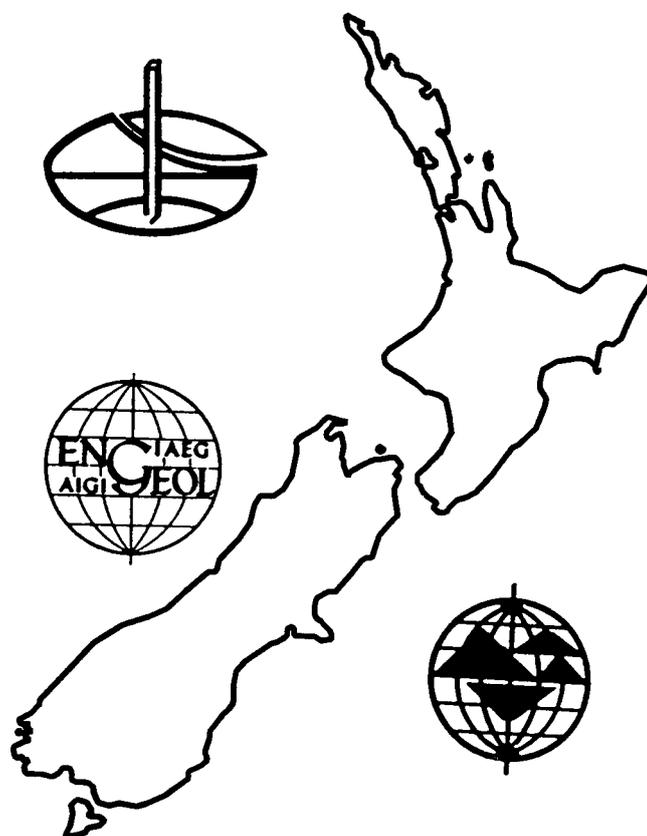


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N.Z. GEOMECHANICS NEWS

No. 51

JUNE 1996



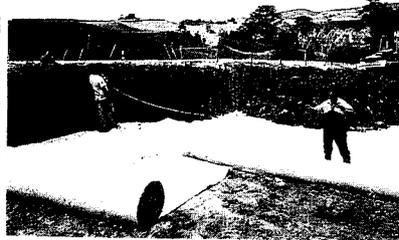
A NEWSLETTER OF THE N.Z. GEOTECHNICAL SOCIETY

INNOVATIVE SOLUTIONS

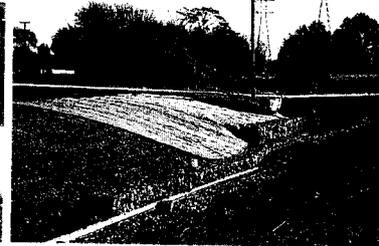
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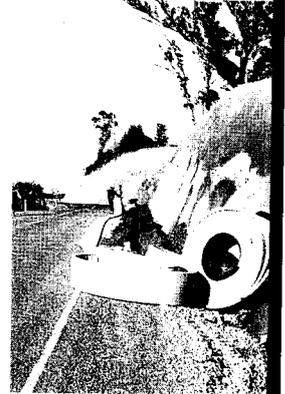
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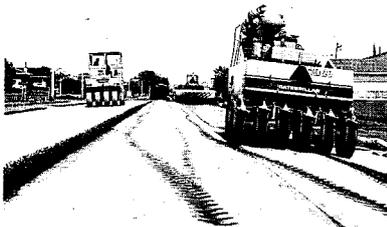
GABIONS & RENO MATTRESSES
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erosion & re-veg. biomat



MEGAFLO
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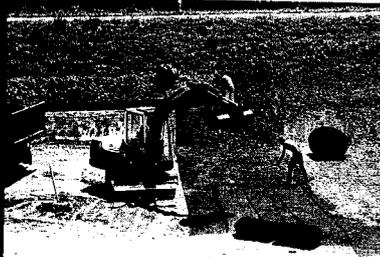
MACCAFERRI NEW ZEALAND



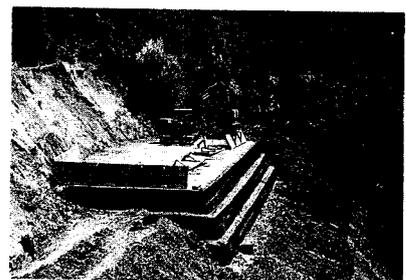
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NZ GEOMECHANICS NEWS

NO.51 JUNE 1996

A NEWSLETTER OF THE NZ GEOTECHNICAL SOCIETY

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EDITORIAL POLICY **NOTES FOR CONTRIBUTORS**

NZ Geomechanics News is a newsletter for which we seek contributions of any sort for future editions. The following comments are offered to assist 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 NZGS
 - 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 e-mail (to the editor) or on floppy disk. Diagrams and tables should be of size and quality 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 magazine 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.

Stephen Crawford
EDITOR

THIS IS A REGISTERED PUBLICATION

"*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. Authors must be consulted before papers are cited in other publications.

Persons interested in applying for **membership of the Society** are invited to complete the application form at the back of the newsletter. The basic subscription rates are given on the information pages at the rear of this issue. These rates are supplemented according to which of the international societies, (namely Soil Mechanics, Rock Mechanics or Engineering Geology) the member wishes to be affiliated. Members of the Society are required to affiliate to at least one International Society.

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PRACTICE COLLEGE

As we venture into the next half century (issue No.51), the most important issue needing resolution is the formation of a geotechnical practice college. This topic was raised at the recent NZGS Symposium at Hamilton and the motion to investigate the practice college was given very strong support. An article and associated papers presented at the Symposium are published here for the benefit of all NZGS members.

NINTH NZ GEOMECHANICS LECTURE

An outline of the Ninth NZ Geomechanics lecture is presented herein by Mick Pender. This is a prelude to the official presentation in Adelaide in July, at the 7th ANZ Conference. There will be a subsequent lecture tour of NZ by Mick to allow local branch members to hear the presentation for themselves.

ENVIRONMENTAL GEOTECHNICS

We welcome the submission of a technical paper on bio-remediation of contaminated soils and groundwater. This aspect of geotechnics is not widely practiced in NZ. Further submissions from geotechnical practitioners in the environmental field is encouraged.

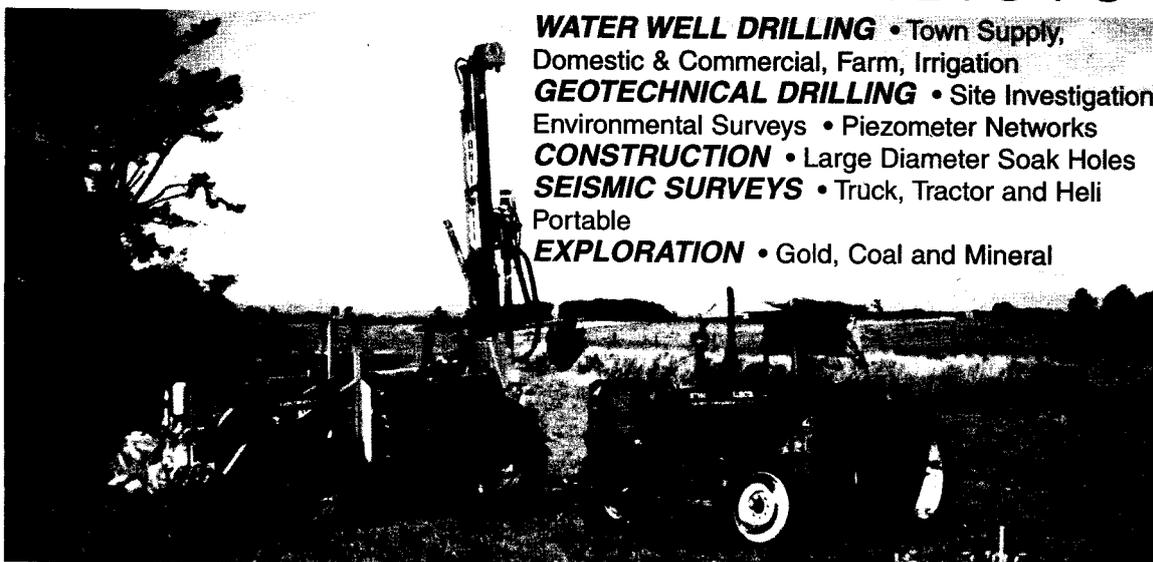
PROJECT NEWS

Many thanks to all those contributors on recent projects who supplied articles for the last issue of Geomechanics News. We would like to persevere with this section of the magazine as the feedback received was positive. If only we could get more articles. A single page (including photograph) only is required on recent developments anywhere in NZ. Articles preferably should be *ground breaking* but not necessarily state-of-the-art. Don't forget to include the company or organisation logo.

Steve Crawford
EDITOR

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WELCOME

Welcome to my first Chairman's corner. My first task is to thank David Bell on behalf of the Society. He has held the position of Chairman for three years, during which the Society has held two symposia, hosted a Young Geotechnical Professionals Conference, conducted a workshop on limit state design and supported two Australasian Vice Presidents. A difficult achievement to follow, thanks Dave for your work and enthusiasm.

NAME CHANGE

At the last AGM, held at the Hamilton Symposium, the Society changed its name to the "New Zealand Geotechnical Society" with the strong support of members present. The reasons for the name change were outlined in the December 1995 issue.

NATIONAL ACTIVITIES

As outlined in the opening paragraph, the Society has had a busy period since the last issue. The Second ANZ Young Geotechnical Professionals Conference was held Auckland at the end of last year. It was a great success with thirty participants (including eight Australians) thoroughly enjoying themselves through meeting other similar aged professionals and learning of their experiences. The Management Committee wishes to thank Maurice Fraser, Warwick Prebble and their team for the organising and running of the Conference.

In February, the Society held its 1996 Symposium which was titled "Geotechnical Issues in Land Development". Topics ranged from the Legal Planning Framework through to Development on Marginal Land and Accreditation of Geotechnical Engineers and Engineering Geologists. It was well attended with nearly 100 participants. The major issue arising from the Symposium was the need to investigate the accreditation of geotechnical professionals. This is further addressed below under Practice Colleges. On behalf of the committee, I wish to thank Tim Browne and his team for all their efforts in running a successful symposium.

On the horizon, we have the 7th ANZ Conference in Geomechanics which is being held in the first week of July in Adelaide. The theme for the conference is "Geomechanics in a Changing World". All members should have received a bulletin containing details on the conference and registration documentation. It is expected that some 150 papers will be presented at the Conference, divided into nine sessions.

IPENZ

Last week I attended a combined Board Members and Technical Group Secretaries meeting at IPENZ. The meeting comprised an update of the activities from the Technical Groups represented, an update on the Institution Plan and discussions with National Office staff.

Of particular note is a paper prepared by Tony Gibson and sent to all MP's on "Professional Engineering Philosophy and the Role of the Professional Engineer in Society as Highlighted by the Cave Creek Tragedy". Tony received strong support for his paper from a number of MP's.

The next IPENZ Conference is to be held in Wellington. The theme is "Engineering our Nations Future" and a call for papers is included in this issue.

PRACTICE COLLEGES

Following recent moves by IPENZ to introduce practice colleges, the Tauranga District Council's formalising of its accreditation process of geotechnical professionals and the overwhelming support of the practice college concept

by those attending the Hamilton symposium on the Sunday, the Society needs to carefully develop a position on the concept.

This is probably the single most critical issue facing the Society since its inception. Input of members will be essential if we are to secure the future of geotechnical engineering as a discipline. Our customers (in particular Local Authorities and private clients) are demanding some form of differentiation for geotechnical professionals and if we can't meet this requirement, we might find related professions taking over some of our traditional areas of work.

The route of the practice college is not clear cut and may be detrimental to the Geotechnical Society as it currently exists. A college is likely to have strict entry requirements and only a portion of Society members will be able to gain access. I therefore ask all members to consider the practice college concept, read John Blakeley's paper and provide feedback to members of the management committee for debate at the next management meeting.

ISSMFE AUSTRALASIAN VICE PRESIDENT NOMINATION

On a lighter note, it is the turn of the Society to nominate the Australasian Vice-President for the ISSMFE. Would members who would like to suggest possible candidates please forward these to the Secretary for consideration.

While it is a busy period for many in the Society, I hope to see a good number of members in Adelaide.

Colin Newton
NZGS CHAIRMAN

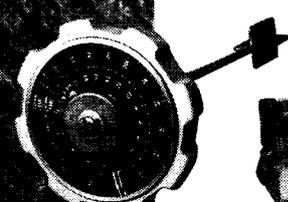
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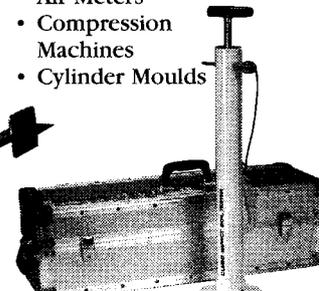
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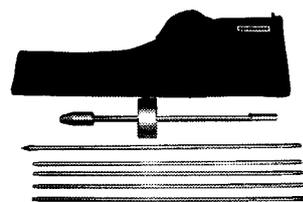
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REPORT FROM THE SECRETARY

NZGS MANAGEMENT

1. MEMBERSHIP

New members joining the Society since the last issue of Geomechanics News are :

M Fox	R Knowles	T Glade	S Croft	M Jayawardanl
P Clark	J Graham	W Gray	H Follas	T Gilbertson
D McNulty	G Higgins	M Flemming	J Meischke	A Milligan
P Fitchett	R Oliver	G Shaw	G Williams	M Burt

2. SOCIETY NAME CHANGE

The AGM held at the February symposium in Hamilton unanimously voted to change the society's name to the *New Zealand Geotechnical Society*.

3. PROMOTION OF NZGS MEMBERS

Don Taylor was awarded Life Membership of the Society in recognition of his contribution to the Society. The contributions of Chris Graham, Trevor Matuschka and Graeme Ramsey were recognised with their promotion to FIPENZ.

Nominations for the promotion of Tim Sinclair and Andy Olsen to FIPENZ were also made at the last NZGS Management Committee Meeting.

4. 1996 MANAGEMENT COMMITTEE

The number of nominations matched the number of places and no election was necessary. Your committee is :

Chairman	Colin Newton
Secretary	Geoffrey Farquhar
Treasurer, ISRM Vice Chairman	Dick Beetham
National Activities, Publications	Alexei Murashev
Editor - Geomechanics News	Steve Crawford
Assistant Editor-GN, Auckland Liaison	James Burr
IAEG Vice Chairman, Canterbury & Otago Liaison	Guy Grocott
ISSMFE Vice Chairman, Wellington Liaison	P Brabhaharan
Co-opted	Mick Pender
Co-opted (Hamilton Symposium)	Tim Browne
Ex officio	David Bell
IAEG Australasian Vice President	Warwick Prebble

5. MEMBERSHIP FEES

Subscriptions have been raised by \$5 for each class for 1996, keeping in line with the Society policy for subscriptions to fund operating expenses without running down our cash reserves. You will receive your 1996 subscription notices soon. Please note that you are being invoiced for only $\frac{3}{4}$ of a year as the IPENZ technical groups bring their subscription year into line with the IPENZ subscription year. The Society subscription year was formerly January to December, and now becomes October to September after the $\frac{3}{4}$ subscription year (January 1996 to September 1996).

Everyone is encouraged to sign the "Privacy Note" on your subscription form. This will enable us to re-publish the useful "Blue" Membership Information Handbook which lists members' names and addresses, Society rules, brief history of Society, details of awards and publications, Management Committee details etc.

It was brought to the attention of the Management Committee that outstanding fees over the past two years

REPORT FROM THE SECRETARY

NZGS MANAGEMENT

totalled \$3,063 including \$1,469 left unpaid for the 1995 year. Please check to see if you have paid your subscription and if necessary forward any payments to the Secretary as soon as possible. Note that unless a member resigns, the Society pays for their ongoing affiliation to the selected international societies (ISSMFE, ISRM and/or IAEG).

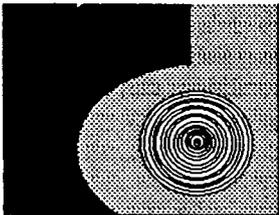
6. STABILITY GUIDELINES

A subcommittee is continuing to prepare the guidelines that were discussed at the Hamilton symposium. Please contact myself regarding contributions, details etc.

7. 1997 IPENZ CONFERENCE - WELLINGTON, 7-9 FEBRUARY - CALL FOR PAPERS

Papers are called for the Geotechnical Session at the conference. Further details regarding the conference are outlined later in this issue of Geomechanics News.

Geoffrey Farquhar
MANAGEMENT SECRETARY



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ISSMFE XIV TH INTERNATIONAL CONFERENCE, HAMBURG, Sept. 6-12, 1997

At least eight abstracts for papers have been received from Australasia. The region has been allocated 56 pages in the conference proceedings.

OTHER ISSMFE NEWS

The 3rd International Congress on Geotechnical Engineering is to be held in Portugal. The next venue for the 15th International Conference of ISSMFE is Turkey. Professor Harry Poulos is to be nominated for the position of ISSMFE President. This nomination is supported by the NZ Geomechanics Society Management. The vote for this position is to be held at the Hamburg meeting.

NAME CHANGE

The following motion was put forward at the ISSMFE Council Meeting on 10 December 1995 in Cairo:

"The name of the International Society for Soil Mechanics and Foundation Engineering is to be changed to the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) This name will become effective immediately following the closing session of the XIV ICSMFE to be held in Hamburg in 1997"

The New Zealand Geomechanics Society and the Australasian Region voted for the motion, with Mr Max Ervin appointed our proxy to vote at the Cairo meeting. The recommendation of the Board was to change to the International Society for Soil Mechanics and Geotechnical Engineering. This required no dissenting vote at the Cairo meeting, or two-thirds majority at two Council meetings.

The Cairo vote for the name change was unsuccessful. The motion will be put again at the Hamburg meeting.

COMMUNICATIONS TASK GROUP

Mr Max Ervin, the Australasian Vice-President, leads a Communication Task Group of ISSMFE and reports that he is working towards the setting up of a ISSMFE Information Retrieval System. He recently went to Sweden in April 1996 to meet with the SGI to further this aim. This is an important opportunity to provide a strong international database which will be as good on a local or regional level as local groups want to make it.

NEWS FROM THE AUSTRALIAN GEOMECHANICS SOCIETY

The Australian Geomechanics Society narrowly lost their bid to host the XV International Conference of the ISSMFE in 2001.

The AGS is bidding to host the 2000 Geo-engineering conference in Melbourne. This is to be a combined effort from ISSMFE, ISRM and IAEG. The feeling is that Australia stands a very good chance of success.

7TH AUSTRALIA-NEW ZEALAND CONFERENCE ON GEOMECHANICS

The above regional conference of ISSMFE will be held from 1-5 July 1996 in Adelaide. The Australian Geomechanics Society is organising the conference. Further details are presented later in this issue of *NZ Geomechanics News*.

NEXT ISSMFE BOARD MEETING

The next board meeting is to be held in Chile in October 1996. Max Ervin will be attending on behalf of the NZ Geotechnical Society (NZGS). If any members wish to have an input please make contact with the Secretary of the NZGS (G.B. Farquhar, C/o Fax No.: (09) 379 1210).

This report was sourced from recent correspondence with Max Ervin (ISSMFE Australasian Vice President) and the ISSMFE Newsletters - Editor).

REPORT FROM AUSTRALASIAN VICE PRESIDENT IAEG NZGS MANAGEMENT

1. THE AUSTRALIA-NEW ZEALAND CONFERENCE ON GEOMECHANICS "Geomechanics in a Changing World" Adelaide 1st - 5th July 1996.

This is an official regional conference of the International Association of Engineering Geologists (IAEG) and members are encouraged to attend. Flyers will have been received recently by all New Zealand Geotechnical Society (NZGS) members in the mail.

2. IGC BEIJING, CHINA, 4-14 AUGUST

This is an official IAEG event, at which our annual Council Meeting, Executive Committee meeting and assembly will be held. The sessions relevant to Engineering Geology are all arranged in the first week, August 5-9. IAEG members should have received a first circular several months ago.

In particular, I would welcome any comments or suggestions about IAEG matters generally, from members, before I travel to China to attend our committee meetings.

3. BYLAWS

Draft bylaws were sent to National Groups several weeks ago and should have been received by the NZGS. To some extent I had pre-empted our comment by consulting the Chairman, Secretary, Treasurer and IAEG committee members last year. Please make any further comment to me before the end of June. We will be discussing these in Beijing.

4. INTERNATIONAL SYMPOSIUM ON ENGINEERING GEOLOGY AND THE ENVIRONMENT

Organised by the President of IAEG, Prof. Paul Marinos and the Greek National Group, this will be the official IAEG Conference and is to be held on 23-27 June 1997 in Athens.

Themes to be explored in relation to engineering geology, will be:

- Geomorphological processes
- Natural and man-made hazards
- Regional planning and management
- Hydrogeology, waste disposal and environmental health
- Mines and quarries
- Protection of geologic and geographic heritage
- Legislation
- Education

This will be a fascinating conference with some excellent field trips.

5. PRIZES

The *Hans Cloos Medal* and *Richard Wolters Prize* are being voted on at present and will be decided at our next executive committee meeting in Beijing, in August.

6. GEO-ENGINEERING CONFERENCE, YEAR 2000

As an initiative to bring about closer cooperation between the international societies (IAEG, ISRM, ISSMFE). They are joining together to organise a geological engineering conference in the year 2000. Suggested themes are:

- underground works
- landslides
- environmental geotechnics

The Australian Geomechanics Society (AGS) has two groups which have offered to stage this conference. A bid from Australia will receive a fair amount of support, especially from the ISSMFE because they have narrowly missed out on ICSMFE's in the past. Australia is looking for IAEG and ISRM support also. Naturally, I am supportive.

Warwick Prebble
AUSTRALASIAN VICE PRESIDENT, IAEG

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1. MEMBERSHIP

With the four yearly International Congress having finished on the 29th September, this report will concentrate fairly heavily on the activities at that conference and associated Board and Council meetings.

Membership figures for July 1995 were provided with the Board Business Papers.

For comparison, there are 43 National Groups of the ISRM. Memberships of the larger groups is as follows: UK 421, July 411, Sth Africa 404, Japan 362, Germany 358, France 261, Australia 250. New Zealand is listed as having 55 members. Other significant groups are: China 73, India 97, Korea R 200, SE Asia 10, Austria 200, Finland 105, Greece 87, Norway 180, Portugal 105, Russia 60, Spain 187, Sweden 175, Switzerland 194, Canada 213, Brazil 135 and Venezuela 56. These figures are provided to give some idea of the strength of rock engineering around the world and the fact that some areas (e.g. Eastern Europe and China) are under-represented in the ISRM.

2. ISRM BOARD MEETING

An ISRM Board Meeting was held on the 9th September in Tokyo. Matters that were decided/discussed at the Board meeting were:

- The 1996 Rocha Medal was awarded to Dr Mark Board of the USA for a thesis entitled *A numerical examination of mining industry seismicity*. There were two Australian entries and, evidently, these were very highly regarded and ranked.
- Should the ISRM consider changing the voting rights of national groups, with say more votes (cf one at present) for the larger groups? It was suggested that the new Board may address this.
- Should official or conference language be changed? Hot issue - most VPs have a view that some change is necessary but what? See John Hudson's statement on page 42 ISRM News Journal V3(1) for one view.
- The ISRM was concerned that the ISSMFE may be changing its name to include the words *Geotechnical Engineering*.

A new Board was elected at the Council meeting. It consists of:

President	Prof. Shunsuke Sakurai	Japan
VP Africa	Dr J. Nielsen van der Merwe	South Africa
VP Asia	Dr Ou Chin-Der	China R (Taiwan)
VP Australasia	Mr Garry Mostyn	Australia
VP Europe	Prof. Giovanni Barla	Italy
VP North America	Prof. Herbert Einstein	USA
VP South America	Prof. Michael Van Sint Jan	Chile

In addition the president invited Prof. John Hudson (UK) and Prof. Sun Jun (China PR) to join the Board as VPs at large. Dr Jose Delgado Rodriques completes the Board as Secretary General.

3. 8TH INTERNATIONAL CONGRESS

The 8th International Congress of the ISRM was held in Tokyo (actually 25 km out of the CBD, but that is almost the inner city) between 25th and 30th September. In summary, the congress was a great success, due in no small part to the support from both local ISRM members and Japanese industry. About 250 papers were published in the proceedings and 55 chosen for formal presentation. Due to minor format requirements, many of the papers (6 of 11 Australian and 12 out of 12 South African papers amongst others) were held back and will be published in Volume 3.

There were a total of 709 registrants of whom 501 were from Japan. Australia was very well represented with 14 registrants. Mick Pender was the sole New Zealander.

Future Board Meetings will be held at:

- | | | |
|------------------------------|---------------|-----------------------|
| • EUROCK96 | Turin, Italy | 3-5 September, 1996 |
| • 36th US Sym.Rock Mechanics | New York, USA | 30 June - 3 July 1997 |
| • 9th Int. Congress of ISRM | Paris, France | 1999 |

The location for a Board meeting in 1998 is still to be decided.

