement of the Building Code that floor levels of residential space are maintained above the 2% AEP storm event (many district plans require this to be above a 1% AEP). The clear inference from this design approach is that some flood damage will result from storm events which exceed this flood level. Mitigation generally requires that the building will remain stable under such an event.

For subsidence, it is generally accepted that vertical settlements can occur to a building so long as material damage does not result. Experience shows that it is differential settlement which causes material damage and for vertical settlements less than 25mm, differential settlement is generally within tolerable limits.

For land slippage it is generally accepted that if a slip extends beneath a building envelope some damage will result unless provision has been made to avoid movement in the building. Reasonable estimates of the size of a slump event can be made. It is however difficult to assess the probability of, or when, a slump will occur as this is generally associated with climatic conditions which induce an infrequent response. Thus the type of assessment is quite different from that associated with inundation.

Similar considerations can be made with falling debris to those associated with land slippage. However, an added complexity occurs in that it is difficult to predict accurately the mobility of the debris after an event occurs.

Erosion rates are generally based on historical studies and knowledge of the materials involved. However such studies are based on known sea and water flood levels. World climatic changes make such historical data unreliable and hence such predictions should be limited as to the duration over which they are applicable.

5.2 <u>*Land Affected by Hazard*</u>

5.2.1 It is most important that this is clearly defined in the Act and we propose the following definition: “The land concerned means any land likely to affect or be affected by the building work”.

5.3 <u>*Effect of Hazard on a Building*</u>

5.3.1 The following distinctions should be provided for within section 36 either by description in the clauses or reference to other sections of the Act.

a) Where the hazard is perceived to be unlikely to cause ‘material damage’ to the building then a building consent may be issued.

b) Where the hazard is perceived to be likely to result in ‘material damage’ to the building if it occurs then at the discretion of the Territorial Authority a building consent may be issued subject to s34(4) of the Building Act.

c) Where the hazard is perceived as likely to result in issues of health or safety to the occupants of a building then no building consent may be issued unless such effects are mitigated. (As a society we note, that of all the hazards listed for consideration, the highest risk to safety of building occupants is that imposed by falling debris and to the best of our knowledge this is the only hazard which has resulted in death or injury of occupants since the Building Act was implemented).

5.3.2 In the above recommendations we have drawn on the terminology used in the equivalent s106 of the RMA where the concept of 'material damage' is used. It is our opinion this concept should be reflected in s36.

5.3.3 We note the term 'material damage' is not defined and suggest the following definition: *"Material damage" is any displacement of a building or its elements or cracking of individual elements within a building which is other than aesthetic and has been caused by a natural hazard.*

5.4 *Duration of Hazard Assessment*

5.4.1 The degree of risk associated with the above listed hazards is difficult to quantify with any certainty at the time an assessment is made and the reliability of that assessment changes with time following the assessment. Thus it is important that a time scale is introduced into the legislation over which the assessment of such hazards are applicable.

5.4.2 The society considers it is appropriate for hazard assessments to consider the period of 50 years after the assessment is made and the legislation should introduce such time effects. (This is consistent with the 50 year period introduced within the Building Act s39 for the minimum intended life of a building and in the building code for durability of materials and flood risk assessments).

5.4.3 The NZGS notes that the 50 year return period storm event considered by the Building Act is inconsistent with the 100 year return period event which most commonly forms the basis of catchment study evaluations of flood levels carried out under the requirements of the RMA. The NZGS would encourage consistency in this time period between different Acts. This would require a survey of all Territorial Authorities to identify the most appropriate time scale and is outside the scope of our submission.

5.5 *Responsibility of Territorial Authority*

5.5.1 The society considers it essential the legislation define the responsibility of the Territorial Authority rather than try to provide immunity from liability as exists within s36(4). In our opinion the Territorial Authority's responsibility should be limited to requiring each of the above listed natural hazards be assessed where it has knowledge of the existence of the hazard through its own records or has reason to suspect a hazard may exist to a building based on any enquires it may make during the normal course of its business.

5.5.2 Once a Territorial Authority has identified the need to assess a natural hazard then its responsibility should be limited to receiving from the building consent applicant a competent assessment of the hazard (this may include peer review where it has reason to doubt the adequacy of an assessment), at the time of issuance of a building consent to providing the information to the DLR to register the assessment report on the title, to retaining a copy of the report and to ensuring any mitigating measures recommended are implemented.

6.0 Modifications to Proposed Changes Recommended by Building Industry Authority

6.1 The society is not in favour of the proposed changes recommended by the Building Industry Authority (BIA) because it will retain the current s36(2) blight on a title. We do not consider the BIA approach sufficiently addresses the concerns our members have regarding the current legislation. It is our opinion a more radical change is required. The changes proposed by the BIA are a rewrite of the current legislation which does not fully address the inequality and confusion arising from the current legislation. We acknowledge however, the proposal of the Building Industry Authority is a significant improvement on the current drafting of s36. If the Department of Internal Affairs does not accept the society's position then we recommend the following modifications be made to the BIAs proposals.

6.1.1 Land Affected by Hazard

Our definition of land as given in 5.2 above should be adopted.

6.1.2 Definition of Hazards

A definition of the meaning of hazards as set out in 5.1.3 above should be included.

6.1.3 Duration of Hazard Assessment

It is important that a duration over which the hazard is to be assessed is included in the Act (refer section 5.4).

6.1.4 Damage to Building

We recommend the concept of material damage as exists in the equivalent section 106 of the RMA be introduced into s36 (see definition section 5.3.3).

6.2 Included with this submission is a copy of the transcript from the speciality conference held in Christchurch in August 2001 together with a copy of the amendment to s36 as proposed by the BIA. [Neither are reproduced in *NZ Geomechanics News*]

N S (Paddy) Luxford
Chairman of NZGS Working Party on s36 Building Act

Draft Subdivision Standard DZ4404

The draft of the revised Standard DZ4404:2001 *Land Subdivision and Development Engineering* closed for public comment at the end of August. This Standard is a revision of NZS 4404:1981 *Code of Practice for Urban Land Subdivision*. The Geotechnical Society's submission on the draft is reproduced below minus the appended comments from members. Standards New Zealand's initial response to the submission is published following. Currently the draft Standard is before the review committee with the final version due out in 2002.

DZ4404:2001 Land Subdivision and Development Engineering

We present to you the NZ Geotechnical Society submission on the above draft standard. This review has concentrated on the geotechnical part of the draft, namely Section 2. We note that no input was requested from the Society when preparing this draft document. You will see from a selection of the appended comments from our members that significant editing of the geotechnical part of the document is considered necessary. A full appendix of comments will be mailed to you along with this submission.

It appears that the general approach to this geotechnical update has been to rationalise NZS4404 and NZS4431. No significant attempt has been made to:

- Upgrade requirements relating to geotechnical assessment or
- Address the issue of registration/competency of geotechnical professionals.

We consider that at least one of these aspects must be covered by the new standard.

There has been extensive industry discussion on the integrated approach of geotechnical risk and assessment particularly with regard to subdivisions. Several documents and papers have been published by the Society and its members since NZS4404:1981 and these will be referenced or included in our postal submission. Included in these documents are cross-references to the EQC Act, NZS4203 and relevant sections of the Building Act [e.g. section 36(2)]. More recent requirements and sample checklists for geotechnical stability assessments are also presented. Similar sample checklists can be compiled for earthworks and foundations for a revised DZ4404.

The place of geotechnical registers or geotechnical practice colleges has been investigated by the NZGS in response to a call from IPENZ. This was concluded to be largely impracticable for the relatively small geotechnical community in NZ. Some Territorial Authorities have their own registers in place, either formally or informally, to varying degrees of success. The references to Professional Geotechnical Engineer, Registered Engineer experienced in soils engineering or (approved) Engineering Geologist in the draft are effectively little more than an indication.

In our opinion, upgrading the requirements for geotechnical practice is more practicable rather than instituting and enforcing a register of competency, and we recommend that the former approach be carried out.

We recommend a revision to the framework of geotechnical assessment for subdivisions to highlight the process of broad hazard and risk assessment, preliminary and supplementary geotechnical investigation, planning and design, peer review, quality assurance during construction, as-built documentation and communication of residual risk and maintenance of land.

We list some of the weaknesses identified by our members, which should be addressed in revising the current draft:

- It is vague on who should be responsible for geotechnical assessment. It is dangerous to split geotechnical responsibility between the geotechnical engineer and other design professionals.
- The draft is in places too prescriptive and not definitive enough in others. Some parts of the draft read more like guidelines and these parts should be identified as commentary rather than Standard requirements.
- The Geotechnical Engineer should not be able to determine the applicable criteria for stability analyses – these should be identified in the standard. Stability assessment criteria have now been removed from the NZ Building Code and it is appropriate that criteria should be inserted in a revised subdivisional code.
- Seismic criteria are not addressed in the code.
- There is an undue emphasis on fill to the exclusion of natural ground.
- There is also not enough attention given to excavations, compared to sections on fill.
- The assessment of both filled and natural ground for building foundations is not included. The title of Part 2 reveals this weakness by referring only to "Land Stability and Earthworks" when a major part of the Statement of Professional Opinion (Schedule 2) concerns foundation requirements and limitations for the completed land.
- A better title would be "Land Stability, Foundations and Earthworks".
- There is undue emphasis on maintaining the current landscape, particularly for urban development
- There is a need to upgrade the as-built requirements, e.g. for plans and for certificates.
- The scope of Part 2 given in the existing standard is better than that proposed in the draft.
- The geotechnical language used is out of date. Some of the terms are indefinite: "where appropriate", "within acceptable limits" (without stating what these are),

NZS4431 may (or may not), with or without modification, produce stable fills…".

- The aims and processes of geotechnical assessment are not clearly identified.
- The role of engineering geology is not prominent.
- There are no requirements or guidance for peer review.

Several positive comments to address the above are presented in our members' submissions, which will be appended to our postal submissions. However, it is not always appropriate to simply edit the existing draft text.

We therefore recommend a re-draft of Section 2 of DZ4404:2001 with specialist input from geotechnical practitioners. The NZ Geotechnical Society is prepared to provide this input.

Stephen Crawford
Chairman, NZGS Committee for Review of DZ4404:2001

Response to Public Comment Draft DZ 4404:2001 Land Subdivision and Development Engineering

Thank you for your comments on the draft standard DZ 4404:2001 Land Subdivision and Development Engineering, particularly on Part 2 dealing with land stability and earthworks.

These have been forwarded to the Technical Committee that is developing the standard and will be considered by that committee when progressing the draft's development through to the published version which is expected in June 2002.

At its meeting held on 3 October 2001 the Committee has taken the view there are no national standards for geotechnical assessments and that NZS 4404 is not the document for launching a full review of geotechnical standards as any such standard should sit outside the NZS 4404.

The Committee recommends that Standards New Zealand should consider developing new standards for specialised geotechnical assessments of land stability, earthworks and foundation design.

I have already taken up this matter internally and IPENZ should be shortly approached with a view to setting up a case for new geotechnical standards.

Regarding your specific comments on various clauses of Part 2 of the draft of DZ 4404:2001 these will be given due consideration and it is believed that the document can be considerably improved as a result of your submissions.

Mr Marton Sinclair, a member of the P4404 Committee, who is looking after this Part of the Standard will be contacting you for any necessary input.

Shafiq Islam
Project Co-ordinator
Standards New Zealand

Proposed Australasian Chapter of the International Geosynthetics Society (ACIGS)

I though it would be of interest to NZ Geotechnical Society members to learn that an Australasian Chapter of the International Geosynthetic Society (IGS) is currently being formed.

The driving force is mainly our colleagues from Australia who would like to see relevant parties from NZ come on board. I have offered our services at Maccaferri to act as an initial contact point for NZ and to co-ordinate with the fledgling Aussie group.

Over the last couple of years I have had comments from many sectors of the engineering community suggesting that it may be advantageous for a local geosynthetics industry group to be formed. I believe ACIGS to be the appropriate vehicle.

For those members of the NZGS who are not familiar with the IGS, I refer them to the following IGS synopsis. You may wish to view the IGS web site at http://igs.rmc.ca

The key Australian Contacts are:
Fred Gassner
Golder Associates Pty Ltd, Melbourne
Fax: 61 3 8862 3501
Email: fgassner@golder.com.au

Dr A (Malek) Bouazza
Ph: 61 3 9905 4956
Email: malek.bouazza@eng.monash.edu.au

Currently there are seven IGS Members from NZ already who make use of the IGS benefits. With geosynthetics playing an increasingly significant role in NZ engineering works, I would strongly recommend at least one member from each company who have an interest in the NZGS to also consider the IGS through the new local ACIGS chapter. I shall keep NZGS members informed on developments.

Chris Brockliss
Managing Director, Maccaferri NZ Ltd

International Geosynthetics Society – Synopsis

The International Geosynthetics Society (IGS) was founded in Paris, on 10 November 1983. The Society brings together individual and corporate members from around the world, who are involved in the design, manufacture, sale, use or testing of geotextiles, geomembranes, related products and associated technologies, or who teach or conduct research about such products.

Aims of the IGS

- to collect and disseminate knowledge on all matters relevant to geotextiles, geomembranes and related products, e.g. by promoting seminars, conferences etc;
- to promote advancement of the state of the art of geotextiles, geomembranes and related products and of their applications, e.g. by encouraging, through its members, the harmonisation of test methods, equipment and criteria; and
- to improve communication and understanding regarding such products, e.g. between designers, manufacturers and users and especially between the textile and civil engineering communities.

The following benefits are available to IGS members

- a membership card and an IGS lapel pin
- the IGS Membership Directory, published yearly, with full addresses, telephone, email and telefax numbers of members
- a Newsletter, *IGS News*, published three times a year
- information on test methods and standards.

Discount rates

- for any document published in the future by IGS
- at all international, regional or national conferences organised by IGS or under its auspices
- for subscriptions to the journals *Geotextiles and Geomembranes* and *Geosynthetics International*
- preferential treatment at conferences organised by IGS or under its auspices
- possibility of being granted an IGS award.

The following additional benefits are available to corporate members

- right to use the IGS logo at exhibitions and in promotional literature
- priority (by seniority of membership within IGS) at all exhibits organised by IGS or under its auspices
- possibility of joining a specific international committee in order to discuss topics of common interest.

The benefits of Student Membership include

- *IGS News*
- special student discounts at all IGS sponsored/ supported conferences, seminars etc
- listing in a special student members category in the IGS Directory (this may help both the student and future employers in making contact)
- eligibility for awards (and in particular the IGS Young Member Award)
- listing of theses relating to geosynthetics on the IGS web site.

Eligibility: Membership is open to individuals or corporations whose activities or interests are clearly related to the scientific, technological or practical development or use of geotextiles, geomembranes, related products and associated technologies. Most members (90%) belong to the IGS through chapters. Applications should be sent to the IGS Secretariat, either through the chapter or directly.
Annual Fees: Individual member US$45; corporate member US$1000; student member US$0. Chapter fees are set by the chapter.

For further information and details on membership, visit the IGS web site (http://igs.rmc.ca) or contact:
Mr Peter E Stevenson
Secretary of the IGS
226 Sitton Road, Easley
SC 29642-8393, USA
Tel: 1 864 855 0504
Fax: 1 864 859 1698
Email: IGSsec@aol.com

Guidelines for Design & Construction of Geosynthetic-Reinforced Soil Structures in New Zealand (Transfund NZ Research Report No. 194)

Alexei Murashev, Beca Carter Hollings & Ferner

Geosynthetic-reinforced soil (GRS) structures have been found to be cost-effective compared to traditionally used retaining structures in specific situations. As a consequence the application of GRS to structures carrying roads and/or pedestrian traffic is rapidly increasing. Possible applications of GRS structures on highways include:
- Reinforced embankments in place of viaducts
- Reinforced embankments supporting highways
- Repair of slope failures
- Bridge abutments.

In addition to their low cost compared with conventional structures, evidence from recent earthquakes indicates that GRS structures are less prone to damage under seismic loads than conventional type structures.

In one of the first Transfund projects to be co-funded by industry, researchers from Beca (Beca Carter Hollings & Ferner Ltd) have been working with Transfund New Zealand to develop guidelines for design and construction of GRS structures, both walls and slopes, for use in New Zealand. Co-founders of the project were Anchor Wall Systems Ltd (US and Australia), Firth Industries Ltd (NZ), Geotech Systems Ltd (NZ), Ground Engineering Ltd (NZ), and The Reinforced Earth Company (Australia & NZ).

Stage 1 of the project (Research Review) was undertaken in 1997-1998, and results were published as a Review and Discussion paper (Transfund NZ Research Report No. 123) in 1998.

Stage 2 of the project was undertaken 1999-2000 and resulted in the preparation of draft comprehensive guidelines for design and construction of GRS structures (Transfund NZ Research Report No. 194). The guidelines were developed for use by New Zealand consultants, contractors, and Road Controlling Authorities.

Design procedures for GRS structures address a number of important aspects such as design tensile strength and durability of geosynthetic reinforcement, load combinations, properties of backfill materials, interaction between backfill and geosynthetic reinforcement, methods to assess stress–strain state and stability of GRS structures, as well as uncertainties associated with the design procedures.

Most New Zealand material codes are, or are about to be, expressed in the limit state design format using a load and resistance factored approach. In the last 8 years the limit state design approach has been actively promoted by the New Zealand Geotechnical Society. Therefore, the draft of the guidelines have been written in the limit state design format using a load and resistance factored design approach.

The published draft of the guidelines contains the following information:

General Information Concerning GRS Structures

The following information about GRS structures is provided:
- Limitations
- Lateral displacement
- Minimum embedment depth for walls
- Seismic design (general requirements)
- Tolerance of facing to differential and internal settlement
- Design life
- Site investigations, for both feasibility assessments and detailed investigations
- Properties of foundation and reinforced-backfill soils
- Design philosophy
- Load combinations (and the load factors to be applied)
- Serviceability Limit State (general requirements).

Design of GRS Walls

Guidelines for the design of GRS walls for external stability under static conditions are separated into the main failure modes likely to occur:
- Forward sliding
- Overturning
- Bearing capacity failure
- Deep-seated failure.

Guidelines for the design of GRS walls for external stability under seismic conditions are based first on an assessment of seismicity of the site, together with a determination of accepted probability of occurrence and the design-basis earthquake. Then procedures for analysing the external stability of GRS walls under seismic conditions are presented.

Guidelines for the design of GRS walls for internal stability under static and seismic conditions are given under the following failure modes:
- Reinforcement rupture
- Pullout
- Internal sliding.

Guidelines for local stability analysis of GRS walls consider the following:
- Structural strength of facing elements
- Durability of facing elements

- Resistance to bulging
- Strength of connections between facing elements and geosynthetic reinforcement
- Local overturning
- Stability of unreinforced facing section above the highest reinforcement layer.

Design of GRS Slopes

Guidelines for the design of GRS slopes for external stability under static and seismic conditions are separated into the main failure modes likely to occur:
- Forward sliding
- Deep-seated failure
- Bearing capacity failure
- Local bearing capacity failure
- Excessive settlement.

Guidelines for the design of GRS slopes for internal stability under static conditions summarise the analysis methods adopted, as follows:
- Maximum size of the zone to be reinforced
- Geosynthetic reinforcement tension
- Chart design procedures
- Distribution of reinforcement
- Length of reinforcement required
- Trial layout of reinforcement.

Guidelines for the design of GRS slopes for internal stability under seismic conditions recommend use of the pseudo-static stability analysis method.

The need for intermediate reinforcement layers in GRS slopes is an additional check that is to be undertaken.

Subsurface and Surface Water in GRS Structures

Measures to control subsurface and surface water run-off are discussed.

Contracting Procedures

- Method and Material Specification: The Method and Material Specification approach includes the development of a detailed set of GRS structure drawings and material specifications. An example of this specification is given.
- Performance or Design Build Specification: The Performance or Design Build Specification approach is to purchase design, materials and construction from a single source. An example of this specification is given.

Both approaches have advantages and disadvantages, and these are discussed.

Computer Programmes for Design of GRS Structures

Eleven computer programs for the design of GRS structures that have been developed by suppliers and researchers are listed.

Appendices

The appendices include reprints from standard works and methods, specifications, and other material necessary as guidelines:
- Design tensile strength and soil-reinforcement interaction
- Environmental conditions and durability of geosynthetic reinforcement (reprinted from an FHWA research report)
- Information about geosynthetic reinforcement to be supplied by the manufacturer/supplier
- Deformation analysis method, being a reprint of Cai & Bathurst (1996) "Seismic-induced permanent displacement of geosynthetic-reinforced segmental retaining walls", *Canadian Geotechnical Journal*, 33: pp937-955.
- Local stability of GRS walls with segmental precast concrete unit facings
- Specifications for GRS Structures: Method and material specification; Performance specification.

Comment on the draft is invited from persons and organisations concerned with this project.

Report No. 194 can be obtained from:
Standards New Zealand
Private Bag 2439, Wellington
Phone: 04 498 5991
Fax: 04 498 5994
Email: snz@standards.co.nz
Order direct from: www.standards.co.nz

Comments should be submitted to:
Dr Alexei Murashev
Beca Carter Hollings & Ferner Ltd
P O Box 3942, Wellington

New National Drilling Standard

Article reproduced with permission from *Standards* magazine, August/September 2001 issue

The new national drilling Standard NZS 4411.2001 *Environmental standard for drilling of soil and rock*, is now out and copies have been distributed to local government bodies throughout the country. It will also be of relevance to bore owners and drillers.

The project began three years ago at the initiative of the Auckland Regional Council, and was funded by the Sustainable Management Fund (SMF), to improve drilling, bore construction and reduce the likelihood of environmental damage.

Accordingly, the Standard sets out minimum national environmental performance requirements for drilling of soil and rock, the design, construction, testing and maintenance of bores, the decommissioning of holes and bores and record keeping.

A 1997 survey estimated that more than 100,000 wells exist in New Zealand which could pose a threat to groundwater resources either now or in the future. The Standard therefore, aims to protect groundwater resources from degradation caused by poor drilling, sealing and/or maintenance practices.

The new publication provides regional councils and other local bodies with a valuable tool for protecting this resource and it is expected that it will be used by local authorities as rules in regional or district plans, or as conditions to resource consents.

Due to the funding from the SMF, free electronic copies of the Standard can be downloaded from the SNZ web shop at www.standards.co.nz.

2002 PHOTO COMPETITION
Theme: Site Mishaps

Entries need to be received by the end of March 2002

Please send	**original photos to:**	**or digital photos to:**
	Debbie Fellows 6 Sylvan Valley Ave Titirangi, Auckland	Grant Murray gmurray@skm.co.nz

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Many people seem to believe that a computer is a machine that allows you to use Microsoft software. Of course, there are many other programs out there, all of them designed to do specific tasks. The problem is to know which ones will allow you to achieve your business objectives effectively

Hoare Research Software Ltd (HRS) has been helping scientists, engineers and business analysts with this task for more than 10 years. When starting the company, Dr Ray Hoare, the founder, decided he would no longer write software, but would instead market products that come out of the USA, from a variety of companies.

The "Value added" component of Hoare Research Software Ltd is the in-depth knowledge of a large number of specialised data analysis and computational products, so that customers are assured of reliable pre-sales advice and post-sales support.

One important part of the Hoare Research Software Ltd marketing program is the seminar series, which lets people see exactly what they can do with the products they may have heard about but don't yet know. Hoare Research Software Ltd also does training itself, or arranges training by contractors, so users of their software can get full value from it.

Hoare Research Software Ltd is particularly passionate about Mathcad - NZ engineers seem to be well behind the rest of the world in adopting this basic calculation and design documentation tool. To learn more phone Marc at 0800 477 776 for a brochure or come to a seminar near you.

For more information on the full range of products from Hoare Research Software Ltd, go to www.hrs.co.nz, or email info@hrs.co.nz for a software guide.

BOOK REVIEW

The Geotechnics of Hard Soils – Soft Rocks

This review is of the recently published Volume 3 of this title, which records proceedings of a conference held in Naples in October, 1998. My review of Volumes 1 and 2 appeared in *Geomechanics News*, No. 59, June 2000.

The volume contains keynote lectures, general and panel reports for each of the main conference sessions, and 'round table' papers. As with Volumes 1 and 2, the overriding theme is one of ongoing concern amongst designers over the fact that "hard soils and soft rocks escape the principles of Soil Mechanics or Rock Mechanics".

Did the conference come up with a way out of this bind? It did, by recognising the need for relevant geological modelling (e.g. see Fookes PG, Baynes FJ & Hutchinson JN, 2000, "Total geological history: a model approach to the anticipation, observation, and understanding of site conditions", *GeoEng 2000*, Volume 1, Invited Papers, pp 370-460) rather than relying solely on numerical analysis based on laboratory test results of doubtful worth. Regrettably, there will probably have to be some major life-losing or financial disasters before this message is sheeted home to site investigators/modellers whose profession is not geology.

This is a most interesting and useful collection of papers which (together with Volumes 1 and 2) you should definitely get hold of if you have a complex foundation, slope, or tunnelling project in soft/weak geological conditions for which precedent engineering performance or experience may not be well enough documented to guide you.

In addressing the conference, the President of ISSMGE, Professor K. Ishihara, noted how "hard soils and soft rocks are the interdisciplinary subject where members of the three societies can share the common interest and benefit from mutual interaction". Perhaps developing more inter-society technical committees/commissions offers a natural way of progressing the union of ISSMGE, IAEG and ISRM that is being increasingly advocated.

Reviewed by:
Bruce Riddolls
Golder Associates (NZ) Ltd

The Geotechnics of Hard Soils – Soft Rocks
Proceedings of the Second International Symposium, Naples, Italy, 12–14 October 1998, Vol 3

Editors:	A Evangelista & L Picarelli
Publisher:	A A Balkema, Rotterdam
Date Published:	2000
Web shopping on:	http://balkema.jcn.nl/ima/balkema/index
Price:	EUR $159.50

WANTED – Book Reviewers

NZ Geotechnical Society has a number of recently published books available for review. These books have been supplied free to the Society, by the publishers, for review purposes. We are looking for eager volunteers to review the following books:

- **Subsurface Drainage for Slope Stabilisation**. K Forrester, ASCE Press, 2001.
- **Influence of Gravity on Granular Soil Mechanics**. R Katti, A Katti & D Katti, AA Balkema Publishers, 2000.
- **Geotechnical Testing, Observation and Documentation**. Tim Davis, ASCE Press, 2001.

The reviews are to be succinct and critical appraisals of the books in the order of 1 or 2 A4 pages in length. Reviews will be forwarded to the publishers. Upon completion of the review the book reviewers can keep the book – now there is a good incentive for you!

If you are interested please contact:
Debbie Fellows
Management Secretary
Ph (09) 817 7759 Email dfellows@xtra.co.nz

PROJECT NEWS

SH60 – Takaka Hill Washout Repair Project, Nelson

Client – Transit New Zealand
Consultant – Opus International Consultants Ltd, Nelson
Contractor – Excell Corporation Ltd, Nelson
Date – July 2000

Heavy rainfall and a blocked culvert caused a slope failure along a 50 metre section of SH 60 on the Takaka Hill west of Nelson making the state highway hazardous to road users. Initial attempts to stabilise the slope and roadway using a combination of backfill, gabions and rock facing across the steepest and narrowest 20m section of the washout were unsuccessful.

After discussion with the consultant and contractor, Permathene suggested the use of Syntex 2x2 and 4x4 HS Woven Geotextiles in the construction of a Mechanically Stabilised Earth (MSE) wall.

The proposed wall was designed using Rankine earth pressure theory. Adequate drainage provisions for both the reinforced wall fill and retained backfill and a level grade at the toe of the retaining wall was assumed. The long-term design strength (LTDS) of 9.5 kN/m for Syntex 2x2 and 18.0 kN/m for Syntex 4x4 was taken in the design. The following minimum factors of safety were taken into consideration:

- 1.5 for internal reinforcement pullout and tensile overstress
- 1.5 for external sliding
- 2.0 for external overturning and bearing capacity

The construction sequence comprised:

- Grading the formation area to remove any rocks and debris.
- Place two 150mm thick layers of AP 65 aggregate with the stronger Syntex 4x4 Geotextile to form the basal reinforcement.
- Place Syntex 2x2 Geotextile in 600mm layers with compacted sand derived from the local Onekaka Schist to the design height of 6m.
- The wrapped face of the wall was hydro-seeded and a row of Poplar Poles were planted at the base and on the central terrace of the wall to give additional protection from the UV exposure.

This successful project demonstrates the performance and cost benefits of geosynthetic solutions.

Syntex is distributed by Permathene Ltd in New Zealand and manufactured at an ISO 9002 facility. Syntex 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:

Moninder (Witty) Bindra
Permathene Ltd – Civil Engineering Division
Phone: 09 829 0741
Email: bindra@permathene.co.nz

GeoNet Landslide Response

What is GeoNet?

GeoNet is the name given to a modern New Zealand wide network of instruments designed to monitor earthquakes, volcanic unrest, land deformation, land instability, geothermal activity and tsunamis. GeoNet, which will be phased in gradually over seven years, is 60 percent funded by the Earthquake Commission (EQC). It is being designed, installed and operated by the Institute of Geological & Nuclear Sciences Limited (GNS) on behalf of EQC and the New Zealand community.

Introduction

New Zealand is exposed to a wide range of geological hazards (earthquakes, volcanoes, tsunamis, landslides and geothermal activity) that have the potential to cause extensive damage with more severe social and economic consequences than the experience of the last 60 years would indicate.

The Earthquake Commission is funding GeoNet to improve the monitoring of geological hazards and the quality of associated research data in New Zealand. GeoNet will collect data on landslides and landslide occurrence and make it publicly available. Methods for making this information available include the landslides newsletter, published annually, and future plans for a web-based database interface.

The GeoNet monitoring system is a non-profit ‘public good’ initiative and will contribute to the development of safer communities. Accurate and timely data about geological hazards will guide the response to any disaster and help reduce community vulnerability through better understanding, planning and mitigation of geological risk.

Basic data collected from GeoNet will be “free-to-air” – in other words, available at no charge to New Zealanders and the worldwide research community. Any organisation, including GNS, may use the basic data to provide customised packages of added-value information on a commercial basis.

The landslide component of the GeoNet service is intended to:

1) Provide an appropriate level of response to landslide events
2) Compile a database of landslide locations and attributes
3) Publish a yearly catalogue of landslide occurrence.

This draft document sets out a process for assessing and implementing an appropriate response to various classes of landslide ((1) above). Feedback on this proposal from people working with landslides is invited and welcomed.

Process and Timetable

The process proposed for the GeoNet landslide rapid response initiative consists of:

a) Publication of a draft landslide rapid response plan in *LANZLIDES* newsletter (August 2001).
b) Presentation of the proposed plan to the Geotechnical Society Symposium on “Engineering and Development in Hazardous Terrain” (August 2001).
c) Collation of responses to the 1st draft and publication of a 2nd draft plan in the Newsletters of the Geotechnical Society and the Geography/ Geomorphology Society and other suitable forums (November 2001).
d) Presentation of a final draft plan at the 3rd LANZLIDES Workshop (April 2002).
e) Final document posted on the GeoNet website and sent to list of registrants (June 2002).

Background

GNS (and its predecessors, DSIR Geology and Geophysics and the NZ Geological Survey) have been collecting information on landslides for at least 50 years. During the last decade a number of projects have been developed to organise landslide data. Compilation of a landslide inventory began in 1992 and contains information on landslide location and other attribute data (for example magnitude, type, cause and trigger). In 1996 the concept of a landslide catalogue was developed as the most appropriate means of accurately recording the frequency of landslide events.

The GeoNet project formalises the funding for the collection of landslide data on a systematic basis and provides for the data collected to be publicly available. The collection of landslide data is considered to be in the national interest. Formerly, Public Good Science funding for this was limited and GeoNet puts the maintenance of a national database and the collection of rapid response information on a more viable financial footing.

Landslide Expertise

An important component of landslide data collection is the rapid response to major landslide events when they occur. The variety of landslides that have occurred over the last few years has highlighted the wide range of disciplines involved in landslide work and the need to be able to draw on a range of expertise when responding to landslides. Through the GeoNet project it is proposed to create a national register of appropriately qualified individuals drawn from a wide range of disciplines, from which teams may be selected and equipped to respond quickly to major landslides.

It is envisaged that the pool of available expertise will combine a mix of experience and be drawn from the following disciplines:

- emergency management
- landslide research
- geotechnical consultants
- geotechnical contractors
- soil conservation

Landslide Response

The purpose of the response missions will be threefold:

1) To collect reliable, consistent information on significant landslides in New Zealand
2) Ensure that appropriate advice is available to maximise public safety
3) Provide publicly available documentation of significant landslides.

At July 1, 2002, the aim is to have available a national register of personnel and equipment for deployment in response to significant landslide events. The composition of the team required would depend on the nature of the landslide, any pre-existing contractual arrangements and would involve a range of disciplines.

The rapid response to landslide initiative will provide disbursements to enable a team to visit a landslide. (Team members time costs will need to be met by their own organisations).

The criteria GeoNet uses for activating a rapid response are landslides that cause (or have the potential to cause) any of the following:

1) Death or serious injury (requiring at least hospitalisation)
2) Subsequent catastrophic events (for example breaching of a landslide dam)
3) Direct damage to the value of one million dollars or greater
4) Indirect costs (economic losses) of greater than ten million dollars
5) Threats to public health (e.g. water supply contaminated, sewage discharge)
6) Significant research interest.

Draft procedure for activation

GNS maintains operational centres at Gracefield (near Wellington) and Wairakei, with duty seismologists assigned at all times. The duty officers carry pagers and cellphones and out of hours use home computers with high-speed data links to access the monitoring system. A commercial call centre handles inquiries after hours and reports of geological hazards are directed to the duty officer, who also has links to Civil Defence and EQC.

Under the proposed landslide response plan, upon receiving notification that a major landslide has occurred, GeoNet operations staff will consult with emergency management authorities to assess the level of response required based on the criteria outlined above. The operational objective is for the response to be mobilised (if required) less than 24 hours after GeoNet Operations is notified of a landslide event.

If a multi-institutional response is deemed appropriate a 'landslide response team co-ordinator' will make an assessment of the expertise required and contact appropriate persons on the landslide register to determine their availability. Once the team has been selected GeoNet operations will facilitate getting them on site and providing any resources they require (e.g. aerial photography, specialised monitoring equipment etc). It is estimated that response might span 48 hours, after which time remediation or clean-up work might be well advanced.

Two grades of response have been identified:

Definite team response: This level would automatically be activated for landslides that have a significant level of public interest. From the examples given below it can be seen that landslides that require this level of response involve issues of public safety or significant economic costs. The examples include landslide dams with a potential for catastrophic failure (and the response is designed to provide the co-ordination of technical expertise to maximise public safety) and landslides that kill or seriously injure people. The other type of landslide are those that cause or have the potential to cause a significant economic impact.

Possible team response: This level of response is indicated for landslides that do not meet the criteria above and for which the level of response will depend on the nature of the landslide. GNS may respond to such events within the context of independently-funded research projects and that response could involve a site visit or it could involve obtaining landslide data from third parties.

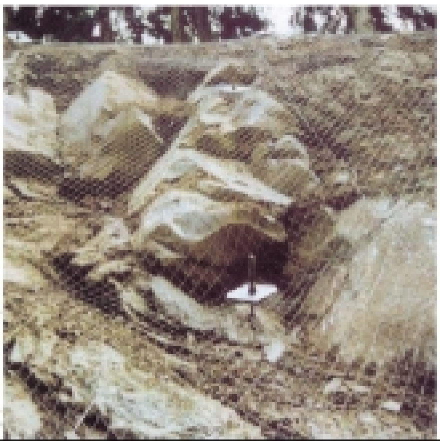
Role of rapid response team

The primary role of the rapid response team is to document the landslide and its effects. This would include assessing the potential for further failure at the site and could involve the deployment of monitoring equipment.

The information required to document a landslide is considered to be the following:

i) A description of the site geology
ii) Engineering geological descriptions of the source material and the debris (using the NZ Geotechnical Society's *Guidelines for the Field Description of Soils and Rocks in Engineering Use*)
iii) A description of the landslide (trigger, slope history, type, mechanism, cause(s) and activity status)
iv) An evaluation of the damage to life and/or property including secondary economic impacts (e.g. the impact of road closure on business activity). An estimation of the damage ratio can be provided where appropriate.
v) Photographic documentation.

49°
83



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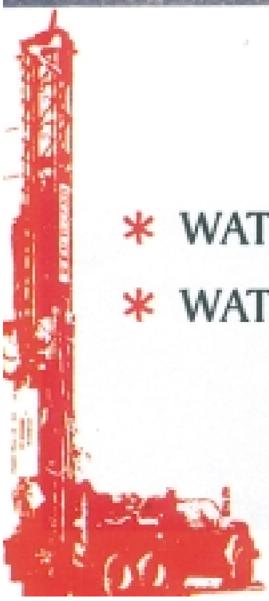


Reporting

The team members will be responsible for preparing a brief report for publication in an appropriate forum. The report will be peer reviewed to maintain quality assurance. Data gathered from the report will be included in the landslide catalogue and added to the landslide database.

Equipment register

GeoNet will also maintain a register of equipment that can be called for by the response team if it is required (e.g. extensometers, automated remote theodolite, RTK GPS).

Rapid Response Examples

Comparison of the proposed response activation criteria with a number of landslides that occurred during the period 1996-2000 provides a guide to different levels of potential response:

• = indicates where GNS has responded by visiting the landslide in the field

1996			
	Definite:	Turakina – landslide dam	•
	Possible:	Oponae – SH2 blocked for one week	•
		Ruato Bay – SH30 blocked for one week	•
1997			
	Definite:	Nuhaka Sheet Erosion – economic losses >$10 million	
		Poerua – landslide dam	
		Auckland – injury requiring hospitalisation, 2 homes destroyed	
		Franz Josef – rockfall affecting tourist facilities	•
		Fox Glacier – rockfall affecting tourist facilities	•
	Possible:	Waioeka Gorge – SH2 blocked	•
		Dargaville – residents evacuated	
		Whitianga – house destroyed (occupants unharmed)	
		Wellington – 3 houses evacuated (occupants unharmed)	•
		Blackball – house destroyed (occupants unharmed)	
1998			
	Definite:	Takaka – injury requiring hospitalisation	
		Dargaville – death	•
		Waitotara – landslide dam	
		Lower Hutt – public health	•
	Possible:	Greymouth – economic losses >$10 million	
		Mt Taranaki/Opunake – direct losses of >$1 million	•
		Mahoenui – SH3 blocked, economic losses >$10 million	•
		Greymouth – economic losses >$10 million	
		Whangarei – 7 homes evacuated	
		Auckland – 2 homes evacuated	
		Thames – house destroyed	
1999			
	Definite:	Queenstown – 30 houses evacuated	•
		Poerua – landslide dam	•
		Greenstone Valley – landslide dam	
	Possible:	Paekakariki – SH1 blocked	•
		Dunedin – port infrastructure threatened	?
		Raurimu – house destroyed	•
2000			
	Definite:	Otira Gorge – death	
	Possible:	Nevis Bluff – economic losses >$10 million	•

Table 1 The number of landslide events where a rapid response would have been initiated using the criteria outlined above.

Year	1996	1997	1998	1999	2000
Definite Response	1*	5	4	3	1
Possible Response	3*	5	7	3	1

* Records for part of year only

This draft document sets out a process for assessing and implementing an appropriate response to various classes of landslide. Feedback on this proposal from people working with landslides is invited and welcomed.

Please forward your responses to:

Grant Dellow
Institute of Geological and Nuclear Sciences

P O Box 30-368
Lower Hutt
Email: g.dellow@gns.cri.nz

COLMIX – The Process and its Applications

Bachy Soletanche Ltd

Important Note for the Reader: This report details the Col-Mix process and design procedures and is based on French conditions. Therefore, some design parameters and concepts may not be directly applicable to New Zealand conditions and design procedures. To confirm appropriate design and construction parameters we suggest that you seek advice from a competent and specialist consultant or contractor as detailed at the end of this report.

Introduction

The construction of lime columns using a deep mixing process has been widely used for many years, particularly in the Scandinavian countries. The characteristics of the columns depend on the interaction of the lime and the clay chemistry and therefore the application of this process is limited to areas of consistent and suitable clay mineralogy. More recently other binders, particularly cement, have been introduced into deep mixing processes and these allow a much wider and controlled application of the process of deep mixing.

The COLMIX process was developed in the late 1980s and creates columns or panels of stabilised soil in the ground. The soil mass is broken down during a drilling process using multiple overlapping counter-rotating augers. Lime and/or cement in powder or grout form is then introduced and mixed into the soil employing the same augers as mixers during their withdrawal from the ground. Because the binder can be tailored both to particular soils and to the results required, the process has much wider application than more traditional soil mixing procedures.

COLMIX columns may be used as load carrying members for light foundations. Panels may be adapted to insitu soil retention structures. COLMIX may also be used in slope stabilisation and soil reinforcement.

This paper describes the origin, development and principles of the process, together with examples of its application which are described and discussed, with particular reference to quality assurance and control measures. Design methods and tables are presented for two principle applications of bearing capacity improvement and control of unstable embankments.

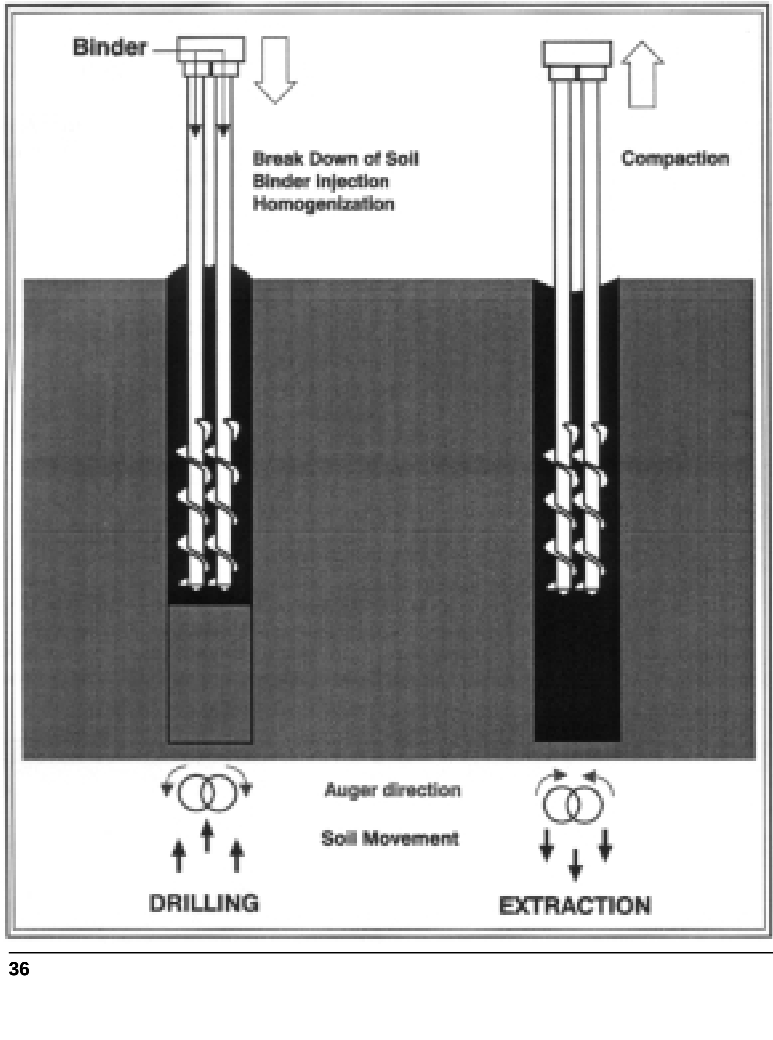


Figure 1 COLMIX process

Origins and Development

In order to improve the stability of railway embankments, SNCF (Societe Nationals des Chemins de Fer) and LCPC (Laboratoire Centrale des Ponts et Chaussees) invited tenders for the design and implementation of a "process to construct stabilised and compacted soil columns".

Bachy designed the COLMIX process which was selected and successfully used on a railway embankment at Vierzon in France.

The principle of deep mixing using single augers of blades has been developed over the last ten years, especially in Scandinavia for stabilisation of weak sensitive clays and Japan for construction of retaining structures to significant heights. More recent developments have also taken place in Italy and North America.

The COLMIX process, utilising multiple augers in a two stage process, received the 'Prix de l Innovation' in 1987 from the FNT (Federation Nationale des Travaux Publics). The process is now patented in several countries. Further development has considerably broadened the original field of application.

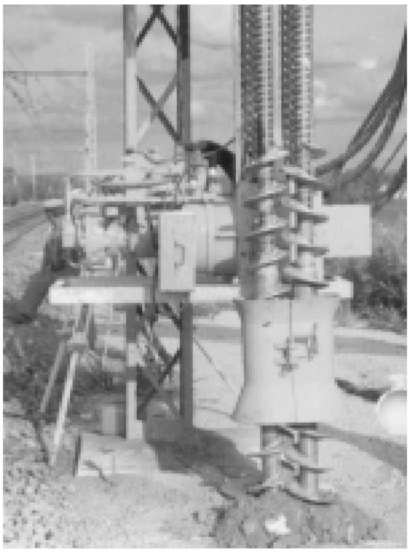


Figure 2
COLMIX in action

Principles of the Process

Construction of COLMIX columns is carried out in two distinct phases (see Figure 1).

Drilling

The in-situ soil is broken down using the overlapping continuous flight augers (two, three or more in a line). Binder is introduced through the hollow stems of the augers. The binder mass is then mixed within the soil by adjusting the rate of penetration and speed of rotation of the augers. This enables the soil/binder to be mixed correctly forming a homogenous column.

Extraction

Compaction of the column is achieved by extracting the tool and changing the direction of rotation of the auger whilst simultaneously applying a downward counter thrust.

Where the soils are highly cohesive, it is possible to improve the quality of mixing by raising and lowering the augers several times.

The principle advantages of an overlapping auger system over conventional deep mixing methods are that the binder soil mix is more homogeneous and that compaction by reverse rotation is possible.

Fields of Application

Principle Areas of Use

To date, COLMIX has been used in five principle areas:

- stabilisation of embankments and slopes
- improvement of bearing capacity for shallow foundations
- retaining walls (reinforced if necessary)
- cut-off walls
- fixation of polluted soils

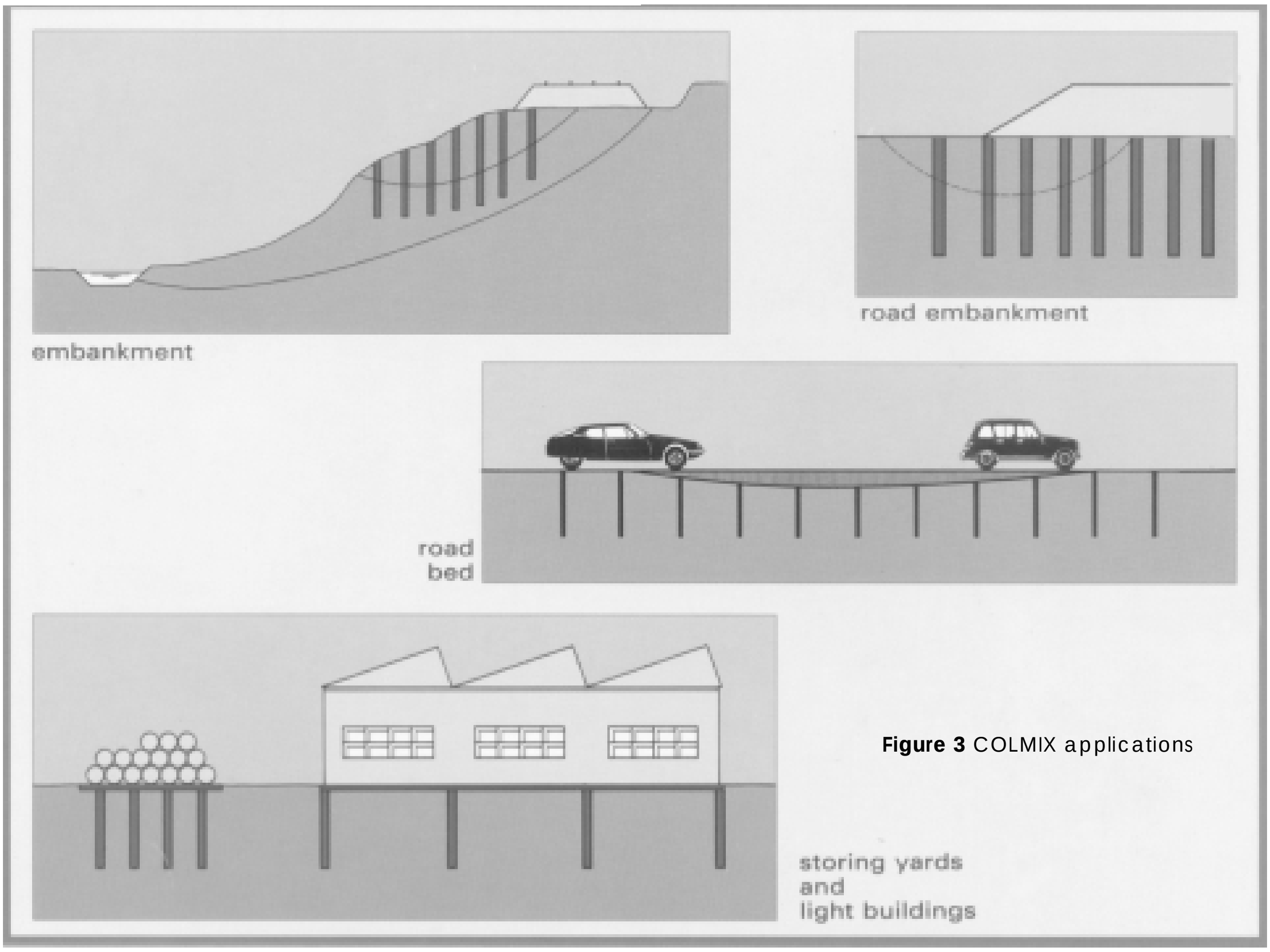


Figure 3 COLMIX applications

Advantages of the COLMIX process

The principle advantages of the process are as follows:

- no spoil
- no vibration
- low noise
- clean working area
- working area required is small
- adaptable
- can be used on slopes
- light, easily transportable equipment (especially for smaller column sections)
- can be used adjacent to existing structures

Limits to use

Construction of COLMIX columns is possible in most types of soil except where boulders or very hard strata bands are envisaged.

Technical Characteristics

Column Geometry

The columns in plan take the form of a rectangle with semi-circular ends due to the linear association of two, three or more overlapping augers.

Figure 4 gives a resume of currently used auger diameters and configurations. Sections and perimeters quoted are theoretical. Actual column sizes have been found to be 10-20% larger than the auger diameter, probably due to the compaction phase.

Selection of Binder

The binder usually comprises lime and/or cement. The mix constituents are determined after careful consideration of the following:

- physical binder/soil mechanism
- chemical binder/soil reaction
- pozzolanic property of any clay present
- required property of the columns.

The COLMIX process is often used in weak clays. The lime reacts with the clay in two ways:

1) ion exchange between the lime and clay molecules (the clay becomes less sticky which then improves the quality of mixing achieved)
2) a pozzolanic reaction over a period of months between excess lime present and the clay particles. This reaction causes an increase in strength.

Auger	w mm	L mm	Section m^2	Perimeter m
Twin	230	410	0.08	1.08
	290	500	0.13	1.33
	360	625	0.20	1.66
	420	740	0.27	1.96
	500	875	0.38	2.32
Triple	360	890	0.29	2.19
	420	1060	0.41	2.60
	500	1250	0.57	3.07

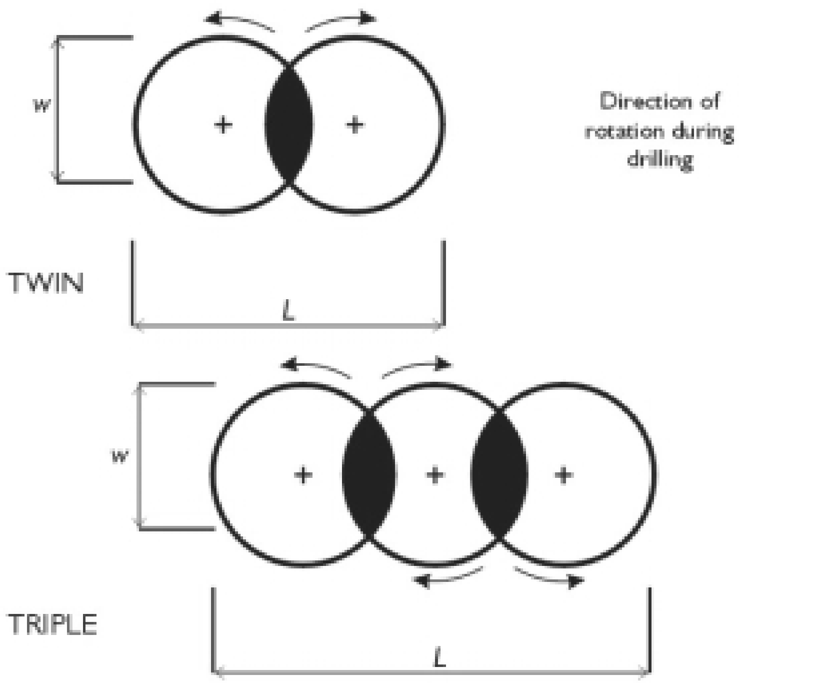


Figure 4 COLMIX column network

The binder is normally introduced in grout form ('wet' process), although it is possible to use dry powder in soils with a high water content.

At Vierzon, the soil's water content was 24%, and the composition of the binder was as follows:

400 kg/m3 cement
320 kg/m3 slaked lime
724 kg/m3 water

For a 0.08m^2 section, the binder usage was 30 to 40 litres/m of the column. The column therefore contains approximately 10% cement and 8% lime by dry soil weight.

Column Characteristics

From extensive field test results, the mechanical characteristics of a typical column in a clay soil have been found to be:

- unconfined compressive strength (UCS) 1 MPa +
- shear strength UCS/3
- modulus of elasticity 50 to 100 UCS

Properties in sandy soils have been observed to be higher than those given above.

Quality Control

There are a number of quality assurance and control measures which are used to ensure homogeneity, integrity and quality of the columns:

- measurement of sonic velocities in three directions (typically 2000 m/s)
- uniformity of the phenolphthalein reaction, indicating the presence of cement
- parameter recording during installation (speed of insertion and extraction, rotation speed direction and torque, binder flow, depth of augers etc)
- sampling of mix from a given depth
- excavation/extraction of the column
- laboratory sampling
- core sampling (difficult)

Process Design

Introduction

Retaining walls are designed using classical design methods (e.g. Berlin Wall). Cut-offs require a detailed study of permeability, usually by laboratory testing and field trials. Fixation of polluted soils is also designed using laboratory and field trial techniques.

There are therefore two primary fields which require specific design methods:

1) improvement of bearing capacity
2) stabilisation of embankments and slopes

These require different design approaches. In the case of bearing improvement, the aim is to transfer the majority of the load onto the columns so as to limit the load carried by the compressible soil. For stabilisation of slopes the aim is to improve the bulk characteristics of the in-situ soil to reduce or halt the instability. It should be noted that columns using lime also have a drainage effect.

Bearing Capacity Improvement

Figure 6 shows the working mechanism assumed for the design approach.

The primary assumptions are:

- the compressible soil layer is underlain by a relatively incompressible layer, (although this is not essential) the column is assumed rigid
- the uniform applied load, q, causes settlement in the compressible layer which induces the development of negative skin friction on the columns, and hence load is transferred proportionally to the columns
- the column load is transferred to the underlying soil by end bearing and positive skin friction.

Stabilisation of Embankments and Slopes

The majority of unstable slopes do not have clearly defined slip surfaces. The more normal situation is where overall motion has become unacceptable with respect to serviceability requirements.

The working mechanism for analysis is assumed to be a

Fig 5 Exposed COLMIX columns

horizontal motion giving rise to a displacement, which increases with time due to creep, soil modification or consolidation.