Garry Mostyn
AUSTRALASIAN VICE PRESIDENT, ISRM



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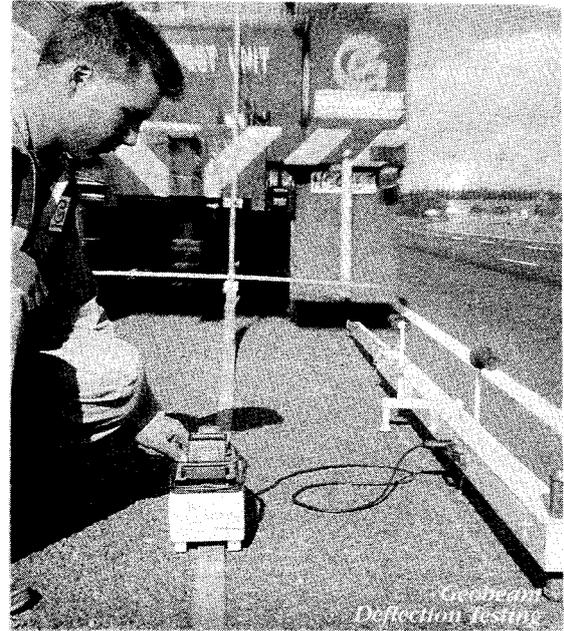
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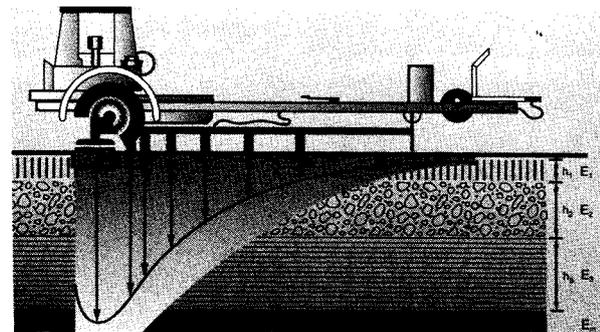


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AUCKLAND BRANCH

Rock Engineering Design Audits

On 3 April 1996, Professor John Hudson from Imperial College, London addressed a large meeting on aspects of technical audits of rock engineering projects. His talk began with a review of advances in rock engineering over the last three decades. He then outlined his concept of an "Interaction Matrix" for rock engineering which seeks to capture the essential components of a particular problem and to highlight the likely interaction between these components. Without a basic understanding of rock mass interactions e.g. between joints, in-situ stress and water flow, the development of appropriate solutions will be hindered. Particular emphasis was given to the need to audit modern numerical codes to ensure that it will correctly model the rock mass interactions present within a specific problem.

The talk finished with examples of rock engineering problems from Professor Hudson's experience. These stressed the need to determine at an early stage the correct geological model and to examine it for potential failure mechanisms and/or problem sources. Examples were also given of problems which proved difficult to predict even by very experienced rock engineers.

The technical paper forming the basis of Professor Hudson's talk is presented later in this issue of *NZ Geomechanics News*.

Planned Auckland Branch Meetings

- 4 June - Panel discussion on pile construction including speakers from the contracting industry.
- July - Bob Semple (Woodward Clyde)
- 7 August - The 1996 NZ Geomechanics Lecture by Professor Mick Pender

Branch meetings will be held at the Auckland School of Engineering. Other meetings are planned but details are not yet finalised. Flyers notifying all Auckland members of NZGS will be posted prior to each meeting.

Clive Anderson
AUCKLAND BRANCH CO-ORDINATOR



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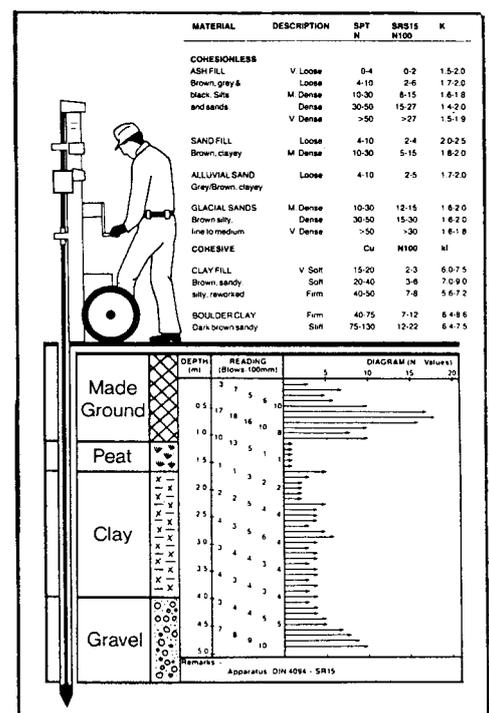
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CANTERBURY BRANCH

There have been no local branch meetings to date this year. The following programme is planned for the remainder of the year:

- Design investigations for the Otira Viaduct, Arthur's Pass.
- Graham Ramsay and Brian Paterson
- Akaroa Landslip monitoring and remedial works. 26 July 1996.
- Mark Yetton
- Marlborough Sounds Fast Ferry Dispute.
- Professor Bob Kirk and Dr Martin Single (to be confirmed). This is proposed to be a joint NZ Geotechnical Society/NZ Coastal Engineering Society meeting.
- 1996 Geomechanics Lecture: Aspects of the Geotechnical Behaviour of Some New Zealand Materials - Prof. (Mick) Pender.
- New Zealand Geotechnical Society Student Prize presentations (Southern Zone)

Guy Grocott
CHRISTCHURCH BRANCH CO-ORDINATOR



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- Geraghty and Miller (ModelCad, ModFlow, QuickFlow)
- INTERPEX (Seismic, Electromagnetics, VLF, TEM, Firstpix, Gremix, Temix)
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OTAGO/SOUTHLAND BRANCH

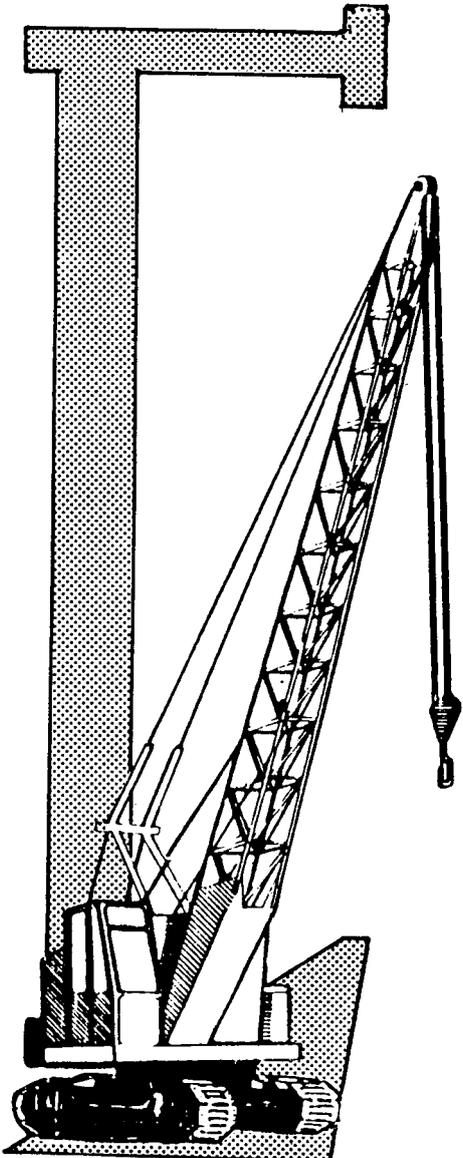
The Otago Branch of the New Zealand Geotechnical Society has gone into recess while the Branch Coordinator catches his breath. Ian Walsh of Works Consultancy Services is lined up to give a talk on the design and problems encountered with the McCarthurs Bend realignment of State Highway One. He has also suggested a local workshop on the newly adopted roading materials standards. It is likely that most of our activity will be in the second half of the year.

New Zealand Geological Conference, Dunedin, November 1996

I have been informed by the organising committee that there will be specific themes for the conference but that these will be confirmed once abstracts have been received. The idea is not to be too specific which might put potential participants off submitting a paper. Papers with an engineering geology or geotechnical theme will be welcome. There will be a number of field trips, with at least two having an engineering geology flavour to them; Macraes Mining and the Lower Clutha river. Ian Turnbull of IGNS, Dunedin is in charge of organising these trips. It is likely that I will be involved in the Lower Clutha trip and Dave Bell may be asked to contribute to the Macraes Mining trip.

Phil Glassey
OTAGO/SOUTHLAND
BRANCH COORDINATOR

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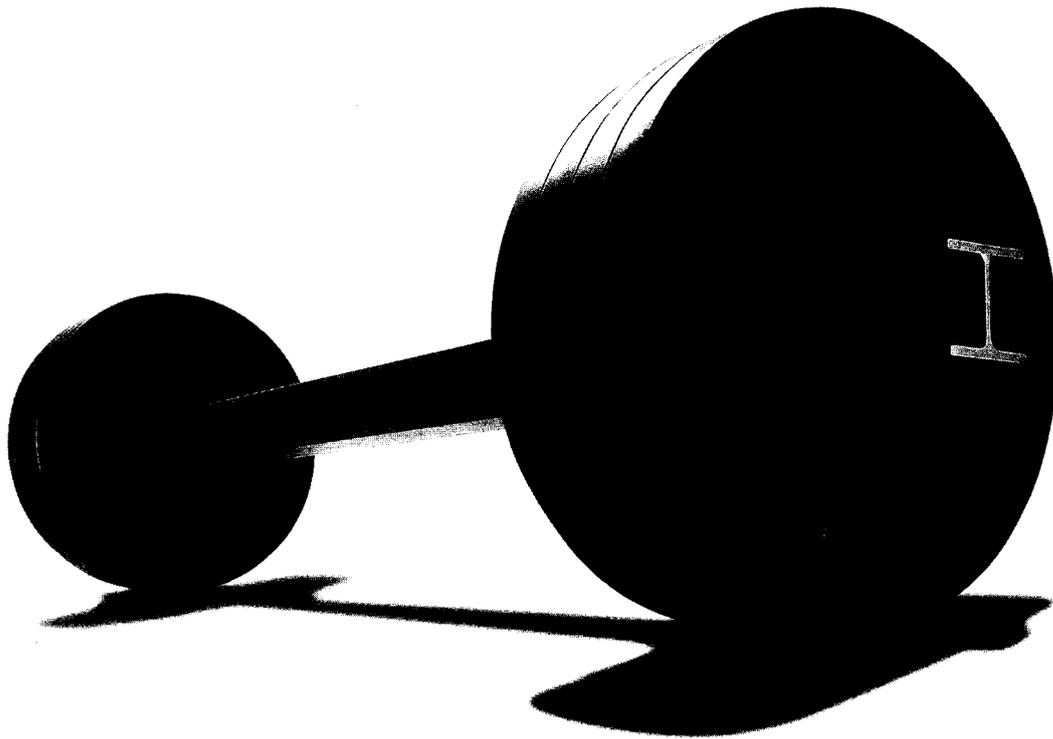


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**ASPECTS OF THE GEOTECHNICAL BEHAVIOUR
OF SOME NZ MATERIALS**

M J Pender

Department of Civil & Resource Engineering, University of Auckland

Mick Pender's lecture aims to remind the members of the NZ Geotechnical Society about the following aspects of the materials which we encounter:

- very little systematic data is available about the soil and rock masses we deal with everyday in our practice of geotechnical engineering
- many of the materials we deal with are unusual and not covered in the traditional soil and rock mechanics literature
- as our soils are sufficiently different from those found elsewhere we need to exercise caution when importing offshore correlations between soil properties
- there is an extensive range of methods that can be used to determine values for soil and rock mass parameters

The approach adopted in the lecture is to present information about some NZ soil and rock masses with which Mick has personal experience. In NZ there is not a sharp distinction between soil and rock, rather there is a continuous spectrum of materials. As this reflects the range of materials Mick has worked with, the examples given in the lecture range from cohesive and cohesionless soils to unweathered (but closely jointed) hard rock. Extensive information about particular materials is not presented but rather aspects of the behaviour of various materials are used to illustrate several interesting features about our soil and rock masses.

The materials covered are soil derived from complete weathering of Wellington greywacke, Auckland residual clays formed from weathering in situ of Waitemata Group soft rocks, swelling pressures against retaining walls, vane and cone profiling of volcanic ash, properties of pumiceous sands, pile driving resistance in rockfill, rock mass stiffness of central North Island soft rock, in situ stresses in coal, shear strength and slope stability for unweathered closely jointed greywacke.

The lecture will be presented as follows:

Adelaide: 7th Australia NZ Conference on Geomechanics, Adelaide, Friday, July 5 at 9.00 am

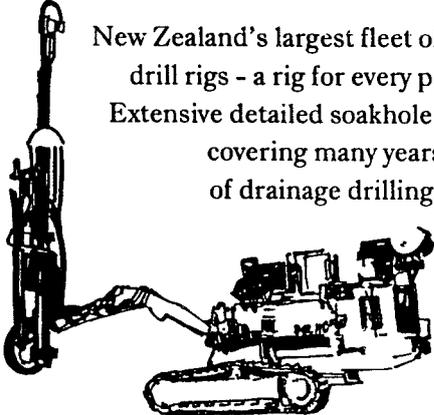
Auckland: Wednesday August 7 at 6 pm, Rm 1.401, School of Engineering

Wellington: Wednesday August 14

Christchurch: Wednesday August 21

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RECENT BUILDING INDUSTRY DETERMINATION

I would like to draw to the attention of members of the Society the Building Industry Authority Determination No.95/005: *Construction of a house on a steep site* (see Summary extract from BIA News below). I have had no involvement in this project and my only knowledge of it is what is produced in the determination. However, on the face of the information presented, the inference from the determination that I draw is:

- (1) You must undertake drilling and laboratory testing of several locations on even a small site and then carry out computer analyses of a large number of potential slip circles.
- (2) If the above is carried out you will get the right answer with respect to determining the stability of a site.

I believe this is a very dangerous precedent to set in any geotechnical determination for several reasons: Firstly, it suggests that even small sites will require extensive drilling testing and analyses. Secondly, and probably more importantly, it can be inferred from this determination that such procedures will arrive at the correct answer. The determination seems to ignore the importance of an understanding of the geology, site history and site settings as a means of assessing stability of a site.

I anticipate that the legal profession could use this decision against professionals on any site where an assessment is all that the professional has used to determine the site stability and as such, the Geotechnical Society should make strong recommendations to the Building Industry Authority with respect to this determination.

N.S. Luxford - Geotechnical Director at Babbage Consultants Ltd, Auckland

The BIA determination implies the engineer who gave "expert evidence" to the effect that holes and computer analyses = a competent geotechnical assessment has set a de facto standard for small house sites in Auckland. The decision against (Auckland City Council) ACC will put all councils in an invidious position when considering assessments based on visual, geotechnical and air photo interpretation regardless of whether a computer analysis will adequately model the particular slope in question.

M.J.D. Stapleton - Geotechnical Principal at Babbage Consultants, Auckland

DETERMINATIONS ISSUED

BIA News No.55, March 1996

No. 95/005

Construction of a house on a steep site Issued 14 December 1995

The building concerned was a house on a steep site. The house had been completed under a building consent. Another four houses were proposed to be erected on the same site. The site displayed arcuate or amphitheatre-like features. Visual assessment indicated some slumping and creep of surface layers.

The questions before the Authority related to site investigations and soil stability analyses and to the disposal of surface water.

As to site investigations, the Authority considered that in this particular case it was not appropriate:

- (a) To rely on hand auger boreholes, which should be supplemented by machine auger boreholes.
- (b) To "revise" an apparently anomalous box shear test result. Further tests should be made to resolve the discrepancy.

- (c) To rely on hand calculations for only six slip circles. Further computer calculations should be made so that a larger number of potential slips, including non-circular slips, could be analysed and a search done for the one with the lowest factor of safety.

As to the disposal of surface water, the fact that flooding had been experienced on a property downhill of the site did not of itself establish a failure to comply with the building code. However, the territorial authority's replies to various questions raised by the owner of that property had left the Authority uncertain as to the grounds on which the territorial authority had issued the building consent. However, further information supplied by the territorial authority at the request of the Authority satisfied the Authority that the on-site drainage system complied with the building code and that the territorial authority's system was capable of accepting the discharge from the on-site system.

The Authority accordingly determined that specified additional geotechnical investigations were to be undertaken and that the plans and specifications were to be modified as necessary, if at all, in the light of the results of those investigations. The building consent was confirmed in respect of the disposal of surface water.

IRRIGATION DAM REPAIR

In recent years, the Northland Dairy Company has been actively promoting the development of irrigation dam schemes to irrigate farm pastures during the dry summer months, to extend the milking season and to improve associated returns for dairy farmers. These projects often involve construction in geologically complex conditions with farm land encompassing large areas of alluvium and historic swamp formations.

In 1995, Tonkin & Taylor was engaged to investigate and design the repair works for an irrigation dam where a slope failure had occurred during the final stages of construction. The dam is situated on the fringes of the Hikurangi swamp which is an extensive alluvial formation situated to the west of Hikurangi township, 14 km north of Whangarei. The structure, with a crest length of 200 m and a height of 12 m was nearing completion when a large scale failure occurred encompassing the whole downstream shoulder.

Following the failure, our investigations established that the dam was founded on a deep alluvial formation of firm silts. Measured thicknesses ranged from 12 m to 25 m. Raised foundation pore pressures developed from the surcharge effects from the dam. The resulting softening and loss of shear resistance at the downstream toe was considered to be the most likely cause of the dam failure.

The repair works were subsequently designed to restore the original design intent and achieve the owner's volume storage requirements. The critical design aspects included the following:

- incorporation of an upstream and downstream 4 m high berm for stability
- a row of pore pressure relief wells beneath the downstream shoulder. (These wells also serve to intercept foundation seepage within some near-surface thin sand layers)
- an inclined internal chimney drain extending the full width of the dam, to address the possible risk of cracking at the abutments and across parts of the dam - given the varying thickness of the underlying compressible alluvium
- dam instrumentation for monitoring foundation pore pressures during reconstruction

The reconstruction of the dam commenced in October 1995 and was completed in January 1996. The monitoring of pore pressures, during the construction period and in the subsequent period to date, shows that the drainage wells have successfully maintained low pore pressures beneath the downstream berm. Upstream of the drains and beneath the downstream shoulder, pore pressures have been kept below critical design levels. Settlement markers were also recently installed as part of the monitoring works and these will be surveyed regularly to check actual surface movements.

The development of farm dams in Northland has the potential to provide greatly improved returns to farmers but requires the use of specialist investigation and foundation design inputs in areas of weak foundations which underlie much of the dairy farm land within the region. The investigations and remediation design has demonstrated the need for careful assessment of foundations in the region, particularly where deep soft alluvial soils may be present.

Chris Freer, Principal and Senior Geotechnical Engineer at Tonkin & Taylor, Auckland.

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Interviews were made by Geoff Farquhar at 7.30am on the Sunday morning.

WARWICK PREBBLE

I like the flow of the conference. The day flows into the night, and the night flows into the day. It is well organised. I can't comment on the papers since I gave one. There is an enthusiastic group of people reluctant to leave the topic alone even in the small hours of the morning.

NIGEL FITCH

Do you expect learned comments?? It's 7.30am on a Sunday morning. It is good in these conferences to pick up on areas in which one is not directly involved but have impact on geotechnical engineering i.e. basic research in geology as illustrated in Warwick Prebble's paper, and methods of deriving insurance ratings (the paper by Bruce McLean, with "hard and soft" soils).

CHRIS NICHOLS

I really enjoyed it. It was an opportunity to establish a network again and catch up with people. I enjoyed Max Ervin's perspective on things, the way that he looked in from the outside.

ROB OLIVER

I enjoyed the wine.

CLIVE ANDERSON

Tim Browne has done an excellent job of organising this symposium.

JOHN BLAKELY

I worked through the 1970's and attended the 1981 symposium. I then left the profession. I have come back to find the same issues facing the profession. I have three impressions about this symposium.

1. It is time to move forward
2. The NZ Geotechnical Society is the Society that can take initiatives in moving forward.
3. Taking a piece out of Scott Vaughan's and Brian Gunson's paper, "The Geotechnical profession should consider ways in which performance can be improved by way of approved practitioner or minimum standards and guidelines for geotechnical work. Failure to do this will ensure that variable standards of geotechnical work and development will continue to occur and will not improve the perceptions of territorial authorities, the public and the civil engineering profession towards geotechnical engineering".

Post Script - How to recognize an engineer or geologist in Hamilton

At the Blue Note Cafe (the centre of Hamilton life on a Saturday night), a young lady, considerably younger than the group she approached, asked a group of somewhat middle aged men whether they were a group of architects or scientists. They apparently stood out from the crowd in the courtyard of the Blue Note Cafe, not necessarily because their age, but because they all had pens in their top pockets.

(Ed - the ink blot is usually a good hint)



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GROSS INTEREST IN DOMESTIC WASTEWATER STANDARDS

The joint Standards Australia/Standards New Zealand Committee WS/13 *Septic Tanks* has been inundated with comments on two draft standards for domestic wastewater. The draft standards are AS/NZS 1546 *Septic tanks for domestic wastewater* and AS/NZS 1547 *On-site domestic wastewater management*. More than 300 comments were submitted for the first standard and 600 comments were received for the second.

WS/13 is also working on a draft standard for Aerated Wastewater Treatment Systems that is likely to be as popular as the other two. The three standards will eventually form part of a "one-stop-shop" volume that will meet all on-site domestic wastewater disposal options.

The suite envisaged at present will cover:

- suggested infrastructure for local and State authority involvement in the control of on-site domestic wastewater systems, including effective operation and maintenance,
- performance requirements for septic tanks,
- specifications for tanks made from concrete, cement mortar, glass reinforced plastics, plastics,
- aerated wastewater treatment systems, composting toilets, site evaluation methods, soil assessment and effluent disposal options.

Each of the proposed standards uses a new performance based approach i.e. focuses on outcomes rather than prescribing how to achieve such outcomes. This new direction in thinking has come about as a result of a better understanding of the nature of different soils and the absorption of effluent.

In the past, standards for septic tanks and domestic effluent have been developed according to the belief that a scientifically rigorous and exact approach to *septic tank disposal field design* and implementation was possible. However, time has shown this belief to be fallacious because any one of a number of factors could vary throughout the year and could prevail in determining the effective performance of an on-site system. It is also become clear that in many cases the use of prescriptive approaches has not achieved sound environmental outcomes.

The standard clean water percolation test, which has been used for so long now, has largely been abandoned by most modern designers as the sole design approach, although it can have a supplementary role in building up a full site evaluation picture.

Standards developed under the new performance based approach will set up a framework to ensure that a quality process is set in place and that levels and lines of responsibility are clearly defined.

For further details please contact Ron Humphreys at Standards New Zealand (04) 495 0938.

By Ron Humphreys, Manager, Building Group, Standards New Zealand.

STANDARDS BODIES SIGN REVISED ACTIVE CO-OPERATION AGREEMENT

Standards New Zealand and Standards Australia have signed a second revision of the 1992 Active Co-operation Agreement that governs relations between the two bodies.

The revised agreement was signed on 17 April, 1996 during the Pacific Area Standards Congress (PASC) in Queensland, Australia. Standards New Zealand Chief Executive Peter Davenport says the agreement has been streamlined and updated to reflect current practice in standards development. In particular, more flexible, co-operative working arrangements for marketing and seminar services, should provide more scope for joint ventures.

There have also been changes to the role and constitution of policy review bodies. The review bodies now have the opportunity to be involved in the processing of approvals for standards development projects.

Changes to the constitution of Standards Policy Boards (SPBs) should result in a broader range of New Zealand representation on the boards. The former Joint Standards Advisory Committees that report to the SPBs have been replaced with Standards Co-ordination Groups (SCGs) that can be either joint, single country or work in parallel. SCGs can be set up on an "as required basis" to co-ordinate standards

development. This allows for a more flexible structure than in the past. Standards Task Groups can also be set up for short term projects and then disbanded when the projects are completed.

"The idea is to set up a policy structure that is representative of industry's requirements and to have more effective representation of New Zealand's interests," says Mr Davenport.

NEW ZEALAND STANDARDS NOW AVAILABLE ON CD-ROM

A range of CD-ROMs has been released by Standards New Zealand, giving the users of standards the opportunity to maintain their standards library in electronic form.

All New Zealand Standards have been put through the conversion and indexing process, including joint Australian/New Zealand Standards and standards from ISO, IEC, Britain, USA and Canada that are adopted as New Zealand Standards. Standards New Zealand marketing manager Keverne Trevelyan says the CD-ROM release is the culmination of a project that began more than six months ago.

"With over 2000 documents to index, scan and check for current amendments, etc, it was a demanding task. The end result is just what our customers have been asking for - instant access to up-to-date documents," he said. Subscribers will receive new CD-ROMs every 60 days to maintain that immediacy.

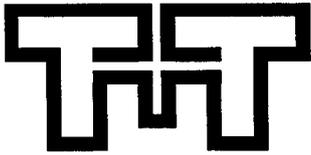
The new development is part of the Worldwide Standards Service, a product of Information Handling Services (IHS) in Denver, Colorado. The link with IHS gives New Zealand users an additional benefit because, as well as receiving all their New Zealand Standards on disc, they also get a fully searchable index to 440 catalogues of standards from publishers worldwide.

Access to the text of a standard is through the index. The user types in a keyword from the title of the standard, or a generic term that describes the content, or the actual standard's number if it is known. The index disc is then searched and all standards matching the search terms are listed on the screen. Highlighting the desired document and specifying "document images" on the pull-down menu generates a prompt to insert the appropriate CD-ROM containing the selected standard. The next thing the user sees is an image of the first page of the selected standard on the screen.

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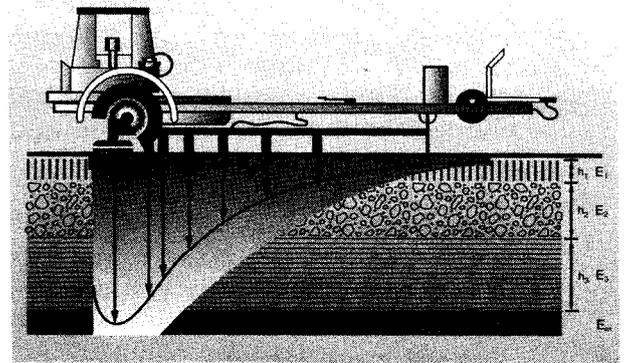


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NZ GEOMECHANICS SOCIETY

The news and discussion forum for NZ's geotechnical professionals

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The issue of a Geotechnical Professional Practice College was raised at the Hamilton Symposium during the discussion session following the presentation of papers by Bruno Petrenas and John Blakeley: (these papers are published after this article) Strong support was shown by those attending and the challenge was laid at the feet of the Management Committee.