The columns are generally staggered over a minimum of three rows. In addition, columns at or near the slope are positioned with their major axis parallel to the slope (Figure 7).

Having determined a column size and layout, it is necessary to check:

- stability of the soil/column mass against slip at its base
- shear resistance of the columns against defined slip surfaces.

This requires a sound understanding of the material properties and mechanisms.

References

"COLMIX – The Process and its Applications", Bachy Soletanche Ltd, Mr C N Harnan, Bachy, United Kingdom, Ms Y Iagolnitzeu, Bachy, France

Contact:

Bachy Soletanche – New Zealand Agent
Hiway Stabilizers Ltd
Graeme Quickfall
Phone: 09 426 3419

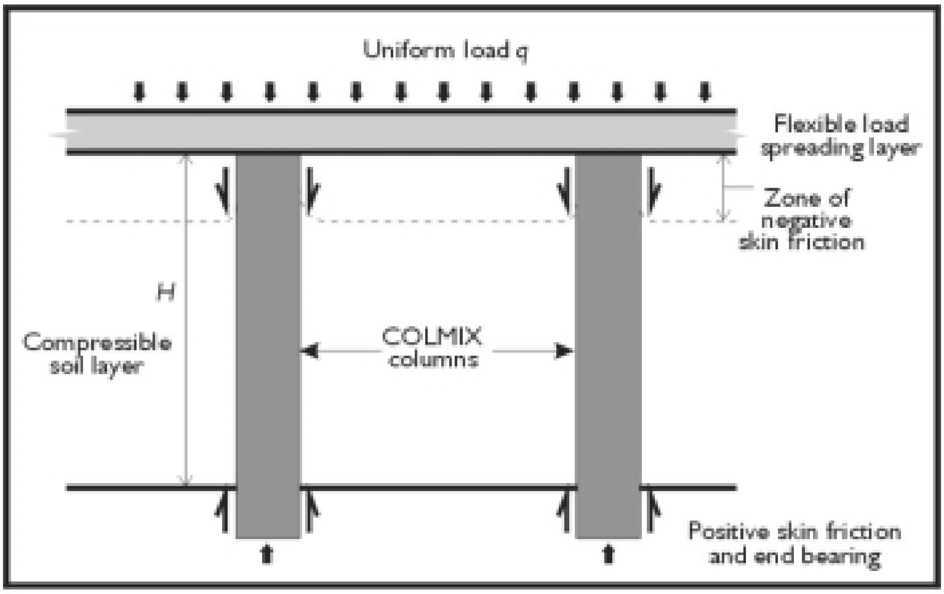


Figure 6 COLMIX columns for improved bearing capacity/settlement control

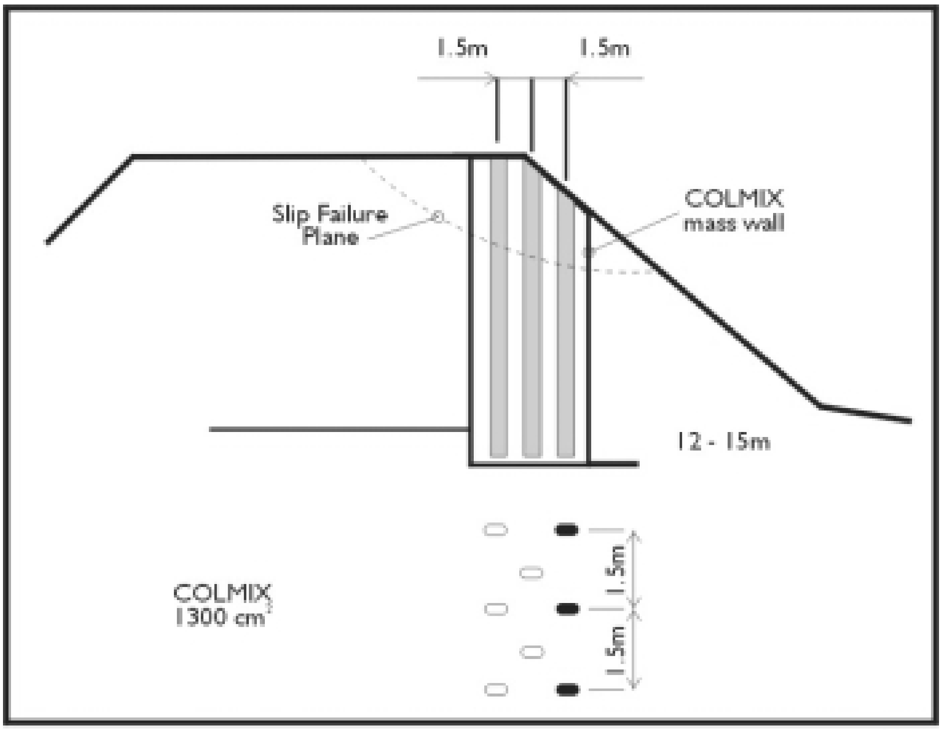


Figure 7 COLMIX columns for slope stabilisation

THE BOB WALLACE COLUMN

There is nothing I like better than a good argument. For example, you can talk to any assembly of people these days and they will bemoan the falling standards of education and the fact that kids today have it easy at school. My favourite tack is to present the entirely justifiable argument that the problem is with the curriculum and incompetent teachers. This usually manages to cause offence because so many bleeding heart liberals have been duped into believing that teaching is a difficult job. What nonsense!

I also take great pleasure in vilifying the absurd presumption that no one should ever fail and everyone should be rewarded for simply participating. It is amazing how quickly you can get into a bun fight but you know I'm right. The facts speak for themselves. We have university graduates who can't structure a sentence or spell righteous indignation and yet they are graduating with good marks for participating in degree courses.

Don't you just love those old guys that say, "You've got it lucky! In my day, it were tuff." I can remember the Head of Civil Engineering at my University solemnly announcing to the 120 bright faced undergraduates on day one of my degree that only 25% of us were going to make it to graduation. He was almost right, 38 students graduated four years later – I still have the photo. I would guess that of those that dropped out 75% simply failed and the rest gave up or changed course because it was too tough or they didn't like it.

Think of the status afforded to a course where only 1 in 4 applicants had the capacity and resources to pass. How valuable would those graduates be? What sort of demand for our services would there be in the market place? What salaries could we command?

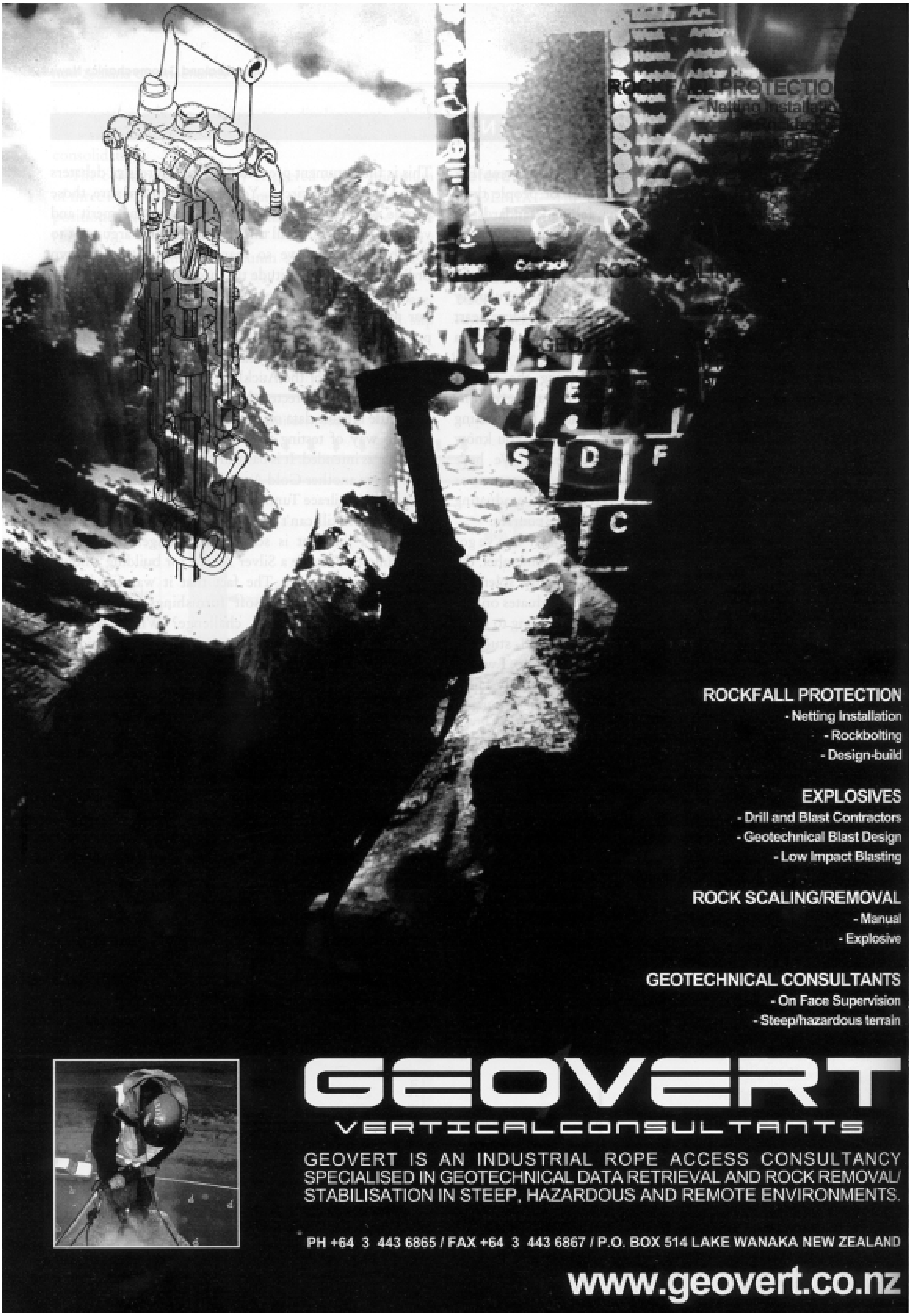
We might then start to win the argument that we deserve more recognition for our contribution to society. This is the argument presented by the aggressive debaters found in educated circles. You know them I'm sure, those people who defend teachers by attacking the merit and value of engineers. I call this the 'impossible' argument to win because we have so many examples of our own ordinariness and ineptitude that are indefensible.

Take the ACENZ Merit Awards. Here is the pinnacle of our profession. The projects that we are supposed to be proud of and that can be held up as shining examples of our endeavour and skill. This year we gave a Gold Award for a seismic retro-fit of the Auckland Harbour Bridge. Now I am happy to be corrected, but to my knowledge we have very little reliable data on which to base the design criteria and no way of testing to see if the remedial works will perform as intended. It is basically an award for guesswork.

We gave another Gold Award to a project related to the Manapouri Tailrace Tunnel. I've spoken about this project before and I still can't understand how we can take any pride in a job that is so far over budget and behind programme. We gave a Silver Award for building a house in a residential street. The fact that it was filled with switchgear rather than soft furnishings is irrelevant. Where was the technical challenge? Where was the innovation? How is that going to inspire a generation of enthusiastic engineering disciples?

We gave an award for some gardening on the Main Street of Fairlie. We gave Merit Awards for road projects that were finished late, partially opened, have outstanding claims and already have serviceability problems. Incredibly, one of these meritorious projects involved spreading some asphalt across some flat land in a relatively straight line. I guess these awards were for participating. How marvellously PC.

I hate losing arguments so please, give me something to boast about.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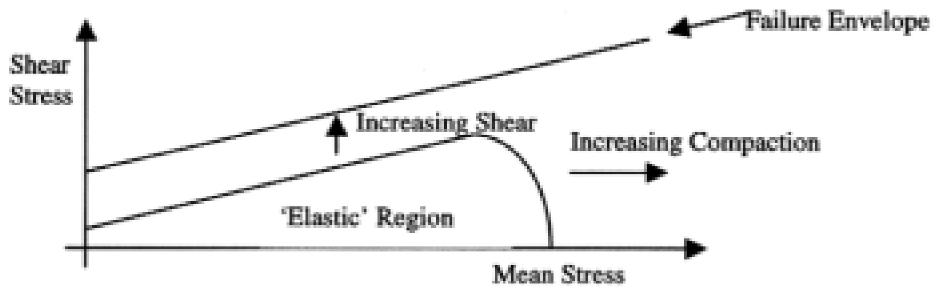
SPECIAL INTERESTS

Numerical Analysis in Soil Mechanics, Part 3

Sergei Terzaghi, Sinclair Knight Merz

For various reasons we had a break last issue, so to briefly recap: in Part 1 we looked at the impact on stresses that the selection of three different constitutive models would have in the case of undrained loading of an embankment. In Part 2 we looked at the pore pressures generated as a result of undrained loading, in particular the pore pressures being generated due to change in mean stress. We said in this article we would look at plasticity and influence of plasticity on the model.

Generically, plasticity implies non-recoverable strain as a result of applied loading. However for soils, this may be as a result of a compaction process (volumetric loading), or as a result of a shear loading causing dilation (volume change) or displacement/failure. The two processes can be visualised on the simple figure below. Obviously, a change from elastic to plastic behaviour requires a definition of a yield point and it is how we define the behaviour once yield is reached that is the subject of this discussion.



In conventional soil mechanics, a compaction process is usually measured using the consolidation test. For the purposes of this discussion I am using the term compaction rather than consolidation, as strictly speaking, consolidation refers to the process of squeezing water out as the compaction of the soil skeleton occurs.

The consolidation test in 1-D represents elastic and plastic behaviour rather nicely in that one usually divides the test into two portions. The first portion is virtually elastic in that any movement within that stress range is recoverable (Cs). The second portion, the so-called virgin curve, is actually plastic in that it represents largely non-recoverable strain. Theoretically, the pre-consolidation pressure is the yield point, and the subsequent behaviour is defined using a different parameter (Cc).

This is very difficult to represent in a Mohr-Coulomb model, or any other simple elastic or elastic/perfectly plastic model, as the stiffness is a single parameter rather than a bi-linear or non-linear parameter (remember Cc varies linearly with the log of stress). In addition, the 'yield' and transition to plastic behaviour in this compaction process reflects a hardening (an increase in stiffness), rather than our more conventional understanding of a yield point in a failure mechanism and subsequent softening.

The ratio between the 'elastic' over-consolidated stiffness and the 'plastic' normally consolidated stiffness may be as little 1.5 to 3 for a sand. The ratio typically increases to 3 to 7 for a conventional NC clay and up to 120 or more for the 'crushable' soils often found throughout the South Pacific. In practical terms this means that we can only choose a single parameter to represent the soil modulus if one stays within a constrained stress field or range. The problem is exacerbated in a lot of cases when one is changing from an 'elastic' to a 'plastic' state and possibly back again.

An additional complication in terms of modelling is how to translate this 1-D modulus into a 2-D or 3-D modulus. In 2-D or 3-D space the volumetric changes are more correctly described by a bulk modulus defined in terms of mean stress. In grasping the non-linearity implications presented above it is perhaps more understandable why in multi-dimensional cases it is more accurate to define the volumetric behaviour associated with the consolidation phase of the tri-axial test.

Increasing shear stress or shear deformations introduce plasticity of a different kind. Shear deformations occur in all kinds of loadings and the stress-strain curves we are generally quite familiar with show that increasing strain leads to a decrease in stiffness.

For stress levels below failure there would appear to be a similar sort of yield point to that described above. If the shear is decreased below that point the behaviour is 'elastic' (with a comparatively stiff unload-reload modulus), whereas above that yield point, the modulus drops quite markedly to a 'plastic' value.

The consequence of the 'plastic' shear behaviour is dependent on the loading case. In undrained loading it will lead to a change in pore pressure whereas in drained loading it will lead to a volume change dependent on the initial state of the material. The tendency towards volume change is controlled by the angle of dilatancy. This can be specified in a number of ways, though it is a measure of the difference between the peak friction angle and the friction angle in constant volume shear. It should be noted that it can be either positive (stronger) or negative.

From a practical Geotechnical Engineering perspective the more important 'yield' point for shear loading is the point of failure. At this yield point the entire material is plastic and in most failure mechanisms the movement gets 'localised' to a shear surface. In numerical work this localisation is a major problem not yet satisfactorily resolved.

Fortunately there are a number of more advanced soil models available in most sophisticated analysis packages that have gone some way to replicating this behaviour and how these work will be discussed in a future column.

TECHNICAL ARTICLES

Geomechanics Lecture 2001
Hazardous Terrain – An Engineering Geological Perspective

Warwick M. Prebble, Dept. of Geology, The University of Auckland

Abstract

New Zealand is well endowed with hazardous terrain. Examples discussed here are from the Taupo Volcanic Zone, East Coast Deformed Belt, Southern Alps and North Island weak rock.

Placing each site in a geological context and focusing in from the regional view leads to appropriate geotechnical models. Many faults, landslides, volcanoes and areas of geothermal activity are not obvious at the site but are identifiable at the regional scale.

Debris avalanches from weakened andesite volcanoes are large, infrequent, extremely hazardous events. Conditions promoting failure persist and smaller, frequent avalanches and flows are known. Sensitive rhyolitic silts are widespread in northern regions and fail as slide-flows. Greywacke and schist rock masses of the Southern Alps are subject to large, deep-seated topples, which lead to rock slide avalanches. Debris aprons are found below deep ravines in toppled slopes of the Alps and also in toppled limestone dip slopes of the East Coast Deformed Belt. Overtoppling of dip slopes is probably underestimated. Block sliding on tectonic clay seams is now well known from many areas of weak rock.

Comparative geomorphology, remote sensing and mapping have assisted identification of block slides on clay seams in deeply weathered weak rock throughout the Auckland region. At Tokaanu and Tongariro, the same approach, including outcrop mapping at considerable distances from the "site" has led to recognition of faults, explosion craters, grabens, geothermally weakened ground, landslides and run-out areas for collapsing volcanoes.

Introduction

This paper offers a personal view of the contribution that engineering geology has made to our understanding of hazardous terrain, drawing upon 35 years of experience in field-based research on engineering projects and in areas selected for their hazardous and challenging nature. The examples are from a collection of case histories with which I have been closely involved. To some extent this may deliver a single point of view, however this is balanced and reinforced by the contributions of many co-investigators over the years;- colleagues, associates, clients and graduate students.

Recognition and assessment of geologic hazards is a basic platform of engineering geological practice and a prerequisite for successful geotechnical engineering.

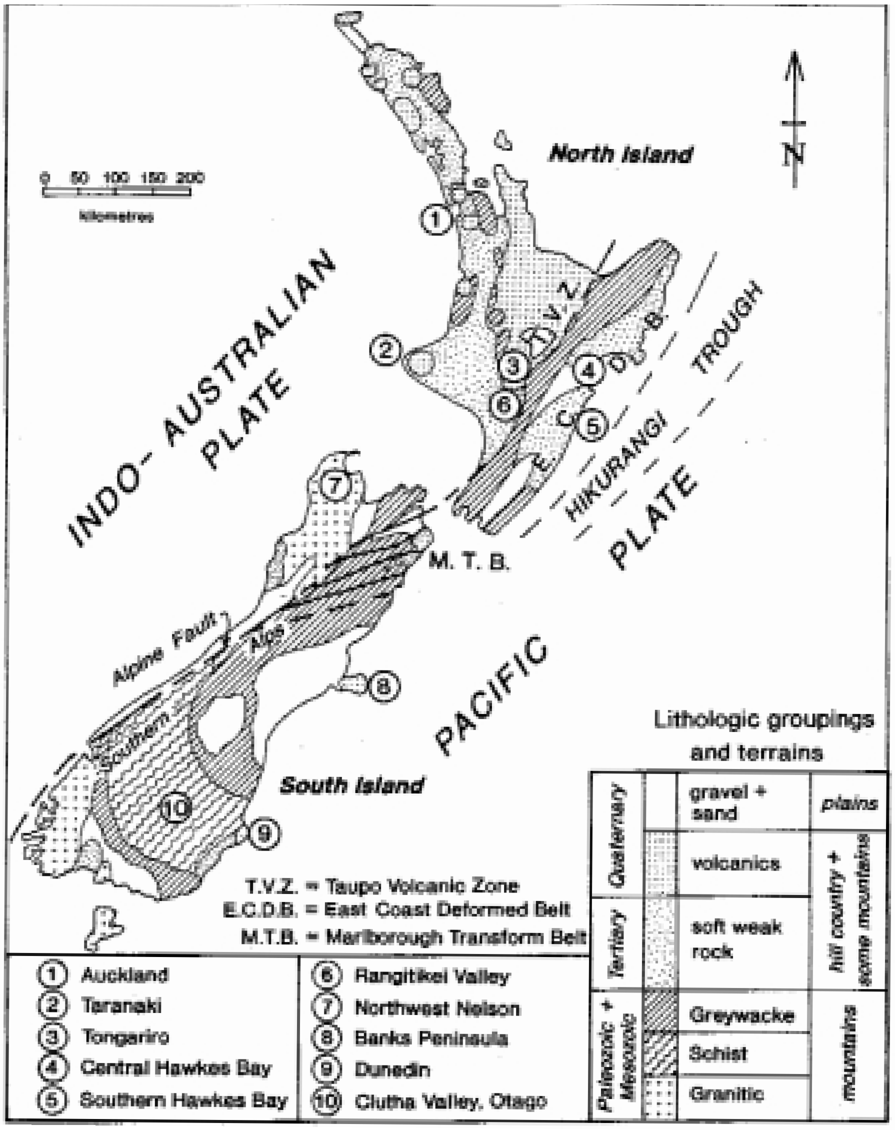


Figure 1 Major tectonic features, main lithologic groupings and engineering geological terrains of New Zealand

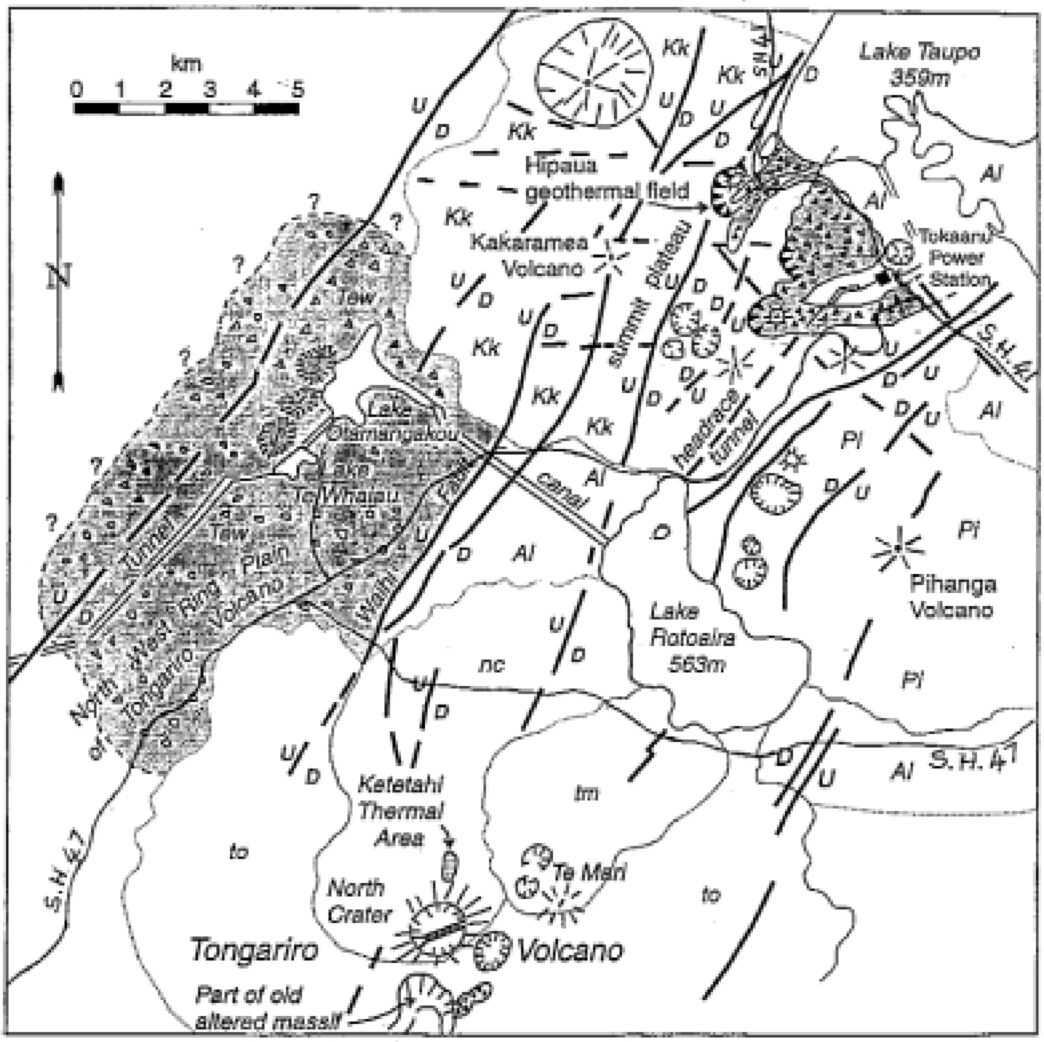


Figure 2 Tongariro Volcano, north-west ring plain and the Tokaanu area. Taupo Volcanic Zone. Cover beds of volcanic ash and tephra have been omitted.

Legend for Figure 2: Tongariro Volcano, north-west ring plain and the Tokaanu area.

A : Slope movement features and deposits

- headscarp to landslide / debris flow
- slide block
- debris mound
- debris field, debris fan, tongue
- trench, pull-away zone (E.N.E. only, on Tongariro North Crater)
- Tew — Te Whalau Formation (avalanche debris)
- Al — alluvium of Rotoaira and Taupo basin

B : Faults and Volcanic Craters

- U/D — Fault, (U) Upthrown (D) Downthrown (N.E. set)
- Faults, inferred (NE, SW + E-W sets)
- Summit crater
- Large basin-shaped crater (? explosion crater or lava filled crater)
- rhyolitic dome

C : Lava flow and scoria fields, originating from the following volcanoes:-

- tm — Te Mari Crater } Tongariro volcano
- nc — North Crater } Tongariro volcano
- to — Tongariro volcano, older massif
- Pl — Pihanga volcano
- Kk — Kakaramea volcano

Without earth surface processes and deeper crustal tectonics this land of ours could not exist and we would be deprived of the immense challenge and professional satisfaction that is offered by practising on an obliquely convergent, complex plate margin. New Zealand is a highly varied landmass with many different terrains (Figure 1) displaying defective and difficult rock masses and soil masses, crafted by a collection of hazardous geologic processes.

I intend to take this opportunity to reflect upon the value of a comprehensive approach to geotechnical mapping as a critical first step for field investigations and developing tentative site models. An essential part of this process is to start with a regional picture and then focus down to the actual site. "Total" mapping as it is sometimes called involves many factors, which make up our analysis of hazardous "terrain". Geomorphology, defects, materials, groundwater, geologic history, structure, tectonics and volcanism all play a part. Recognition and understanding of geotechnical hazards demands investigation across a huge range of scales – from the microscopic fabric of rock and soils to the morphology of mega-landslides. A comprehensive approach can provide a reasonably complete picture of the site or region . The coordinated use of remote sensing, geomorphology and field mapping over a significant region is a way of identifying hazards and difficult ground conditions, which are present at the site but concealed from view by weathering and overlying deposits.

This paper presents information from a wide range of hazardous terrain. Included are: Hydrothermally weakened andesite stratovolcanoes, altered and faulted massifs in an active volcanic rift, ignimbritic plateaus and terrace remnants, elevated and defective sedimentary rock of the East Coast Deformed Belt, areas of greywacke and schist mountain range collapse and block slides in weak rock. Both the science and art of engineering geology will be alluded to – the science of gathering data and information and the art of observation which makes this process possible in the first place.

Active Volcanic Terrain

My first experience with engineering geological endeavour of any kind was to grapple with the challenges facing the Tongariro Power Development in the mid-1960s. I soon grew accustomed to the extreme variety of andesitic and rhyolitic deposits and the complex geometric relationships between them. A period of secondment to the relatively stable and predictable granitic terrain of the Snowy Mountains Scheme quickly disavowed me of any complacency about Tongariro and served to impress upon me just how very active, unstable and unpredictable the whole of the TPD area is. I rapidly discovered that the challenge was twofold. Firstly there was the threat from renewed volcanic activity and other hazards such as landslides, hydrothermal eruptions, faulting and earthquake. Secondly there was the legacy of past volcanic activity – the collection of rock masses, soils, groundwater systems and topography in which the scheme had to be sited and built.