I believe this to be the most important issue facing the Society and it needs to be addressed carefully to ensure that the functions of the Geotechnical Society are not diminished by the establishment of a Practice College. There is a demand from our clients to provide formal identification of geotechnical professionals and a need to protect the field of geotechnical engineering from other allied professional groups. A number of other benefits can also be identified. IPENZ has simplified the procedures in establishing a framework for a College, further encouraging its formation. The important issue is the potential for a reduction in work for Society members if we do not respond to this challenge.

In his paper, Bruno Petrenas states "Tauranga District Council has established an accreditation process to access the academic training and practical experience applications in respect of geotechnical engineering and engineering geology. "In the past, Council officers have made their own judgements as to who were the specialists and who were not, and the accreditation process merely seeks to formalise that judgement..".

Experience had shown Tauranga DC that the criteria of Engineering Registration was not appropriate in identifying who is a Geotechnical Professional. It can be concluded from reading the paper that the new accreditation process is more rigorous, open and fairer for professionals than the previous "behind the counter" process.

Petrenas also discusses the problems faced by individuals when they select a professional for projects with a significant geotechnical component. Tauranga DC is not alone and that other local authorities, as well as private individuals, are facing the same decision regarding who are competent Geotechnical Professionals.

A Practice College would enable professionals who practice in the field of geotechnical engineering and engineering geology to differentiate themselves by the mere fact of belonging to the College and, most likely, with the use of post-nominals. The College would be self-governing with a number of requirements to be achieved (as suggested by John Blakeley) as:

- continuing professional development
- professional indemnity insurance
- other practice review processes

Entry would be on the basis of peer review of qualifications and experience with a standard to be achieved. The College would need to operate under a code of ethics with a discipline committee required to hear complaints. To be effective, the College would require high entry standards, resulting in a number of Society members being unable to achieve admission and the development of inter-personal tensions. It is likely that between 50 and 150 of the Society's 400 or so members would be eligible for admission into the College.

The establishment of a College has some serious disadvantages for the Geotechnical Society. I am concerned about the establishment of a "superior" group or class with the Society and there will be liability issues to be worked through to protect the College, the Society and IPENZ from damages as a result of a member failing in their professional duty.

Another area to be addressed is whether the College could achieve a "critical mass" which would not impose large financial burdens on its members. Is there a case for the formation of an Australasian College?

A MATTER OF PRACTICE COLLEGE

ARTICLES

Because of the impact a Practice College would have on the Society, members are urged to consider the concept of a Practice College for the field of geotechnical engineering and engineering geology. Could you please provide your feedback to the Secretary for discussion at the next Management meeting.

Colin Newton, NZGS Chairman

The following papers by Blakeley, Petrenas and Taylor are reprinted from the Hamilton Symposium proceedings to provide background on the practice college and geotechnical issues to all society members - Ed.

- “Selective Listings - IPENZ Perspective”
- John Blakeley
- “Accreditation of Geotechnical Engineers and Engineering Geologists” - Bruno Petrenas
- “Geotechnical Issues in Land Development” (Keynote Address)
- Don Taylor

SELECTIVE LISTINGS — IPENZ PERSPECTIVE

John P Blakeley
Deputy President IPENZ
Centre for Advanced Engineering, University of Canter-
bury, Christchurch, New Zealand

SYNOPSIS: Recent (1994) changes in the IPENZ rules to broaden its membership base and also to allow the establishment of Practice Colleges are reviewed. Possible future changes in the Engineers Registration Act are discussed and a proposal being developed by IPENZ for the use of Post-Nominals.

It is proposed that the New Zealand Geomechanics Society establish a Practice College for recognition of particular specialisation(s) of its members. How such a College might work in practice is then discussed.

1. INTRODUCTION

I am pleased to be able to participate in this Symposium. As Chairman of the Society, I presided over an earlier Symposium on "Tunnelling in New Zealand" held in Hamilton in 1977.

Some of the issues being discussed at the present Symposium have been around for a number of years. During my time as Chairman in the late 1970s, I recall considerable discussion on the issue of land stability certificates for subdivisional work which were being proposed by territorial local authorities and the important consideration of who should sign them. I also remember the issue being raised of the better recognition of the particular skills and experience of engineering geologists and whether this could be done by some sort of statutory recognition such as registration (similar to the Engineers Registration Act 1924).

The objective of this paper is to give an IPENZ perspective on the issue of recognition of particular qualifications and experience in geomechanics by means of some type of register.

2. RECENT CHANGES IN IPENZ RULES

Over the last few years considerable changes have been initiated within IPENZ with the objective of broadening and expanding the membership base.

These changes were canvassed in the "Pathways to the Future" document of IPENZ (1993) and reflected changes in the centre of activity of the Institution away from regionally based Branches and towards Technical Groups, within which most of the learned society activity of the Institution is now based.

The New Zealand Geomechanics Society which was founded in 1958 became the first Technical Group of the Institution in 1965. There are now 18 Technical Groups of IPENZ and discussions are ongoing with other groups wishing to join.

Until the rule changes were implemented in September 1994 following on from the "Pathways" document, many members of Technical Groups were not eligible to be members of the Institution itself. Two new grades were then introduced as follows.

Technical Membership is open to anyone with suitable experience and who holds a relevant tertiary qualification such as NZCE, or a science or technology degree not covered by other grades of membership.

Associate Membership is an interest-based type of membership which is open to anyone interested in becoming part of IPENZ but who would not qualify for other categories of membership.

It is hoped that many members of Technical Groups will take up the opportunity to join IPENZ through one of these two membership categories.

The same rule changes introduced the concept of Practice Colleges and this is discussed further under Section 5 below.

3. REGISTRATION OF ENGINEERS

Since 1924 professional engineers in New Zealand have had the privilege of statutory recognition through the Engineers Registration Act. A common professional interview procedure has enabled people with the required qualifications and experience to become Members of IPENZ or registered engineers, or both.

There has been considerable debate within IPENZ in recent years as to whether the Institution wished to continue with statutory recognition of engineers' registration or, if it was to be abandoned, IPENZ would prefer to take the initiative and set up its own register.

Although at IPENZ Council and (subsequently) Board level, views on this were rather mixed, it appeared that the membership at large quite strongly supported continuance of statutory recognition because this was seen as recognition by Government of the importance of tasks carried out by professional engineers.

Government views on this issue have also varied in recent years but it now seems clear that registration of professional engineers is to continue, especially in regard to matters concerning public health and safety and there is the opportunity of significantly upgrading the Engineers Registration Act in the near future.

At present, the Engineers Registration Act 1924 (and subsequent amendments) contains

no requirements to:

- continue to practise in areas of claimed competence,
- undertake a specified amount of continuing professional development over a given period of time,
- adhere to a Code of Ethics

Also, there is no distinction as to the field of engineering the registrant is qualified in. It is possible to remain on the register without undertaking any continuing professional development or actively practising in a particular field and there are many retired people still on the register. Although the IPENZ Code of Ethics is printed on the back of the Annual Practising Certificate as a guide, there is no mandatory requirement to adhere to it.

This situation could make the engineering profession extremely vulnerable to criticism for failing to police its own standards if a major engineering incident was to occur which was attributable to professional incompetence.

4. PROPOSAL FOR THE USE OF POST-NOMINALS

At present, IPENZ is developing a proposal for an improved system of recognition of professional engineers (and technologists) in New Zealand which requires:

- continuing practice in professional engineering (or technology)
- self certification of an agreed minimum annual amount of continuing professional development
- adherence to the IPENZ Code of Ethics and (possibly)
- the maintenance of professional indemnity insurance, either directly or through one's employer.

The use of a post-nominal such as Pr.Eng. or Pr.Tech. will be the incentive to make an *annual commitment* to the above (at the time of renewal of the annual IPENZ subscription) and it is hoped that the post-nominal will also help to elevate and differentiate the image of professional engineering (and technology) in New Zealand.

The present proposal is for IPENZ to take

the initiative of setting up a register of its own Members and Fellows who have given the required continuing commitment in order to use the post-nominals, but to leave the door open for a subsequent joint register to be established with the Engineers Registration Board which may have statutory recognition.

Such a joint register may also have to be open to other people who are not Members or Fellows of IPENZ but who must be able to demonstrate that they are qualified to be eligible for the equivalent membership grade in order to be on the register.

5. ESTABLISHMENT OF PRACTICE COLLEGES

As noted in Section 2 above, the IPENZ rule changes introduced in September 1994 made provision for the establishment of Practice Colleges.

Members would have to be prepared to comply with requirements established by the self-governing college such as continuing professional development, professional indemnity insurance, and possibly other practice review procedures.

The intention was that the Practice College concept was to be initially applicable to IPENZ Members and Fellows prepared to give the annual commitment described in Section 4 above. Ultimately this would be in order to maintain international recognition of IPENZ qualifications by overseas professional engineering institutions, which are themselves seeking to introduce a CPD requirement.

However this intention has now been replaced by the proposal for the use of Post-Nominals described in Section 4 above, leaving the way clear for the term Practice College to be applied to more specialist groups within IPENZ.

As noted in Section 3 above, the present Engineers Registration Act is very much for the recognition of generalists only and it is envisaged that any replacement legislation will still only be for generalists within the main broad fields of professional engineering, rather than any detailed specialist field of activity.

Two groups within the Institution who are at present indicating that they wish to have a specialisation recognised are:

- (a) geotechnical engineers and engineering geologists, especially in the field of land stability certification
- (b) fire engineers.

It is suggested that such groups can set up their own Practice College within the Institution and draw up their own rules for admission to that College, which may then become the requirement imposed by outside bodies (eg local government organisations), before people can undertake certain types of work. It would be up to each College to decide on its own CPD requirements.

6. OPERATION OF PRACTICE COLLEGES

If the New Zealand Geomechanics Society wishes to proceed with a system of recognising the appropriate level of specialisation to undertake specified geotechnical tasks, then I believe that establishment of a Practice College as provided for in the IPENZ rule changes of September 1994 is an appropriate method of doing this.

However there are serious legal considerations involved and it should be made very clear that any register established listing members of a Practice College is of people whose qualifications and level of appropriate experience have been closely assessed and who are also prepared to give a *regularly renewed commitment* covering continuing professional development, ethics, continuation of practice in the field and possibly professional indemnity insurance cover.

Being on the register should not be interpreted by outside bodies as certifying competence in a particular field.

My suggestions for further consideration by the Society as to how a Practice College would operate are:

- (a) It should be under the overall control of the Society but at "arms length", with a management committee being either appointed or elected by the Society and accountable to both the Society and to the

IPENZ Board (since IPENZ is the parent body).

- (b) It should establish its own annual fee for each person who is on the register of the members of the College.
- (c) It should determine whether there should be just one overall register, or alternatively separate listings of particular specialisations.
- (d) Admission to the College would be on the basis of peer review of qualifications and experience plus (possibly) an interview to clarify any uncertainties, *plus* a commitment given on annual renewal of membership covering the matters listed in the second paragraph of this Section.
- (e) There may either be only one broadly representative admission panel or alternatively separate panels for particular specialisations within geomechanics (especially if the register is to list such specialisations).
- (f) It should set its own admission and discipline standards but should keep both the Society and IPENZ (as the parent body) closely informed of these and being given the opportunity to comment on them.
- (g) It should establish its own requirements for continuing professional development and may become involved in arranging courses for this, either on its own behalf or through the Society.
- (h) All people listed on the register should be required to keep records of their continuing professional development undertaken each year, including documentary proof of attendance at courses which would be subject to audit, probably on a random basis.

7. CONCLUSION

I hope that the Society will now give serious consideration to the establishment of a Practice College. As the first Technical Group to be established within IPENZ in 1965, it would be

entirely appropriate if the Society were to make this pioneering move which is now provided for under the rules of the Institution.

8. REFERENCE

IPENZ (1993). The Pathway to the Future. October 1993. 12 page brochure.

ACCREDITATION OF GEOTECHNICAL ENGINEERS AND ENGINEERING GEOLOGISTS

Bruno Petrenas, Director of Technical Services, BE, ME, Dip PM. MIPENZ, Reg Eng, MCIT
Tauranga District Council, Tauranga, New Zealand

SYNOPSIS

Tauranga District Council has established an accreditation process to assess the academic training and practical experience applicants hold in respect of geotechnical engineering and engineering geology. This accreditation process has provided a basis on which geotechnical reports would be accepted from applicants in respect of geotechnical matters without Council having to have reports referred to independent checking.

Reliance on an annual practising certificate under the Engineers' Registration Act and/or the IPENZ Code of Ethics has proved to be an inadequate assurance of practitioners' compliance in the specialist area of geotechnical engineering.

In the past, Council officers have made their own judgements as to who are the specialists and who are not, and the accreditation procedure merely seeks to formalise that judgement and no other changes are proposed or implied. The only areas where specialist input is routinely required would be on slope stability problems of some magnitude and difficult settlement problems such as when it is proposed to build on uncontrolled fill.

1. INTRODUCTION

The Tauranga District Council under legislation such as the Building and Resource Management Acts has a responsibility to ensure that land development and subdivision and building construction is planned and undertaken to particular standards. The standards are generally of a nature to ensure that Council is protected in such matters if development and construction problems arise.

Up until May 1993 there was no formal mechanism in place regarding the acceptance of geotechnical reports from consultants. Staff made a decision from whom to accept geotechnical reports which were submitted as part of the subdivisional development process.

However, such decisions could be viewed as being arbitrary and tended to be based on experience to date. There had been requests from consultants that reports prepared by them on geotechnical matters, be accepted by Council. To achieve this in a fair and reasonable way and to ensure that Council was not being exposed as to liability issues a process to scrutinise and evaluate the academic training and experience in geotechnical matters was proposed. The proposal was to ensure that reports from such individuals were of a certain standard and quality on which assessment could be made as to whether a particular subdivisional development was to be given approval.

2. ACCREDITATION PROCESS

An established process has allowed the Council to assess the academic training and practical experience applicants held in respect of geotechnical engineering and engineering geology. The assessment has provided a basis on which geotechnical reports would be accepted from applicants in respect of the above mentioned matters without Council having to have the reports referred to another person for assessment. In addition, there were associated amendments to Council's Code of Practice for development. These amendments defined the nature of information to be provided in geotechnical reports and other information. The suggested amendment to the Code was publicly notified and opened for submissions for one month and also was circulated directly to consultants in the Bay of Plenty and Waikato areas.

The result of submissions to Council was that Council policy was confirmed to implement an approval process in respect of geotechnical engineers and engineering geologists to evaluate academic training and experience and such policy was to be implemented in general accord with Attachment A. The Director of Planning and Environment was also given delegated authority to confirm recommendation from the geotechnical panel regarding whether applications for acceptance of qualifications were successful or unsuccessful.

Presently, at the time of subdivision application, the development engineer or his assistant visits the site and makes a decision as to the levels of soils reporting appropriate. On very small subdivisions less than five lots where no particular soils problems seem apparent, no soils reports are required from the developer.

On small subdivision where there are particular soils issues to be addressed and on all major subdivisions a report is required as to the suitability of the site for subdivision and building development. At that time the development engineer or his assistant makes a

judgement as to whether reporting from a registered engineer or specialist geotechnical engineer is appropriate. The situations where specialist input is required are almost always limited to where there is a major slope stability issue to be addressed, (for example building on or near seacliffs or relic slips) or where there is a particularly difficult settlement problem to be addressed. For example, where uncontrolled filling has been placed across soft, underlying material. For those situations where we deem that specialist input is required, we are currently imposing a condition of subdivision that a specialist geotechnical engineer provides soils reports that demonstrate the suitability of the site for building development.

3. BACKGROUND

The Council's role is one of ensuring that the people submitting reports are competent and the Tauranga District Council can accept with a high degree of confidence. The fact that it is no longer appropriate for all registered Civil Engineers to undertake all soils problems has now become established and is reflected in such documents as:

(a) **NZS 4404: "Code of Practice for Urban Land Subdivision"** which defines the Soils Engineer as a person who is currently entitled to practise as a Registered Engineer and has experience in soils engineering acceptable to the Council; and

(b) **The Branz Study Report SR4 (1987): "Assessment of Slope Stability at Building Sites"** which refers to Civil Engineers who have *specialised as "Geotechnical Engineers"* and says "that not all Civil Engineers will necessarily have the required skills and experience for carrying out slope stability".

The purpose of the Geotechnical procedure is to establish and formalise in an impartial, professional and fair way, some minimums in terms of geotechnical knowledge and experience that is acceptable to Council. Its implementation will hopefully leave a high degree of responsibility etc with Engineer. To my mind, we can have all the procedures in the

world but the concept is to ensure that those involved in geotechnical matters have a sufficient degree of technical competency in geotechnical matters to allow reliance to be placed on their work. The option of engaging consultants to review a design is there, but this places the Council in the position of passing on additional costs to an applicant and the resultant delays. The customer invariably perceives the delay as being caused by "Council bureaucracy" rather than any shortcomings on the part of his design professional. Council staff are also very reluctant to criticise the designer in front of his client. Furthermore, should a designer get out of his depth on a geotechnical matter, the reviewer inevitably becomes a defacto designer as he continually points out the shortcomings of the design until at last by a process of elimination, the designer comes up with something that the reviewer will accept. More often than not this is a bare minimum solution. Why should Council, through its agent who is reviewing the design, assume this defacto designer role? It is obviously much better from a customer point of view for them to go to those who have their qualifications approved and obtain the right advice from the start.

The issue of Code of Ethics and the creation of a privileged group within the Tauranga area is not really our concern. Our concern is ensuring there is competent advice in reports being submitted to Council, that recognise local geotechnical issues and minimise Council's liability.

The role of Council is not to review and assess the adequacy of information for each project. Given the changing role, Council is endeavouring not to be a checker of a checker but endeavouring to provide a mechanism where those who meet certain requirements lay their knowledge, experience and liability on the line to a greater degree. This approach is consistent with certification and the Building Act; that is, certifiers are listed "based on competency". The greater the Council

involvement, the greater the liability we buy into.

In response to the Territorial Authorities of the Auckland Region's request for comment on the use and acceptance criteria for Producer statements, the New Zealand Geomechanics Society in November 1992, made the following comments:

"The Geotechnical Services that many members of the Geomechanics Society provide address the stability of land, slopes, compressible soils, erodeable soils, filled ground and investigation and design of foundations, earthworks and earth retaining structures. Producers include designers, specifiers and construction contractors, all of whom should provide assurance that Geotechnical matters have been assessed and taken into account in the design and construction.

Reports by providers of Geotechnical Services should be prepared by persons who have academic and practical experience at a standard recognised in the profession and acceptable to the Territorial Authority. Reports should comply with the Territorial Authority's guidelines as to procedure of investigation and supervision and content of report. They should also comply with statutory requirements and relevant standards and they should recognise the two essential aspects of Geomechanics which are *geology* and *engineering*. Specialist services such as Geotechnical should only be provided by appropriately qualified and experienced persons and do not recognise the important input of Engineering Geologists to many geotechnical problems.

Geotechnical professionals would have involvement in design and design review but perhaps the most important is construction review. Due to the inherent uncertainties associated with many aspects of geotechnical engineering, it is essential that inspections are undertaken during construction to verify design assumptions and to recommend modifications if necessary. The importance of

such inspections has long been recognised by design professionals who have recommended to their clients that such inspections are necessary and why many Local Authorities who have required inspections during construction by appropriately qualified professionals.

Producer statements in the field of geotechnical engineering should be provided only by professionals with specialist training and practical experience in the field of geotechnical engineering. The qualifications and training depend on the nature of services being provided. If a geotechnical report provides engineering recommendations then the reporter should be an experienced registered engineer. They should also be involved in observation of construction to ensure that the intent of the recommendations are adhered to and to make modifications if necessary. However, there are also situations where investigation procedures for specific sites can be defined better if they are preceded by geomorphological examination which can best be undertaken by engineering geologists. Engineers issuing producer statements should also have mandatory membership of a professional association. This could be either active membership of ACENZ or corporate membership of IPENZ.

It must be remembered that geotechnical engineering is a specialist field and it is important that only those with the necessary specialist training and practical experience should be permitted to issue producer statements.”

3. WHY HAVE ACCREDITATION?

Whilst there is quite a bit of hazard information located in various places in Council, this has not been developed into a comprehensive hazard map of the kind envisaged by different professional bodies. One of the concerns in formalising hazard information is trying to deal fairly with land owners whose properties may be devalued (perhaps unjustifiably) by a broadbrush hazard information. I am of the

view that we should only develop and formalise hazard maps for those areas where the benefit of doing so outweighs the negative aspects associated with them. We must not lose sight of the fact that we are here to look after the interests of our ratepayers and not consulting engineers.

Tauranga's soils are not any more difficult to deal with than those in many other areas of New Zealand. The development engineer has personally found them to be much more predictable than the complete jumble that is found in Auckland. The basis of a listing of accredited geotechnical engineers as I see it, is that in all areas of New Zealand there are some soils problems more appropriately addressed by a specialist geotechnical engineer than the non-specialist registered Civil Engineer (just as there are some medical problems more appropriately dealt with by a brain surgeon than a GP). It is believed that by and large the profession realises this. The purpose of the listing is to formalise the decision making as to who is the specialist and who is not. Ever since about 1984 the engineers in the County, City and District have realised the need to differentiate between the two and have simply made their own somewhat arbitrary judgement on the matter. The fact of the matter is that the reports done by specialists are as different from those done by non-specialists as chalk is from cheese. Furthermore, the reports done by the non-specialists are all too frequently less conservative than those done by the specialists. This is the reality of what is happening on the ground.

As already commented upon, the listing procedure is primarily aimed at situations where the developer (not the Council) is the client. It is suggested though that the first and most important task in managing the consultant is to ensure that the persons engaged are competent for the task (reference the FIDIC Guidelines on the selection of Consulting Engineers that places prime emphasis on "selection by ability" and lists technical competence as the first of the matters

to be evaluated). Unfortunately, many clients are not at all good in determining this and there is nothing but trouble for all parties when some homeowner has rather innocently spent their hard earned money on an inadequate report. This does occur and Council is not looking after its customers' interests when it allows them to repeatedly fall into the same trap. Council officers also end up coming under extreme pressure from enraged or heartbroken clients to accept a report from someone who is not up to the task he/she has taken on. It is far better to get it right in the first place and set up systems to ensure the right person is engaged from the start.

On the surface, the setting of standard tests sounds like a good idea, but in reality it is not. What is being suggested is the Council defining what tests etc must be done in the areas of various risk and thus making the preparation of soils reports relatively "idiot proof". In practice however, the determination of what level of testing is appropriate is dependent upon more factors than simply the area. For example, the cost of the structure proposed has a bearing. It is not appropriate to do the same level of testing for a gazebo as for a multi-million dollar project. Also the amount of testing done on nearby similar sites is also of relevance. If the engineer has already done extensive testing on the similar site next door he/she will not need to do the same amount of testing as if he/she is coming in cold. The decision as to what level of testing is appropriate is an expert decision which should not be taken away from the designer. We should allow the designer to use their skill in this matter. I am strongly opposed to the prescriptive, blunt instrument approach of Council specifying the level of testing required. It is well nigh impossible to draw up requirements that allow for all the relevant factors. If we call up the roles that fits the worst case scenario then we are faced with the alternative of either becoming bloody minded and enforcing it in all cases or alternatively backing off and agreeing to a lesser standard.

If we do back off however, we have significantly increased our liability by breaking our own rules and also by becoming a defacto designer by specifying the level of investigations.

We, in Council, are not specialist soils engineers and are not competent to judge the appropriate level of investigation. A far better approach is to ensure that only the right people are doing the work and then let them use their expertise to determine the appropriate level of testing.

When presented with a report by someone with inadequate skill, the end result is invariably far from ideal. The Council usually gets sucked in to becoming a sort of defacto designer as it is continually asked the question: "Will you accept this?" Ultimately by a process of elimination, the consultant ends up covering most of the points that Council thinks he should have. The end result however is that most of the shots have ended up being called by Council and Council has become so thoroughly immersed in the process that it is fully liable for the outcome. It should also be noted that Council does not have on its staff, specialist geotechnical engineers capable of calling all the shots on geotechnical matters.

It is agreed that it is a shame that we cannot rely on the Code of Ethics. It would be very good if we could simply ask for a registered engineer and be sure of a satisfactory outcome. The reasons for a lack of confidence in application of the Code of Ethics could be due to:

- (a) failure to realise that some geotechnical problems have now become areas best handled by specialist; or
- (b) over-estimation of their competence; or
- (c) financial pressure.

The fundamental issue is that the Council perceives a need for a specific listing of persons qualified and experienced to act as geotechnical engineers in the Western Bay of Plenty area. Reliance on an annual practising certificate under the Engineers Registration Act and/or the IPENZ Code of Ethics has

proved to be an inadequate assurance of practitioners compliance in this specialist area.

The Tauranga District Council does not accept the producer statement arrangements promulgated by the inter-professional group because they do not provide for any transfer of liability and hence there is no benefit accruing to us. This is not an overly-cautious position as our responsibilities are to protect ratepayers at large, not accept risks on their behalf in the interests of benefiting private individuals or companies. ACENZ is correct in that the application of this system logically does lead to the accreditation this for other engineering specialisations.

It is the view of the professional staff of the Tauranga District Council that it should be a role of the professional institutions to undertake the examination and accreditation of individuals in specialised fields of engineering. Indeed we believe that IPENZ should be undertaking this role, if necessary under licence to the building industry authority. In the absence of the professional bodies grappling with and resolving the issue of accreditation of specialisations then there is no doubt that other bodies and individuals will attempt to fill the gap, not entirely satisfactorily in our opinion.