The area around the Tokaanu Power Project and the Otamangakau and Te Whaiau dams (Figure 2) was particularly enigmatic. A successful resolution came only with the help of the regional approach and photo-geology. The complex Tongariro Volcano with its collection of craters, thermal areas and lava flows became a type area for elucidating the obscure and altered formations at Tokaanu and also provided clues as to the source of unusual deposits at Te Whaiau and Otamangakau.

My day to day professional involvement was, of necessity, at the distinctly practical level. Whenever time allowed I pursued background research in the form of field mapping on Tongariro Volcano. This work gave rise to the site models for places like Tokaanu and Te Whaiau – Otamangakau. It also began to reveal the greater extent and nature of hazards from the volcanoes but it was to be several more years before the sector collapse and eruption of Mt St Helens provided us with a classic example of a major cone slope failure and debris avalanche.

Debris Avalanches and Debris Flows From Andesite Cones

Active andesite cones in the Taupo and Taranaki Volcanic Zones have a history of generating lahars and ash frequently and, less often, pyroclastic flows and lava. They are also subject to much larger, less frequent but catastrophic cone collapse, giving rise to large debris avalanches, debris flows and mud flows. (Palmer, Alloway and Neall 1991). Sector collapse, similar to that seen at Mt St Helens in 1980 (Schuster, 1983) is inferred to have happened numerous times at Taranaki and Ruapehu. Some original field work (Prebble, 1967) and current research (LeCointre, Neall, Wallace and Prebble in press) indicate that similar events are also characteristic of the Tongariro volcano, affecting in particular the north-western summit, cone and ring plain. Some debris avalanche and debris flow deposits from the region are shown in Figure 3 and the geomorphology of the volcano in Figures 4a and 4b. Modern, smaller debris avalanches and flows caused by the collapse of hydrothermally weakened ground along fault scarps in the Hipaua geothermal field (Figure 2) high above Lake Taupo, have happened twice in the last 150 years. These clay rich flows overwhelmed local villages. Prehistoric debris flow deposits are also found in the Tokaanu area (Figures 2 and 3).

The Te Whaiau Formation (Figures 2 and 3) is a cohesive debris flow deposit, which originated from a massive debris avalanche on Tongariro volcano. This example shows the value of a regional approach in which field mapping and geomorphology were combined in order to clarify of the origin, nature and distribution of the formation. This was critical to the Power Development in two ways. Firstly the formation provided a foundation for 2 dams displaced for geological reasons from their original

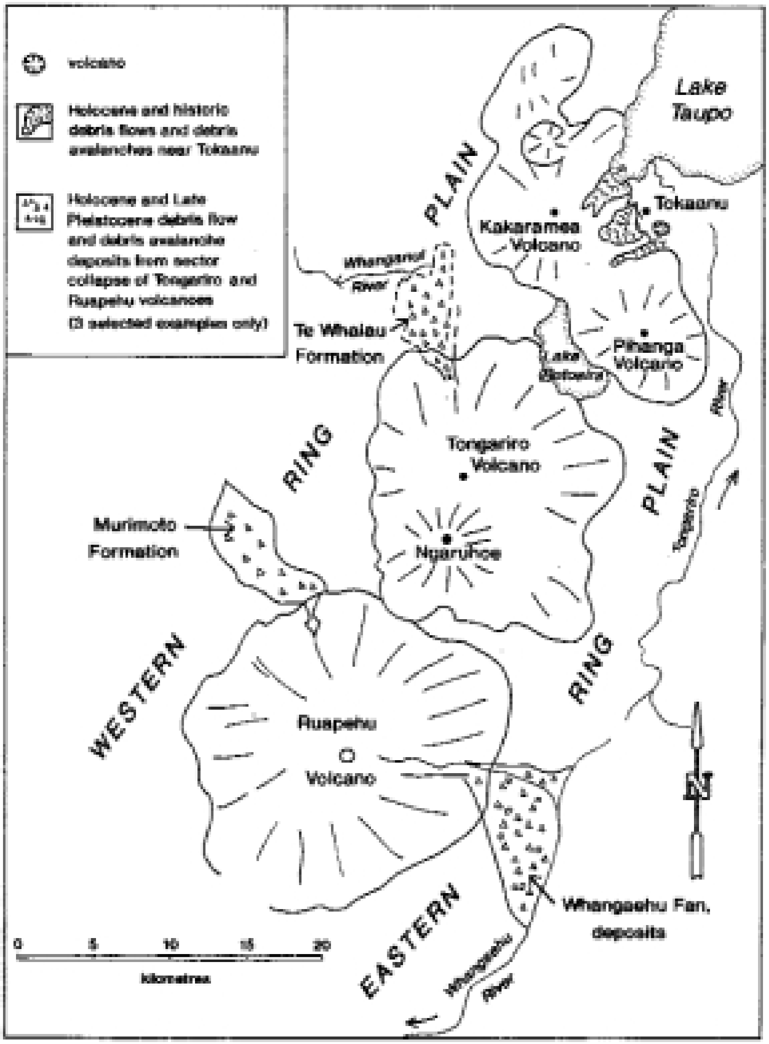


Figure 3 Selected debris avalanche and debris flow deposits in the Tongariro Volcanic District, southern Taupo Volcanic Zone. The Te Whaiau Formation and 2 other large, more recent (Holocene) debris avalanche deposits are shown. The Holocene and historic debris flow deposits from the Kakaramea Volcano behind Tokaanu are also shown.

sites during excavation. Secondly it marks a major debris avalanche and debris flow event which could happen again.

The Te Whaiau formation was first recognised at Otamangakau and Te Whaiau (Figure 2) and informally named the blue-grey clayey silt formation (Prebble, 1967). At the time it was seen as being strangely out of character with the alluvial soils and tephra deposits with which it is interbedded in the ring plain. Of particular note were the angular fragments of hydrothermally altered andesite, the blue-grey clayey matrix, the breccia like texture and the low mounds of debris, which the deposit formed. These contrasted with the outwash fans, terraces and swamps which surround them and led to the conclusion that the formation was a debris flow deposit from a violent phreatic eruption of Tongariro volcano (Prebble, 1967 and 1969a). Other volcanoes in the area are not hydrothermally altered and were discounted as a possible source. Moreover, fieldwork at the time on Tongariro revealed several exposures of altered material within the old massif of the volcano. Geothermal activity at Ketetahi and Red Crater supported the notion of a hydrothermal origin and an eruption involving water, giving rise to the debris flow. From the point of view of the geological model at the dam sites this theory reinforced the picture of an irregular, thick layer of the impermeable blue-grey clay overlying deeper alluvial deposits of the ring plain. This was important to the determination of founding levels for the dams and the containment of the reservoirs.

A problem at the time of investigation was the presence of "gravel lenses" encountered by the drillholes within the clayey silt. Unlike the permeable artesian gravels beneath the clayey silt, these "lenses"were fairly impermeable and did not appear to have any hydraulic connection outside the clayey silt as determined by the testing programme. However they remained a concern, from a possible leakage point of view. An explanation was eventually provided by the logging of the foundation and core trench (Prebble and Dow, 1969). Large blocks of bedded, compact, andesitic clayey gravel and fragile very weak conglomerate, up to 10m across, were exposed by the excavation. These are megaclasts, rafted along in the debris flow from a source higher up on the volcano. Easily disaggregated, they probably gave rise to the gravel lenses encountered during the drilling.

I hold the conviction that this example highlights the merits of regional engineering geological mapping, in this case up to 15km from the dam sites but driven specifically by the need to understand the geotechnical setting of andesite volcanoes and their ring plains. Moreover, a comprehensive approach to data collection, including geomorphic data, was vital to success. Further, investigation never stops and the logging of excavations during construction was part of the feedback necessary to answer questions posed at an earlier stage – in this case the mysterious gravel lenses.

This deposit was renamed the Te Whaiau formation (Prebble, 1995a) and has been reviewed in the light of volcanological knowledge gained since the power development investigations of the 1960s. This current study (Le Cointre, Neall, Wallace and Prebble, in press) confirms that the Te Whaiau Formation is a single, massive volcaniclastic deposit interbedded within gravelly and sandy sediments of the north-west ring plain of Tongariro volcano. The approximately 0.5km^3 clay-rich, matrix-supported gravel has lithologic and physical properties that are typical

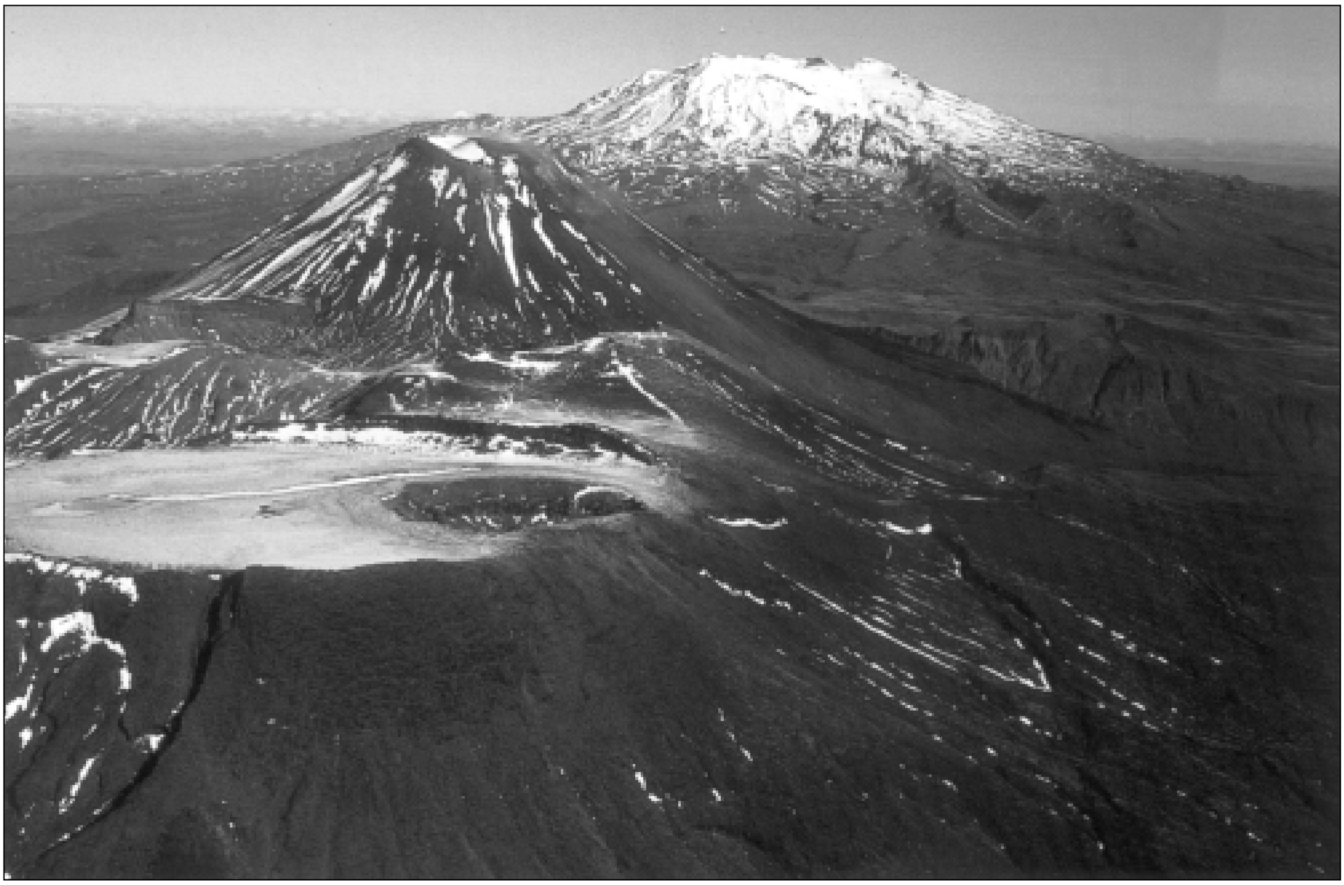


Figure 4a Aerial view of Tongariro Volcano from the north. The flat-topped North Crater in the foreground lies in front of the old altered massif of the summit of Mt Tongariro, considered to be the remnants of the source area for the Te Whaiau Formation. A model derived from this view is shown below in Figure 4b.

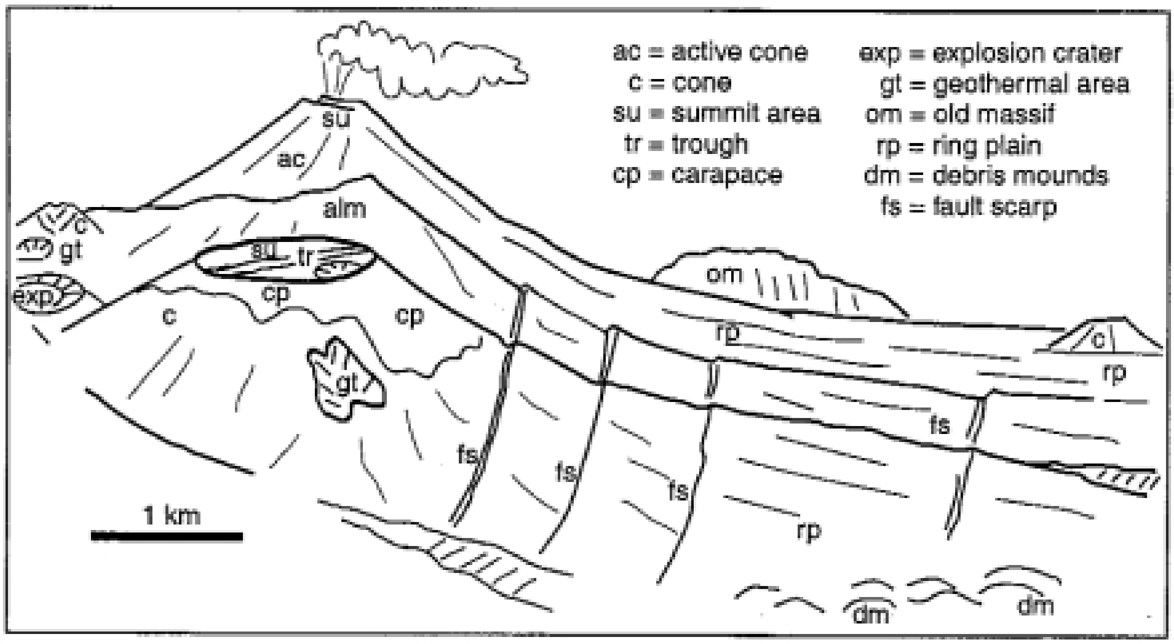


Figure 4b Geomorphic elements of a complex andesite volcano. This model is based upon the Tongariro volcano, illustrated above in the photograph, Figure 4a. Note that "alm" in the figure represents the altered massif of the old Tongariro volcano.

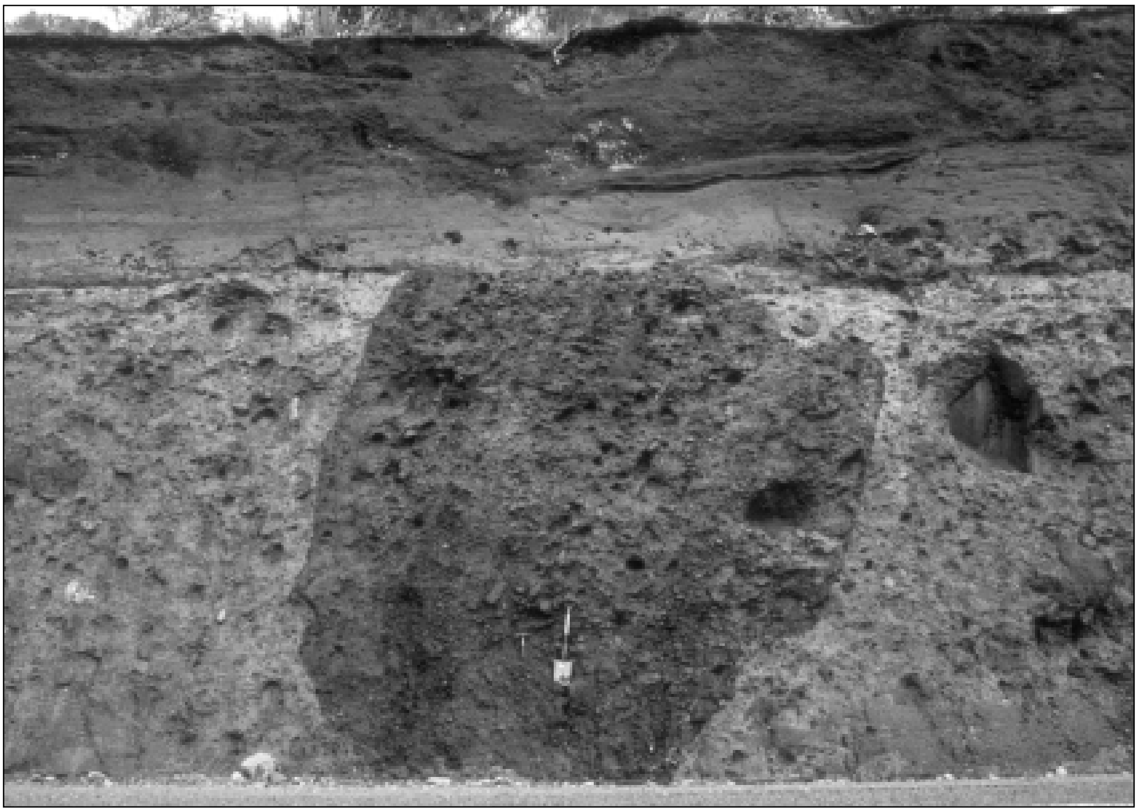


Figure 5 Te Whaiau Formation cohesive debris flow deposit exposed at the side of State Highway 47. The large dark block in the centre with the spade for scale is a megaclast of compact andesitic gravel, with the bedding now tipped up almost to the vertical. The megaclast is supported in the clayey matrix gravel, which makes up most of the formation. The covering beds of volcanic ash lie on top of an erosion surface cut across the Te Whaiau Formation.

of a cohesive debris flow. Clays in the matrix are derived from hydrothermally altered andesite lava, breccia and tuff. Distribution of the deposit and the clay assemblage suggest a source area in the vicinity of the present Tongariro summit. Most of the proximal part of the deposit is buried under a carapace of late Pleistocene lavas forming the north-western summit (North Crater) and flank of the mountain. Further out on the ring plain the medial and distal lithofacies are exposed, especially in new roads cuts of SH 47, and include large volcaniclastic megaclasts (Figure 5) like those seen over 30 years ago in the dam excavations. Other very large clasts include blocks of fractured andesite. These megaclasts show that the matrix was very supportive of large fragile blocks and is very thick, filling in stream channels and shallow gullies. Small hummocks are present only at the distal end of the deposit. These features suggest that the Te Whaiau Formation has been emplaced by a fluid-saturated debris avalanche that changed into a clay-rich debris flow which was stopped at 15km from source by elevated terrain across large boundary faults of the Taupo Volcanic Zone.

Stratigraphy of the cover beds and dates on an underlying lava flow indicate that the Te Whaiau Formation was emplaced between 55 and 60 ka. Jigsaw- fit fractured volcanic bombs suggest that an explosive eruption through hydrothermally altered rock and pyroclastics of the summit geothermal field triggered a deep-seated slope failure of a massive sector of the proto-Tongariro volcano to form the initial avalanche. Since then the new carapace of North Crater has been built up over the geothermal field and part of the deeply altered old massif, thus perpetuating the conditions for instability. A sequence of tephras, loess, paleosols and debris deposits in the ring plain overly the Te Whaiau Formation and indicate continuing activity and cone building since the collapse, which created the deposit. The lack of a distinctive head scarp in the source area indicates that the initial scar and pull away have been either eroded away or buried by younger lavas or destroyed by subsequent eruptions. It appears that younger lavas now conceal the head of the old slope failure. A well-developed trench across the surface of the North Crater of Tongariro may be an incipient pull away zone for the next sector collapse.

By international standards the Te Whaiau Formation is relatively small volcanic mass flow deposit. The lithology and geometry of the formation reflect high mobility of the initial saturated avalanche, rapid transformation of the avalanche into a clay-rich debris flow and preservation of the carrying capacity of the slug-like flow to at least 15km from source.

Devastating avalanche –induced debris flows must be considered a potential volcanic hazard for the north-west ring plain of Tongariro.

Figure 6 Geology of the faulted andesitic massifs of Kakaramea and Tihia volcanoes, in the centre of the Taupo Volcanic Zone, south of Lake Taupo.

Altered and Faulted Andesitic Massifs

The andesitic massifs of Kakaramea and Tihia volcanoes lie in the centre of the Taupo Volcanic Zone rift, south of Lake Taupo (Figures 2 and 6). The form of these volcanoes has been much modified by erosion, faulting and graben development into a series of step-like scarps and benches.

In addition to the youngest NNE striking faults of the Taupo rift, several other sets of faults and fractured zones are inferred from the geomorphology and were confirmed by ground conditions in the Tokaanu Tunnel. The northern part of Tihia is extensively hydrothermally altered. A thick ash cover, weathering, alteration and dense mature forest cover meant that considerable reliance had to be placed upon geomorphic interpretation of aerial photographs and comparison with other volcanoes in the region.

The Hipaua geothermal field is situated along the zone of the Waihi Fault (Figure 6), in steep unstable ground 500m above lake Taupo. Thermal activity is concentrated along 1km of the fault scarp where it is intersected by E-W and NW-SE trending topographic lineaments. The latter lineament is defined by breaks in slope, saddles, small andesitic cones, a rhyolite dome and stream directions. It can be followed into the Kaimanawa Mountains as a series of co-linear streams, saddles and valleys, which probably follow a large fractured zone. Similar evidence for the fracture control of geothermal fields north of Taupo is presented by Wan Tianfeng and Hedenquist (1981) and also by Hamlin and Prebble (1998). Where the major NW-SE lineament was intersected in Tokaanu Tunnel, a 1km wide zone of soft extremely weak smectite clay was encountered with some very closely fractured and altered rock, crushed zones, gouge, water inflows and temperatures of 27 to 40ºC (Prebble, 1977 and 1986). The smectite clay made up 50 to 80% of the ground and caused severe swelling in the 1km long section of weak material.

The lineaments were interpreted as fractured zones and possible faults. The NW-SE lineament along the foot of the volcanoes coincides with the Tokaanu and Waihi geothermal fields and crosses the Tokaanu Power Station and tailrace canal. High groundwater temperatures were found beneath the tailrace excavation where it is crossed by the lineament. Investigation drillholes met water at 100ºC at 30m depth and “played”as geysers to about 30m above the ground. Situations such as that raised the possibility of hydrothermal eruptions as a consequence of removal of lithostatic or hydrostatic load.

The tailrace design was considerably modified, with a raised invert, reduced lining and increased width.

Most of the north-east slopes of Tihia behind Tokaanu and Waihi show signs of slope failure (Figures 2 and 6). Long sinuous tongues and shorter lobes of hummocky slope are more or less ubiquitous, except for the penstocks ridge which is considered to be in place. The penstocks are founded on ribs of fractured andesite. In the case of the bottom rib beneath anchor block 1 and the rear wall of the power house the rock is also very seamy with a network of soft clay seams and gouge. The ribs are surrounded by firm to stiff clay, a fairly uniform residual andesitic soil mass derived from alteration of lava, breccia and rubbly scoria. Reference to the exposures on the Tongariro volcano (Figure 7, for instance) clarified the origin of the formations at Tokaanu through a careful textural and stratigraphic comparison at a range of scales.

Large curved landslide scarps and slide blocks are found along the Waihi Fault scarp (Figure 6) where alteration has weakened the ground. The landslide area covers up to 12km^2 and extends up to 500m above Lake Taupo. Historic landslides in 1846 and 1910 originated as massive failures of the fault scarp in the geothermal field and culminated in debris avalanches and debris flows which engulfed the lower slopes south of the present Waihi village. The debris forms a huge fan, which protrudes out into the south-west corner of the lake. Very soft, extremely weak clayey deposits are

Figure 7 A reference locality for an engineering geological model of andesitic deposits, at the base of Ngauruhoe volcano in the head of the Mangatepopo valley. A fractured rock tongue (lava flow) is exposed at top left. Scoria rubble covers lava flows to the right. Avalanche debris and reworked alluvial deposits are seen in the foreground.

found in a broad zone for 2km along the Waihi Fault scarp where it coincides with the Hipaua geothermal field. Above this zone, tension cracks several m deep and some up to many m wide were recorded in the andesite flow rock mass and breccia along and parallel to the top of the fault scarp (Prebble, 1986). The soft clay and thermal activity are directly below. Continuing retrogressive failure of the scarp is to be expected. Elevated topography and permeable ground above the continuing thermal activity will presumably maintain a groundwater supply and significant pore pressures in the extremely weak clayey materials.

Complex rotational-translational slope failures and debris flows are postulated for this area and seem to be compatible with the eye witness descriptions of the 1846 and 1910 landslides (Prebble, 1986).

Similar but older landslide masses make up most of the slopes behind Tokaanu and on either side of the penstocks and power station. The head of this broad landslide zone is the edge of the Mt Tihia summit plateau and graben in which there are at least 4 shallow explosion craters. One of these is breached by a slope failure, which sent a clay-rich debris flow of very soft altered material down the slope a few hundred metres south of the power station. This deposit is very similar in content to the Te Whaiau Formation but is a smaller event and much younger. It possibly flowed down the slope in the last 1000 to 2000 years. During power project construction of roads and spoil dumps small slope failures were initiated on either side of the penstock slope.

The selection of a tunnel route and power station site in the Kakaramea-Tihia altered and faulted massif poses several challenges for hazard identification and assessment. Lying right in the centre of the Taupo Volcanic Zone active rift, it is in particularly hazardous terrain. The tunnel route avoids active faults, grabens , explosion craters, landslides and geothermal fields. Even so it encountered hot swelling ground (Prebble, 1977). The power station faced a very restricted choice of possible sites and narrowly avoided the hazards referred to except for geothermal activity, which forced a change of design for the tailrace (Prebble, 1969b).

In the Tokaanu area, accurate geomorphic interpretation was essential to hazard identification and assessment Recognition of volcanic facies through a mask of intense alteration was an important step towards distinguishing landslide deposits from in-situ ground. Regional geological information and a detailed knowledge of the range of facies that could be met came only with experience of the volcanoes to the south, in particular Tongariro. Figures 4 and 7 are examples of reference localities, which were used for information on andesite volcanoes.