A Council's geotechnical listing procedures are a local response to a problem where the professional bodies seem unwilling or unable to effectively deal with. It is the responsibility of the professionals to regulate themselves and I believe there is a perception in the community, and certainly within territorial local government that there is considerably more that can be done in regard to the accreditation of specialisation, the enforcement of the Code of Ethics and discipline of professional engineers. The profession does not appear to deal with that effectively and until that is done the community will find ways of regulating the profession externally.

4 GENERAL COMMENTS ABOUT ACCREDITATION PROCESS

The interview panel has been concerned that no engineering geology specialists have presented for accreditation to date. It is vital that engineering geology expertise is available to specialist geotechnical engineers practising in the Tauranga area and also available to assist Council where required.

The panel has also felt that it was important that the rationale behind the accreditation process should be made widely known. It should be made quite clear that the purpose of Tauranga District Council's policy on accreditation of specialist geotechnical engineers is certainly not to require that all soils problems be addressed by those who have gained accreditation. Most foundation designs and soil problems will continue to be addressed by registered engineers. There will be no Council requirement for special accreditation to address the straight forward matters.

The purpose of accreditation is to have a list of approved geotechnical engineers or engineering geologists to address those soil problems which in the judgement of the Tauranga District Council's Development Engineer, require specialist input. In the past Council officers have made their own judgements as to who are the specialists and who are not and the accreditation procedure merely seeks to formalise that judgement and no other changes are proposed or implied. It is anticipated that the only areas where specialist input is routinely required would be on slope stability problems of some magnitude and difficult settlement problems such as when it is proposed to build on uncontrolled fill. However, this is not to say that Council may on the odd occasion seek input from a specialist geotechnical engineer on the question of some significance such as liquefaction potential for a multi-storey building site.

The applicants' information as submitted was generally poor and in some cases, quite irrelevant. The panel could also see a potential problem arising with regard to the use of peer review. Peer reviews from accredited

specialists would be required if unaccredited engineers carried out relevant work. Peer reviews requested by Council of accredited specialists should also be made only by accredited specialists. With the limited number of specialists accredited so far, this could create difficulties.

5. RISK & PROFESSIONAL NEGLIGENCE

In the real world there is risk in everything. The only sure way of taking absolutely no risk is to do absolutely nothing! The real art of engineering is balancing those risks out at levels acceptable to the client and society. It is for the client, who is suggested in our case as represented by Councillors, to decide what level of risk should be taken. It is the job of Council staff to brief the client on what the risks are in a balanced way. In some cases, different District Councils are now erring on the conservative side or trying to take no risk at all. This is understandable when one considers past history of Councils taking far too much risk and being taken to the cleaners for subdivision stability failures.

There is no doubt that the nature of work performed by a professional engineer involves a blend of skill and specialisation including a recognition that there must also be a commitment to principles and ethics. However, on occasions, these two aspects can be in conflict. There has also been an increasing emphasis on specialisation within the profession of engineering. Specialisation has brought about a change in the inter-relationships of the professions found to be working together on a project. For complex projects a matrix of relationships and responsibilities between professional persons can occur. Although specialisation can be considered to be a societal phenomenon in the thinking of the consumer it does not follow that he or she will distinguish between the level of reliance to be placed on advice from a civil engineer, as against a specialist geotechnical

engineer on a matter normally dealt with by the latter.

To the consumer, he or she is dealing with a professional engineer. The consequences in law of not distinguishing between the two may be lost in the consumer but they should never be lost on the professional engineer.

Competency has the inherent quality of currency. Competency can be equated with knowledge. The difficulty today with the complexity of professions has not diminished the need for greater emphasis on currency of professional knowledge.

6. CONCLUSION

The purpose of the accreditation propose is to establish and formalise in an impartial, professional and fair way some minimums in terms of geotechnical knowledge and experience that is acceptable to Council. Its implementation will hopefully leave a high degree of responsibility with the engineer or engineering geologist. The fundamental issue is that the Council perceives a need for a specific listing of persons qualified and experienced to act as geotechnical engineers in the Western Bay of Plenty area.

Reliance on an annual practising certificate under the Engineers Registration Act and/or the IPENZ Code of Ethics has proved to be an inadequate assurance of practitioners compliance in this specialist area. It is the view of the professional staff of the Tauranga District Council that it should be a role of professional institutions to undertake the examination and accreditation of individuals in specialised fields of engineering.

7. REFERENCES

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- NZ 4404; *Code of Practice for Urban Land Subdivision*
- The BRANZ Study Report SR4 (1987) *Assessment of Slope Stability at Building Sites*

ATTACHMENT A

TAURANGA DISTRICT COUNCIL GEOTECHNICAL PROCEDURES CRITERIA FOR APPROVAL OF QUALIFICATION OF GEOTECHNICAL ENGINEERS AND ENGINEERING GEOLOGISTS

1.0 OBJECTIVE

Council has legislative responsibility to ensure that land development and building construction are planned and executed to adequate standards.

One of the fields in which Council will need to be provided with advice is in Geotechnical Engineering which has to do with the stability of the ground in which development takes place and by which buildings and other structures are supported.

Council is concerned to take reasonable precautions to ensure that advice given to it upon Geotechnical matters, either directly or in support of development applications, or in execution of developments, is based upon sound professional training and experience.

Both formal academic training and practical experience are required in the two disciplines of Geology and Engineering but not necessarily in the same person.

Any geotechnical investigation should be oriented in the general geology and geomorphology of the area (encompassing the particular site) of which a general study demands academic training in Geology (especially geomorphology and geological mapping) and practical experience in its application to land-use planning and to engineering problems. Such regional information may be available in previous publications or reports or it may be prepared specifically for the particular development being proposed.

When it comes to designing and implementing engineering works necessary for the use of the land, then academic training and experience in Civil Engineering are necessary with particular emphasis upon soil mechanics, geotechnical engineering, engineering geology

and encompassing design, specification and supervision of construction.

Geotechnical Engineering advice includes (but is not restricted to) the functions of the "Soils Engineer" as defined by Council's Code of Practice for Development.

2.0 QUALIFICATIONS AND EXPERIENCE REQUIRED

2.1 Academic Training

The usual requirement should be a first degree from an approved university with concurrent or subsequent specialised courses in relevant subjects.

For Geological and geomorphological appraisals:-

A university degree in Geology or Earth Sciences with specialist courses in Engineering Geology and optionally Geomechanics and/or Geotechnical Engineering.

For Geotechnical Engineering:

A degree in Civil Engineering from an approved university with core subject matter in Geology and Geomechanics supplemented with specialist courses in two electives from Engineering Geology, Geotechnical Engineering, Rock Mechanics or Geomechanics.

2.2 Practical Experience

For Registration under the Engineers Registration Act 1924, 4 years advanced practical training under a mentor is required.

The same concept can be applied to Geologists and Soil Scientists who offer specialist services thus:-

A minimum of four years' post-graduate experience in Geology applied to civil engineering or to land stability evaluation, under the tutelage of a Registered Engineer or experienced Geology or Soil Science

Graduate, who has countersigned reports prepared by the applicant.

3. APPLICATIONS FOR ACCEPTANCE

3.1 Applicants for acceptance as specialist advisers shall provide:

- * evidence of academic qualification
- * evidence of tutelage from their mentor (Registration under the Engineers Registration Act, or Corporate Membership of IPENZ shall suffice)
- * A list of relevant geotechnical reports which they have prepared, stating:
 - geographic location of site
 - reference number of report
 - dates
- * copies of two reports selected from the above list and be prepared to supply further samples from the list on request.

3.2 Experience in the specific geological environment of the Bay of Plenty is required.

3.3 Apart from the applicant's academic and practical training and experience the constraints and facilities of his commercial organisation will be considered with relevance to:

- * Quality assurance facilities
- * Autonomy of decision
- * Delegation of support activities
- * Professional indemnity insurance

3.4 Applicants will be required to attend an interview in Tauranga, with a panel comprising two independent senior geotechnical professionals and a senior professional from the Council's staff.

EXPLANATORY NOTES

1.0 APPLICATION FORMAT AND CONTENT

1.1 Fee

A non-refundable fee of \$675.00 (GST inclusive) is to accompany each application

1.2 Legibility

Text should be typed wherever possible, and other material such as graphics should be of a quality to photocopy clearly.

1.3 Computer printouts

These may be submitted as part of sample reports but must be supported by sufficient explanatory notes and calculations to confirm understanding.

1.4 Qualifications and Experience

These are defined in the attached statement of criteria

2.0 FORM OF APPROVAL

2.1 Individual Only

Only individual applicants (and not firms) can have their qualifications approved.

2.2 Five Year Period

Each approval is valid for a period of five years only, after which qualifications and experience will be reassessed.

However a review could be undertaken at anytime within that period where circumstances warrant as a result of an engineering incident and on recommendation of the panel.

2.3 Limitations

Acceptance of an individual does NOT imply any approval for designs that such an individual may subsequently produce or certify.

3.0 DEFERRED APPLICATIONS

3.1 Further Information

The panel may defer an application when further information is required and the applicant will be requested to supply such information.

3.2 No Additional Fee

No additional fee is required when submitting this further information although it may be necessary to supply a new statutory declaration.

4.0 DECLINED APPLICATIONS

4.1 Explanation

Reasonable efforts will be made to explain in general terms why an application has been declined.

4.2 Remedial Advice

In some cases the panel may recommend that a declined applicant undertake particular further

training, work under a mentor, or gain more experience before re-applying.

4.3 Re-application and Fee

Anyone may re-apply at any time and this will require payment of the full fee normally chargeable at the time of the re-application.

5.0 AUTHORISED PERSONS

The Oaths and Declarations Act 1957 provides that persons authorised to witness a statutory declaration include Members of Parliament, Justices of the Peace, Solicitors, Court Registrars or Deputy Registrars.

6.0 PROCESS

The panel will recommend to the Director of Planning and Environment whether an applicant is or is not regarded as being suitable for acceptance as a specialist adviser in geotechnical engineering and/or engineering geology and with or without restrictions or conditions, as appropriate.

The Director of Planning and Environment's decision shall be final.

7.0 LIABILITY

Accreditation by the Tauranga District Council does not provide for a transfer of liability from the accredited person to the Council or the panel.

Geotechnical Issues in Land Development

Key Note Address

D K Taylor

Consulting Engineer, Auckland, New Zealand

SYNOPSIS: All land development raises some geotechnical issues. Responsibility for seeing that these issues are addressed rests with Local and Territorial Authorities in terms of the Resource Management Act and the Building Act.

The N.Z. Geomechanics Society has, over many years taken, and continues to take, a leading role in establishing the standards by which geotechnical issues are addressed. However, available knowledge and technology have been applied erratically for reasons which are political, legal, and commercial in origin. Recent developments in administration of the Resource Management and Building Acts have increased awareness of Geotechnologists to their responsibility and vulnerability.

This address reviews the range of geotechnical services and existing standards and the extent to which they are applied, and suggests how important it is that Geotechnologists, collectively, establish and adhere to more coherent and definitive standards of professional care.

1. INTRODUCTION

The fact that the N.Z. Geomechanics Society is convening this symposium and working to produce guidelines for geotechnical practice in land development must mean that the Society is concerned about present practice and is prepared to go to some trouble to improve it.

That could be a tall order for land development is a wide topic, even from a geotechnician's point of view.

What is involved?

We could include the processes of:

- Assessment of existing land use capability
- Land reshaping
- Reclamation from swamps or waterways
- Strength improvement

- Slope stabilisation.

and consider factors of:

- bearing capacity
- settlement
- slope instability
- internal pressures
- swelling and shrinkage
- erosion (surface and internal)
- Liquefaction
- earthworks control

in the converting to a new purpose, improvement or modification of land for:

- building sites and their local infrastructure
- public infrastructure (transport, water supply, waste disposal, power generation)
- recreational use

- conservation (erosion control, flood protection)

involving:

- geology
- geomorphology
- soil mechanics
- civil engineering

and for the purposes of pastoral, agricultural and horticultural production and soil science.

Pre-occupation of existing codes of practice and of the Society is with Urban Development - that is building sites and their associated infrastructure, but all of the other kinds of development may require geotechnical input to various extents.

2. AVAILABLE TECHNOLOGY

The basic tools for investigation and testing to produce data for analysis have been around for a long time but there is a continual development and refinement, notably with in situ testing and logging of physical properties.

Examination of the reaction of the ground to body stresses and external forces has been enormously facilitated by the development of computers, which has allowed analysis of more intricate theoretical mechanisms in more complex ground conditions.

The danger is that computational sophistication has outstripped the provision of valid physical data, leading to an illusion of mathematical precision in a field more heavily dependant upon judgement than any other branch of engineering.

3. THE INFLUENCE OF SCALE & PURPOSE OF DEVELOPMENT UPON GEOTECHNICAL PRACTICE

All of the available technology can be applied - at a cost.

The ability of the geotechnologist's client to pay and that client's perception of the return for the expenditure will, in the end, determine what

techniques the Geotechnologist is able to apply to a specific development.

It is the technologists function to understand and to convey to the client, the advantages, limitations and cost of the techniques available for the client to decide if they are affordable.

Major developments for buildings, infrastructure, or primary production generally employ skilled professional advice, of all sorts, including the application of sophisticated geotechnology and construction supervision, especially where the developer is the end user.

However the situation is not always so simple, and where the development is for immediate "on-sale" the professional adviser may have to fight harder to be accepted upon viable terms. It is the territorial authorities who are responsible for the enforcement, through the Resource Management Act and the Buildings Act, of standards of development, and hence for judging the quality of the professional advice depended upon by the developer - and the Local Authorities themselves.

In urban housing development the case is rather special.

The end users are people of modest financial means, who may have committed all their capital and much of their future earnings without any direct say in the way in which the land is developed, no direct contact with the professional advisers and with very limited capacity, or physical space, to deal with geotechnical failures. These people, and owners of smaller commercial developments depend heavily upon enforcement of standards by Territorial Authorities..

It is those standards, and their enforcement which continue to be a major concern of the N.Z. Geomechanics Society.

4. THE COSTS - AND WHO PAYS

B.G.C. Elwood at the 1981 Symposium on Geomechanics in Urban Planning (Ref. 1), pre-

occupied with the special issue of slope failure said:

"My fear is that all disciplines associated with the approval of land for urban purposes will exercise an increased standard of care to avoid subsequent allegations of negligencethe costs of section development are likely to soar".

"The conflict between planning objectives and engineering consideration will place increased demands upon your members to devise codes of practice which aim for an acceptably low probability factor of slope failure at an acceptably low cost factor".

He hoped that we would produce a further publication to guide urban development. His remarks can apply to geotechnology in all aspects of land development.

The geotechnologist ventures on dangerous ground in being the arbiter of what level of cost is affordable; but he/she needs to consider where the costs may fall, and needs to be objective about the degree of certainty of the results of geotechnical effort. (See Figure 1).

4.1 Costs

From the broadest community point of view the cost/benefit decisions of using, or not using, land involve complicated considerations of national and local economics, existing land ownership and use, precedents set, and political pressure, as well as the technical questions of feasibility.

From the geotechnical viewpoint costs are involved in:

- Investigation and planning of development
- Construction and precautions
- Remedying failures
- Defending legal attack
- Blame for negligence

Clearly the better the investigation and planning, the better the evaluation of construction and precautionary costs and the less the likelihood of over expenditure or failure and

blame.

The first assessment of feasibility is required of Regional Councils and then district and City Councils, in producing regional and district schemes. General information upon land resources and methods of assessment are available from the N.Z. Land Resource Inventory maps (Ref.10) and the NWASCA report of 1987 (Ref. 9).

The NZLRI maps are small scale so some examination of specific areas is necessary. For this purpose geotechnical input comprises mainly geological and geomorphological assessments which might cost in the order of \$10,000 per sq km and which are capable of producing a risk-based zoning which could be the basis of "use - don't use" decisions. In practice such decisions are not made by Councils, to my knowledge. Another use of the zoning is an indication of the varying intensities of more detailed investigations required and this is what has happened in practice. Rarely is the content of these investigations specified and this is where geotechnologists have to make a judgement.

Costs of more detailed investigations will depend upon the complexity of the sub-strata and the cost per unit area depends upon the amount of land examined in one commission. If that land is one domestic building site then it could be bearing a cost between \$2,000 and \$6,000 for an assessment.

If a calculation of slope stability is required the cost will be in the order of \$20,000. Even then the geotechnologist needs to be objective about the precision of the result and very careful about the wording of the report.

Those orders of cost, even much more, may be quite acceptable for major industrial, commercial or infrastructural developments, but generally are beyond the means of individual householders.

4.2 WHO PAYS

If the Geotechnologist does not live up to the "accepted standards of the profession" (in the opinion of the Courts advised by "experts") and a landowner suffers a loss as a result, he or she could be judged negligent and will pay - perhaps sharing some of the cost amongst colleagues in an insurance scheme after paying a significant premium.

The spread of monetary costs of damage to private property by land instability is illustrated in Figure 1. In addition there are social costs, including the mental strain which is especially significant to people of modest means, aged or otherwise physically handicapped.

Logically the cost of investigations, engineering and supervision ought to be paid by party expecting to benefit, which is the developer of the land who may be a private individual, a private or public company, or a public body. Some of the cost may be carried indirectly by the community via the Territorial Authority on the basis that there is some community benefit from the development. Current practice is to pass on to the developer the directly identifiable costs of the Authorities surveillance and approval.

5. WHAT ARE THE PRESENT TECHNICAL AND PROFESSIONAL STANDARDS

5.1 Resource Management Act 1991

The Act requires Regional Territorial Councils to consider natural hazards including:

- erosion
- sedimentation
- landslip
- subsidence

where uses such as:

- erection and modification of buildings
- excavation or other disturbance of the land
- deposition of any substance on the land
- primary production

will or may affect adversely human life, property or other aspects of the environment.

All of this applies whether the land is subdivided or not, but it is only when it is subdivided that technical standards are provided.

In Part X Clause 220, conditions of subdivision may include:

- provision be made to *the satisfaction* of the territorial authority for.... protection against erosion, subsidence, slippage, inundation... arising or likely to arise;
- filling and compaction of the land and earthworks be carried out to the *satisfaction of the Territorial Authority*.

5.2 New Zealand Standard: Code of Practice for Urban Land Subdivision: NZS 4404 - 1981

This defines a Soils Engineer as:

"a person who is currently entitled to practice as a registered engineer and has experience in soils engineering *acceptable to the Council*, or such other person as the Council may specifically approve as being competent"

and in Section 203 defines the function for which a *Soils Engineer shall* be appointed Section 204 sets out the general extent of preliminary site evaluation required.

Sections 205, 206 address planning and design and construction including soil investigation, stability criteria, quality of filling material, compaction standards for fill material. (The only section which provides quantitative standards, drawn from NZS 4431, Ref 4) erosion control, provision for services, temporary drainage, inspection and quality control.

Sections 207 provides for a final report as to the suitability of the *filled ground* and the *original ground*.

NOTE: This document pays considerable attention so *filled ground* and says very little about investigating and testing natural (original) ground, notably less about evaluating the stability of *existing slopes*.

5.3 Slope Stability in Urban Development (DSIR Information Series No. 122 Jan 1977 (Ref. 5))

Provided a general view of slope stability evaluation.

5.4 BRANZ Study Report SR4 1987, Assessment of Slope Stability at Building Sites (Ref. 6)

Sought to establish a uniform approach to the assessment of slope stability.

The respective functions of engineering geologists and geotechnical engineers are discussed without specifying their training and experience in a definitive way.

The report then goes on to describe appropriate means of investigation, testing and analysis, in both soils and rock and concludes with a damning discussion of Factor of Safety:

"Factors of safety of less than unity are frequently derived from the analysis of stable slopes, despite the rigorous investigation and testing procedures used to define the input data. Conversely, failures have occurred on slopes which, according to the analysis, using input data based on equally rigorous investigation and testing procedures, have yielded factors of safety substantially greater than unity".

So much for mathematical precision!

The report makes repeated reference to the cost

Taylor: Geotechnical Issues in Land Development

of investigations, observing that: "the scope of work may vary according to the ability or willingness of the client to pay for the level of assessment *actually required*: (sic). And "all parties should recognise that any attempt to minimise costs by reducing the scope of investigation may significantly impair the validity of the assessment".

Well, who else but the Geotechnologist can decide "the level of assessment actually required" - and who else should stand up and refuse to compromise by doing less than is "actually required" because the client can't, or won't pay?

5.5 The Building Act 1991 and The Building Regulations (Ref. 7)

The act provides for the vetting and licensing of certifiers *by the Building Authority* (Section 51 and 52) establishment of the independence of their action (Section 56 (6) and (7)) and forbids limitation of their liability. Geotechnologists may well be in the position of Certifiers.

Be warned that "buildings" under the act include:

- dams retaining more than 3m depth and more than 20,000 cubic metres volume of water
- retaining walls retaining more than 1.5 metres depth of ground (lower if there is a surcharge).

Section 36 (1) of the Act states that the Territorial Authority *shall* refuse to grant a building consent where the land on which the building is to take place is subject or likely to be subject to various defined forms of instability *unless the Territorial Authority is satisfied* that - adequate provision has been or will be made to protect the land or building or to restore damage.

Section 36 (2) provides a "let out" for the Territorial Authority in certain circumstances where the owner, in effect, accepts the risk.

Note that the Building Authority judges the

capability of Certifiers. The Territorial Authority has to be satisfied with the outcome - either by reliance upon its own staff or upon the opinion of external experts, which implies a value judgement by the Territorial Authority of the qualifications of the experts, and of the extent of their investigations.

Where then are the definitions of the appropriate qualifications and the investigations?

One Territorial Authority has embarked upon an expensive process of formal, transparent examination of the credentials of experts who put themselves forward as being competent. This is an exception for most, if not all, other territorial authorities appear to make informal judgements in private.

As to the appropriate investigations we have to look to the definitions and verification methods of Regulation B1/VM4, (subject of criticism by the NZ Geomechanic Society) which is confined to the foundations of buildings, and provides *performance* requirements and quantitative guidelines for the restricted circumstances of health and safety.

Clause 2.2.1. states that "The ground conditions at the building site shall be investigated to the *extent necessary*:"

This does not take us far towards a definition of investigation standards.

By whatever means the acceptability of experts is judged by territorial authorities there needs to be a better set of standards to judge the appropriateness of the investigations when "the scope of the work may vary according to the ability or willingness of the client to pay".

5.6 Are The Standards Being Used?

From the foregoing discussions it is apparent that there are standards, codes, or advisory documents in existence dealing with:

Land Resource Inventory (Ref.10)
Urban Land Subdivision (Ref. 3)

Earthfill for Residential Development (Ref.4)

(also adequate for most earthfills except high quality earth dams for example)

Slope stability at building sites (Ref.6)

(much of it basic to any sloping site)

Those documents may need some elaboration and "tweaking up" to latest developments but they are useful.

But are they being used?

There is a wide spread practice of territorial authorities to write their own standards or to edit the existing ones to an extent that does not seem to be justified on grounds of local geological peculiarities. There is widespread (but not exclusive) reluctance on the part of territorial authorities to adopt land use, or hazard zoning such as would result from the NAWASCA guidelines (Ref. 9).

The Building Act which sought to avoid just that proliferation is under attack with a Planning Tribunal declaration which implies that a Territorial Authority may require performance criteria additional to or more restrictive than those specified in the Building Act. The declaration is being appealed to the High Court.

In the Auckland Region at least there is a wide variation in use of codes of geotechnical practice. One local body (Ref. 8) has produced from a consultation process, a very good code. Others judge reports made to them by in-house processes not necessarily "transparent" or by calling for peer reviews from external sources.

6. WHAT HAS HAPPENED SINCE 1981?

The proceedings of the 1981 Conference (Ref.1) collect seven final papers under the heading of "What should happen". In that context what *has* happened? I would suggest that results have been erratic and less than one would have hoped.

It would require some effort to survey results

nationwide but this Conference may like to consider the following questions, in relation to 1981:

1. Is there an improved coverage of medium and large scale basic geological maps?
Are geological appraisals commonly made as part of regional or local land use planning?
2. How widespread are Urban Land Use Capability Surveys?
3. Were coherent guidelines for minimum impact development of the Upper Waitemata Harbour Catchment produced and used?
4. Were the general principles useful in other areas?
5. Have the Territorial authorities developed satisfactory systems for recognizing and recording geotechnical hazards and zoning around them?
6. Have Territorial Authorities enforced much more rigorous standards for the geotechnical evaluation of subdivisions?
7. How often are (geotechnical) problem areas identified only after they are covered with houses? Is the problem of soil shrinkage by desiccation recognised by territorial authorities.

7. WHAT WE NEED

Mr Elwood's hope that we would produce a further publication to guide development has not yet been realised, in the geotechnical sense anyway.

With one or two exceptions neither have the territorial authorities done much in that direction. Even in those exceptional cases more elaboration of the extent and content of geotechnical investigation reports is necessary, as would be apparent to anyone confronted by quite elementary deficiencies in some reports being present by professionally qualified people - and often accepted by Territorial Authorities.

If the clients "ability or willingness to pay" has ruled the day then it shouldn't. Some of those reports would never pass the standard of care of

the profession beyond a charge of negligence in the most liberal shade of informed opinion within the NZ Geomechanics Society.

The Society must formulate a view of what constitutes a reasonable standard of performance in geotechnical matters to protect its members from the pressures of the "unwilling client", their more commercial aggressive colleagues, and ultimate very expensive legal attack.

Only the territorial authorities can enforce those standards (as they are obliged by law to do) but the profession needs to formulate them.

Probably it is too much to hope for a completely standardised approach by all territorial authorities for that involves legal and political factors which the Society can affect only indirectly. But the profession would be well served by an agreement within the NZ Geomechanics Society as to the standards of care expressed as:

- The extent of investigation appropriate at various stages of land-use planning and development
- The required content of geotechnical reports
- The limitations of reliability of quantitative calculations of soil mass behaviour
- Appropriate standards of inspection during construction
- Appropriate qualifications of geotechnical experts

8. CONCLUSION

Members of this Society offer specialist services in a field which is least amenable to precise calculations, and which is recognised by the Insurance Industry as presenting the highest risk of claims of professional negligence.