Landslides are present in other geothermal areas and altered ground further north in the Taupo Volcanic Zone. There are some similarities to Tokaanu, for instance at Te

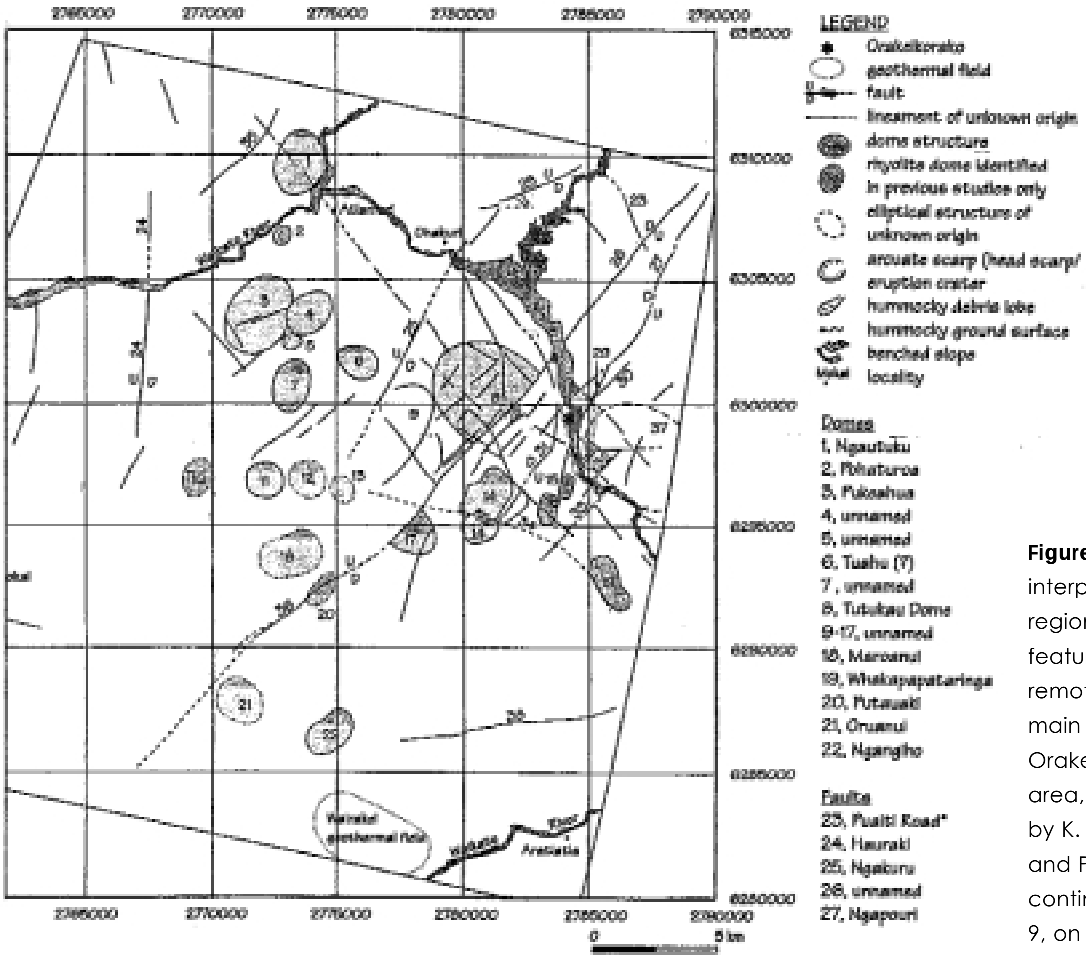


Figure 8 An example of an interpretative map of regional geomorphic features produced from remote sensing. This is the main part of a map for the Orakei Korako – Atiamuri area, Taupo Volcanic Zone, by K. A. Hamlin, from Hamlin and Prebble (1998). Legend continues alongside Figure 9, on next page.

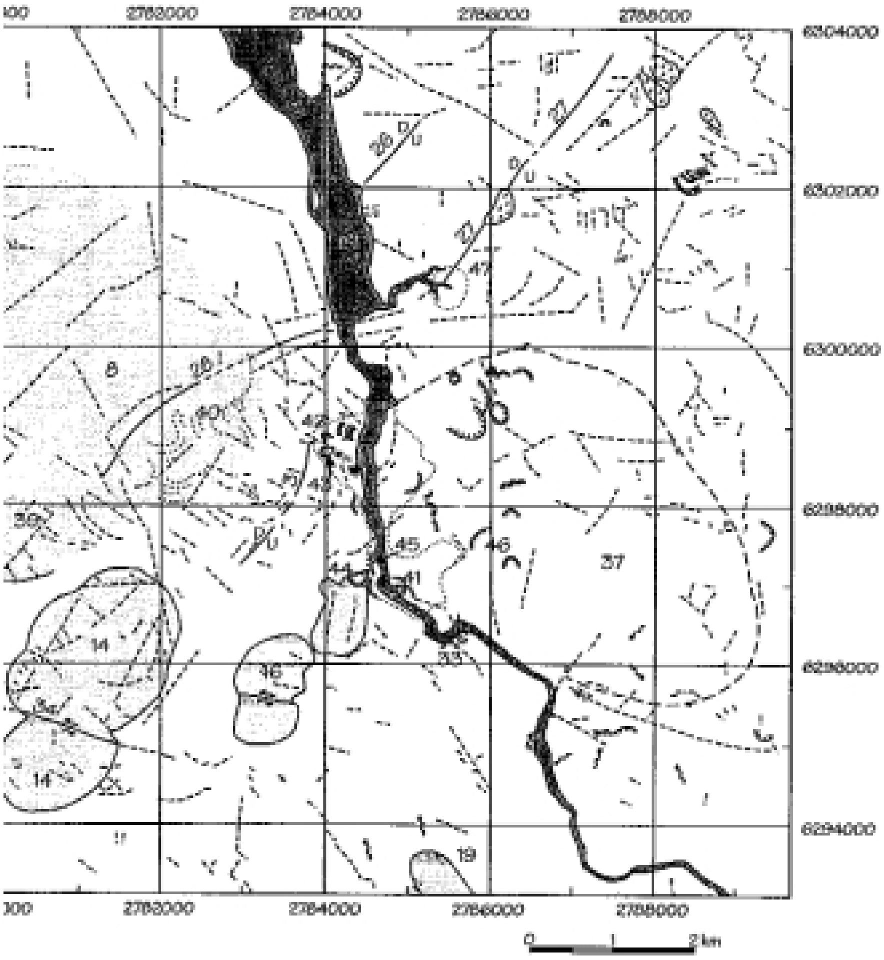


Figure 9 An example of an interpretative map of local geomorphic features for the Orakei Korako area. This is the main part of a map produced from remote sensing by K.A. Hamlin, from Hamlin and Prebble (1998). Note that the Legend is a continuation from alongside Figure 8, on previous page.

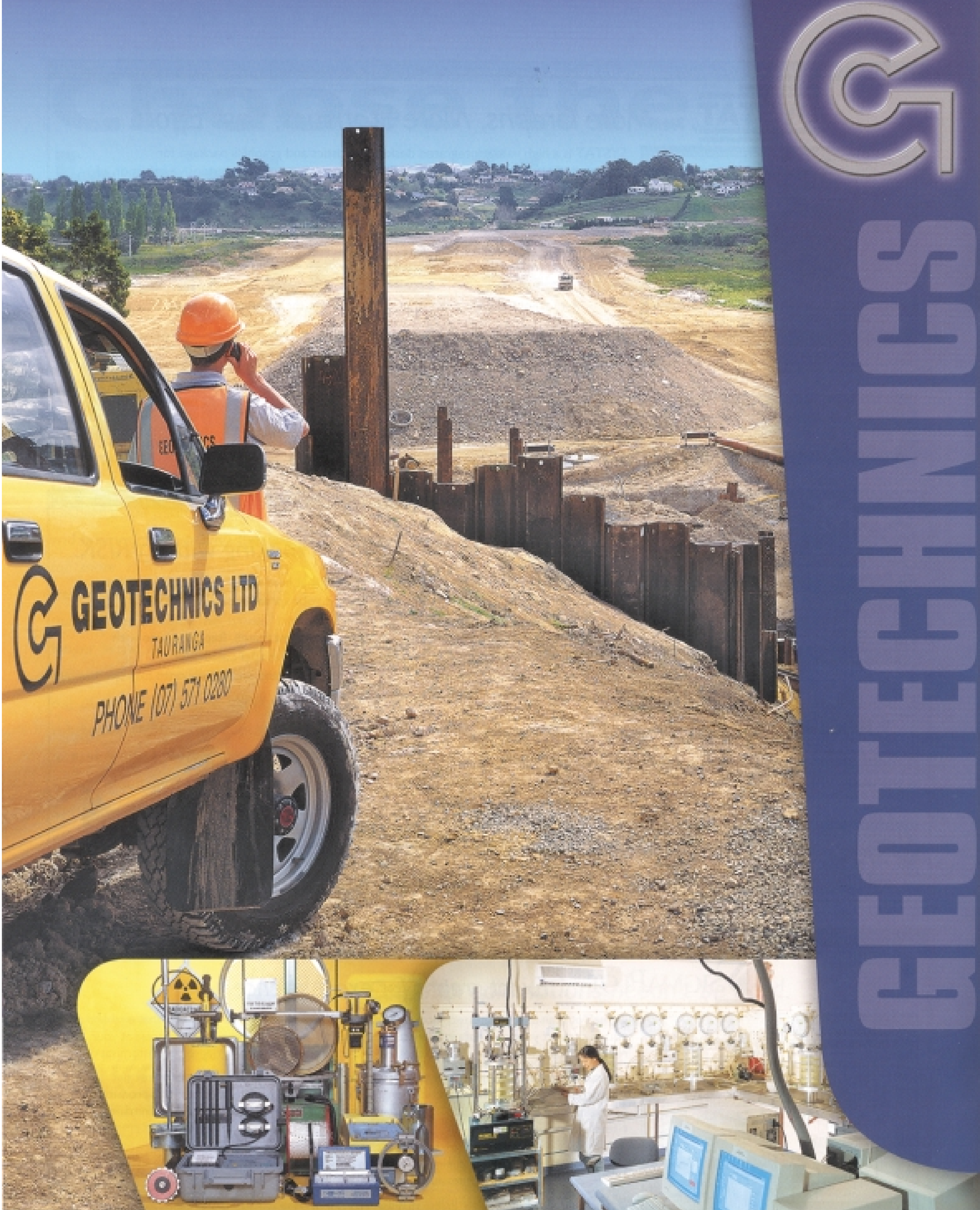
Kopia where the Paeroa Fault scarp has generated large debris avalanche deposits from thermally altered ground and active thermal areas, including the current geothermal field. At Orakei Korako (Figures 8 and 9), thermal activity and alteration have generated earth slides, slumps and earth flows at the head of a slope which steps up progressively across several fault scarps. Facing similar constraints to the Tokaanu area because of lack of exposure, the interpretation of the geomorphology and geology, especially of faulting, landslides and geothermal features was achieved here by remote sensing (Hamlin and Prebble, 1998).

Earth Slides and Flows From Ignimbritic Plateaus and Terrace Remnants

Events in the Bay of Plenty twenty years ago demonstrated the potential for instability in ignimbritic soil masses of rhyolitic composition in certain situations, such as elevated terrace remnants. Topography at the edge of the volcanic plateau, in the Bay of Plenty, is characterised by numerous slender, steep-sided, finger-like terrace remnants. Similar features are found also in the Auckland region, adjacent to the main estuaries and harbours. Each remnant belongs to a formerly more extensive terrace constructed from a series of either pyroclastic flow deposits or tephra and pyroclastic material which has been eroded and then redeposited. The deposits are of 2 main types, interlayered with each other: thick, irregular, undulating layers of rhyolitic sand, pumice and breccia and thinner intervening layers of very soft to stiff clay. Plaeosols are often found at the top of the clay layers. Considerable physical variation exists: lateral changes in strength, abrupt vertical changes in grain size and soil type and a wide variation in water content. Figures 10a and 10b illustrate soil mass conditions typical of the Ruahihi area and are broadly applicable to other places with irregular, undulating and interbedded layers of coarse and fine soil masses. These are consistent with a series of buried topographies or paleo-topography, each of which is marked by discontinuous faint paleosols at the top of the fine clayey layers.

Successive periods of eruption and deposition followed by erosion and weathering are envisaged to have produced this valley-in-valley form and the sensitive clays. In these non-welded deposits the open porous fabric of rhyolitic pumice and the soils derived from it have a potential for holding water and for some collapse. Weathering would produce clays and a delicate very porous microfabric similar to that found in some thermally altered deposits. Delicate and open fabrics have a high potential for collapse, water release and flow.

At Ruahihi for instance, many soils have low density, high porosity, high sensitivity and a potential for collapse and flow. Ranges of water contents exceeded liquid limits and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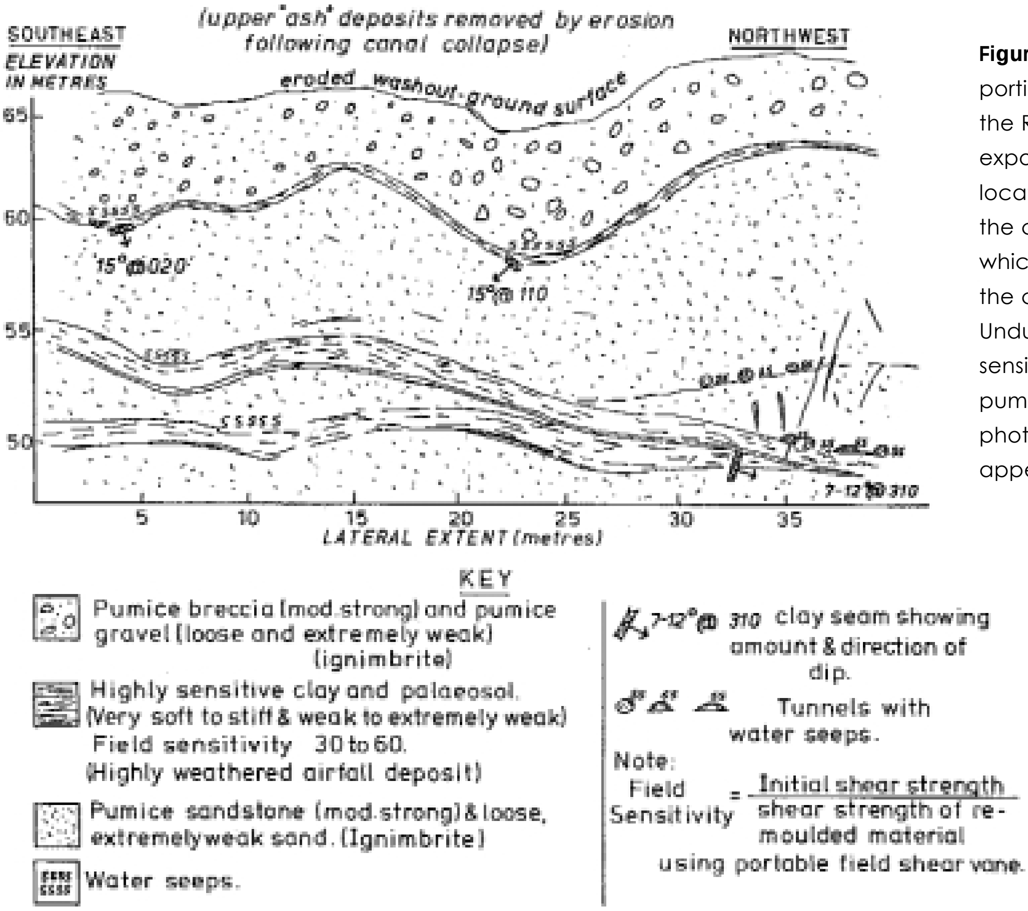


Figure 10a Elevation sketch of a portion of in-situ ground beneath the Ruahihi Canal washout. The exposure is a vertical face located in the deepest part of the centre of the main gully, which formed immediately after the collapse of the canal. Undulating, irregular layers of sensitive clay overly rhyolitic pumice sand to sandstone. A photograph of this exposure appears below in Figure 10b.

Figure 10b Moderately strong rhyolitic pumice sandstone, sand and extremely weak, highly sensitive clay layers exposed beneath the Ruahihi Canal collapse. A laminated sensitive clay layer dips down to the right in the middle distance. This exposure is also illustrated above in line drawing Figure 10a.

field shear vane sensitivities of 30 to 60 were common. Even after several months of drainage water was still flowing out of natural pipes at low points in the sands above the clays. This situation led to the notion of a series of perched, confined, superposed ribbon aquifers. This is a consequence of the paleotopography, which involved superposition, deposition, erosion and weathering – repeated several times over to make up the deposits of each terrace.

Springs are found issuing from the base of blind gully head-walls and side-walls at the low points in the paleosols. Hummocky ground and mounds are often found some distance downslope. These features are indicative of very mobile fluid slide-flows in the sensitive layers and have been identified in the area around Ruahihi, elsewhere in the Bay of Plenty, and at a number of places in Auckland such as the upper Waitemata Harbour, Manukau lowlands and Beachlands. Similarly sensitive rhyolitic materials of a residual hydrothermal alteration origin at Orakei Korako are thought to have encouraged large block slides.

The key to understanding these slope failures at Ruahihi and Auckland was provided by detailed mapping of exposures, which revealed the succession of paleotopographic surfaces, ribbon aquifers and sensitive clay layers. Combined with the subtle geomorphology of the terrace remnants, this suggested a slide-flow model for failure of the soil masses. At Orakei Korako, detailed geomorphology, outcrop logging and alteration mineralogy are providing a deeper understanding and a useful model as part of a current study.

Deep Seated Topples in the Southern East Coast Deformed Belt

Toppling has been known for some time in scarp slopes (anaclinal slopes or "back slopes"). However it also happens in dip slopes, in particular cataclinal underdip slopes in which the dominant, pervasive defects dip in the same direction as the slope but a steeper angle. Traditional wisdom would suggest that these slopes are inherently stable and more or less self- buttressed against failure. Such is not the case. This came as a surprise and was only discovered by a very comprehensive programme of regional and detailed engineering geological mapping over a very large area, coupled with a study of stereo-pair aerial photographs.

Thirty-six dip slopes in Marlborough were studied, initially for their apparent stability compared to other areas of the East Coast Deformed Belt. Only 4 rock slides were found, in areas of more gently dipping limestone. There are also many relatively surficial earth and debris flows across all rock types, including shales.

The strong limestones are non-porous materials with an interlocking mosaic of microscopic grains of calcite and quartz whereas the very weak shales are slightly porous with a continuous "turbulent"network of clay microaggregrates wrapped around microscopic grains of calcite.

The relationship between rock type and defects to slope failure was described by Prebble (1995b and 1996) and is summarised in Table 1. Rock type, defects and geomorphology were mapped over an area of 120km^2. Some of the 36 slopes showed scarps, benches, screes, mounds and a few ravines with lodes extending downslope from them (Table 1).

Close examination revealed that the scarps were reverse (facing uphill). Other important differences from the usual forms of slope failure then emerged such as a head bench instead of a steep head scarp, a convex and slightly bulging main body instead of a concave and depleted one, and the absence of an override zone or bulging toe. It was clear that some form of mass movement had taken place in these slopes. Detailed mapping showed that the bedrock was very disturbed and dilated and had been bent over towards the valley in the middle of the convex and bulging part of the slope. Deep and very unstable ravines down the middle of a few slopes gave critical data on the detail and depth of the bending over of the tabular limestone rock mass. From that information the model of toppling and over-turning of the rock mass was developed. Toppling has also been reported in cataclinal underdip slopes by Cruden and Hu (1994).

Table 1 Relationship of rock type and defects to slope failure in Marlborough

Rock type Rock mass	Dominant Defects	Slope Failure	Subsequent Slope Movement	Topography
•Strong limestone, tabular rock mass	•Crush zones. Extremely closely spaced fractures. Dips 30° to 80°. Slope angle less at 15° to 42°	•Overtopples (flexural and block flexural, complex, leading to rock mass bulging)	•Stony debris flows •Rock fall and screes •Debris avalanche	•Convex slope, uphill facing scarps. Bulges, screes. Ravines with stony debris flow lobes •Debris aprons below
•Strong limestone, tabular rock mass	•Crush zones. Extremely closely spaced fractures. Dips 15° to 25°, parallel to slope.	•Rock slides	•Debris flows from toe	•Head scarps •Block fields •Pull away zones, ponds and swamps
•Very weak shale. Fissile rock mass to clay gouge soil	•Wide clayey crush zones	•Debris flows	•Debris flow	•Stream-like and glacier – like lobes

Using geomorphology to compare slopes without ravines or sufficient exposures, it was concluded that 32 cataclinal underdip slopes showed evidence of deep seated toppling. The term "overtoppling" was put forward (Prebble, 1996) as a way of distinguishing this variety of toppling from the commonly observed modes in scarp slopes (anaclinal slopes). The toppled masses extend to 50m deep and are in the order of 1km^2 in area. Rock above the bending surfaces varies from coherent masses to chaotic debris. Considerable dilation and loosening has reduced mass strength to that of coarse gravel. As a result the toppled masses are subject to debris flow and to collapse as catastrophic rock and debris avalanches.

An example of overtoppling is given in Figure 11. Age and recurrence of toppling and collapse are not well constrained. Stratigraphy in the run out area for debris avalanches indicates that a large collapse took place in the last 3500 to 5000 years. Successive aerial photos show that

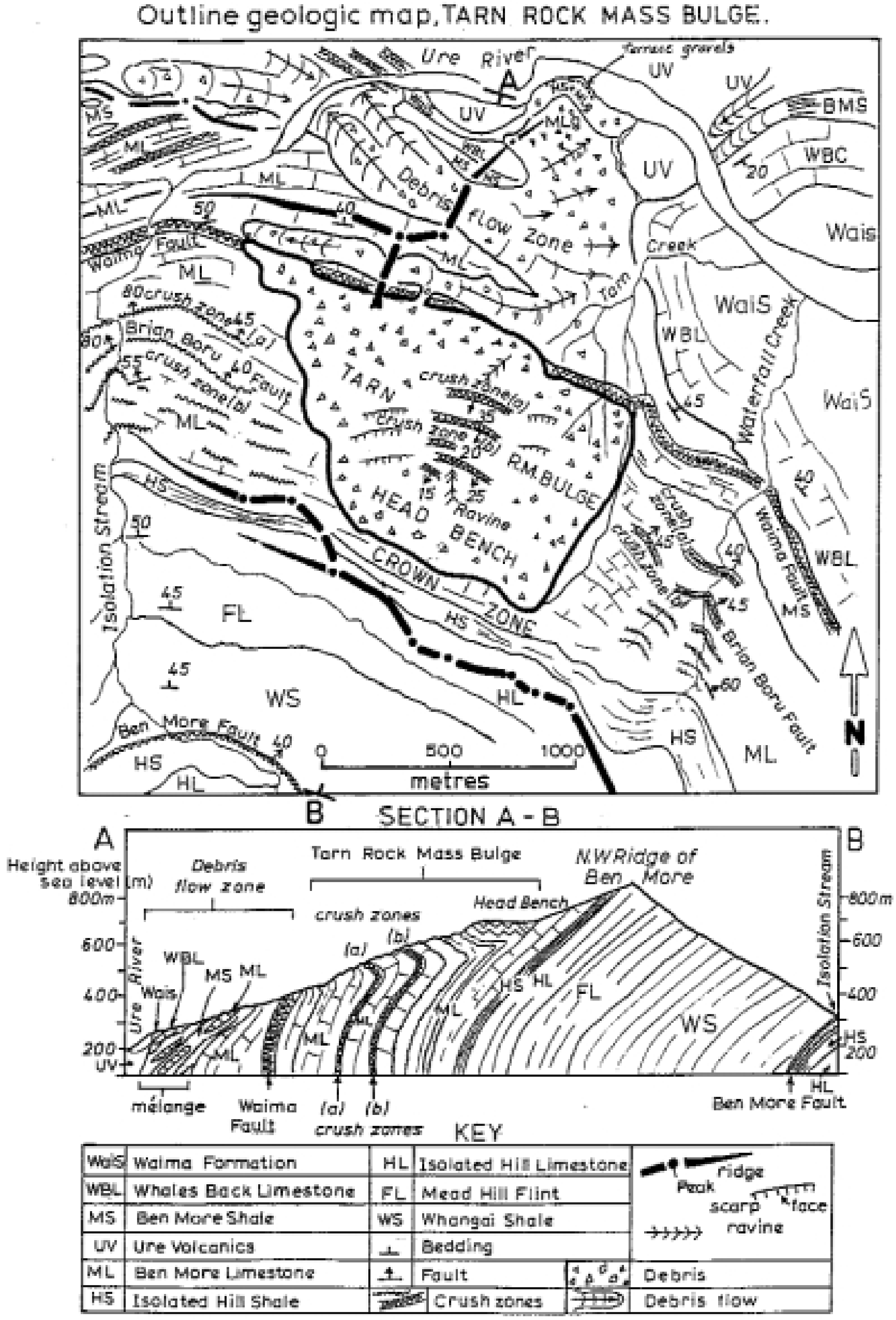


Figure 11 An example of an overtopple. The Tarn slope failure – a rock mass bulge in Marlborough.

the ravine discharges significant debris flows every 50 years. These are sufficiently large to carry through to the river 1km below. Comparative geomorphology indicates that the scarps on the bulge may be 100 to 500 years old.

Recognition of overtoppling in Marlborough testifies to the value of comprehensive geotechnical field mapping and remote sensing, at a range of scales, over a large area of common tectonic and lithologic character.

Mountain Range Collapse in the Greywackes of the Southern Alps

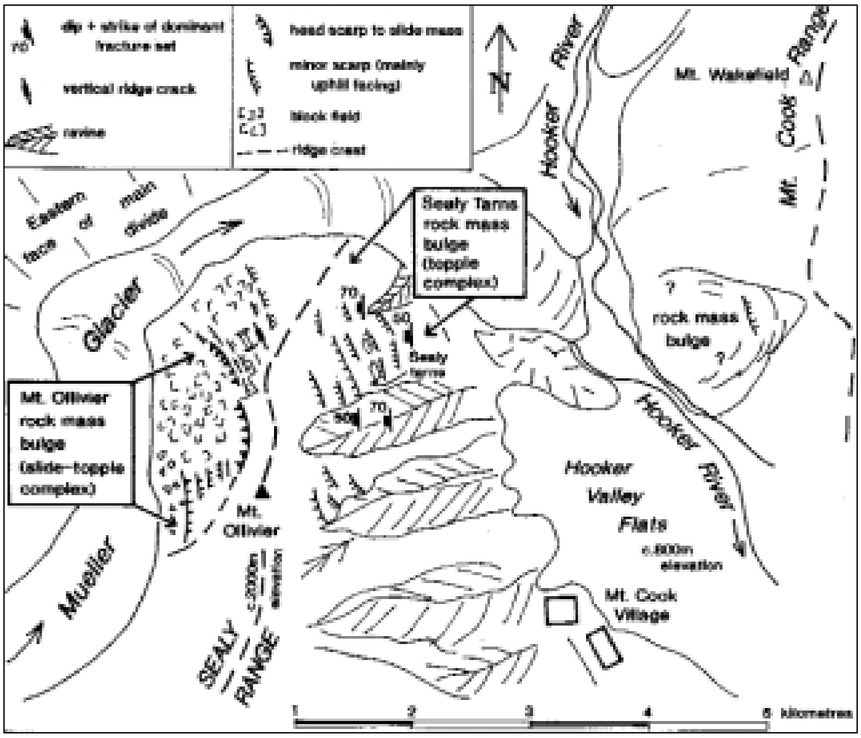
Recognition of toppling in Marlborough led to a search for similar features in the Southern Alps and in particular an examination of scarps described as ridge rents and gravity faults (Beck, 1968). Two areas have been visited, Arthur's Pass and Mt Cook. Each is complex, with major active faults. Possible splays of these faults could also be present. Although the rock at each area is referred to as greywacke, some of it is low-grade schist.

Large uphill facing scarps are seen around Arthur's Pass and are particularly well developed on the Kelly Range, 15km north of the Pass and near the acute intersection of the Alpine and Hope Faults. Uphill facing scarps in this area may be attributable to faulting and subsequently to toppling. Some are probably the direct result of toppling. A considerable amount of fracture dilation on the Kelly Range, up to 1m in places, indicates significant ridge top cracking and therefore ridge crest spreading. Toppling is seen on both sides of the range and is associated with deep ravines, screes and highly unstable edges to the ridge crest. A major difference from Marlborough is the well-developed glacial topography which has left deep, steep sided valleys and high level benches, now unsupported that the ice has gone.

Spectacular uphill facing scarps can be seen on the Sealy Range above the Hooker Valley and near Mt Cook village. Some of these have trapped bogs and ponds behind them such as the famous Sealy Tarns. Toppling on this scarp slope (anaclinal slope) has produced a series of scarps on the side of the ridge, which is a sloping bench and was previously referred to as the Sealy Tarns rock mass bulge (topple complex) by Prebble (1995a) and is shown in the map on Figure 12. This bench terminates along the side of the ridge, in a deep ravine with a large fan below it. Several bending surfaces and progressive block toppling are exposed in the ravine (Figure 13). The other side of the range is, at least in part, a cataclinal slope and is occupied by a large, chaotic, slide-topple complex (Figure 14). This was referred to in the 1995 account as the Mt Ollivier rock mass bulge. One scenario for geomorphic development suggests that the ravines are the sites of previous collapses and that the Sealy Tarns bench will be the next bulge to fail. Failure can also be take the form of combined sliding and toppling as seen on the Mueller Glacier side of the range. The two styles of failure combine to produce mountain range collapse.

Figure 12 Map of the Sealy Range, showing large complex topples at the Sealy Tarns and below Mt Ollivier. Referred to as rockmass bulges by Prebble (1995a).

Figure 13 Toppling in closely fractured and crushed greywacke, adjacent to the Sealy Tarns, Mt Cook National Park. Exposed face is a few hundred m high. Deep gullying cuts through the dilated and toppled rock mass, 700m above the Hooker Valley.



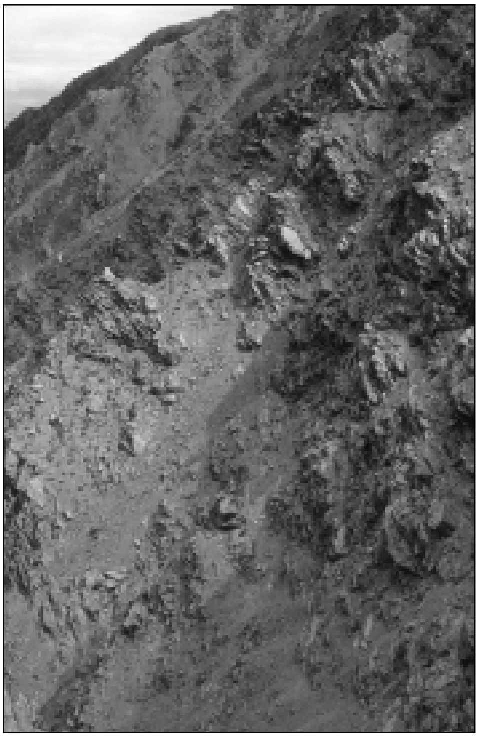


Figure 14 A topple – rock slide complex on the Sealy Range, above the Mueller Glacier, Mt Cook National Park. Open ridge cracks, fracture dilation, uphill facing scarps (these are dark and in the shade in the photograph) and secondary block sliding are found in this complex slope failure. Further downslope to the right is a block field of chaotic rock fall debris.

The uphill facing scarps are compatible with a flexural toppling mode, but the multiple bending surfaces seen in most of the topples suggest that complex toppling modes are involved. Multiple block toppling, block-flexural toppling and collapse mixed in with toppling should all be considered.

Firm conclusions cannot be drawn at this stage but it appears that the role of toppling in mountain range collapse in the Alps may be very significant. It could also be that deep-seated toppling is a realistic alternative to the gravity faulting mechanism proposed by Beck. Toppling does not require either the double-sided, symmetrical aspect of his model or the very deep gravity faults, which Beck proposed through the base of the mountain ranges.

Most of the toppling is asymmetric and very messy. One particularly large toppled mass of 20km^2 with a very intricate and wavy pattern of uphill facing scarps and some very large chaotic block fields has been identified in greywacke and schist west of Arthur's Pass. Large ruptures and a collapse in the centre of the toppled mass have left a deep broad ravine. This enables an estimate to be made of the volume of the topple, which is around 1 to 2km^3.

In all these examples, remote sensing with stereopair vertical photos and field mapping at a range of scales were used to identify tectonic features and slope movement. Mapping included lithologic, structural, geomorphic and geotechnical criteria.

Block Slides in Weak Rock Terrain

During the last 25 years it has been recognised that in weak sedimentary rock, generally of late Tertiary age, bedding parallel clay seams and crush zones give rise to block and debris slides. Originally known mainly from events such as the Abbotsford Slide in Dunedin (Coombs and Norris, 1981) these seams were once considered to be "unique" in terms of New Zealand experience (Gallen, Beca, McCraw and Roberts, 1980). However these clay seams have been identified as basal rupture surfaces to landslides in many other localities of geotechnically similar rock masses such as the Rangitikei Valley (Stout 1997, Thompson 1981, Prebble 1995a), Hawkes Bay (Pettinga, 1987) and Auckland (Prebble, 1995a). Refer to Figure 1 for these localities.

Research has shown that far from being "unique", as originally suggested for Abbotsford, clay seams acting as basal ruptures and others, which potentially could do so, are found throughout weak sedimentary rock terrain in New Zealand. Stout (1977), Thompson (1981), Pettinga (1987) and Prebble (1995a and b) document the presence of clay seams as basal rupture surfaces and describe aspects of the complexity and multi-stage development of these landslides over the last approximately 10,000 years. Areas of several km^2 and volumes ranging up to 0.1km^3 are involved. These studies depended upon regional and comprehensive mapping over large areas in order to

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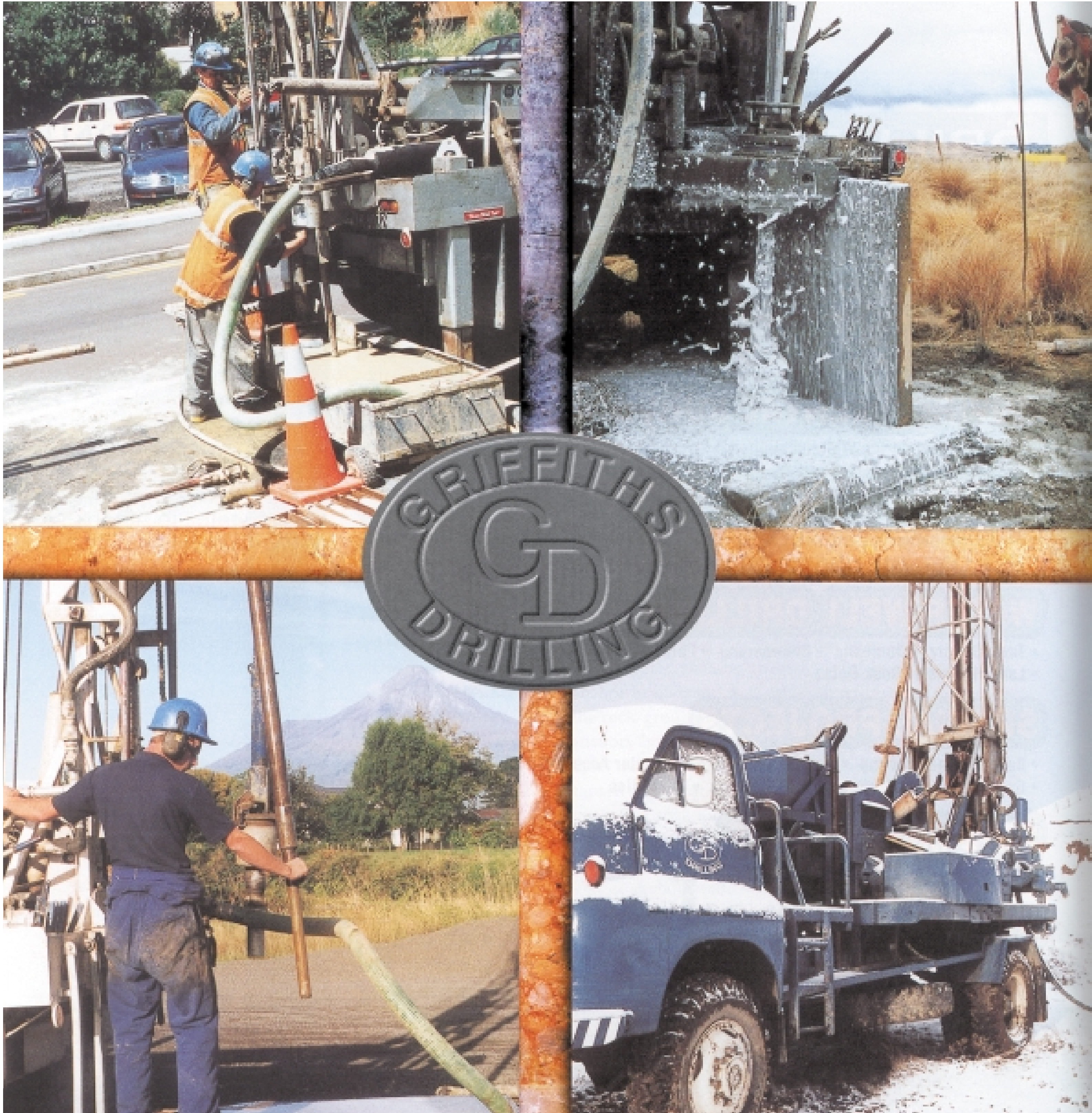
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recognise the presence and importance of the pervasive clay seams and put together appropriate engineering geological models. They were all carried out in areas of relatively well-exposed rocks, rapid uplift and erosion and less intense chemical weathering than further north in New Zealand.

Block Slides and Clay Seams in Auckland

It was some time before clay seams and block slides were confirmed in the Auckland region, leading to the recognition of the southern landslide zone (Prebble, 1995a). This is an area of around 100km^2 (Figure 15) in which most of the slopes have deep-seated failures on bedding-parallel clay seam rupture surfaces. Wedge and complex failures are also found. Slope instability was known to be widespread in the area (Kermode, 1991).

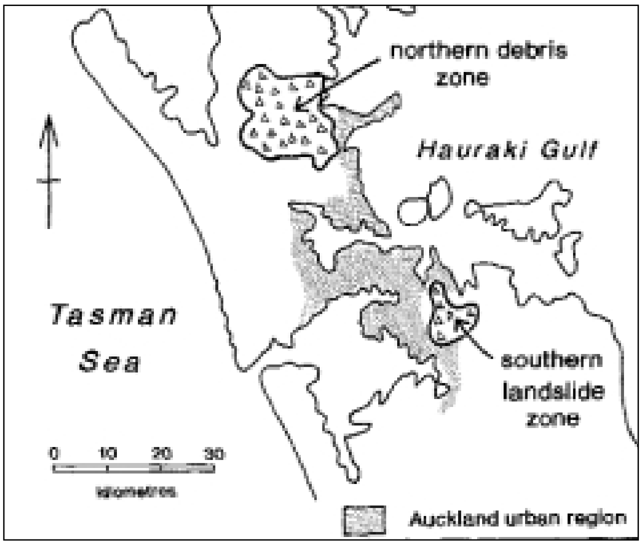


Figure 15 Map of the Auckland region showing location of the southern landslide zone. The northern debris zone is Miocene but has Holocene reactivation. (After Kermode, 1991)

Clay seams of significant continuity were confirmed by Wylie (1989) in a water supply tunnel and reservoir platform (Figure 16). Residual soils up to 20m thick, close fracturing and faulting of the bedrock and the relatively slow rate of uplift and erosion all reduce the opportunity for inland exposures. The landslide topography is subtle. Geomorphic mapping as in Figure 17 for instance (Prebble, 1990 and 1999) and regional studies (Table 2) for seismic hazards and for earthquake-induced slope instability (Williams and Prebble, 1998) indicate that clay seams are likely to be present throughout the southern landslide zone and elsewhere in weak rock terrain in Auckland. The seams are found throughout all weathering grades and deep within unweathered rock. They vary from coatings on fractures to seams of gouge and show crushed wall rock and splays, typical of a tectonic origin, probably that of flexural slip at depth during macroscopic open folding. A flexural slip origin for bedding plane shears in gently dipping claystone and siltstone was proposed by Fell, Sullivan and Macgregor (1988). The shears provided rupture surfaces for slope failures. Hutchinson (1988 and 1995) contends that the potential for flexural slip has been underestimated as an origin for shears, which can develop into basal ruptures of landslides.

A major problem in developing a rigorous engineering geological model is determining the variability, continuity and strength of the clay seams. These are all critical to stability. Continuity of a seam over 50m, with continuous exposure, was provided in a tunnel excavation in South Auckland. However, correlation of seams between drillholes during investigation is usually very difficult unless there are distinctive marker beds. Careful and detailed logging of cores, inspection shafts, trenches and natural exposures has achieved such correlation at sites in the southern landslide zone. Earthworks have subsequently confirmed the continuity of the seams and all aspects of the model in general (Figure 18).

Landslide Hazard Mapping in Auckland

Information on block sliding in the southern landslide zone in particular has contributed to the overall understanding of landsliding in the region. This was integrated into the analysis of landslide hazard during earthquake and heavy rainfall for the Auckland region as part of the recent lifelines study. Using the GIS-based Arc-Info system, areas susceptible to ground shaking, slope instability and liquefaction were identified and presented as a series of maps. A 2000 year return period earthquake was used, both a distributed hazard model based on the existing seismic records and a specific epicentre model based on the Kerepehi Fault to the East of Auckland. Table 2 from Williams and Prebble (1998) shows the properties of the soil and rock mass groups that were used. Criteria in this table are critical to the integrity of the whole analysis and were the result of accumulated engineering geological mapping and logging experience. A series of scoring (rating) tables for soil and rock mass category, slope grade and ground acceleration during earthquake were devised and gave scores which were summed to provide a hazard score. An interpretation was made of that score in terms of a relative hazard class, approximate factor of safety and percentage of slopes expected to fail. These classes were shown on final maps produced for the Auckland Engineering Lifelines Project and have also been presented and described by Williams and Prebble (1998).

Incipient Sliding and Proto Block Slides

A clay seam in a tunnel in the southern landslide zone penetrates narrow fractures above the seam, but not the fractures below it, which are tightly closed. This may be evidence for a very small displacement or incipient block

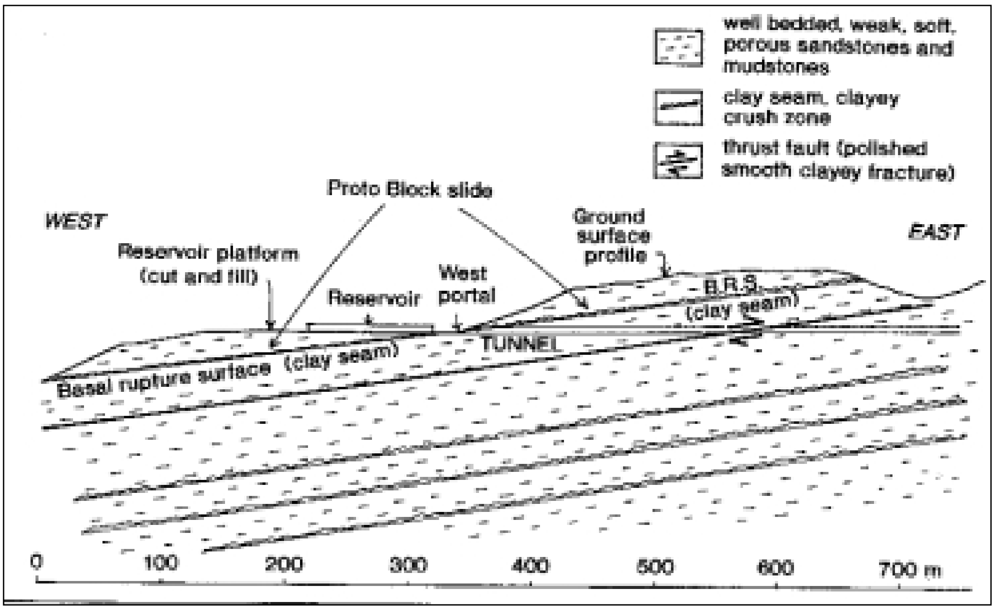


Figure 16 Section through a proto block slide, clay seams and crush zones in weak rock in a water supply tunnel, southern landslide zone, Auckland. (After Wylie, 1989)

Figure 17 Part of a geomorphic map produced from aerial photograph interpretation in the southern landslide zone, Auckland. (From Prebble, 1990 and 1999)

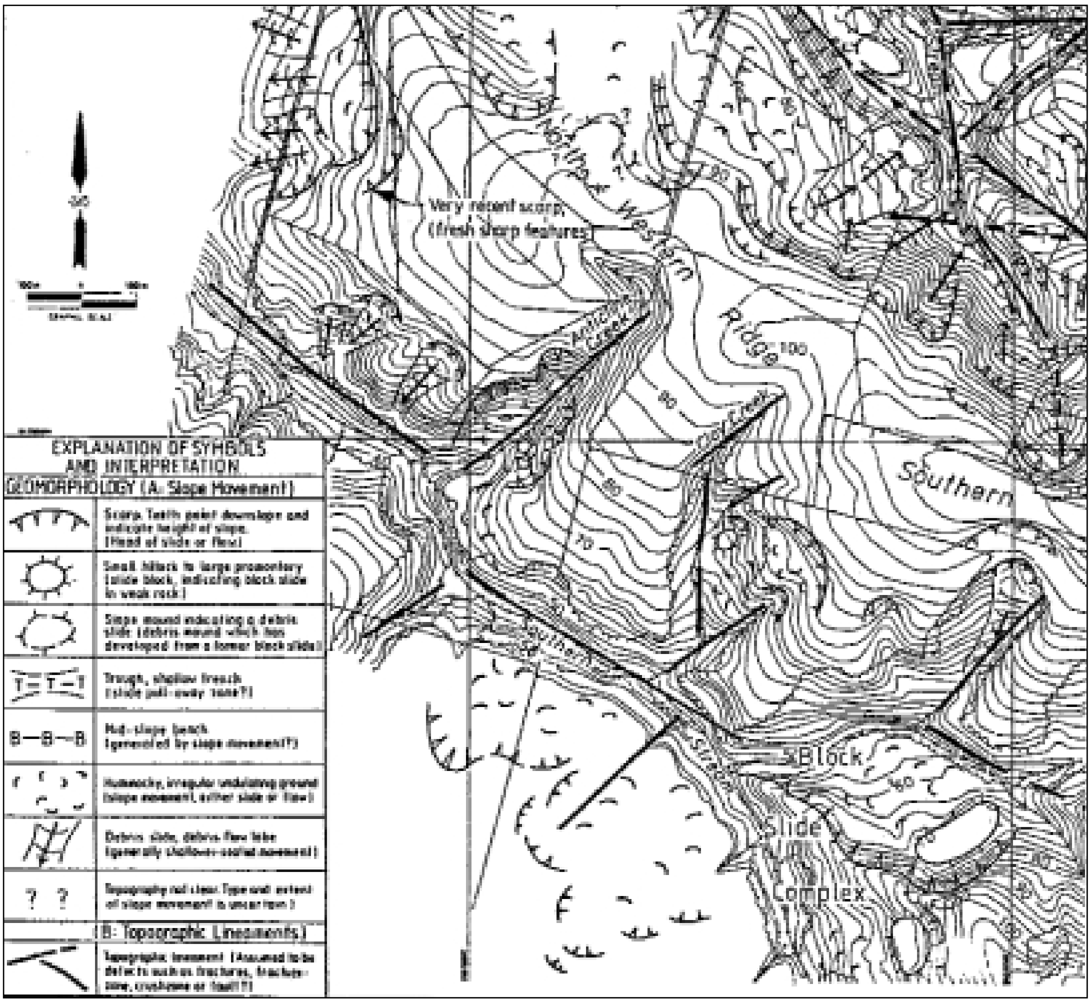


Table 2 Classification of soil and rock groups and their physical properties and response to earthquakes, in the Auckland region. Produced for the Auckland Engineering Lifelines Project. From Williams and Prebble (1998).

Table 2: Soil and rock groups: Physical properties and response to earthquakes

Soil / rock mass group	Soil foundation condition	Soil category	Engineering description of soils/rock	SPT blows/ 300mm (N)	Shear wave velocity (m/s)*	Typical ground failures resulting from earthquakes
1	Residual Soil Overlying Rock	Residual and colluvial soils, ash and weathered tuff:- up to 30m, overlying greywacke; up to 20m overlying interbedded sandstone and mudstone; conglomerate and basalt	CW:-** sand/silt/clay; HW:- gravel in a silty sand/clay matrix; MW:- very weak rock; SW-UW:- weak to moderately strong rock	5 - 25+ 15 - 50+ 30 - 100+ 50 - 200+	100 - 300 200 - 500 300 - 1000 500 - 2000	Generally minor to nil damage to gentle slopes; Movements on critically steep slopes, and on gentle slopes in sandstone and mudstone with clay seams, undercut by streams and coastal erosion.
2	Firm to Stiff Sediment of Pleistocene age	Alluvium; and basalt, ash and tuff overlying alluvium	Soft to very stiff alluvium; Sensitive pumiceous silt; silt, peat and clay; Loose to dense sand and breccia; Ash, tuff and basalt overlying these deposits	5 - 25***	100 - 300	Widespread failure of coastal cliffs and river banks; Movement on moderate to steep slopes; Localised liquefaction of saturated loose sand lenses in severe**** shaking
3	Coastal Deposits	Beach and dune sands; Man-made fills overlying zone 1 or 2 deposits	Medium dense fine sand and shell, saturated; Loose fine sand, unsaturated	5 - 40	100 - 500	Localised liquefaction of saturated loose sand pockets
4	Estuarine Deposits of Holocene age	Stream alluvium and swamp deposits; Man-made fills overlying zone 3 or 4 deposits	Very soft to stiff mud, silt, peat, pumiceous clay; typically saturated	0 - 10	50 - 200	Widespread sliding failures of moderate slopes; Widespread liquefaction of saturated sand deposits in moderate shaking

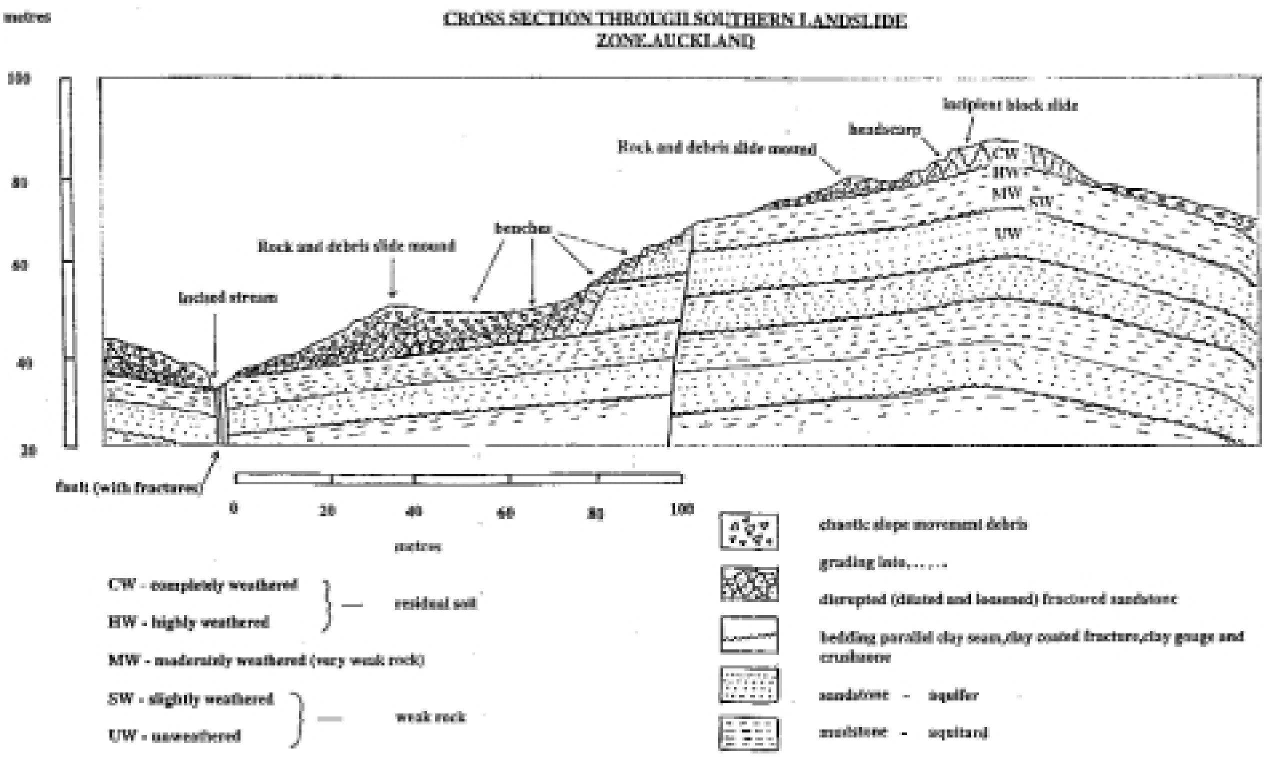
* Values of shear wave velocity are assessed

** Rock Weathering Grades: - CW completely weathered; HW highly weathered (soil); MW moderately weathered (very weak rock); SW slightly weathered; UW unweathered (rock)

*** Where basalt rock overlies deep alluvium, the rock stiffness does not significantly influence site behaviour

**** Shaking levels: - Severe ≥ 0.40g ≥ Strong 0.20g ≥ Moderate 0.15g ≥ Moderate to Low 0.1g ≥ Low 0.05g

Figure 18 Cross section view of a general model for block sliding in the southern landslide zone, Auckland



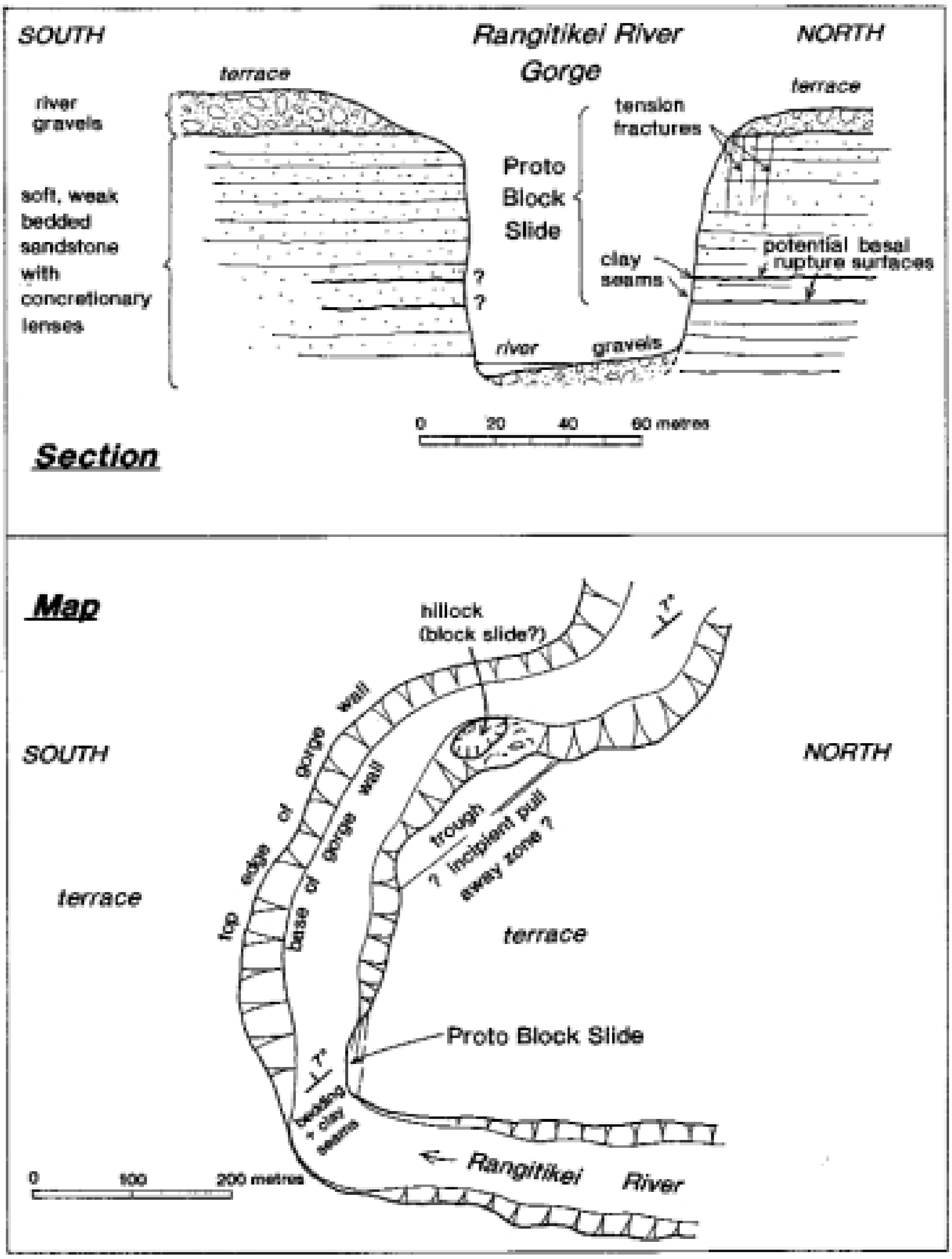


Figure 19 Map and section through a proto block slide in the gorge of the Rangitikei valley, central North Island. (From Prebble, 1995a)

sliding on the seam and is referred to as a proto block slide (Figures 16 and 18). Trenches adjacent to the tunnel confirmed the presence of pull away zones and sliding which could be related to the seam in the tunnel. Proto block slides in which the movement has been several cm were recognised in the gorge walls of the Rangitikei River (Figure 19). Geomorphology of the gorge and terrace surfaces indicated that short displacement block sliding and slabbing, on clay seams was an important process of gorge widening. It was observed that the proto block slide shown in Figure 19 is at the narrowest part of the gorge for that section of the river. The argument was put forward that it is the narrowest part because it will be the next portion of the wall to fail. The age of the terraces are known so that a rate of gorge widening and of river downcutting can be established.