Our standard of care is ill defined.

We are vulnerable to disparate opinion amongst our colleagues and to a range of different criteria applied by Local and Territorial Authorities.

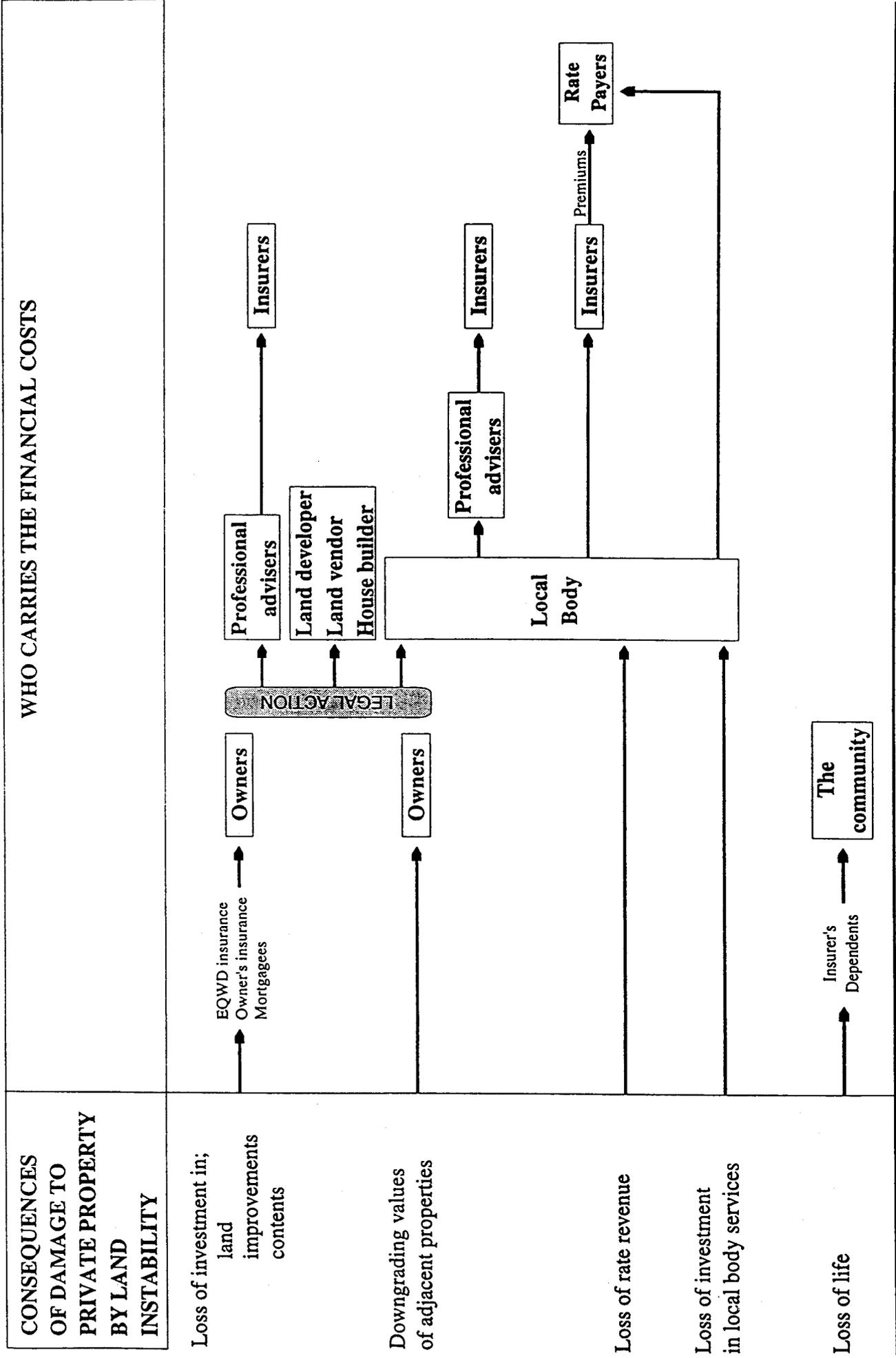
A feeling of discomfort has lead to this

Symposium 15 years after we last addressed the problem.

A more unified standard within the Society is necessary.

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5. Slope stability in Urban Development, DSIR Information Series No. 122 January 1971
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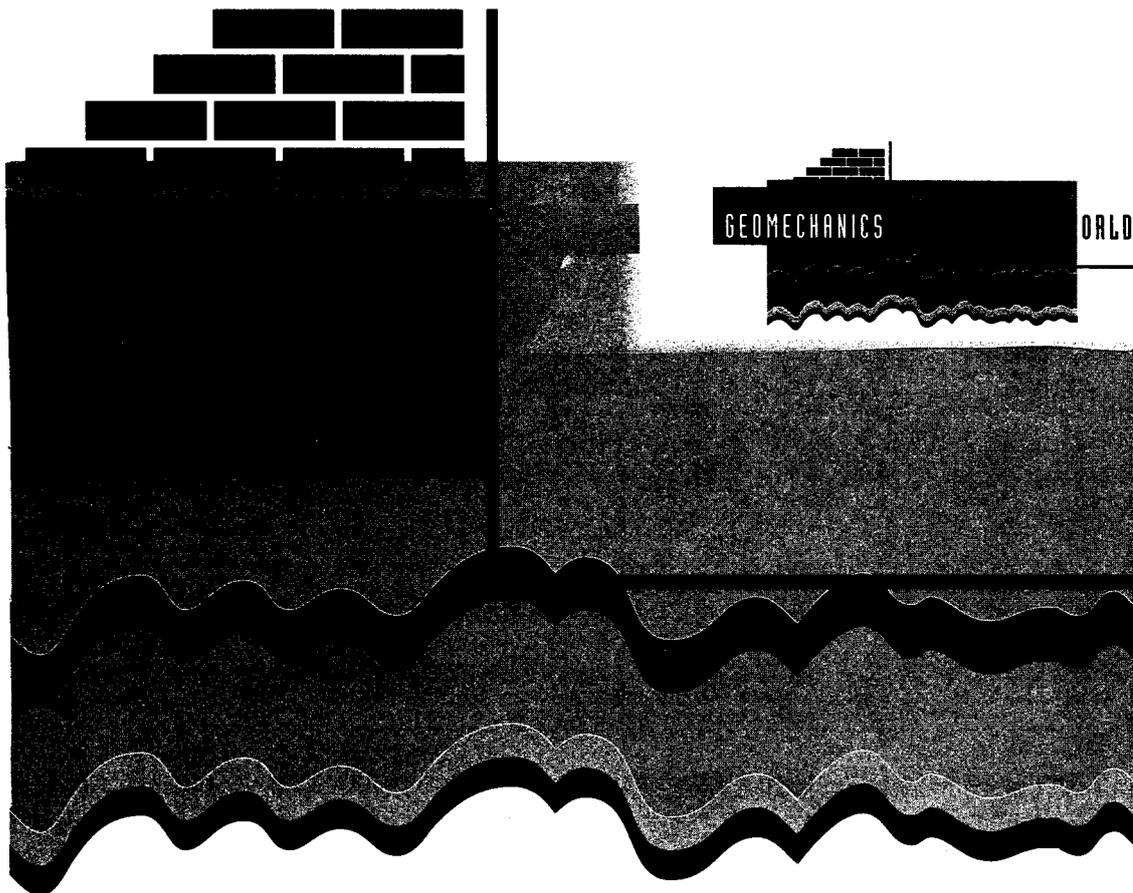


Monetary costs of landslip damage Figure 1

TECHNICAL PAPERS

- SOME ENGINEERING PROPERTIES OF A VOLCANIC SAND
- S. Pranjoto, T.J. Larkin, L.D. Wesley, & M.J. Pender
- THE TECHNICAL AUDIT OF ROCK ENGINEERING DESIGN
- J.A. Hudson
- IN-SITU BIOREMEDIATION: A COST-EFFECTIVE APPROACH FOR TREATING
CONTAMINATED SOILS AND GROUNDWATER
- R.J. Hicks, R. Harwood, D. Whyte and C.H.Nelson

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SOME ENGINEERING PROPERTIES OF A VOLCANIC SAND

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SUMMARY

Pumice sand is widespread over the central part of the North Island due to frequent past volcanic activity. The pumice has distinct properties different from that of quartz sands. The index and engineering properties are reviewed. The most significant difference from typical quartzitic sands is the grain softness of pumice. The particles are easily crushed by a finger nail. The other major difference is the void ratio, which is about twice that of typical quartz sands. This two factors are suggested as being substantially responsible for its different behaviour, as found in a series of consolidated drained triaxial tests on specimens with free end platens.

INTRODUCTION

Extensive deposits of volcanic sand are found in the central part of the North Island. Problems have been encountered when this sand has been involved in some geotechnical projects in the recent years. The very high erodibility of the pumice sand in a hydro development has led to a catastrophic failure in the region of canals and intake structure. These occurrences highlighted the unique behaviour and properties of this pumice sand, and stimulated an interest to study to the basic engineering properties and behaviour.

The distinctive property of pumice sand is the softness of the grains, which are easily crushable under only modest finger nails pressure on a glass plate. This is in contrast with quartz sand which has very high level of crushing pressure; perhaps reached at the base of large earth dams (in the order of several MPa). This difference is expected to lead to index and engineering properties of pumice sand that are different from those of quartzitic sand. As many empirical formula are derived from sand of quartzitic origin, it may be misleading to apply them to interpret test results on pumice sand.

In situ cone penetrometer tests have been widely used to obtain data for sand deposits. Various methods for interpreting cone test result are summarised by Lunne and Christoffersen [6] and Robertson and Campanella [8]. Considering the very high pressures developed around the advancing cone the possibility of grain crushing in volcanic sands is very high.

Some testing has been done to obtain the index properties, strength properties, and the stress-strain-volume change behaviour. With the newly developed K_o testing apparatus, the constrained modulus D , the coefficient of lateral stress at rest, K_o , and the slope of the normally consolidation line have also been obtained. The first two parameters will be useful to develop a mathematical model of expansion of a cavity in an infinite granular medium. Using this mathematical model, one can predict the difference of the cone penetration resistance between pumice sand and quartz sand, so that the commonly available formula to interpret cone test results for quartz sand may be calibrated to be used for pumice sand. The third parameter could be used to compare with the slope of the critical state line e - $\log p$.

BASIC PROPERTIES

Grain Size Distribution

The volcanic sand used in these tests comes from the Puni river, hence it has become known as Puni sand. It contains a small amount of impurities. Mercer No 1 sand a quartzitic material, was also tested as a direct comparison. Mercer No 1 has a very small content of pumice. They have a similar range of particle sizes in the grading curve, although the distributions are not the same. A new composition of particle sizes for test specimens (of both sands) was made by excluding particle sizes bigger than 1.18 mm and smaller than 300 μm . The proportion

of the particle sizes between 1.18 mm and 300 μm was based on the natural proportion of pumice sand in this range. The ratio of diameter of specimens (70 mm) to the maximum particle size was considered to be of a reasonable order. Figure 1 shows the grading curves for natural composition of both sands and that for the test specimens.

Grain Features

The main feature of the pumice grains is their softness. A small amount of very fine particles was collected at the end of each of the triaxial tests. Figure 2 shows the change in the grading curve from the initial specimen grading for tests under 150 to 500 kPa cell pressures. Increase in cell pressure results in more particle crushing and further shift in the grading curve.

Scanning electron microscope photographs were taken of both a pumice grain from Puni sand, and a quartz grain from Mercer No. 1 sand. Figure 3a below shows the vesicular nature of the pumice grain. This is typical for all range of sizes. The vesicles are formed in glassy igneous rocks by the expansion of a bubble of gas or steam during the solidification of the material. It is also apparent that there are internal voids trapped within each grain. The flaky grains have subangular to angular shapes. Some have a fin-like structure on the surface. All these features make it susceptible to grain breakage and crushing. Figure 3b shows the very different nature of a quartz sand grain, which is solid, subrounded shape, and hard.

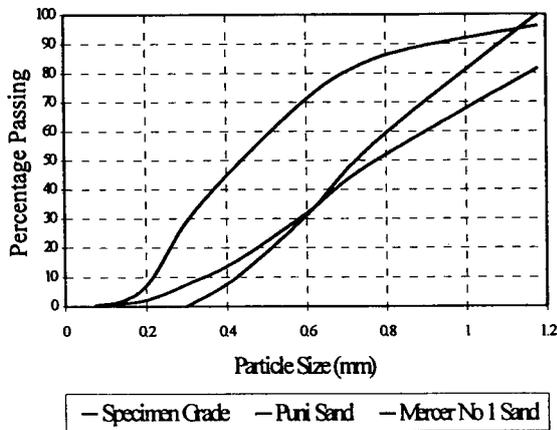


Figure 1 The natural and specimen grading curves

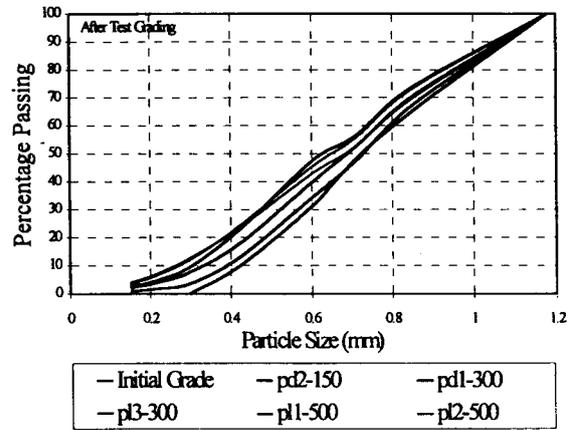


Figure 2 Grading curves initial and after test



Figure 3a Pumice grain on 710 μm sieve

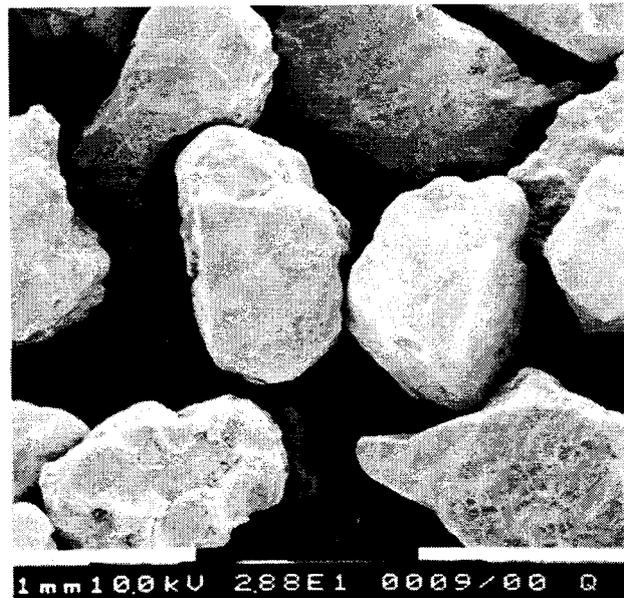


Figure 3b Quartz grain on 710 μm sieve

Specific Gravity Tests

Three series of specific gravity tests have been done on the Puni sand for each particle size range retained on the series of sieves used in determining the grading curves. The first series, which contains a small percentage of non pumiceous material, shows a clear tendency of increasing solid density with decreasing particle size, from 2.18 t/m^3 for grains on 1.18 mm sieve to 2.76 t/m^3 for grains on $75 \mu\text{m}$ sieve. As pumice is basically silica, it was expected to have an upper bound of solid density of 2.7 t/m^3 . However, for the fine particles of 75 to $150 \mu\text{m}$ size, which is beyond the range of sizes used in the specimen, G_s is found to be 2.76 t/m^3 , greater than the supposed the upper bound. This is due to the non pumice content which has solid density greater than 2.7 t/m^3 .

In the second series the impurities content was removed by a simple centrifugal technique for grain size from $300 \mu\text{m}$ up to 2.36 mm . This technique was developed as it was observed that pumice grains were light in water compared with the non pumice, some pumice even floated on the water surface. The results confirmed that larger pumice particles have a lower solid density, which implies more air trapped inside the solid. As it is very difficult to obtain pure pumice grains smaller than $300 \mu\text{m}$, the pumice grain of $1.18 - 2.36 \text{ mm}$ size were ground to break them into smaller particles. The very fine grains smaller than $150 \mu\text{m}$ were then collected and tested. The third test series of ground pumice shows a solid density of 2.48 t/m^3 for particles smaller than $63 \mu\text{m}$, which is still below the solid density of silica. Figure 4 shows the consistent pattern of the solid density vs particle size.

The reported solid density of each particle size is actually an average of the results of 3 tests done simultaneously under the same conditions. It is worth noting that the variations in results were up to 0.04 t/m^3 , which is considerably more than that of quartz based sand. This variation was also found by Galloway [3]. The nominal solid density of the samples was calculated based on the proportion and solid density of each size range in the specimen material. For the Puni sand specimen, these procedures yields a value of 2.27 t/m^3 , while for Mercer No 1 sand a G_s value of 2.58 t/m^3 was found.

Determining the specific gravity of pumice particles for each particle size range and then using a weighted average for the whole sample is an interim solution. Even using this approach, there are difficulties with the proper determination of void ratio as the standard method of determination of specific gravity requires immersion in water. The SG so determined will reflect penetration of water into the interior of the particles. If this occurs the SG value determined is not appropriate for determining void ratio which is intended to reflect the voids between the particles and not the voids within the particles. Pending a resolution of this problem the results herein were derived using the specific gravity of 2.27 determined as explained above.

Bulk Density and Void Ratio

Maximum and minimum densities of the specimens were obtained in accordance with NZS 4402, 1986 [12] and the corresponding minimum and maximum void ratio accordingly. The basic properties of both sands are summarised in Table 1. The void ratios for Puni sand are distinctly different, being about twice that of a typical quartz sand.

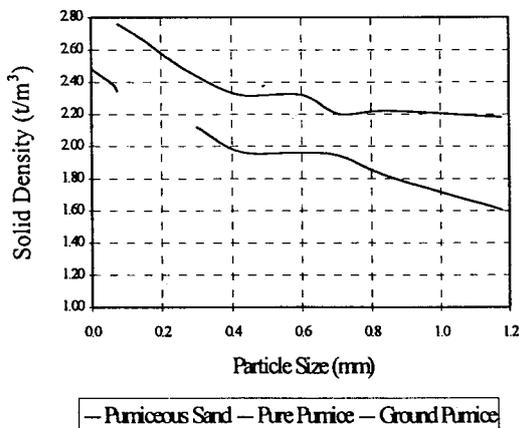


Figure 4 Solid density vs particle size

Table 1 The basic properties of the specimens

	Puni Sand	Mercer No 1 Sand
γ_{\max} (t/m^3)	0.926	1.471
γ_{\min} (t/m^3)	0.782	1.266
e_{\min}	1.452	0.754
e_{\max}	1.906	1.039
G_s (t/m^3)	2.27	2.58
d_{50} (mm)	0.73	0.73
C_U	0.741	0.741
Grain shape	flaky subangular to angular	solid subrounded

TRIAXIAL TESTING

A series of isotropically consolidated, dry, drained triaxial testing with free end platens has been carried out on both Puni and Mercer no 1 sands with 25 - 500 kPa cell pressures. These tests were done on dense and loose specimens, which were made up at the maximum and minimum void ratios. The test programme was designed to approach the critical state line both from above and below, i.e. prior to shearing some samples have void ratios larger than those at the critical state, and some others have lower void ratios.

Critical State Line

The aim of compression testing with free ends was to achieve a deformed sample in a condition known as the critical state. In this state the original structure of particles have been completely altered (Ishihara [4]), and it is achieved when the whole sample deforms homogeneously with zero volume change, zero deviatoric stress change under a constant strain rate of loading (Chu and Lo [1] ; Schofield and Wroth [11]). Developed from the idea of yield surfaces and critical voids ratio line (Roscoe, Schofield, Wroth [9]), the concept of critical state was proposed by Schofield and Wroth in 1968 [11]. This state can be achieved from any original structure and density and needs mobilisation of large strains. The critical state concept presents a unified explanation of stress-strain-volume change behaviour, although experimentally it is not easy to achieve. Hence, much discussion has occurred concerning the existence for such a state for any soil (Konrad[5], Parry [7]).

The Free Ends

Free ends were used to provide almost friction free radial expansion on the boundary of the sample. The free end was made up of an enlarged polished platen, and two layers of a rubber membrane with High Vacuum Silicon grease smeared between the membranes, and between the platen and the first membrane (Rowe, [10]; Chu and Lo [1]). The membrane was cut in a radial and circumferential fashion to lessen the constraint when it expands radially. The enlarged platen is 20 % larger than the initial sample diameter to accommodate the expanding diameter of sample as the test proceeds.

Sample Preparation

Techniques to make loose and dense specimens have been developed with reliable consistency. A dry deposition method was applied by using a small opening glass funnel to place carefully and slowly the sand at the centre of a 3 way split mould. As the funnel is raised slowly the sand will pour from the centre downward radially toward the mould at the angle of repose, and build a sand cone with the top at the tip of the funnel. When the elevation of sand in the mould has reached the required height, the surface is levelled off by a vacuum process to remove the excessive sand. The same technique is applied for a dense specimen, except that the sample is placed on a vibrating table prior to removal of the excess sand to achieve the minimum volume.

Results and Discussion

Figure 5a and 6a show that the deviator stress vs axial strain curves of Puni sand and Mercer No 1 sand have a different pattern. The peak and residual stress for Mercer sand were typically achieved at 5 - 15 % axial strain, while for Puni sand the strain was from 10 % to 50 % (even more for loose specimen under 500 kPa cell pressure, test pl6-500). A rapid and marked decrease from peak stress to residual stress is also demonstrated for Mercer sand, as opposed to a lower gradient and smaller decrease in stress for Puni sand specimens.

For the Puni specimens, some portion of the voids are actually recesses on the grain surface, while some occur between the fin-like structures on the surface. This portion is not accessible by the moving grains during the shearing process. However, it seems of no major relevance as indicated in Figure 5b and 6b that a much larger percentage of void ratio in contractive Puni sand specimens was reduced than that of Mercer No 1 sand specimens. In other word Puni sand is highly compressible, and it requires a large strain mobilisation before the peak and/or residual stress are achieved. The high compressibility is very likely facilitated by the flaky angular shaped grains, which is responsible for the high void ratio, and the softness of the grains which results in fracture during compression tests and give leads to a large reduction in the void ratio. The amount of particle crushing is not completely reflected in the shift of the grading curve as some of the fractured grains derived from angular particles will still have the same effective particle diameter.

The critical state lines are shown for both Puni and Mercer No 1 sands on the e vs $\log p'$ curves in Figure 5b and 6b. The critical state parameters for the e vs $\ln p'$ plane are derived as follows:

Puni sand: $\lambda = 0.347, \Gamma_1 = 4.400$
 Mercer No 1 sand: $\lambda = 0.119, \Gamma_1 = 2.603$

where: λ = the slope of critical state line
 Γ_1 = the specific volume at $p' = 1$ kPa
 p' = the mean effective pressure = $(\sigma_1' + \sigma_2' + \sigma_3')/3$.

The pumiceous sand results give a clearer definition of critical state line than those of the quartzitic sand. This may be due to the difficulty in achieving stable dilatative samples which expand uniformly along the height.

Compared with other sands' critical state lines (Collins et al [2]), the location of Puni sands is very remote from the other reported results. For example, Ottawa sand and Reid Bedford sand were reported as having $\lambda = 0.028, \Gamma_1 = 1.754$; and $\lambda = 0.065, \Gamma_1 = 2.014$, respectively. The slope of critical state line for Puni sand is also found to be parallel with the normally consolidated line obtained from the K_0 tests ($\lambda = 0.375$), an agreement which is expected within the framework of critical state theory (Figure 7).

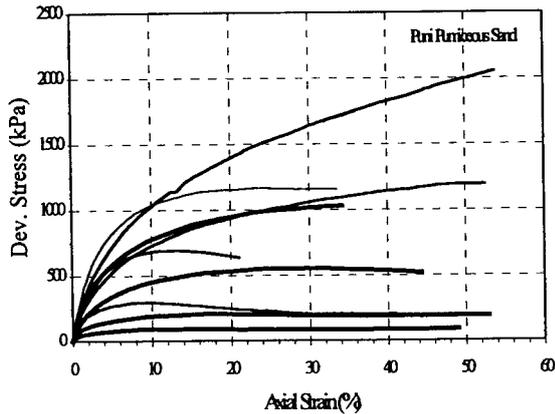


Figure 5a Deviator stress vs axial strain curves (Puni Sand Tests)

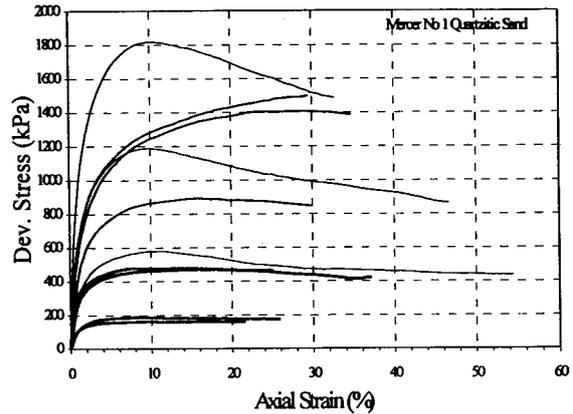


Figure 6a Deviator stress vs axial strain curves (Mercer No 1 Sand Tests)

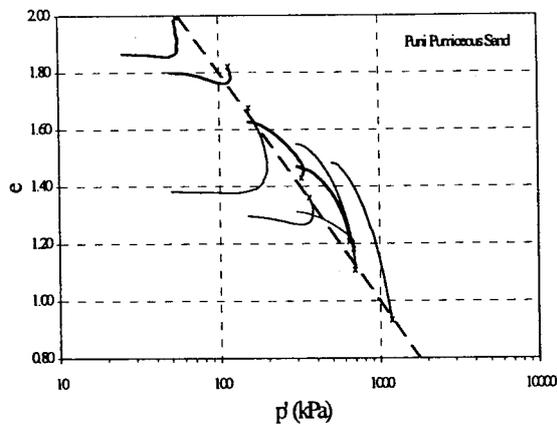


Figure 5b Void ratio e vs $\log p'$ curves (Puni Sand Tests)

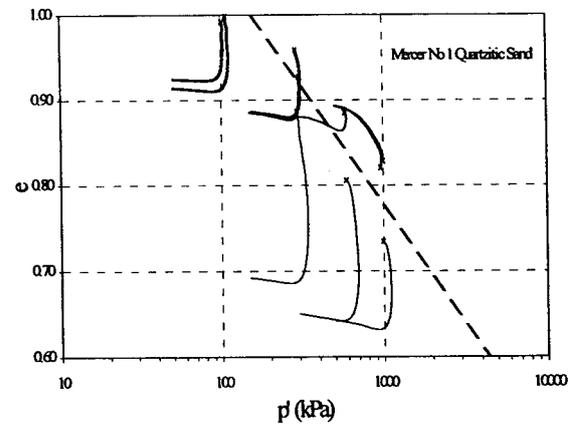


Figure 6b Void ratio e vs $\log p'$ curves (Mercer No 1 Sand Test)

Legend for Figures 5a and 5b:

— p 18 - 2 5	— p 15 - 5 0	— p 14 - 1 5 0
— p 13 - 3 0 0	— p 17 - 3 0 0	— p 16 - 5 0 0
— p d 5 - 5 0	— p d 2 - 1 5 0	— p d 3 - 3 0 0
— cs - line		

Legend for Figures 6a and 6b:

— q 15 - 5 0	— q 17 - 5 0	— q 12 - 1 5 0
— q 16 - 1 5 0	— q 11 - 3 0 0	— q 13 - 5 0 0
— q 18 - 5 0 0	— q d 3 - 1 5 0	— q d 1 - 3 0 0
— q d 2 - 5 0 0	— cs - line	

Table 2 indicates that the internal friction angle ϕ' is not solely dependent on the hardness of the grain nor the compressibility. Nevertheless the high maximum strength of Puni sand is unlikely to be utilised since it requires mobilisation of deformation beyond the range of normal engineering practice.

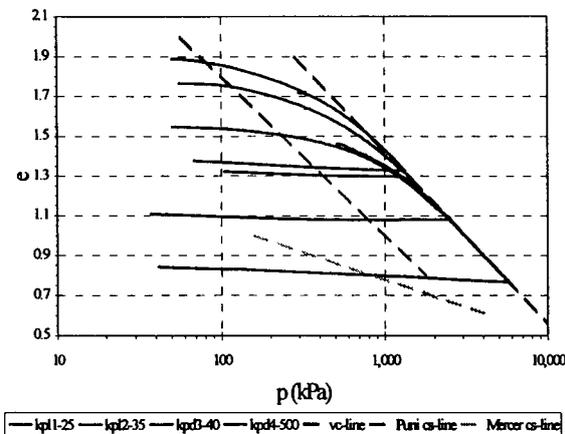


Figure 7 ϕ vs p' from K_0 test for Puni Sand

Table 2 Peak and residual internal friction angle ϕ

	Dense	Loose	Residual
Puni Sand	44	41	41
Mercer No 1 Sand	41	38	38

CONCLUSIONS

The basic engineering properties and behaviour of Puni sand has been identified. The trapped air in the “solid” grain of Puni sand results in a decreasing solid density with increasing particle size, and a high variation of the solid density results between the simultaneously conducted tests for a particular particle size range. The high compressibility of Puni sand specimens is responsible for the large strain mobilisation required to achieve the peak and residual stress. The softness and flaky angular shape of the grains are suggested as the key factors of the high compressibility. Although the Puni grain is easily crushed by finger, it has peak and residual internal friction angles greater than 40 degrees. The critical state line was also successfully determined for both sands. The one dimensional consolidation line, from K_0 tests, was found to be parallel with the critical state line.

ACKNOWLEDGEMENT

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THE TECHNICAL AUDIT OF ROCK ENGINEERING DESIGN

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ABSTRACT

In the application of rock mechanics to rock engineering design, there is now a considerable infrastructure of theoretical, numerical and empirical design techniques. However, there is currently no formal procedure by which designs can be independently audited. In this paper, the three components of such an audit are discussed. They are 1) establishing the information required to design a particular project, 2) evaluating the capability of standard analysis techniques and more advanced numerical codes in terms of the 'rock mass'-'engineering structure' in question, and 3) being able to systematically identify potential hazards and recommend their mitigation by engineering actions. These components should also be documented, so that a transparent audit trail is established.

INTRODUCTION

In many fields of engineering, there are standard procedures for validating designs and ensuring that the engineered item will indeed adequately perform the required function. Auditing procedures have been developed in these other engineering fields to ensure that the overall designs are checked, the components are manufactured according to the specifications, and the finished product satisfies the necessary quality assurance inspections. In rock engineering for civil purposes, we have not yet implemented similar auditing procedures. This is partly because the application of rock mechanics to rock engineering is still relatively young, say 40 years; it is partly because the host material on or in which the structure is built, i.e. rock, is a natural material; and it is partly because of the complexity of rock engineering projects.

So, whilst the current absence of such procedures can be explained, as we travel into the next Millennium, it will no longer be acceptable to implement designs for major projects without some form of independent audit. Whatever the skills of a client or consulting engineer, it will always be helpful and professionally responsible to conduct a formal audit of the design of such rock engineering projects, especially in circumstances where the rock mass is complex, the engineered structure is complex, or both. This will be the case for dam foundations, hydro-electric schemes, disposal schemes, etc.

The auditing and design validation process is comprised of three main steps:

- establishing the information required to design the structure;
- establishing the required analysis procedure, together with the applicability of different procedures and numerical codes; and
- establishing the hazards that are inherent in the scheme and how they can be mitigated.

In the future, it will be necessary to link in directly the environmental auditing procedures, but these are outside the scope of the current paper – which is dealing with the technical rock engineering design audit. Associated with these steps, there will be documentation procedures so that a transparent and trackable audit trail is generated. Then, even the audit itself can be checked.

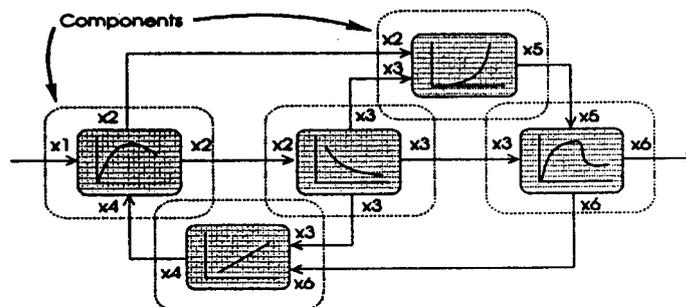


Fig. 1 The processes inherent in the behaviour of a combined 'rock mass'-'engineering structure' can be manifold and complex – as illustrated conceptually in the diagram. There will be a variety of interacting mechanisms which need to be understood individually and in combination before a rock engineering design can be developed and implemented.

The audit steps can be considered in terms of the conceptual diagram in Fig. 1. For a given proposed rock engineering structure in a given rock mass, there will be a set of physical variables and a set of mechanisms linking the physical variables in a system such as that illustrated in Fig. 1. Generally, there will be many more variables and interactions than shown above. To establish the information required to design the structure, it is necessary to know all these system components including the potential engineered components.

To establish the required analysis procedure and the applicability of different procedures and numerical codes it is necessary to consider whether the analysis and the numerical codes adequately capture the essence of the variables and interactions in the system. As yet, there has been no auditing procedure developed to accommodate this need.

To establish the hazards that are inherent in the scheme and how they can be mitigated, the stability of the 'rock mass'-'engineered project' has to be assessed. Are there any pathways of mechanisms which can cause major instability and lead to collapse? What are the hazards associated with the particular scheme? Is one sequence of engineering operations likely to induce instability, whereas another sequence would avoid this possibility? Can simple engineering operations significantly mitigate the possibility of the major hazard identified?

This paper is an introduction to the subject of auditing rock engineering projects in line with the requirements discussed above. As projects become larger, more imaginative and more complex, more expensive, and subject to more stringent auditing requirements, it is perhaps surprising that currently we have no method of formally auditing the design of rock engineering projects and the hazards associated with them. It is a professional requirement that we should have a capability to conduct an independent audit of a design, particularly by being able to audit the information required, audit the design procedures and computer codes, and audit the hazards that could occur together with proposed mitigation measures.

AUDITING THE INFORMATION REQUIRED FOR DESIGN

Imagine that a slope in a dry hard rock is being designed, such as the one illustrated in Fig. 2.

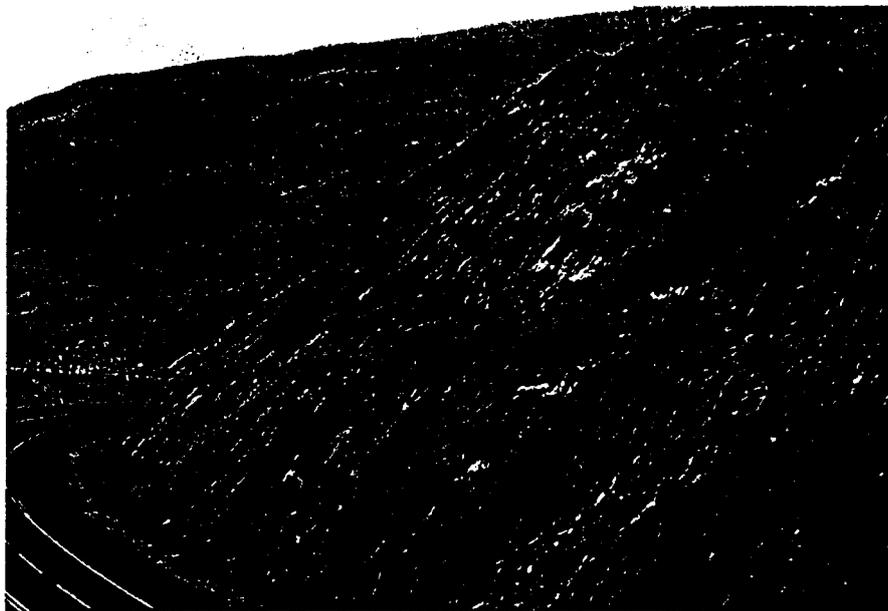


Fig. 2. Rock slope in Scotland on the A82 trunk road.

The design of the slope can be adequately established using the recognized techniques for avoiding slope instability due to plane, wedge and toppling failure of rock blocks delineated by existing discontinuities [1,2]. The slope design is developed in order to avoid the possibility of kinematically admissible blocks or to inhibit failure with support. Then, only the relative geometry of the discontinuities and the slope (dips and dip directions) and the friction angle are necessary for the analysis. For the slope in Fig. 2, the slope was altered as the azimuth of the road changed and the possible occurrences of plane and wedge failure changed. The type of analysis procedure for this case can be graphical, as shown in Fig. 3 [2].

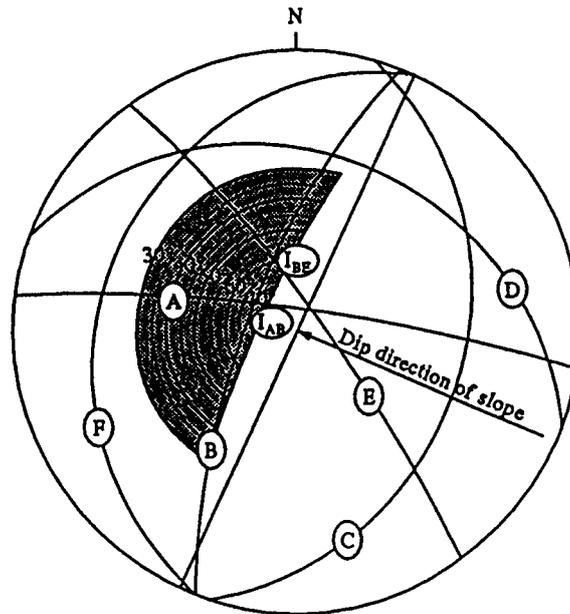


Fig. 3. Analysis of wedge failure using the stereographic projection technique, the geometry of the discontinuities, and the slope (dips and dip directions), and the angle of friction.

Similarly, one can consider all the basic techniques of rock mechanics which are generally used, such as estimation of the stress concentration around openings and rock mass classification techniques [2,3]. The information required to support these analyses and methods is well defined and built into the procedures. The auditing question is whether this information is sufficient, especially when the design becomes more complex, say in moving from a machine hall cavern to a cavern for storing pressurized gas. In a survey of papers on the design of different projects, the items listed in Fig. 4 were found to have been used [2].

WATER PRESSURE TUNNELS IN HYDROELECTRIC SCHEMES	LARGE UNDERGROUND CAVERNS	RADIOACTIVE WASTE REPOSITORIES
<i>In situ</i> stress	Depth of cavern	<i>In situ</i> stress
Discontinuity persistence	Discontinuity orientation	Induced displacements
Topographic factors	<i>In situ</i> stress	Thermal aspects
Presence of faults/folds	Presence of faults	Discontinuity geometry
Location of tunnel	Rock type	Permeability
Discontinuity aperture	Discontinuity frequency	Time dependent properties
Rock mass geometry	Discontinuity aperture	Elastic modulus
Discontinuity fill	Pre-existing water conditions	Compressive strength
Tunnel water pressure	Intact rock elastic modulus	Porosity
Pre-existing water conditions	Rock mass elastic modulus	Density

Fig. 4. Items considered in the design of different rock engineering schemes.

So, even if the design apparently only involves a standard form of design procedure, it is still necessary in a formal audit to ensure that 1) all the relevant physical variables and mechanisms have been identified, 2) that their combined operation has been accounted for in the design, and 3) that a hazard analysis has been conducted.

AUDITING NUMERICAL CODES

If the system of variables and mechanisms conceptually illustrated by Fig. 1 has been identified and it is intended to use a numerical code for the analysis, how does one know that the numerical code covers the system space desired, i.e. all the mechanisms defined by the physical variables involved in the system have been modelled? This is a separate audit to whether the code is internally operating correctly. The audit is to establish whether the code is adequate to analyze the problem.

Because of the relatively recent history of computer analysis for rock engineering, very little has been done to co-ordinate information on numerical codes. A start has been made by the Decovalex project [4] which is spearheaded by Professor Stephansson and stimulated by the need to have advanced thermo-hydro-mechanical codes for the study of radioactive waste disposal. The word Decovalex is an acronym for the DEvelopment of COupled models and their VALidation against EXperiments. An example of the type of information being co-ordinated by this project is shown in Fig. 5.

Code	Fluid flow equation	Explanation of terms
THAMES (Equivalent permeability tensor by crack tensor approach)	$\frac{\partial}{\partial x_i} \left(\frac{r_i k_{ij} \partial h}{\mu} \right) - \rho_m \theta S_i \rho_i \beta_p \frac{\partial h}{\partial t} - \rho_i C(\Psi) \frac{\partial h}{\partial t} - \rho_i S_i \frac{\partial}{\partial x_j} \left(\frac{\partial h}{\partial x_j} \right) + \rho_m \theta S_i \beta_i \frac{\partial T}{\partial t} = 0$ The permeability tensor: $k_{ij} = \frac{1}{3} (P_{ij} \delta_{ij} - P_{ij})$ (see Table 6.1 for P_{ij})	r_i —ratio of relative permeability in unsaturated area to the permeability in saturated area, θ —porosity of the fractured medium, β_i —thermal expansivity of fluid, β_p —compressibility of fluid, $C(\Psi)$ —specific fluid content, h —total hydraulic head, T —temperature, P —pore pressure, S_i —degree of saturation, g —gravity acceleration, μ —dynamic viscosity of fluid
MOTIF (Fluid flow through both poroelastic medium and fractures)	<i>For poroelastic medium</i> $\frac{\partial(\rho_i \zeta)}{\partial t} + \frac{\partial(\rho_i \eta)}{\partial x_i} - \rho_i Q_i = 0, \quad \zeta = E_{pm} U_{ij} \epsilon_{ij} + \frac{\Delta P}{M} - \frac{\theta}{\rho_i} \frac{\partial \rho_i}{\partial T} \Delta T$ <i>For fracture flow</i> $(\rho_i E_{pm} U_{ij} \epsilon_{ij}) \frac{\partial \epsilon_{ij}}{\partial t} + (\theta \epsilon_{ij}) \frac{\partial \rho_i}{\partial P} (\rho_m g) \frac{\partial h}{\partial t} + (\theta \epsilon_{ij}) \frac{\partial \rho_i}{\partial T} \frac{\partial T}{\partial t} - \frac{\partial}{\partial \zeta} \left(\epsilon_{ij} \rho_i \frac{k_{ij}^* \rho_m g \partial P}{\mu} \frac{\partial P}{\partial \zeta} \right) - \rho_i \epsilon_{ij} Q_i - M_i = 0$	M —Biot's isothermal hydroelastic constant, q_i —Darcian velocity vector, ζ —change in volumetric fluid content per unit volume, ϵ_{ij} —mechanical aperture, ϵ_{ij} —hydraulic aperture, ζ_i —coordinates along the fracture plane, M_i —net mass flux from solid matrix, k_{ij}^* —permeability tensor of solid matrix, Q_i —source term of fluid
CASTEM 2000	$\frac{\partial}{\partial x_i} \left\{ -k_{ij} \left[\frac{\partial h}{\partial x_j} + \left(\frac{\rho_i}{\rho_m} - 1 \right) \frac{\partial z}{\partial x_j} \right] \right\} + \frac{\partial \theta}{\partial t} = 0, \quad k_{ij}^* = \frac{\rho_m g}{12\mu} (\epsilon_{ij}^* + \Delta \epsilon_{ij}) \delta_{ij}$	z —geodetic head, k_{ij}^* —permeability tensor of rock matrix, ϵ_{ij} —mechanical aperture in l -principal direction, ϵ_{ij}^* —initial mechanical aperture
ROCMAS	$\frac{\partial \phi}{\partial t} - \frac{\epsilon_{ij} \delta_{ij}}{\rho_m} \frac{\partial(\rho_i)}{\partial t} = \frac{\partial}{\partial x_i} \left[\frac{\beta_i}{\rho_m \mu} k_{ij} \left(\frac{\partial P}{\partial x_j} + \beta_i g \frac{\partial z}{\partial x_j} \right) \right], \quad \phi = \frac{\beta_i}{\rho_m} \delta_{ij} \epsilon_{ij} + \frac{\beta_i P}{\theta} + \frac{\beta_i T}{\theta}$	z —coordinate in z -direction of a (x, y, z) frame $\beta_i = \rho_m + \beta_i(T - T^*) + \beta_i(P - P^*)$ —fluid density as functions of both temperature and pressure
HYDEF (FEM code for linear and non linear transient and steady state fluid flow through porous media and fractures)	<i>For porous media</i> $\frac{\partial}{\partial x_i} \left(k_{ij} \frac{\partial h}{\partial x_j} \right) = \Pi \frac{\partial h}{\partial t} + \frac{b}{K^*} \frac{\partial P}{\partial t} - b \dot{\epsilon}_{ij}^*$ with $\Pi = \left[\frac{\theta^*}{K^*} + \frac{(1 - \theta^*)}{K^*} + \frac{b^2}{K^*} \right] \gamma_i$ and $h = -\frac{P}{\gamma_i} + z$ <i>For fractures (Darcian flow)</i> $k = \frac{\epsilon_{ij}^* \rho_m g}{12\mu} [1 - \beta_i(T - T_0)] [1 + \nu(T - T_0)]$ $\dot{\epsilon}_{ij} = \dot{\epsilon}_{ij}^* + \Delta \epsilon_{ij}$	ρ_m, μ —initial density and viscosity of the fluid k —fracture permeability $\epsilon_{ij}^*, \epsilon_{ij}$ —current and initial mechanical aperture T, T_0 —current and initial temperature γ_i —bulk fluid weight k_{ij} —permeability tensor of porous medium P, P^* —pore pressure and total mean pressure [$= -tr(\sigma)/3$] θ^*, b —connected porosity and Biot coefficient $\epsilon_{ij}^* = tr(\epsilon^*)$ —volumetric non elastic strain K^*, K^*, K^* —modulus of compressibility of fluid, solid grains and the skeleton, respectively
UDEC (Flow through fractures only)	<i>Darcian flow along fractures by parallel plate model</i> $q = \frac{(\epsilon_{ij}^* + u_{ij})^3 (\Delta P / L^*)}{12\mu}$ $P = P^* + R_i Q_i \left(\frac{\Delta V}{V} \right) - R_i \left[\frac{2(V - V^*)}{V + V^*} \right]$	q —flow rate along fractures ϵ_{ij}^* —initial hydraulic aperture u_{ij} —net normal displacement at contacts ΔP —pressure difference between adjacent domains R_i —bulk modulus of fluid V —domain volume at current time step V^* —domain volume at previous time step Q_i —sum of flow rate into the domain from all surrounding contacts Δt —time step, L^* —contact length

Fig. 5. Example of fluid flow information used in modern numerical codes [from 4].

The purpose of the audit being discussed here is not the correctness and validity of the code *per se* but whether the code actually contains the variables and mechanisms which have been identified as the components of the 'rock mass'-'engineered structure' system. If the numerical code does not contain some of the variables and mechanisms inherent in the required analysis, then one has to conclude that the code will not represent the system - unless it can be shown that the code does indeed capture the essence of the system adequately for engineering purposes.

In Fig. 6, there is an example of an interaction matrix with ten variables and the interactions considered most important for characterizing a typical rock engineering system. By considering to what extent any particular code overlays this ideal, both in terms of the matrix components and the actual operation of the code when it is internally coupled, the adequacy of a specific numerical code can be evaluated. This type of auditing work is just now being developed and it is anticipated that it will be utilized as a full auditing tool.

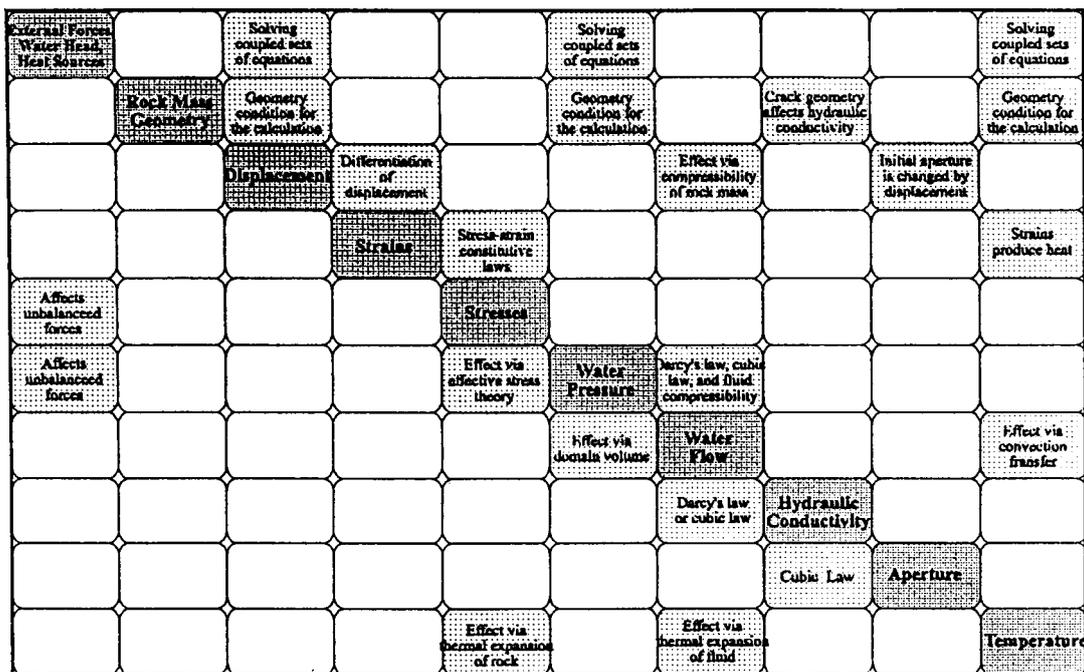


Fig. 6. Establishing the variables and linking mechanisms necessary to capture the essence of a rock engineering design problem (variables along the leading diagonal, mechanisms as the off-diagonal terms, clockwise influence convention).

AUDITING HAZARD PREDICTION AND MITIGATION

Unless the components and interactions in the 'rock mass'-'engineered structure' system are identified, it is not possible to conduct an assessment of potential hazards. The type of slope stability analysis illustrated in Fig. 3 can be used to evaluate the stability of the slope in Fig. 2 in terms of wedge failure. But are there any other types of failure possible? Certainly, plane and toppling failure can be similarly evaluated. But can rock deterioration affect the stability? What happens when it rains? Could water pressure in rock fractures induce failure? Can a freeze-thaw cycle induce failure? Can repeated freeze-thaw cycles over twenty years induce failure? Can 40-tonne trucks travelling on the road cause fatigue failure over a twenty year period? It is only by knowing the mechanisms and the chains of concatenated mechanisms in the system that one can hope to answer such questions.