Age and Rate of Block Sliding

This seems an appropriate note on which to finish presenting information and discussion on examples from my collection of case histories. Age and rate of movement are somewhat complex concepts in this context. Age can be the onset of a first time slide or reactivation of an existing one. It may refer either to the time of pull away or to the time of arrival of debris at the bottom of the slope or further down the channel. In a slide that has moved many times, age may refer to any one or more of many separate movements, Slides will also evolve and change over time. Rate of movement may be merely an average and not the appropriate velocity for any one particular movement.

Thompson (1981) established the age of numerous slides in the Rangitikei valley from a distinctive sequence of tephra, which enabled him to assess their development over the last approximately 10,000 years and identify some as old as perhaps 20,000 years. Le Cointre, Neall, Wallace and Prebble (in Press) have used a sequence of tephra, dated lava flows and radiocarbon to determine the age of debris avalanches at Tongariro. In the Auckland region tephra sequences are well preserved in the sediments which fill in basaltic explosion craters, such as Onepoto Basin on the North Shore. Recently completed stratigraphic drilling programmes will provide dated sequences which may be used by correlation to determine the age of pull away zones, overrides and toe dams for block slides in the southern landslide zone, for instance.

Conclusions

The tectonic framework of New Zealand is one of rapid oblique convergence, shear and uplift. Volcanism in the North gives way to mainly compressional shear in the South.

Coupled with an axial core of fractured greywacke and schist terrain, the alpine regions of the South Island are failing by toppling and sliding. In this active tectonic and geomorphic setting rock mass bulging is considered to be widespread and is caused mainly by deep seated toppling.

In its severest form, overturning of tabular rock masses (overtoppling) is caused by dilational flexural-block toppling in cataclinal underdip slopes. Widespread toppling of this type in limestones of the East Coast Deformed Belt in Marlborough was only identified when comprehensive geotechnical mapping was done over a large area, in combination with a geomorphic and aerial photograph study.

Andesitic cones are subject to collapse. Alteration created by high level geothermal activity on cones can give rise to large, mobile, clay-rich debris avalanches and cohesive debris flows. The conditions which create these devastating flows continue today and include northern Tongariro, Kakaramea and Tihia volcanoes. Identification of the Te Whaiau formation as a large cohesive debris flow deposit was facilitated by regional engineering geological mapping, geomorphology, outrop logging over several years and foundation logging in combination with review of the drillhole data.

Altered and faulted massifs in the centre of the volcanic rift are subject to a diverse assemblage of hazards: faulting, geothermal, explosion craters, landslides, swelling ground, residual hot ground and highly unpredictable ground conditions. Accurate geomorphic interpretation, recognition of volcanic facies through comparative studies and regional engineering geological mapping were essential to the recognition of these hazards.

Ignimbritic plateaus and terrace remnants contain highly sensitive rhyolitic soils and ribbon aquifers which combine to give rise to a series of superposed potential basal ruptures for rapid slide-flow failure. These conditions are as widespread as the deposits, which extend into the Auckland region. Similarly sensitive rhyolitic deposits of a residual hydrothermal origin have probably assisted slope failures in the Orakei Korako geothermal field. Key elements in the identification and understanding of these slope failures came from very detailed engineering geological mapping of exposures, geomorphology and the recognition of paleotopography, ribbon aquifers and sensitive clay layers.

Block slides on clay seams of tectonic origin in weak rock are known throughout the North Island and also in the South Island. The southern landslide zone in Auckland is a concentration of such failures, adjacent to a rapidly growing urban region.

Total mapping – comprehensive geotechnical mapping at a range of scales and including geomorphology and remote sensing continues to be an effective investigation method.

The regional picture, often of a large area up to considerable distance from the site is essential in order to obtain the relevant setting when the site is focused on in detail.

Informative, well exposed or geomorphically well preserved “type” geotechnical localities can provide the critical model for understanding enigmatic engineering sites.

Stratigraphy, structure, tectonics, geologic history and geomorphic development, the petrographic and mineralogic properties of materials and defects and a consideration of a range of earth surface processes have all contributed to the examples discussed in this paper. They are all part of the “total mapping” process and are all essential factors in the recognition and assessment of hazardous terrain and in the development of site models for geotechnical purposes.

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It is a privilege and an honour to give the Geomechanics Lecture. I am very grateful to the New Zealand Geotechnical Society for the opportunity and recognition, which this provides. It is also a pleasure to share some of my engineering geological experiences with the membership at large throughout the country. I must point out that any contribution to the profession and to engineering geological knowledge, which I have made over the years has received input from many others. I would like to thank those people who have directly helped me build up my experience and develop my view of engineering geology and I would also like to acknowledge the organisations, which have made it possible.

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Development) provided invaluable work experience and amazing challenges. Secondment to the Snowy Mountains Authority at an early stage gave me training and experience in engineering geology not available anywhere in New Zealand at that time. Later on, Beca, Carter, Hollings and Ferner added significantly to that and introduced me to the world of consulting practice. This connection has continued and expanded with the help of many other consultants who have also included me in their work. The former National Water and Soil Conservation Authority, the Foundation for Research Science and Technology, The Auckland Regional Council, Environment Bay of Plenty, Environment Waikato, University of Auckland Research Committee and IGNS Ltd have given funding for many of the research projects and graduate students over many years. Finally, The University of Auckland gave me the opportunity to develop new courses in engineering geology and to carry out research-informed teaching with very talented young people and with valued colleagues.

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References

Beck, A.C. (1968). "Gravity Faulting as a mechanism of topographic adjustment". *New Zealand Journal of Geology and Geophysics*. 11(1), pp191-199.

Coombs, D.S. and Norris, R.J. (1981). "The East Abbotsford, Dunedin, New Zealand Landslide of August 8, 1979. An interim report". *Bulletin de Liaison de Laboratoire des Ponts at Chaussees. Special X*. pp27-34. (Proceedings of the 26th International Geological Congress, Paris, 1980).

Cruden, D.M. and Hu, Xian-Qin (1994). "Topples on underdip slopes in the Highwood Pass, Alberta, Canada.". *The Quarterly Journal of Engineering Geology*. 27, pp57-68.

Fell, R., Sullivan, T.D. and MacGregor, J.P. (1988). "The influence of bedding plane shears on slope instability in sedimentary rocks". Proceedings of the Fifth International Symposium on Landslides. In: *Landslides: Glissements de Terrain*, Balkema, Vol. 2, pp129-134.

Gallen, R.G., Beca, G.S., McGraw, J.D. and Roberts T.A. (1980). "Report of the Commission of Inquiry into the Abbotsford Landslip Disaster". Government Printer, Wellington, N.Z. pp196.

Hamlin, K.A. and Prebble, W.M. (1998). "Structural setting and geomorphic features of the Orakeikorako geothermal Field, Taupo Volcanic Zone: A remote sensing approach". *Proceedings of the 20th New Zealand Geothermal Workshop*, Ed: Simmons, S.F., Morgan O.E and Dunstall M.G., Geothermal Institute, The University of Auckland, pp277-284

Hutchinson, J.N. (1988). "Morphological and geotechnical parameters of landslides in relation to geology and hydrogeology". Proceedings of the Fifth International Symposium on Landslides. In: *Landslides: Glissements de Terrain*, Balkema, Vol. 1, pp3-35.

Hutchinson, J.N. (1995). "Landslide Hazard Assessment". Keynote Paper. Proceedings of the Sixth International Symposium on Landslides. In: *Landslides: Glissements de Terrain*, Ed: Bell, D.H., Balkema, Rotterdam, Vol 3, pp1805-1841.

Kermode, L.O. (1991). "Whangaparaoa-Auckland". Infomap 290 Sheet R10/11, 1:100,000. New Zealand Land Inventory, Rock Types. Department of Survey and Land information, Wellington, New Zealand. Map sheet.

Lecointre, J.A., Neall, V.E., Wallace R.C. and Prebble, W.M. (2001). "The 55-60 ka Te Whaiau Formation: A catastrophic, avalanche-induced, clay-rich debris flow deposit from Proto-Tongariro Volcano, New Zealand". *Bulletin of Volcanology, (*in press).

Palmer, B.A., Alloway, B.V. and Neall, V.E. (1991). "Volcanic debris avalanche deposits in New Zealand – Lithofacies organisation in unconfined, wet-avalanche flows". In "Sedimentation in Volcanic Settings", SEPM Special Publication 45: pp98-109.

Pettinga, J.R. (1987). "Ponui Landslide: a deep-seated wedge failure in Tertiary weak-rock flysch, Southern Hawkes Bay, New Zealand". *New Zealand Journal of Geology and Geophysics*, Vol. 30, pp415-430.

Prebble, W. M. (1967). "Tongariro Power Development. Western Diversions. Report on the Geology of Otamangakau upper dam site". NZ Geological Survey, Wellington, pp8.

Prebble, W.M. (1969a). "Tongariro Power Development. Engineering Geology of the Te Whaiau dam site. A report on the geological investigations". NZ Geological Survey, Wellington, pp10 + annex.

Prebble, W.M. (1969b). "Foundation and geothermal problems at Tokaanu power station, Tongariro power development". *Abstracts. Geological Society of New Zealand Conference*, Dunedin, 1969.

Prebble, W.M. and Dow, J.A.S. (1969). "Tongariro Power Development. Otamangakau Dam Foundation Excavations Geological Log". NZ Geological Survey, TPD. Plan.

Prebble, W.M. (1977). "Engineering geological investigations for tunnel location and design". *Proceedings of the Symposium on Tunnelling in New Zealand*. NZ Geomechanics Society. NZ Institution of Engineers. Proceedings of Technical Groups, Vol. 3, Issue 3(G), pp2.1-2.11.

Prebble, W.M. (1986). "Geotechnical Problems in the Taupo Volcanic Zone". In: *Volcanic Hazards Assessment in New Zealand*. Ed: Gregory, J.G. and Watters, W.A., New Zealand Geological Survey Record 10, pp65-80.

Prebble, W.M. (1990). "Manukau Sanitary Landfill. Report on the Geology of the site north of Caldwells and Sandstone Roads, near Whitford". Auckland UniServices Limited. Map to accompany report.

Prebble, W.M. (1995a). "Landslides in New Zealand". Keynote paper. Proceedings of the Sixth International Symposium on Landslides. In: *Landslides: Glissements de Terrain*, Ed: Bell, D.H., Balkema, Rotterdam, Vol.3, pp2101-2123.

Prebble, W.M. (1995b) "Landslides in tabular rock masses of an active convergent margin". Proceedings of the Sixth International Symposium on Landslides. In: *Landslides: Glissements de Terrain*, Ed: Bell, D.H., Balkema, Rotterdam, Vol. 3, pp2145-2151.

Prebble, W.M. (1996) "Identification and analysis of landslides in an area of steep land and complex geology". The New Zealand Geomechanics Society. Proceedings of the Symposium on "Geotechnical Issues in Land Development". *IPENZ Proceedings of Technical Groups*, Vol. 22, Issue 1(G), pp74-86.

Prebble, W.M. (1999). "Geomorphology and Photogeology". Manukau Sanitary landfill. Site north of Caldwells and Sandstone Roads, near Whitford, Auckland. Updated version of Map originally produced for 1990 report and again in 1993. Auckland UniServices Ltd and Beca Carter Hollings and Ferner Ltd. Map sheet.

Schuster, R.L. (1983). "Engineering Aspects of the 1980 Mt St Helens eruption". *Bulletin of the Association of Engineering Geologists*, 20(2), pp125-143.

Stout, M.L. (1977). "Utiku Landslide, North Island, New Zealand". *Geological Society of America Reviews in Engineering Geology*, III, pp171-184.

Thompson, R.C. (1981). "Landsliding in Cenozoic soft rocks of the Taihape-Mangaweka area, North Island, New Zealand". *Bulletin de Liaison de laboratoire des Ponts et Chaussees. Special X*, pp 93-100. Proceedings of the 26th International geological Congress, Paris, 1980.

Wan Tienfeng and Hedenquist, J.W. (1981). "The structural characteristics of the Taupo Volcanic Zone and the Broadlands geothermal field, New Zealand". Geothermal Institute, University of Auckland, Report 80.023.

Williams, A.L. and Prebble, W.M. (1998). "Auckland Engineering Lifelines Project: Seismic hazard assessment". Proceedings of the Eighth International Congress of the International Association for Engineering Geology and the Environment. In: *Engineering Geology. A Global View from the Pacific Rim*, Eds; Moore, D.P. and Hungr, O., Balkema, Rotterdam, Vol. 2, pp809-815.

Wylie, C.A. (1989). "Engineering Geology of a Soft, Weak Rock Tunnel: ARA Redoubt Road No. 2 Inlet Tunnel." MSc thesis in Geology, The University of Auckland.

Weathering Profiles and Characteristics of Waitemata Rocks in Auckland Region

Tara Adhikary, Sinclair Knight Merz, Auckland

Abstract

The weathering profiles of core samples from a number of boreholes in the East Coast Bays Formation (ECBF) of the Miocene Waitemata Group have been studied. Two major types of weathering profile have been identified in the ECBF that can be described as a gradual and an abrupt transition. A change of physical properties and strength characteristics with the degree of weathering has been established. Standard penetration tests (SPT's) indicate a progressive increase in blow counts with depth in the gradual weathering spectrum and significant jump in the abrupt transition type. The laboratory tests conducted in the core samples from the various weathering grades include uniaxial compressive strength tests, point load tests and moisture content. The results indicate that the weathering leads to a weakening of the materials with increased moisture content. A tentative correlation of relative strength and penetration resistance with the grades of weathering is presented. An approach to delineate weathering profiles in the Waitemata sediments has been described.

Introduction

Materials derived from residual and complete weathering of sandstones and mudstones cause problems in the design and construction of heavy engineering structures. The properties of these materials are often misinterpreted. The underlying extremely weak to very weak weathered sandstones and mudstones have variable thickness and geotechnical properties. These materials have frequently been the subject of detailed research and consideration, but findings and conclusions are rarely published.

The flysch sequence of the East Coast Bays Formation generally shows a sharp transition from the weathered rock to the residual soil/completely weathered rock. The classification of the weathered material between the soil and the unweathered rock is not easy and is not often undertaken in general geotechnical studies. This paper examines the types of weathering profiles and their characteristics, based on geotechnical considerations, and describes an approach to delineate the different grades of weathering.

Geology

Les Kermode (1992) describes the geology of the Auckland Region. Miocene Waitemata Group was deposited in a marine Waitemata basin between the two volcanic arcs. The older, mainly submarine arc lay to the west of the present day western coast of Northland, to as far north as Hokianga. The other younger arc, probably more terrestrial, was situated along the line of Coromandel Peninsula and Great Barrier Island. The deepening marine basin extending about 80km both north and south of the Auckland region slowly filled in with a 2km thick succession of sediments derived from the neighbouring lands during the early Miocene (24-15 million years ago). A part of the Miocene Waitemata Group comprises the flysch sequence (alternating sandstone and mudstone) of East Coast Bays Formation, which forms the rolling hill country of the Auckland region and is also exposed on sea coasts. More resistant and strong isolated beds and lenses of the Parnell Grit member are encountered within the flysch sequence. These beds were formed by the debris flows from mass movements of volcanic derived sediments.

Earlier Work

Taylor and Spears (1970), Cripps and Taylor (1981) and Hawkins and Pinches (1992) have studied the influence of weathering on mudrocks. Pender (1971) has shown that void ratio was a useful parameter for categorising the weathered Wellington greywacke. Raisbeck (1973) studied the strength parameters for weathered Wellington greywacke and defined five zones of weathering by the moisture content of the saturated and near-saturated sample. Beavis et al (1982) stated that in pelitic rocks, fabric changes are not so apparent but solution and fracturing have resulted in increased porosity and as a consequence, a reduction in strength. Beavis (1985) and Leung and Radhakrishnan (1990) studied the index properties of common sedimentary rocks like shale, sandstone, limestone and dolomite. Dobereiner and De Freitas (1986) defined weak sandstones as having a saturated uniaixal compressive strength of 0.5 to 20MPa. They consider that a saturated unconfined compressive strength of 0.5MPa lies close to the boundary that separates materials from soil to rock behaviour. Wesley (1988) described three types of weathering profile for residual materials of Miocene Waitemata Group in the Auckland area. They are a) gradual weathering profile b) sharp transition from rock to soil and c) stratified nature of parent rock reflected in soil profile.

Weathering Grade Characteristics and Classification

The grades of weathering are generally identified by visual characteristics, soil or rock like behaviour of the material and its relative strength. The visual characteristics of weathering include discolouration, staining, mineral alteration, textural and fabric changes. Relative strength is assessed qualitatively by nail, knife and geological hammer and quantitatively by unconfined compressive strength tests and point load strength index tests. Behaviour of the material is tested by immersing a sample in water and manually checking the grain bonds.

On the basis of the terms and symbols suggested by IAEG (1981), the following classification system can be applied to the rocks of East Coast Bays Formation:

Grade	Classification	Abbreviation
I	Fresh (Unweathered)	UW
II	Slightly Weathered	SW
III	Moderately Weathered	MW
IV	Highly Weathered	HW
V	Completely Weathered	CW
VI	Residual Weathered (Residual Soil)	RW

Recognition of Weathered Material in ECBF Core Samples

The core samples recovered from approximately 50 machine drilled boreholes undertaken for projects such as the Central Motorway Junction, the Auckland University Engineering School building in central Auckland and Wastewater Improvement Projects of North Shore were studied and the weathered material classified based on visual characteristics, relative strength and rock/soil-like behaviour of the material. The following discussions present the findings.

Discolouration and staining is apparent in the upper part of the weathering spectrum. Orange brown to red brown colouration is normally characteristic of the residual material.

Discolouration is not markedly observed in the less weathered zones where the sandstones are light coloured, varying mainly from grey to medium grey, occasionally green grey, and the mudstones are grey to medium grey, occasionally dark grey. The colour difference between the weathered material below the residual soil/completely weathered rock and unweathered rock is not readily discernible.

Occasionally, brown and orange brown colouration is observed on and around the discontinuity surfaces. Discontinuities in the upper and middle part of the weathering spectrum are less pronounced than in the lower unweathered material.

Texture and fabric changes were found applicable to classify the soil derived from residual and complete weathering. The Residual Soil exhibited homogenous structure and the absence of any original laminated to bedded structure. The Residual Soil was generally found to be cohesive. However, the soil derived from complete weathering retained the original laminations or stratification of differing lithologies giving rise to alternating sand/silt/clay layers.

The disintegration capacity of the material due to its soil like behaviour and weak grain bonds has also been used to grade the weathering profile. This method was successfully applied to the material of the upper part of the weathering spectrum by qualitatively assessing the rate of disintegration when immersed in water. The rate of disintegration decreased in the lower part of the weathering profile.

Relative strength was assessed qualitatively by nail, knife and geological hammer in the weathered rock material. Extremely weak rocks that could be indented by thumbnail and scratched by pocketknife were encountered immediately below the residual soil/completely weathered rock. Very weak (peeled by a pocket knife) to weak rocks (scratched by a pocket knife) were encountered in the lower part of the weathering profile. The unweathered rocks could be scratched by a pocketknife, but occasionally required a single firm blow of a geological hammer to fracture.

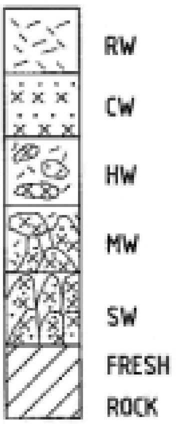


Figure 1 Gradual Weathering Profile

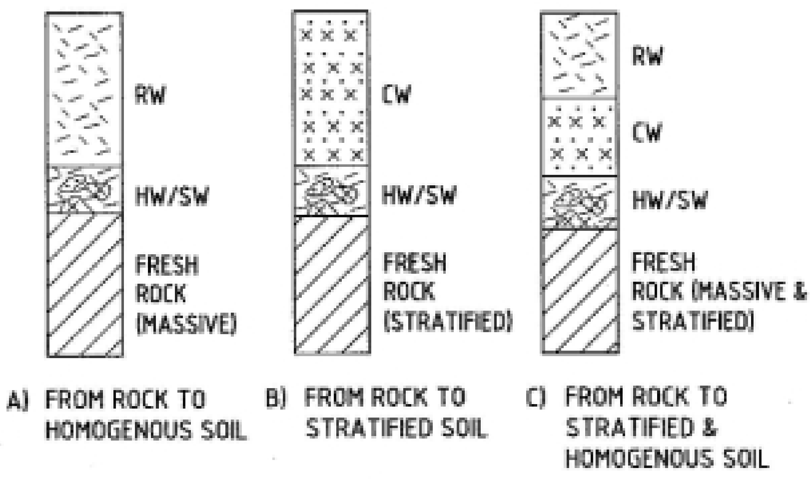


Figure 2 Abrupt Transition Type Weathering Profile

Weathering Grade	Material				Remarks
	Clay, Silty Clay, Clayey Silt, Sandy Silt	**Sand, Silty Sand**	**Sandstone**	**Mudstone**	
VI **RW**	Light brown, orange brown, iron staining, grey with orange brown streaks and mottles, cohesive	Grey, medium grey, occasionally grey with orange brown streaks and mottles			Fabric of the original rock not retained; generally cohesive, homogenous structureless soil of variable thickness; alternating layers of cohesive soil derived from stratified rocks
V **CW**	Pale grey, grey, medium grey, generally cohesive, bedded or laminated	Grey, medium grey, generally cohesionless, bedded or laminated			Fabric of original rock retained; alternating layers of cohesive and cohesionless soils derived from stratified rocks
IV **HW**		Grey, medium grey, generally cohesionless, bedded	Grey, medium grey, occasionally iron stained, fine to medium grained, occasionally coarse grained and gritty, bedded	Pale to medium grey, occasionally iron stained, bedded, occasional organic laminations	Interbeds or intermixing of soil and rock materials or corestones of rock materials in soil materials or soil like behaviour of sandstone/mudstone
III **MW**			Grey, medium grey, occasional staining on joint surfaces, bedded fine to medium grained occasionally coarse grained, gritty and calcareous cemented	Grey, medium grey, homogenous, occasional staining on joint surfaces, bedded, occasional organic laminations	Minor to no soil materials
II **SW**			Grey, medium grey, occasional staining on joint surfaces, fine to medium grained occasionally coarse grained, gritty and calcareous cemented	Grey, medium grey, occasional staining on joint surfaces, homogenous, bedded, occasional organic laminations	Minor to no staining on joint surfaces
I **UW**			Grey, medium grey, green grey, no staining, fine to medium grained, occasionally coarse grained, gritty and calcareous cemented	Grey, medium grey, dark grey, no staining, homogenous, bedded, occasional organic laminations	

Table 1 Visual Characteristics (Colour, Staining, Texture, Fabric)

The Weathering Profile of ECBF

The visual assessment of the core samples in this study confirmed the characteristic weathering profiles of the ECBF identified by Wesley:

1) Gradual
2) Abrupt (sharp transition)

The third weathering profile identified by Wesley is considered to be a feature of the abrupt transition weathering profile and is discussed as its variation.

The Gradual weathering profile shows every grade of weathering from residual soil to unweathered rock. The total thickness of this weathering profile is generally from 5m to 15m. In the core studied the soil derived from residual and complete weathering of the ECBF ranged between 2m and 5m. Figure 1 shows

diagrammatically this typical weathering profile.

In the core studied it was apparent that the Abrupt (sharp transition) weathering profile from rock to soil was predominant. The thickness of the Abrupt weathering profile is much less than the Gradual profile and ranges from 3m to 6m. However, one example of core classified as having an Abrupt weathering profile showed a maximum thickness of 11.5m with 10m of stratified soil. The thickness of the relatively thin transition zone of the weathered material between the soil and the rock was variable from 1m to 4m. However, within this characteristic profile there are three distinct variations or weathering profile sub-groups. The variation is expressed in the transition from rock to:

a) Homogenous soil
b) Stratified soil and
c) Stratified and homogenous soil.

Figure 2 shows diagrammatically the three variations or sub-groups of the Abrupt weathering profile.

The homogenous soil is derived from the residual weathering of the thick bedded to massive parent rocks. The fabric of the original rock is not retained.

The stratified nature of the parent rock (the original fabric) is exhibited in the stratified soil, which is the result of both the residual and the complete weathering of alternating sandstones and mudstones.

Delineating grades of weathering in the transition zone of an Abrupt profile by visual inspection alone is difficult. The assessment of cores for this study identified extremely weak or very weak rocks, major or minor soil materials, and some to minor staining in the transition zone.

Based on the results of this study the visual characteristics and the relative strength of the ECBF have been described for each weathering grade and summarised in Tables 1 and 2.

Physical Correlations of Weathering Profile

Based on the test data from the investigations used in this study a number of general correlations have been established to assist in the characterisation of material properties in the weathering profile of the ECBF.

Standard Penetration Test

As expected the SPT N values increase with depth in Gradual weathering profile and show a marked increase in blow counts in the Abrupt transition profile. A range of characteristic SPT N values for each weathering grade has been summarised in Table 3.

Unconfined Compressive Strength, Point Load and Moisture Content

Establishing correlations with laboratory testing data is somewhat more difficult due to the amount of data available for inclusion in the assessment and the variable nature of the material. However, the following correlations have been postulated.

The estimated unconfined compressive strength derived from the point load index tests in this study were found to be lower than those obtained directly from UCS tests. However, the Point Load Tests do indicate an increase in strength index with depth and grade of weathering. It appears that Point Load Tests do not represent a reliable method to determine unconfined compressive strength of the flysch sequence of ECBF.

Table 2 Consistency/Density/Relative Strength

Weathering Grade	Material				Remarks
	Clay, Silty Clay, Clayey Silt, Sandy Silt	Sand, Silty Sand, Interbedded Silt and Sand	Sandstone	Mudstone	
VI RW	Soft to stiff	Very loose to medium dense	–	–	
V CW	Firm to stiff	Loose to dense	–	–	
IV HW	–	Medium dense to dense	Extremely weak	Extremely weak	
III MW	–	–	Extremely weak to very weak	Extremely weak to very weak	
II SW	–	–	Very weak	Very weak	Occasionally extremely weak
I UW	–	–	Very weak to weak	Very weak to weak	Occasionally moderately strong

Notes: Extremely weak: can be indented by thumbnail and scratched by pocketknife
Very weak: can be peeled by a pocketknife
Weak: can be scratched by a pocketknife
Moderately strong: can be fractured with single firm blow of geological hammer

Table 3 Standard Penetration Test Values

Weathering Grade		Material					General Range (No. of blows per 300mm penetration or penetration for 50 blows)
		Clay, Silty Clay, Clayey Silt, Sandy Silt	Sand, Silty Sand, Interbedded Silt and Sand	Sandstone	Mudstone	Interbedded Sandstone and Mudstone	
VI	RW	3 – 11	–	–	–	–	3 – 11
V	CW	4 – 19	4 – 20	–	–	–	4 – 20
IV	HW	–	–	10 – 40	19 – 50	13 – 50	10 – 50
III	MW	–	–	40 – 100	50 – 100	40 – 100	40 – 100
II	SW	–	–	75 – 50 blows/100mm	75 – 50 blows/100mm	75 – 50 blows/100mm	75 – 50 blows/100mm
I	UW	–	–	100 to refusal	100 to refusal	100 to refusal	100 to refusal

Note: The SPT N values indicate number of blows per 300mm penetration.

Results of Study and Discussion

Visual inspection provides a preliminary assessment of the types of the weathering profile and grades of weathering of the ECBF. Intensive weathering results in the Gradual weathering profile with structureless cohesive residual soil near the surface. Such weathering profiles are observed in the ridges and spurs.

Less intensive weathering results in an Abrupt weathering profile with relatively thin transition. Here the stratified nature of sandstones and mudstones is also reflected in the soil material. In the Abrupt weathering profile, the transition zone between the soil and the rock comprises either highly or slightly weathered material. Abrupt weathering profiles can be observed in the valleys, hill slopes, and are also developed in the formations overlain by Pleistocene Alluvium and tuff.

Difficulty arises in delineating the weathering grades when the visual characteristics do not lend support and the relative strength changes sharply. It should also be noted that the occasional occurrence of extremely weak soil like material in the lower part of the weathering spectrum could complicate the assessment. Whilst weathering has played a significant role in weakening the grain bonds of the rock material, some weak soil like material in the lower part of the weathering profile indicates some sandy sediments have not been greatly affected by the agents of digenesis.

The grades of weathering identified from visual characteristics and relative strength can be supplemented with Standard Penetration Test (SPT), moisture content, unconfined compressive strength (UCS) and point load index test values. The minimum and the maximum values together with the common range have been identified in different weathering grades and materials. These values increase with the decrease in the grade of weathering from the ground surface to depth.

It can be concluded that the combined approach of field and laboratory test results can be used to delineate the weathering profile in the ECBF of the Waitemata Series Rocks in the Auckland Region.

Conclusions

1) The East Coast Bays Formation shows two major types of weathering profiles: a Gradual and an Abrupt

Table 4 Unconfined Compressive Strength (UCS), MPa

Weathering Grade	Material				Remarks
	Clay, Silty Clay, Clayey Silt, Sandy Silt	Sand, Silty Sand, Interbedded Silt and Sand	Sandstone	Mudstone	
RW	0.06 – 0.075	–	–	–	6 test results, one showed 0.25
CW	0.07 – 0.25	0.015 – 0.16	–	–	20 test results, one showed 0.475 (clayey silt)
HW	–	0.06 – 0.25	0.17 – 0.55	0.15 – 0.6	7 test results
MW	–	–	0.55 – 2.0	0.6 – 1.6	14 test results
SW	–	–	0.9 – 3.4	1.0 – 3.2	14 test results
UW	–	–	2.2 – 4.6	3.0 – 16.0	7 test results

Table 5 Point Load Strength Index, (MPa)

Weathering Grade	Material				Remarks
	Sandstone		Mudstone		
	I_s, 50	Q_u[1]	I_s, 50	Q_u[1]	
RW	–	–	–	–	
CW	–	–	–	–	
HW	0.02 – 0.03	0.39 – 0.77	0.01 – 0.03	0.29 – 0.67	6 tests
MW	0.03 – 0.05	0.73 – 1.16	0.03 – 0.07	0.67 – 1.7	10 tests
SW	0.05 – 0.11	1.2 – 2.7	0.04 – 0.23	0.9 – 5.6	13 tests
UW	0.08 – 0.2	1.87 – 4.9	0.04 – 0.23	1.0 – 5.7	16 tests; Q_u occasionally between 9.0 – 24.0 (sandstone)

Table 6 Moisture Content, %

Weathering Grade	Material				General Range
	Clay, Silty Clay, Clayey Silt, Sandy Silt	Sand, Silty Sand, Interbedded Silt and Sand	Sandstone	Mudstone	
RW	28 – 50	–	–	–	28 – 50
CW	28 – 45	26 – 45	–	–	26 – 45
HW	–	–	26 – 29	25 – 32	25 – 32
MW	–	–	21 – 29	23 – 27	21 – 29
SW	–	–	19 – 28	16 – 26	16 – 28
UW	–	–	11 – 25	15 – 26	11 – 26

transition from rock to soil. There are three variations of the dominant Abrupt weathering profile, and these can be described as a relatively thin transition from rock to either a) a homogenous soil, or b) stratified soil, or c) stratified soil and homogenous soil.

2) There is a general tendency for a decrease with depth in staining, textural and fabric changes in the weathering profile.
3) The relative strength of the material and penetration resistance generally increases with a decrease in the intensity of weathering.
4) Correlations have been observed between the grades of weathering and some relevant technical properties of the rocks such as uniaxial compressive strength and point load strength index.
5) Moisture content appears to be a good indicator of weathering. It increases with the increase of weathering grade.

Acknowledgments

The author would like to thank Mr Grant Murray for providing valuable suggestions and to Mr Romy Rodriguez for his assistance analysing laboratory test results. Thanks are due to Sinclair Knight Merz for permission to publish this paper.

References

Dobereiner L. and De Freitas M.H. (1986). “Geotechnical properties of weak sandstones”. *Geotechnique*, 36, No. 1, 79-94.

Gupta, A.S., Rao, K.S. (1998). “Index properties of weathered rocks: inter-relationships and applicability”. *Bulletin of Engineering Geology & the Environment*, Springer Verlag 57, 161-172.

Gupta, A.S., Rao, K.S. (2000). “Weathering effects on the strength and deformational behaviour of crystalline rocks under uniaxial compression”. *Engineering Geology*, Elsevier 56, 257-274.

Kermode, L. (1992). *Geology of the Auckland Urban Area*. Institute of Geological and Nuclear Sciences, 7-19.

Pender, M.J. (1971). “Some properties of weathered greywacke”. *Proceedings First Australia – NZ Conference on Geomechanics*, Melbourne, 423-429.

Pender, M.J. (1996). “Aspects of the geotechnical behaviour of some NZ materials”. *NZ Geomechanics News*, No. 52, Dec 1996, 37-55.

Raisbeck, D. (1973). “Strength parameters for weathered sandstone”. *New Zealand Engineering*, 28 (9), 254-260.

Wesley, L.D. (1988). “Engineering classification of residual soils”. *Proceedings 2nd International Conference on Geomechanics in Tropical Soils*, Singapore, vol 1, 77-84.

COMPANY PROFILES

Geotech Consulting Ltd, Christchurch

Geotech Consulting Ltd is a specialist geological and geotechnical consultancy based in Christchurch. The company is owned and run by three principals (Mark Yetton, Nick Traylen and Ian McCahon) and from time to time employs various contract staff.

Dr Mark Yetton originally formed the company in 1992. Initially Mark's geological work centred on stability and erosion issues on Banks Peninsula, but work on hydroelectric schemes in Westland sparked an interest in the seismology of that region. In 1995 Mark started research work on the paleoseismology of the central Alpine Fault. The results of this work have provided valuable information to insurers, territorial authorities and various infrastructure providers, and have formed the basis of a PhD that Mark completed last year.

In 1998 Nick Traylen joined the company after spending 6 years in Hong Kong working on a range of large-scale infrastructure and building projects. Nick currently works on a wide variety of geotechnical engineering projects, including foundation investigations, retaining design, seismic hazard work and land stability issues. In 1999 Ian McCahon joined Mark and Nick. Ian's presence has increased the geotechnical engineering capacity of the company and also brings with it Ian's specialist skills in hydro, irrigation and waterway engineering.

Geotech Consulting enjoy the range of work they are commissioned to undertake along with the scale and freedom offered by their flexible company structure.

Geotech Consulting Ltd
RD 1 Charteris Bay
Lyttelton Rural Delivery
Phone/fax: 03 3294 044
Email: myetton@geotech.co.nz
Contact: Mark Yetton

Beca Carter Hollings & Ferner Ltd

The geotechnical group at Beca is part of our significant civil engineering resource. Like the company in general, the geotechnical group has grown over the years. The group now has over 30 experts based in Auckland, Wellington, Christchurch and Tauranga, for national and international projects alike.

Beca's geotechnical team provides a comprehensive range of geotechnical, geological and hydrogeological services, and has an IANZ registered in-house soil testing laboratory. From tunnels to bridges, roads to airports, and reclamations to dams, you name it, we'll tackle it.

And we have. The design of an earthfill dam for a mining site in Sulawesi, Indonesia, combined the challenges of construction in tropical soils with the difficulties of working in a remote area of jungle. The design of the new Manukau Wastewater Treatment Plant with tanks, bunds and reclamations constructed over soft marine deposits and peat, was a very different but equally challenging feat of engineering. And of course, the international award winning design of the Otira Viaduct in Arthur's Pass tested the geotechnical team. The foundations for the bridge included large diameter bored piles in an area with high ground water levels and a high risk of rock fall.

Our geotechnical team thrives on teamwork and focused leadership. An emphasis on the fundamentals of soil mechanics and geology is backed up by strong international associations. We take pride in solving complex geotechnical and geological problems and strive to raise the profile of our profession as we provide solutions to engineering challenges.

Beca Carter Hollings & Ferner Ltd
P O Box 6345
Auckland
Phone: 09 300 9000
Fax: 09 300 9300
Email: jmarsh@beca.co.nz
Contact: John Marsh

MEMBER PROFILES

Vicki Moon

Occupation

Lecturer, Department of Earth Sciences, The University of Waikato

Career Path

Eager, even in the '70s, to flee Auckland and the dreaded daily trip across the bridge I migrated south to the University of Waikato for a BSc degree. Quite accidentally, I enrolled in Earth Sciences as an extra subject to fill up my 1st year programme. I got hooked, and haven't really escaped for any extensive period since. I completed an MSc(Hons) in Earth Sciences, then decided to participate in the 'real world'. I was employed as an engineering geologist with a local authority for 12 months, which I enjoyed, but I missed the intellectual challenge of university. Inevitably, I scurried back to an academic life, and completed a PhD in Earth Sciences, whilst also learning to teach as a Junior Lecturer.

My PhD research concentrated on deriving a basic set of geotechnical data on the ignimbrites of the Central North Island, and interpreting these data in terms of the genesis of the materials, and patterns of landscape development. This sparked my long-term research interest into the nature of soft rocks, in particular attempting to put the observed geotechnical properties into the context of the nature of the materials and their formation. In the Waikato we are surrounded on all sides by soft rocks – ignimbrites and mudrocks of the Central North Island, highly weathered greywackes in the ranges, hydrothermally altered rocks of the Coromandel, and the Waitemata Group flysch. This has coloured both my research interests and the emphasis I put on soft rocks and engineering soils in my teaching.

Typical Work Week

In an academic environment the year is clearly subdivided into two blocks: those weeks when the undergraduate students are around, and those when they are not. Most of the year fits into the first category, and this period is devoted to teaching. Apart from the fixed time commitment of running timetabled lectures and laboratories, the only real guarantee is that whatever is planned for the day won't occur. Preparation and assessment is fitted around responding to students' questions. My teaching philosophy is that we can put across basic concepts in lectures quite easily, but the real learning comes from being challenged to think, solve problems, and develop skills for innovation. For this reason I rely heavily on field and laboratory projects which not only teach the basic procedures, but encourage students to develop the skills to think on their feet, and integrate their learning. Much teaching time is thus spent helping individuals or small groups of students. For the summer period, the focus is on research. The nuts and bolts research is undertaken by students, but I get to spend some time in the field with them. Summer is also the time when the previous year's students complete their theses, so many days are spent correcting thesis drafts. At this stage the research comes together, and helping to draw the ideas together and develop interpretive skills in the students makes this my favourite time of year, especially as the students reach the stage of challenging and extending my own knowledge of their research area.

Highs and Lows

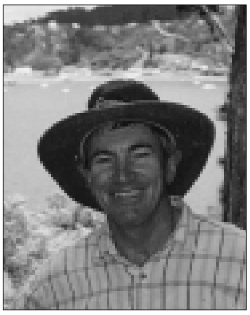
Teaching definitely fits into both categories. Most students coming to university have never heard of engineering geology: to have such an impact on their lives that they launch themselves into a career as an engineering geologist is wonderfully rewarding, and to hear from former students 5 – 10 years down the track who are still enjoying their work suggests that all is not wasted. Even those who do not go on in engineering geology – to develop an understanding of the way the Earth works and the impact of people on the environment in what is now a very large cohort of former students is very satisfying. Teaching is also a low point. The endless paperwork, the financial hassles the students encounter and the impact of these on their studies, and the small minority of students who are there solely to get a meal ticket, mean that there is inevitably a drudgery element involved. At the moment the good bits still outweigh the bad.

Ambitions

I'd like to see science and technology viewed positively in the community, losing the current negative stereotypes. My two oldest kids are showing an interest in careers in science – I don't want them put off by being told that there is no future in the field. Education at all levels is one key to this.

Advice

Follow your interests and enthusiasms. It is important to study in an area where there is employment, but if you don't like what you're studying, you won't enjoy the job.



Peter Riley

Occupation
Managing Director, Riley Consultants Ltd
Chairman, New Zealand Society on Large Dams
Part Time Farmer

Where it all Started
I grew up in Northland building dams in the creek, encouraging them to burst and then riding the flood wave downstream. I also watched landslides slither down the hills and observed the effects of soil erosion. These were very formative years! BE Civil seemed the right direction, and I joined Tauranga City Council for a year gaining wide experience in civil engineering and learning how to handle people.

Following the Water
A desire to work in Water Resources led me to Tasmania where I worked for the Hydroelectric Commission on feasibility studies from hydrology to diversion structures. I designed 2 dams and their spillways. Life as an energetic young man was a lot of fun, experiencing independence in another country, and exploring its wildernesses. I also played rugby for Tasmania (including a game against the All Blacks). To complete my experience I transferred to the construction division working on dams, tunnels, shafts, and realised how little engineers knew about rock, or the three dimensional geological world.

Checking the Rocks to Change Direction
A post graduate study year at Imperial College in London followed, gaining an MSc in Engineering Rock Mechanics and the DIC. The course covered soil mechanics, rock mechanics, engineering geology, hydrogeology, strength of materials and stress analysis. Courses by professors who subsequently wrote the text books put me 5 years ahead of current practice in soil and rock mechanics. Beca Carter Hollings & Ferner encouraged me to put this into practice and I stabilised landslides, reclaimed the Omaha sandspit close to the family farm, developed hydro resources, did feasibility studies on coal mines and a huge number of other satisfying projects.

Paddling my Own Canoe
In 1984 I took up white water kayaking. The adrenalin hit as the kayak accelerates toward a rapid is addictive; controlling a course in the river is a progressive and exciting experience, in risk management. That gave me a great feeling of independence. So much so that I set up my own consulting practice particularly in geotechnical engineering and water resources. Risk management now extended to financial survival! This major change in direction to managing my own business taught me and is still teaching me a great deal.

Achievements
The conception, design, construction and commissioning of Patea Dam was a highlight. To hold a project like that in my hands for 10 years was a once in a lifetime opportunity. Conceiving, designing, building and operating my own 10m millennium dam, using Riley Consultants expertise, is a personal monument. One of very few farm dams with a chimney drain!

Development of Riley Consultants Ltd into a multi-disciplinary practice with an open friendly atmosphere has been enormously satisfying. I get most satisfaction from solving projects with multiple constraints of topography, geology, hydrology, geotechnical, structural and civil engineering; and putting these together in the optimum manner, with a lot of help from my friends!

Advice
Enjoy your work. Put your skills where you derive the greatest satisfaction. Use humour and make your work a fun experience. Keep an open mind – everyone has something to contribute. For the Geotechnic: Be sure you understand the geology, and the failure mode. Base your solutions on these. Use computer calculations to fine tune your model.

Ambitions
To develop Riley Consultants into a major practice in earth and water sciences. Continue to enjoy what I do. Utilise my broad engineering knowledge in ever wider contexts, with a practical background.

LAURIE'S BRAIN TEASER (NO. 5)

Question

What has the quotation below got to do with geotechnical engineering? It is an extract from a longer essay.

"Our age is an age of restless production and of craving for tangible results. On every wall and on every printed page burns the slogan: Earn for the purpose of buying! Vast organisations serve no other purposes but to increase the desire for more merchandise. As a consequence the poor public is so thoroughly occupied with consuming that all its creative capacities are kept in a state of rudimentary development. Newspapers and Ford cars, radios and movies take up so much of the time of the majority of individuals that there is no more chance for the slow, organic growth required for developing well proportioned personalities. Life becomes a breathless race, the victims oscillating between stupid toil, and equally stupid, non-creative dissipation. Each one of the marvellous inventions which serve for systematically spoiling the mentality of the public once represented a sublime adventure in the mental life of an inventor. But the very moment it left the laboratory it turned from an asset into a liability. We are clever enough to invent, but short-sighted enough to fall victims of our very achievements. We excel in discovery and invention, but there is practically nobody engaged in turning our achievements into constructive assets. Compared with this alarming defect of our age, all the other social evils may appear as rather insignificant. We cannot detect in the conduct of the world's affairs any wisdom at work, guided by a deeper insight into the laws of organic development. Instead of wisdom we merely find clever economic considerations and a standardised conception of good and evil which approves or condemns regardless of circumstances and or motives." *(Very slightly edited)*

Answer to Brain Teaser No. 4 (June, 2001)

a) This depends on the number of sub-layers used – with a single layer the ultimate settlement is 652mm (with 4 sub-layers, respectively 0.5, 0.5, 1.0, 1.0m in thickness, the ultimate settlement is 738mm). For simplicity we will use the value from the single layer analysis.

b) At 3 months the time factor T = 0.44, giving a degree of consolidation U = 0.73 (from charts).

1) Using the first method we can write:
652mm = 0.73 × (Required ultimate settlement)
Therefore required ultimate settlement = 893mm
We can now calculate the required additional fill to give this settlement. If H_s is the required additional fill thickness we can write:

$$0.893 = 3\,\frac{0.8}{1+1.9}\log\left[\frac{20(2+H_s)+7.79}{7.79}\right]$$

(7.79 is the initial effective stress at the centre of the layer)

which gives H_s = 2.28m

2) Using the second method, we can calculate the remaining pore pressure at the centre of the layer at time 3 months and ensure this is zero when the thickness H_s is removed. The initial pore pressure when the fill is placed = $20(2 + H_s)$ kPa.
At 3 months u/u_i = 0.42 (from charts)
so that the pore pressure at three months = 0.42 ×$20(2 + H_s)$ kPa
The reduction in pore pressure when the surcharge fill is removed $\Delta u = 20H_s$ kPa
These must be equal which gives H_s = 1.45m

These values are clearly quite different. The reason is that two different formulations ('models') of soil compressibility are being used. The magnitude calculations use the log parameter C_c while the time rate calculations are based on the Terzaghi consolidation theory, which assumes a linear relationship between stress and strain. The two models are simply incompatible and lead to anomalies such as that in the above calculations. Despite this, we all mix the two 'models' routinely (mostly unaware of the fact), and don't seem to get into too much trouble.

EVENTS DIARY

2002

MARCH 13 – 16, 2002, Rotorua, NZ

5th ANZ Young Geotechnical Professionals Conference

Aims:

- To promote professional development of delegates
- Expand and strengthen the lines of communication between young geotechnical professionals
- Introduce young geotechnical professionals to the diversity of opportunities.

http://www.5thygp.com

MARCH 20 – 22, 2002, Singapore

3rd International Conference on Dam Engineering

Conference themes:

- State of the art in the design of small and large dams
- Arch dams, gravity dams, embankment dams, concrete dams
- Dam reliability and safety assessment
- Construction materials for dams
- Dam foundation and seepage
- Dam instrumentation and monitoring
- Dam maintenance and management systems
- Dam optimisation and expert system
- Rehabilitation of old dams and dam heightening
- Environmental aspects and legal issues
- Case histories and studies.

MAY 12 – 14, 2002, Naples, Italy
MAY 16 – 17, 2002, Sorrento, Italy

International Workshop

Occurrence and Mechanisms of Flows in Natural Slopes and Earth Fills(IW-FLOW2002)

Workshop topics:

- Debris flows
- Flow slides
- Earth flows
- Flows in residual soils
- Submarine flows
- Flows in sensitive clays.

http://www.unina2.it/flows2002

followed by:

International Conference

Fast Slope Movements, Prediction and Prevention for Risk Mitigation

Session topics:

- Risk assessment from theory to practice
- Risk mitigation
- Criteria for land management.

http://www.unina2.it/fsm2002

MAY 20 – 23, 2002, Isle of Wight, UK

International Conference on Instability – Planning and Management

Conference themes:

- Instability – planning and management
- Unstable land
- Hazard identification and risk assessment
- Handling information related to unstable land
- Instability – planning and the natural environment
- Coastal and climate change and instability
- Instability management – from policy to practice
- Mitigating the costs of instability.

http://www.coastalwight.gov.uk

JUNE 23 – 24, 2002, Prague, Czech Republic

1st European Conference on Landslides

Conference themes:

- Landslide causes, types, and mechanisms
- Landslides in the eastern Alps and western Carpathians regions
- Landslides and engineering structures, prevention and remediation works.

AUGUST 11 – 15, 2002, Rio De Janeiro, Brazil

4th International Congress on Environmental Geotechnics

Conference themes:

- Design and performance criteria
- Tailings and mine wastes
- Risk assessment
- Management of contaminated sites
- Remediation and related costs.

http://www.4iceg.ufrj.br

SEPTEMBER 16 – 20, 2002, Durban, South Africa

9th International IAEG Congress – Engineering Geology for Developing Countries

Conference themes:

- Engineering geology for developing countries
- Engineering geology mapping and soil testing
- Engineering geology and the environment
- Groundwater
- Case histories and new developments
- Construction materials
- Information technology applied to engineering geology
- Gondwana rocks and engineering geology.

http://stanfield.und.ac.za/Durban2002

NOVEMBER 14 – 20, 2002, Hong Kong

Natural Terrain – A Constraint to Development?

Organised by the Hong Kong Branch of the IMM

- The conference will cover the policies and technical issues behind natural terrain studies including environmental aspects and case studies.
- International keynote speakers are Professors Earl Brabb and Oldrich Hungr, with local keynote speakers from both the Government and private sector.
- Abstracts to be submitted by November 2001

Contact Louisa McAra
E-mail: louisam@atkins-china.com.hk
Tel: +852 2972 1821

NOVEMBER 17 – 20, 2002, Texas, USA

1st International Conference on Scour of Foundations

Conference themes:

- Scour of foundations
- Bridge scour
- Erosion of soils
- Dam scour
- Offshore platform scour
- Prediction of scour depth
- Pier scour
- General degradation and aggradation
- Countermeasure selection
- Scour monitoring.

Abstracts due: 30 September 2001
http://tti.tsmu.edu/conferences/scour

2004

FEBRUARY 9 – 11, 2004, Auckland, NZ

'To the eNZ of the earth'
9th ANZ Conference on Geomechanics

Topics Include:

- Slope instability
- Foundations
- Piles
- Anchors/reinforcement
- Dams
- Roading
- Environmental geotechnics
- Seismic engineering
- Rock mechanics
- Expansive soils
- Engineering geology
- Testing

Call for abstracts and papers: to be advised

NEW ZEALAND GEOTECHNICAL SOCIETY INC.

Management Committee Address List 2001

NAME	POSITION	ADDRESS, EMAIL	PHONE, FAX
Grocott, GG (Guy)*	Chairman	Golder Associates Ltd P O Box 2281 Christchurch ggrocott@golder.co.nz	03 377 5696 Work 03 377 9944 Fax 03 337 0553 Home
Fellows, DL (Debbie)	Management Secretary	6 Sylvan Valley Ave Titirangi Auckland dfellows@xtra.co.nz	09 817 7759 Home 09 817 7035 Fax
McPherson, ID (Ian)*	Treasurer, Wellington Branch Co-ordinator	Connell Wagner Ltd P O Box 1591 Wellington McPhersonI@conwag.com	04 472 9589 Work 04 472 9922 Fax
Crawford, SA (Steve)*	Stability Guidelines, ANZ Conference	Tonkin and Taylor P O Box 5271 Auckland Scrawford@tonkin.co.nz	09 355 6054 Work 09 307 0265 Fax
Berrill, J (John)*	Christchurch Branch Co-ordinator	Department of Civil Engineering University of Canterbury Private Bag 4800 Christchurch Berrill@civil.canterbury.ac.nz	03 3642 381 Work 03 3642 758 Fax
Bauld, C (Chris)	Auckland Branch Co-ordinator, Young Geotechnical's Representative	Tonkin and Taylor P O Box 5271 Wellesley St Auckland Cbauld@tonkin.co.nz	09 355 6000 Work 09 355 6059 Direct Dial 09 307 0265 Fax
Murray, JG (Grant)	Editor of *NZ Geomechanics News*, 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
Riddolls, BW (Bruce)	IAEG Australasian Vice President	Golder Associates Ltd P O Box 2281 Christchurch briddolls@golder.co.nz	03 377 5696 Work 03 377 9944 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
Henderson, J (John)	Dunedin Branch Co-ordinator	City Consultants P O Box 5045 Dunedin Jhenders@dcc.govt.nz	03 474 3834 Work 03 474 3551 Fax
Burton, P (Paul)	Bay of Plenty / Waikato Branch Co-ordinators	Geotechnics Ltd 64 Kaitemako Rd Welcome Bay Tauranga Pburton@tonkin.co.nz	07 571 0280 Office 021 610 067 Mobile 07 544 4910 Home
Mitchell, MT (Mark)		P O Box 9123 Hamilton mtm@geocon.co.nz	07 839 3251 Home 07 838 3119 Work 07 839 3125 Fax

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.
Studies 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.

Basic membership subscriptions (inclusive of GST)

which include the magazine, are:

Members	$73.10
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
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 – *Engineering and Development in Hazardous Terrain* Christchurch 2001	$50	$70
Proceedings of the New Zealand Geotechnical Society Symposium – *Roading Geotechnics 98* Auckland 1998	$40	$70
Proceedings of Technical Groups, Vol 22, Issue 1G *Geotechnical Issues in Land Development* Hamilton 1996	$20	$35
Proceedings of the Auckland Symposium - *Groundwater and Seepage* May 1990	$10	$45
Australia – New Zealand Conferences on Geomechanics:		
Proceedings of the 6th Australia – NZ Conference on Geomechanics Christchurch, February 1992	$50	$100
Proceedings of the 3rd Australia – NZ Conference on Geomechanics Wellington, May 1980	$10	$30
Other Publications:		
Proceedings of the 2nd Australia – NZ Young Geotechnical Professionals Conference, Auckland, December 1995	$25	$40
Shear Vane Guidelines	$15	$20
Guidelines for the Field Description of Soils and Rocks in Engineering Use	$10	$13
Stability of House Sites and Foundations – Advice to Prospective House and Section Owners	$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
6 Sylvan Valley Ave
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
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Full Page Internal	$225	185 wide x 265 high
Half Page Internal	$175	90 wide x 265 high
		185 wide x 130 high
Quarter Page Internal	$150	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. 3mm bleed
4. Advertiser to provide all flyers

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

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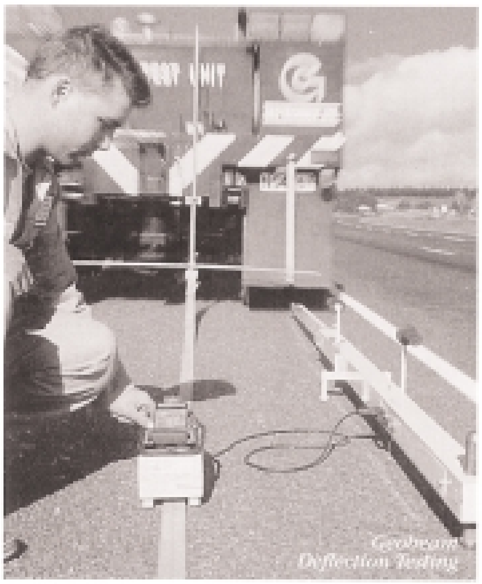

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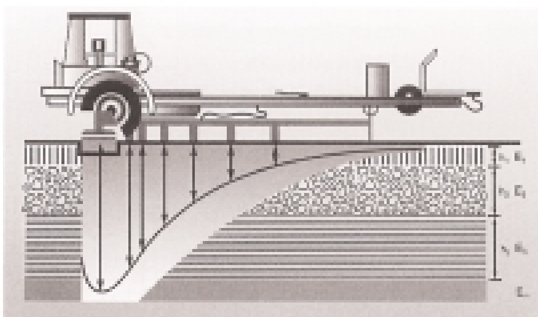

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