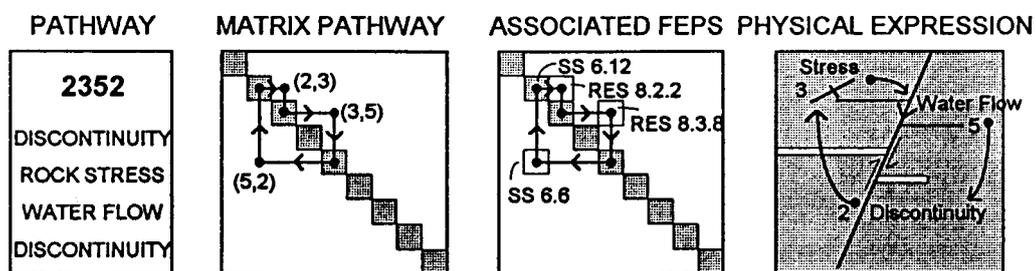


Fig. 7. Studying pathways of mechanisms for hazard analyses – in this case how movement on a discontinuity can affect the rock stress, which can then affect the water flow, which can then cause the discontinuity to move further. The FEPs numbers are the Features, Events and Processes numbers from lists of system features (from Eng et al. [5]).

Fig. 7 shows an example of this pathway analysis, involving a feedback loop starting at the second variable, discontinuity, in the interaction matrix of variables and interactions. The loop travels via mechanisms linking the discontinuity, rock stress and water flow variables back to the discontinuity variable.

If the structure of the system is known, all such feedback loops can be systematically printed out using graph theory techniques. If a variable is subjected to a perturbation induced by engineering, the perturbation can travel around the mechanism loop back to the source of the disturbance. If the perturbation is magnified by the suite of linked mechanisms in the loop pathway, it is known as positive feedback (as opposed to negative feedback when the perturbation attenuates). The perturbation can then travel around the loop again, be magnified further, and continue looping through these mechanisms and running out of control. Major hazards occur when such feedback loops run out of control. Slope failures and rockbursts are good examples of this positive feedback. A dam example is given in [7]. Thus, all such feedback loops can be systematically studied to identify potential hazards. The presence or absence of positive feedback loops is what governs the stability of a site, both as a result of geological disturbances and of engineering disturbances.

When hazardous feedback loops of mechanisms are identified, the system structure can be studied to see the engineering actions that can be taken to inhibit the mechanism pathway. Usually, this will be by changing the orientation, dimensions, waterproofing, grouting, bolting, and supporting. A more subtle problem arises when the construction is only partially complete and a new and temporary loop occurs that is unstable. It is intended in the design that the completed structure will be resistant to perturbations, but the half-engineered structure may not be. This can also occur in architectural design when the completed building would be resistant, but the half-completed structure collapses.

AUDIT DOCUMENTATION PROCEDURES

In line with ensuring a transparent audit trail, it is essential to have suitable documentation. The type of form shown in Fig. 8 is being developed to formalize the auditing procedures and to provide such an audit trail. This is an example of one of the forms, in this case for specifying the variables to be used in the study analogous to the leading diagonal terms of Fig. 6.

As examples of the different variable sets used (which can be at different analysis resolution), the following lists are included. Depending on the purpose of the project and the purpose of the analysis, different variable sets are used. The sets below are for analysis at a coarser resolution than that used for numerical analysis. Larger sets could be developed for a more comprehensive analysis than that used by numerical analysis (cf. Figs. 5 & 6).

A Six Variable Dam System (in [7])

Dam Weight	Water Height
Rock Permeability	Water Pressure
Normal Displacement	Tangential Displac.

A Nine Variable Radioactive Waste System (in [5])

Host Rock	Discontinuities
Rock Stress	Construction
Water Flow/Migration	Heat
Backfill	Canister
Waste	

A Nine Variable Pressure Tunnel System (in [7])

Rock Stress	Induced Stress	Rock Strength	Discontinuity Strength
Water Pressure	Water Leakage	Radial Displacement	Fracture Aperture
Tunnel Diameter			

PROJECT NAME:		ESTABLISH PROJECT VARIABLES, AND THEIR UNITS IF APPROPRIATE	
FORM x.y		VERSION NUMBER: <input type="text"/>	
<i>Note: This QA form is only valid when all items below have been completed.</i>			
A1. What is the name of the system/sub-system?			
A2. Have the state variables been discussed?		Yes <input type="checkbox"/> No <input type="checkbox"/>	
<i>Remember to insert version number at the top right of form</i>			
B. List the main personnel (and their affiliation) who have discussed the state variables <i>If more than four, list the main four here and the complete list in the supporting material</i>		1.	
		2.	
		3.	
		4.	
C. Date(s) of state variables discussion(s)			
D. How many state variables have been chosen?			
E. If appropriate, have units for the state variables been chosen?		Yes <input type="checkbox"/> No <input type="checkbox"/>	
F. Are the units of the state variables compatible?		Yes <input type="checkbox"/> No <input type="checkbox"/>	
G. If appropriate, have the state variables ranges been estimated?		Yes <input type="checkbox"/> No <input type="checkbox"/>	
H. Has the definition of the state variables been included in the supporting material?		Yes <input type="checkbox"/> No <input type="checkbox"/>	
I. Have any difficulties been encountered? (If so, these must be explained in supporting material)		Yes <input type="checkbox"/> No <input type="checkbox"/>	
J. FORM COMPLETED BY:		DATE:	
K. FORM COMPLETION CHECKED BY:		DATE:	
L. COMPUTER FILE NAMES FOR FORM AND SUPPORTING MATERIAL		PRO13A01.DOC & PRO13B01.DOC	
M. WHERE ACTIVE FILES HELD:			
N. WHERE BACK-UP & HARD COPY HELD:			

Fig. 8. Example of the type of audit documentation forms that will be required [9].

Underground Excavations (in[8])

Excavation Dimensions	Rock Support	Excavation Depth	Excavation Method
Rock Mass Quality	Fracture Geometry	Rock Mass Structure	<i>In Situ</i> Stress
Intact Rock Quality	Rock Behaviour	Fracture Aperture	Hydraulic Condition

Stockholm Ring Road Tunnelling ([9])

Rock Type	Slope/Trench Geometry	Tunnel Anchoring	Rock Stress Grouting
Rock Deterioration	Discontinuities	Excavation Damage	Support Degradation
Rock Quality (Q)	Rock Reinforcement	Perturbations	Rock Permeability
Tunnel Support			

and, for hazard analysis, these were reduced to

Rock Strength	Fracture Geometry	Grouting	Bolting
Water Inflow	Slope Failure	Construction	

CONCLUSIONS

In this paper, the technical auditing of rock engineering design has been addressed. It has been noted that currently there is no such capability. The auditing is, however, a professional requirement and increasing importance will be attached to having independent auditing procedures as we enter the next Millennium. Rock engineering projects are becoming larger, more imaginative, more complex, and more expensive.

There are three main auditing components: auditing the information required, auditing the analysis techniques and numerical codes; and conducting hazard assessments. There is a fourth component when the documentation procedures are included. When an audit of this type is completed, there is a transparent audit trail created so that the professional audit requirement is seen to be satisfied. Some aspects of the subject have been discussed and the essence of the procedures described.

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IN SITU BIOREMEDIATION: A COST-EFFECTIVE APPROACH FOR TREATING CONTAMINATED SOILS AND GROUNDWATER

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ABSTRACT

In situ bioremediation is a technically feasible and cost-effective method for the amelioration of soils and groundwater contaminated with many organic compounds. It is particularly attractive at sites where excavation is not possible and where pump and treat options are considered prohibitively expensive due to the length of time required to effectively remove contaminants of low solubility. The ultimate goal of bioremediation is to destructively remove the contaminant by converting it to microbial biomass (bacteria) and harmless by-products of metabolism such as carbon dioxide, water, and inorganic salts. This paper describes and discusses a case history where *in-situ* bioremediation was used to remediate both soils and groundwaters contaminated with non-volatile petroleum hydrocarbons. The remediation system was installed at a truck maintenance facility in Colorado, USA. The remediation system was effective in treating over 16,000 kg of contaminant within a 3 year period with closure being achieved approximately 13 years earlier than predicted using pump and treat technology.

KEY WORDS

Bioremediation, *In-situ*, Hydrocarbons, Oxygen Sources, Carbon Dioxide Monitoring, Vadose, Groundwater

1 INTRODUCTION

1.1 Historical Background

Used motor oil, diesel, gasoline, and automotive maintenance fluids that were released to a used oil sump during maintenance operations at a truck maintenance facility were the source of the subsurface contamination. The used oil sump was in operation for approximately 29 years until its removal in 1988. During this period, the compounds listed above impacted soils and groundwater surrounding the used oil sump. Soil and groundwater assessment activities were initiated in September 1987. Groundwater Technology, Inc. was hired in March 1988 to complete the assessment activities and initiate remediation selection activities in September 1988.

The site is underlain at a depth of about 10.6 meters (m) by interbedded claystone and sandstone bedrock of the Denver Formation. This unit is comprised of siltstone, sandstone, conglomerate, and claystone. Overlying the bedrock are recent alluvial sands and gravels deposited in the South Platte River floodplain. These floodplain deposits are dense, interbedded, and average about 7.5 to 8 m thick. A layer of stiff, very sandy and silty clay ranging in thickness from 1.2 to 3 m rests on the sand and gravel (Rocky Mountains Consultants, Inc., 1987).

The principle aquifer impacted at this site is found within the interbedded alluvial sands and gravels. Indications from surface topography, present drainage, and the water levels encountered during initial drilling, suggested that groundwater flow is north northeast, roughly parallel to the flow direction of the South Platte River 30 m east of the site with groundwater levels occurring at approximately 4 m below ground surface.

1.2 Site Assessment

Assessment activities at the site resulted in the installation of nine monitoring wells (MW 1-9) as shown in Figure 1. MW-2 was abandoned and replaced by MW-2A during client initiated construction activities. The monitoring wells were installed to approximately 7.6 m in depth with 100 mm diameter PVC casings and a screen interval from 4.6 to 7.6 m. Analytical results from the initial soil and groundwater assessment are presented in Table 1. An estimate of the lateral extent of waste oil and gasoline impacted groundwater is shown in Figure 1. Groundwater samples collected from MW-8 located near the former used oil sump contained the highest levels of benzene, toluene, ethylbenzene, and xylene (BTEX) and total petroleum hydrocarbons as gasoline (TPH) with relatively low but detectable levels of chlorinated organics. Total Oil and Grease (TOG) measurements ranged from phase separated product in MW-8 to below detection levels (BDL) in perimeter wells. Analysis of soil samples taken during the installation of MW-8 showed relatively low concentrations of BTEX and TPH, but relatively high concentrations of TOG.

Groundwater samples collected from monitoring wells MW 2-8 were also analyzed for ammonium, nitrate, nitrite, phosphate, potassium, pH, and background bacterial levels. Results of these analyses indicated detectable levels of potassium only and pH levels near neutral (pH = 7). Initial bacterial population densities were relatively high with total hydrocarbon utilizers ranging from 10^3 - 10^5 Colony Forming Units (CFU) per ml and total background heterotrophs ranging near 10^5 CFU/ml as measured by standard plate count methods.

Initial mass balance estimates indicated that approximately 272 kilograms(kg) of hydrocarbons were located in the zone of groundwater fluctuation and approximately 11,700 kg of hydrocarbons existed in the unsaturated and saturated sediments located beneath the former used oil sump. Impacted soil estimates were generated by assuming a 18.2 m radius by 30 cm thick soil volume with an average concentration of 500 mg/kg located beneath the former sump in the zone of groundwater fluctuation and a 9.1 m radius by 5 m column of soil located directly beneath the former sump with an average concentration of 5,000 mg/kg. These estimates were based on analytical results from initial soil borings and supported by analytical results from soil borings taken during the course of the project. Mass balance estimates for groundwater indicated that significantly less hydrocarbon mass (0.14 kg) existed in the dissolved phase. This estimate is expected based on the low solubilities of hydrocarbons in water. This analysis directed the target of the remedial efforts towards the partially saturated and unsaturated impacted sediments which were the source zones for groundwater contamination.

The results of the initial site assessment were summarized as follows:

1. The primary contaminant of concern was waste oil located in the saturated and unsaturated sediment beneath the former used oil sump;

2. Waste oil is relatively nonvolatile, immobile in soil, and inherently biodegradable (Atlas, 1981);
3. Chemical and microbiological analysis indicated that a relatively large population of hydrocarbon utilizing bacteria existed within the zone of contamination, perhaps under limiting nutrient and oxygen conditions;
4. Groundwater occurred at a relatively shallow depth (4 m) in sediments (sands and gravels) that appeared to be relatively permeable; and
5. The extent of groundwater contamination was delineated with impacted groundwater samples showing high levels of BTEX, TPH, and TOG with localized but detectable levels of chlorinated organics beneath the former sump.

These observations, along with the client's need to minimize any disruption to on-going truck maintenance activities, suggested that an in-situ bioremediation system may be appropriate. Therefore, a feasibility study was conducted to test the applicability of using *in-situ* bioremediation and determine mass transport limitations that may be encountered.

The results of the feasibility testing are shown in Table 2. The biodegradation study indicated that significant degradation of the contaminants could be achieved if adequate nutrients and oxygen were supplied.

The results of column studies indicated that hydrogen peroxide (the oxygen source) was very reactive with samples from the 2.5 m depth, reactive with samples from the 5.5 m depth, and moderately reactive with samples from the 3.9 m depth. In addition, the sample from the 2.5 m depth showed an 80 percent reduction in hydraulic conductivity perhaps due to the rapid decomposition of hydrogen peroxide causing small oxygen bubbles to accumulate in the pore spaces of the soil matrix. Results from the 5.5 and 3.9 m samples indicated no change in hydraulic conductivity.

Based on these observations, as well as the fact that high levels of the contaminant were found in the 3.9 m zone, it was determined that an in-situ bioremediation system would be installed with the primary loading of the nutrients and hydrogen peroxide solution occurring at the 3.9 m interval.

1.3 Remediation System Design

The results of the site assessment indicated that the primary targets for the in-situ bioremediation system were sorbed hydrocarbons in unsaturated and saturated sediments located beneath the former used oil sump area and, to a lesser extent, dissolved hydrocarbons in groundwater located beneath and surrounding the maintenance building. Small amounts of phase separated product also existed on the groundwater beneath the former used oil sump area.

Once the impacted subsurface areas were identified, an in-situ bioremediation system was designed, taking into account the results of the laboratory biofeasibility study and the site assessment. The primary basis of the remediation system design was to maximize the transport of oxygen and inorganic nutrients into saturated and unsaturated sediments in the hydrocarbon impacted area to stimulate in-situ bioremediation. A schematic drawing of the in-situ bioremediation system is presented in Figure 2. The primary functions of this system include the following:

- i) Groundwater recovery, treatment, and reinjection;
- ii) Vapor extraction and discharge;
- iii) Stimulation of in-situ bioremediation by subsurface inorganic nutrient and oxygen additions; and
- iv) Phase separated hydrocarbon recovery.

A vapor extraction pilot test was performed to establish radial influence of the vapor extraction system and design parameters for full scale implementation.

Percolation rates and predicted lateral distribution of dilute inorganic and hydrogen peroxide solutions were determined using the assumption of a 3.7 m radius of influence at the water table interface. This information was used as the basis for the spacing of the injection points.

Design of the groundwater system focused on increasing the hydraulic gradient and the rate of transport of dissolved oxygen and nutrients through the zone of contamination through groundwater pumping, nutrient amendment, and reinjection. A 72 hour aquifer pump test was performed to generate aquifer data for groundwater modeling. The results of this modeling (using CPS and DREAM) indicated that one recovery well located near RW-1 and pumping at a rate of 37.8 l/m would induce a sufficient hydraulic gradient and provide sufficient hydraulic capture of injected nutrients and dissolved hydrocarbons.

2 RESULTS AND DISCUSSION

2.1 Groundwater Results

Figures 3, 4, and 5 present results from the nutrient and hydrogen peroxide injection program. Dissolved oxygen measurements show a consistent trend with high levels (10 ppm) near the nutrient gallery and decreasing but measurable values as groundwater migrated toward the recovery well. The observed low concentrations of dissolved oxygen especially near the area of highest contaminant concentrations (MW-1 and MW-8) may have been due to high rates of bacterial consumption associated with hydrocarbon metabolism. Representative ammonia-nitrogen and phosphate monitoring results are presented in Figure 4 which show relatively high levels (10 ppm) of ammonia-nitrogen and phosphate existed across the area of groundwater contamination in May 1991 as required for a successful bioremediation program. Figure 5 presents groundwater analytical data for MW-2A through March 1992 showing nutrient and oxygen migration from the nutrient gallery and injection points over time. It should be noted that chloride was a constituent of the nutrient solution and was used as a tracer.

Average quarterly analytical results for benzene, BTEX, and TPH from monthly groundwater samples collected from MW-1, MW-8, MW-2A, and MW-3 are presented in Figures 6, 7, 8, and 9, respectively. Each figure shows significant decreasing trends for benzene, BTEX, and TPH over the duration of the project. The reductions for MW-1 (Figure 6) and MW-8 (Figure 7) are particularly dramatic with TPH results decreasing from phase separated hydrocarbons in both wells to below detection limits in MW-1 and to approximately 15 ppm in MW-8.

Table 3 summarizes groundwater analytical results for benzene, TPH, pH, and bacterial counts through December 1991. It should be noted that bacterial counts were generally near the lower range as the project was initiated and then increased and reached a

plateau near the higher range as the project progressed. Positive remediation results for benzene and TPH are evident on a per monitoring well basis with particularly positive results obtained for MW-1 and MW-8. Substantiation of bioremediation activity is provided by the associated bacterial analyses which indicate that relatively high concentrations of background heterotrophs and hydrocarbon utilizing bacteria were stimulated and maintained in the groundwater across the site. Analyses on groundwater samples collected from the recovery well showed BTEX concentrations ranging from the low parts per billion range (<3 ppb) to below detection limits (1 ppb).

2.3 Soil Results

Soil borings were conducted near selected monitoring wells during the project and during the installation of monitoring wells. Soil samples were analyzed for BTEX, TPH as gasoline, and Total Oil and Grease (TOG). BTEX results ranged from 420 mg/kg in March 1988 to below detection limits in May 1991. TPH as gasoline ranged from 5,200 mg/kg in March 1988 to 55 mg/kg in May 1991. TOG ranged from 12,000 mg/kg in March 1988 to 1,900 mg/kg in May 1991.

Carbon dioxide was measured at the effluent of the vapor extraction system to monitor the bioremediation progress. The results of this testing are presented in Table 4.

An elevated carbon dioxide concentration was measured from the effluent of the vapor extraction system as compared to the carbon dioxide measurement from MW-9. Additionally, the ^{13}C value for soil gas from the vapor extraction system was consistent with values reported by Aggarwal and Hinchee for carbon dioxide produced by aerobic metabolism of hydrocarbons (Aggarwal and Hinchee, 1991). The ^{13}C value for soil gas from MW-9 was consistent with values reported for non-hydrocarbon impacted sites. The results of this analysis suggested microbial metabolism of hydrocarbons as the primary source of carbon dioxide in the effluent of the vapor extraction system.

3 CONCLUSIONS

The results of operating the in-situ bioremediation system from July 1989 to December 1991 are presented in Table 5. The total estimated amount of contaminant mass removed is 16,143 kg. Of that total, 685 kg (4 percent) was removed via phase separated hydrocarbon recovery from MW-1 and MW-8, 354 kg (2 percent) was volatilized by the vapor extraction system, and 15,100 kg (94 percent) was degraded biologically. Biodegradation results were calculated using the assumptions listed in Table 5. Additionally, 33,400,000 liters of groundwater were extracted, treated, and reinjected during the course of the project. This resulted in an estimated 15 pore volumes of groundwater that were transported through the zone of contamination. The estimated contaminant mass removed (16,300 kg) compares favorably to the initial contaminant mass estimate (11,700 kg), providing further evidence of site remediation.

4 REFERENCES

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Table 1

Initial Conditions

Maximum Groundwater Concentrations:	BTEX ^A TPH ^C as gasoline TOG ^D = Phase separated hydrocarbons Chlorinated Organics ^E	= 2,030 ppb = 1,800 ppb = 4 ppb
Maximum Soil Concentrations:	BTEX TPH as gasoline Total Oil and Grease	= 420 mg/kg = 5,200 mg/kg = 12,000 mg/kg
Inorganic Concentrations:	Ammonium, Nitrate, Nitrite, Phosphate Potassium pH	= BDL ^B = 15.7 - 33.8 ppm = 6.70 - 6.90
Bacterial Counts:	Hydrocarbon Utilizers Background Heterotrophs	= $3.1 \times 10^3 - 1.7 \times 10^5$ CFU/ml = $1.2 \times 10^5 - 6.9 \times 10^5$ CFU/ml

A BTEX = Benzene, Ethylbenzene, Toluene, and Xylene by EPA Method 602 Modified

B BDL = Below Detection Limits

C TPH = Total Petroleum Hydrocarbons by EPA Method 602 Modified

D TOG = Total Oil and Grease by EPA Method 413.2

E Analysis by EPA Method 602

F CFU = Colony Forming Units

Table 2

Feasibility Study

Nutrients: 10, 50, and 100 ppm nutrient solution tested.
10 ppm optimum with 62 percent petroleum hydrocarbon removal in 11 days.

Soils: Samples from 2.5m, 3.9m, and 5.5m zones.
Lithology: Silty Sand Coarse Sand Gravel

Testing:

Soil Sample Depth	H ₂ O ₂ Reactivity	Hydraulic Conductivity Reduction	Nutrient Adsorption	
			PO ₄	NH ₄
2.5m	90%	80%	56%	No change
3.9m	49%	No change	86%	15%
5.5m	78%	No change	74%	53%

Table 3

Groundwater Analytical Results

Monitoring Well	Benzene Range (ppb)	Recent Benzene Results (12/91) (ppb)	TPH ^A Range (ppm)	Recent TPH Results (12/91) (ppm)	pH Range	Background Heterotrophs Range (CFU) ^C	Hydrocarbon Utilizers Range (CFU)
MW-1	220 - BDL ^D	BDL	PSHB - 14	14	6.09 - 7.40	2.7 X 10 ³ - 3.0 X 10 ⁸	6.3 x 10 ³ - 1.3 x 10 ⁸
MW-2A	3 - BDL	BDL	3.3 - BDL	BDL	5.87 - 7.19	7.5 X 10 ² - 9.6 x 10 ⁵	3.4 x 10 ² - 7.3 x 10 ⁵
MW-3	11 - BDL	1	4.0 - BDL	BDL	6.60 - 7.87	3.4 x 10 ³ - 5.6 x 10 ⁶	2.8 x 10 ³ - 1.7 x 10 ⁵
MW-4	BDL	N/A ^E	1.5 - BDL	BDL	6.45 - 6.83	6.5 x 10 ³ - 3.0 x 10 ⁵	1.7 x 10 ³ - 2.8 x 10 ⁶
MW-5	4 - BDL	N/A	11.7 - BDL	1	6.73 - 6.80	1.2 x 10 ⁵ - 1.2 x 10 ⁷	5.5 x 10 ³ - 1.3 x 10 ⁷
MW-6	BDL	N/A	1.4 - BDL	BDL	6.50 - 7.20	1.4 x 10 ⁴ - 4.9 x 10 ⁵	3.4 x 10 ³ - 6.3 x 10 ³
MW-8	180 - BDL	3	PSH - BDL	24	6.08 - 7.49	3.6 - 10 ² - 4.3 x 10 ⁵	4.3 x 10 ² - 3.0 x 10 ⁵
MW-9	BDL	BDL	1.2 - BDL	BDL	6.70 - 6.96	N/A	N/A
RW-1	BDL	BDL	BDL	BDL	6.51 - 7.14	<10 - 8.1 x 10 ³	<10 - 7.8 x 10 ⁴

A TPH = Total Petroleum Hydrocarbon by EPA Method 418.1

B PSH = Phase Separated Hydrocarbons

C CFU = Colony Forming Units / ml

D BDL = Below Detection Limits

E N/A = Not Analyzed

Table 4

Carbon Isotope Analysis

Sample Location	CO ₂ (%)	¹³ C	¹³ C (Reference) ^A
Vapor extraction system	1.27	-26.37	-24.3 to -30.1
MW-9	0.052	-18.14	-18.1 to -24.4

^A From Aggarwal and Hinchee, 1991

Table 5

Remediation Results

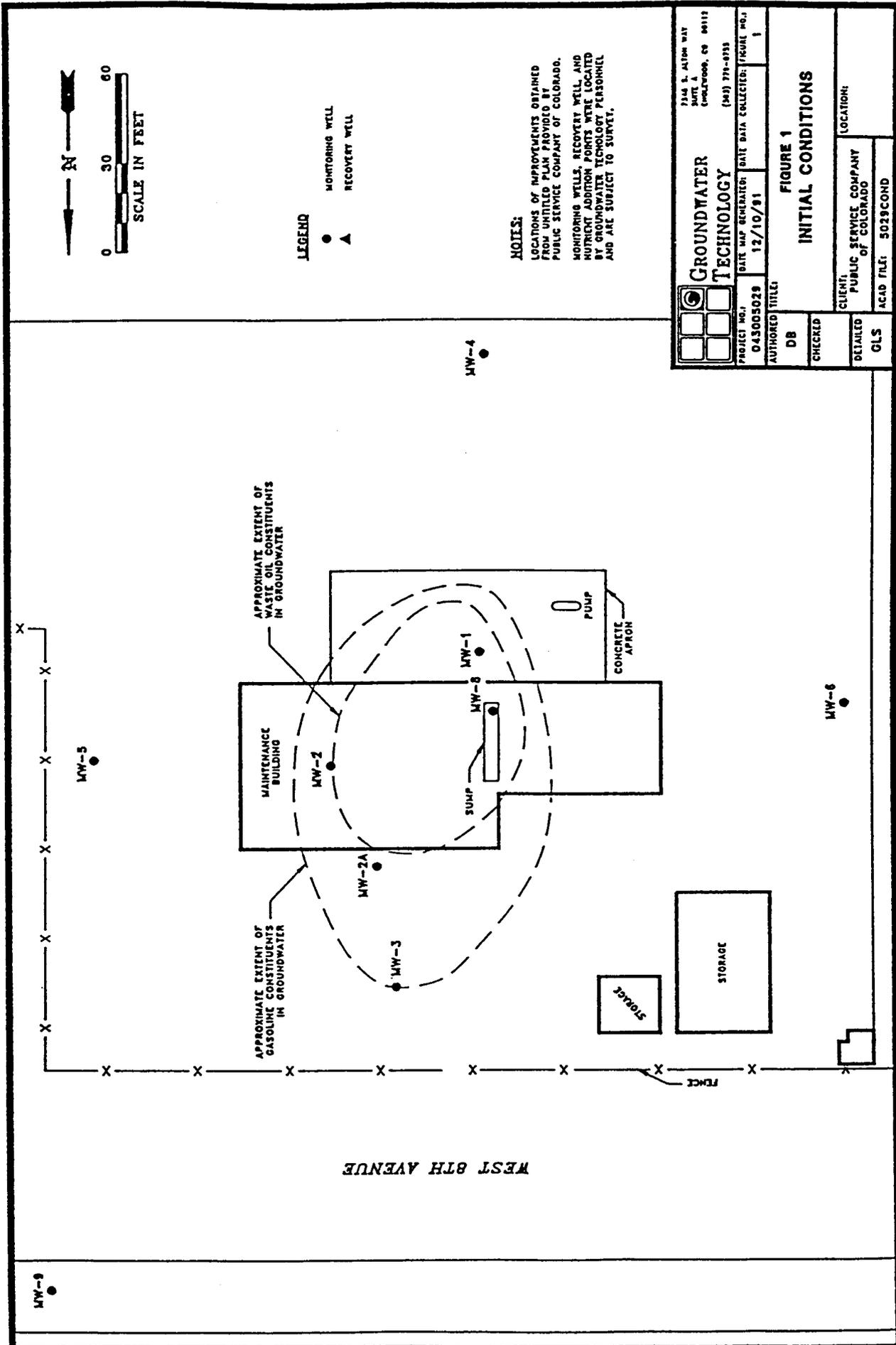
Process	Mass Removed
Phase separated product recovery	685 Kg
Volatilization	354 Kg
Biodegradation ^A	15,105 Kg
Total	16,144 Kg
Total groundwater recovered and reinjected	33,450,000 L
	(15 pore volumes)
Initial Contaminant Mass Estimate	11,703 Kg

^A Estimated from CO₂ measurements from the vapor extraction system effluent. CO₂ measurements were converted into contaminant mass removal rates using the following conservative assumptions.

1. Twenty percent of the carbon dioxide was produced from the biodegradation of native organic matter.
2. Forty percent of the biodegraded organic carbon was evolved as carbon dioxide.

List of Figures

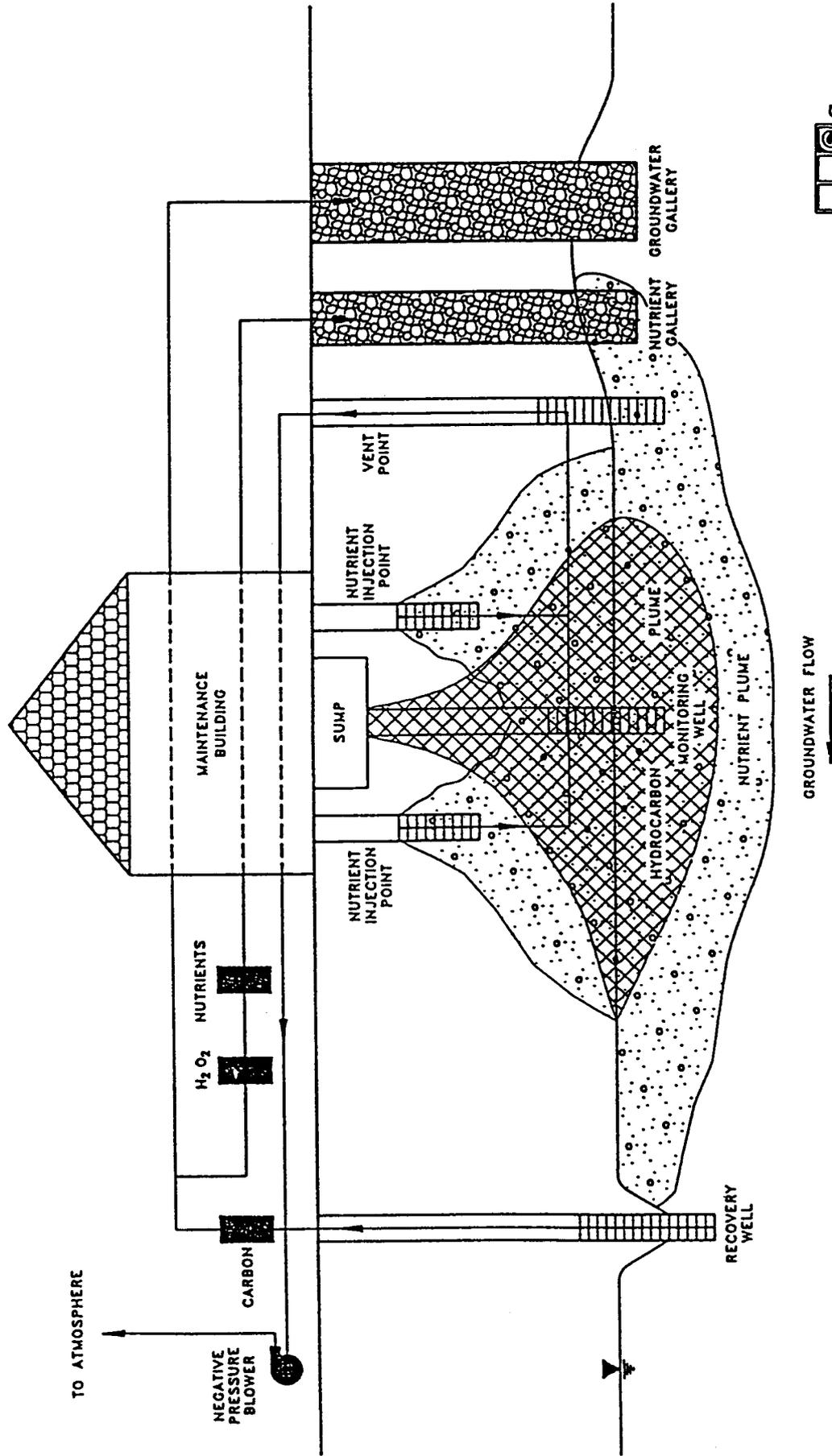
- Figure 1 Initial conditions
- Figure 2 Remediation system schematic
- Figure 3 Dissolved oxygen and hydrogen peroxide in groundwater
- Figure 4 Ammonia-nitrogen and phosphate in groundwater
- Figure 5 Field analyte graph for MW-2A
- Figure 6 Analytical results for MW-1
- Figure 7 Analytical results for MW-8
- Figure 8 Analytical results for MW-2A
- Figure 9 Analytical results for MW-3



		2144 S. ALTON WAY SUITE 4 CHERRYWOOD, CO 80113 (303) 779-0733	
PROJECT NO.	043005029	DATE MAP GENERATED	12/10/91
AUTHORED TITLE	DB		
CHECKED	GLS		
GROUNDWATER TECHNOLOGY		FIGURE 1 INITIAL CONDITIONS	
CLIENT:	PUBLIC SERVICE COMPANY OF COLORADO		
LOCATION:	ACAD FILE: 5029COND		

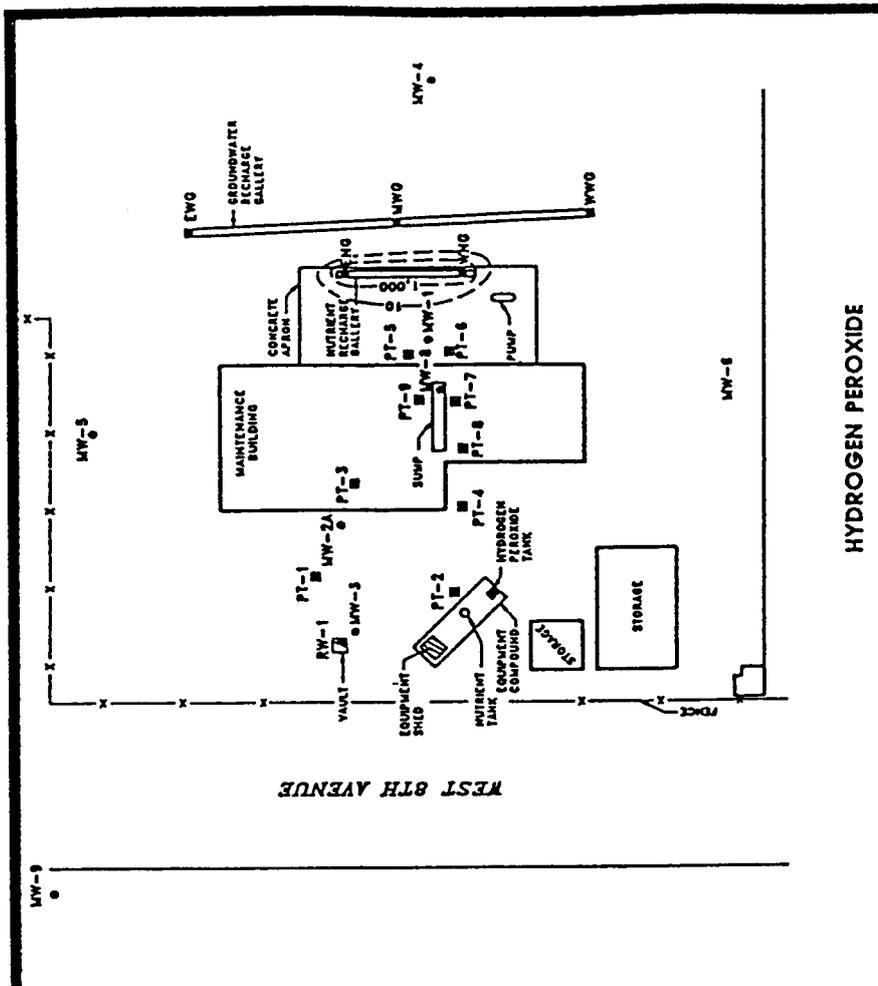
REMEDIATION SYSTEM SCHEMATIC

FIGURE 2:

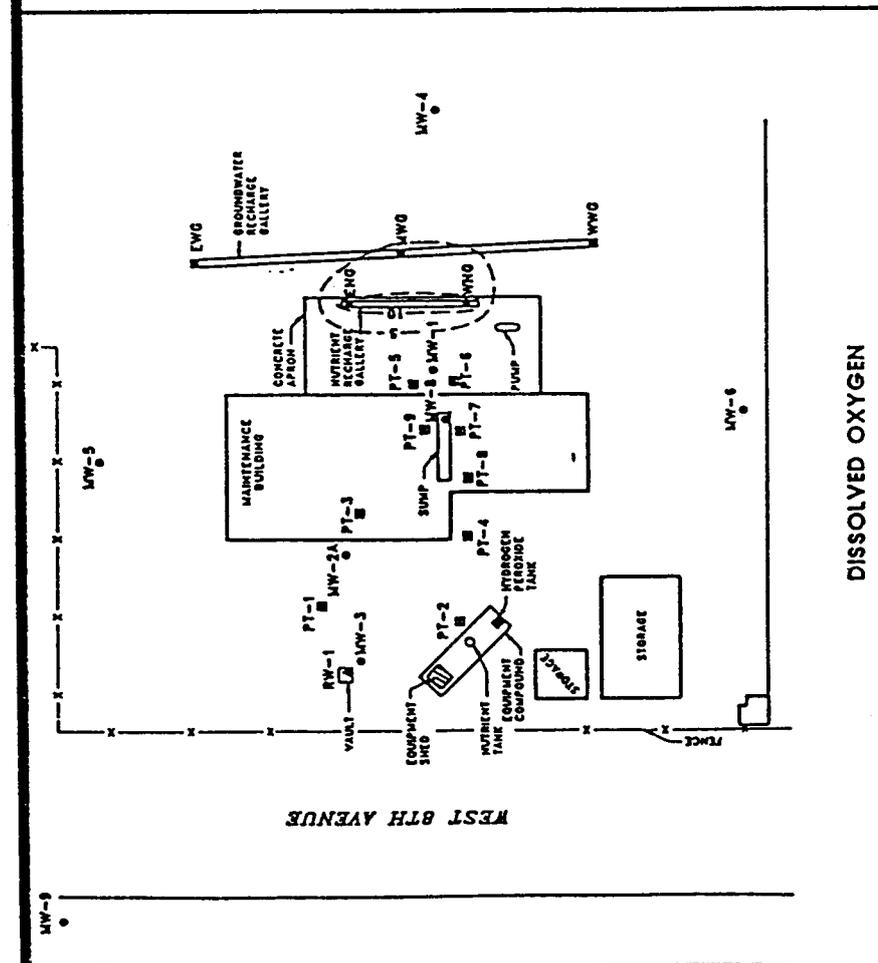


DATED: 05/31/92
DETAILED: GAIL L. STERC





HYDROGEN PEROXIDE



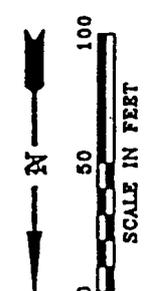
DISSOLVED OXYGEN

GROUNDWATER TECHNOLOGY
 7141 S. ALTON WAY
 ENGLEWOOD, CO 80113
 (303) 773-0733

PROJECT NO. 043005029 DATE MAP GENERATED 05/30/91 DATE DATA COLLECTION 05/01/91

AUTHORED TITLE: **FIGURE 3 DISSOLVED-OXYGEN AND HYDROGEN PEROXIDE IN GROUNDWATER**

CHECKED BY: ST
 DETAILED BY: GLS
 CLIENT: PUBLIC SERVICE COMPANY OF COLORADO
 LOCATION: ACAD FILE: OPMAY-91

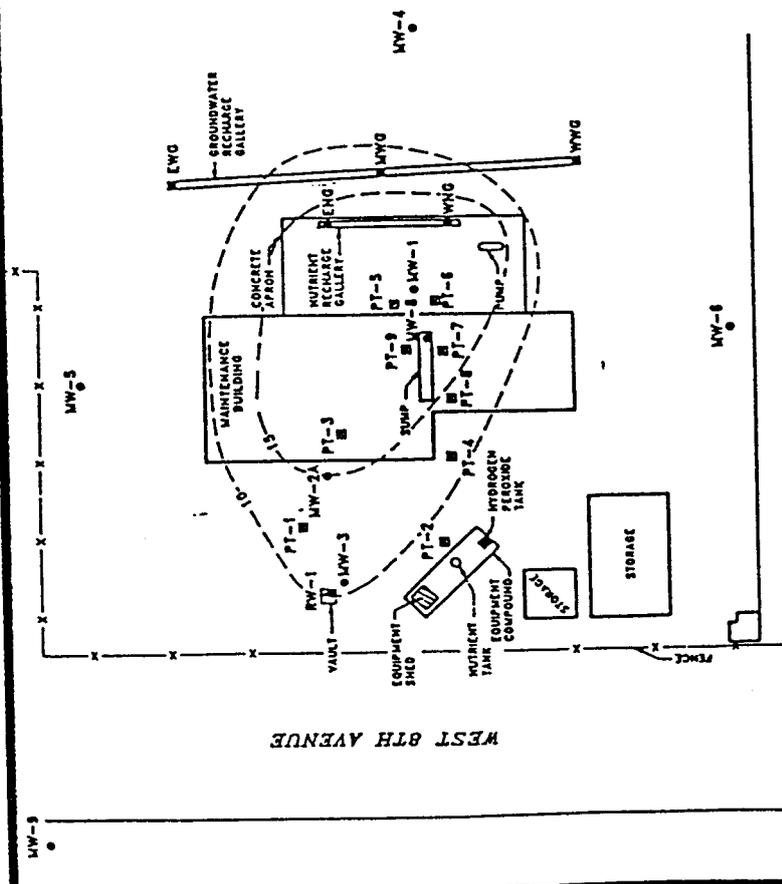


NOTES:
 LOCATIONS OF IMPROVEMENTS OBTAINED FROM UNLITLED PLAN PROVIDED BY PUBLIC SERVICE COMPANY OF COLORADO.
 MONITORING WELLS, RECOVERY WELL, AND NUTRIENT ADDITION POINTS WERE LOCATED BY GROUNDWATER TECHNOLOGY, INC. PERSONNEL AND ARE SUBJECT TO SURVEY.

- LEGEND**
- MONITORING WELL
 - ▲ RECOVERY WELL
 - NUTRIENT ADDITION POINT
 - 5 --- CONTOUR INTERVAL FOR DISSOLVED OXYGEN (PPH)
 - 10 --- CONTOUR INTERVAL FOR HYDROGEN PEROXIDE (PPH)
 - (PPH) PARTS PER MILLION

WELL	HYDROGEN PEROXIDE (PPH)
MW-1	0
MW-2A	0
MW-3	0
MW-4	0
MW-5	0
MW-6	0
MW-8	0
MW-9	0
ENG	1,000
WHG	1,000
MWG	0
RW-1	0

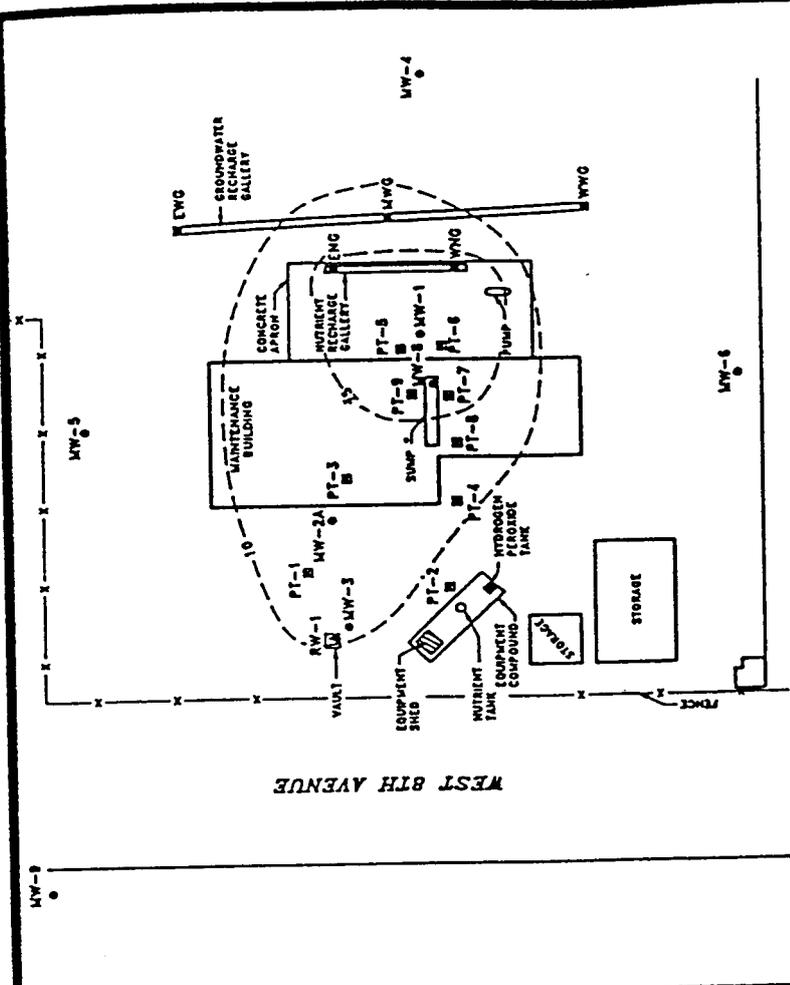
WELL	DISSOLVED OXYGEN (PPH)
MW-1	2
MW-2A	4
MW-3	3
MW-4	3
MW-5	3
MW-6	4
MW-8	2
MW-9	3
ENG	10
WHG	10
MWG	6
RW-1	4



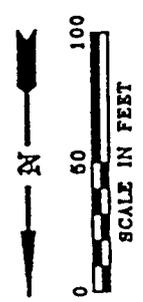
AMMONIA-NITROGEN

WELL	AMMONIA-NITROGEN (PPM)	HYDROGEN PHOSPHATE (PPM)
MW-1	15	25
MW-2A	15	15
MW-3	10	10
MW-4	7.5	2.5
MW-5	5	5
MW-6	5	2.5
MW-8	20	30
MW-9	5	5
ENG	30	25
WNG	30	25
MWO	10	10
RW-1	10	15

- LEGEND**
- MONITORING WELL
 - ▲ RECOVERY WELL
 - NUTRIENT ADDITION POINT
 - 10- CONTOUR INTERVAL FOR AMMONIA NITROGEN (PPM)
 - 10- CONTOUR INTERVAL FOR PHOSPHATE (PPM)
 - (PPM) PARTS PER MILLION



PHOSPHATE



NOTES:
 LOCATIONS OF IMPROVEMENTS OBTAINED FROM UNTITLED PLAN PROVIDED BY PUBLIC SERVICE COMPANY OF COLORADO.
 MONITORING WELLS, RECOVERY WELL, AND NUTRIENT ADDITION POINTS WERE LOCATED BY GROUNDWATER TECHNOLOGY, INC. PERSONNEL AND ARE SUBJECT TO SURVEY.

GROUNDWATER TECHNOLOGY		7248 S. ALPINE WAY SUITE A ENGLEWOOD, CO 80111
PROJECT NO.	DATE MAP REVISION	DATE DATA COLLECTION
043005029	05/30/91	05/01/91
AUTHORED TITLE:		FIGURE 4
ST		AMMONIA-NITROGEN AND PHOSPHATE IN GROUNDWATER
CHECKED	LOCATION:	
DETAILED	CLIENT:	PUBLIC SERVICE COMPANY OF COLORADO
OLS	ACAD FILE	APMAY-91

FIGURE 5
 FIELD ANALYTE GRAPH FOR MW-2A

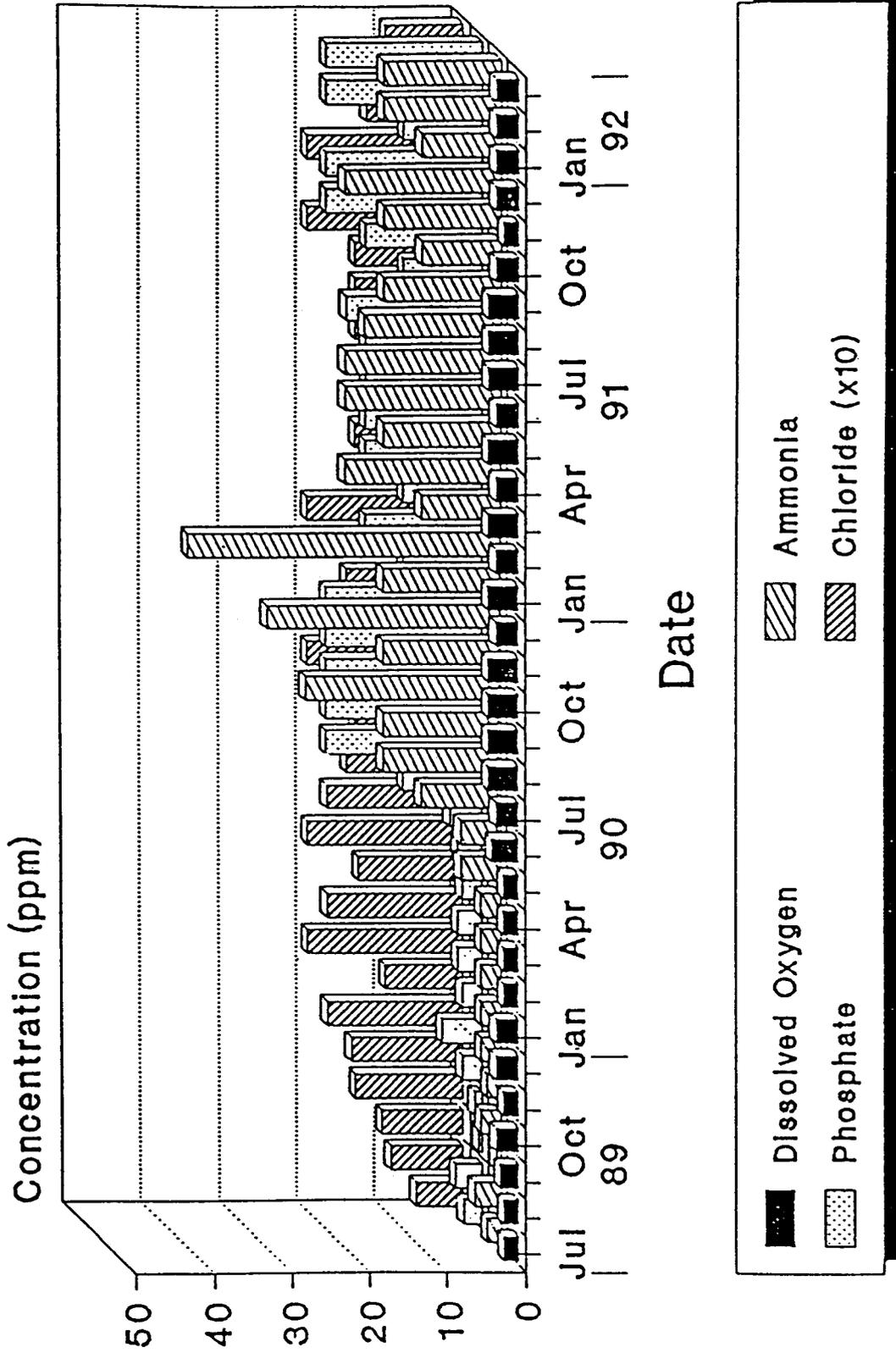
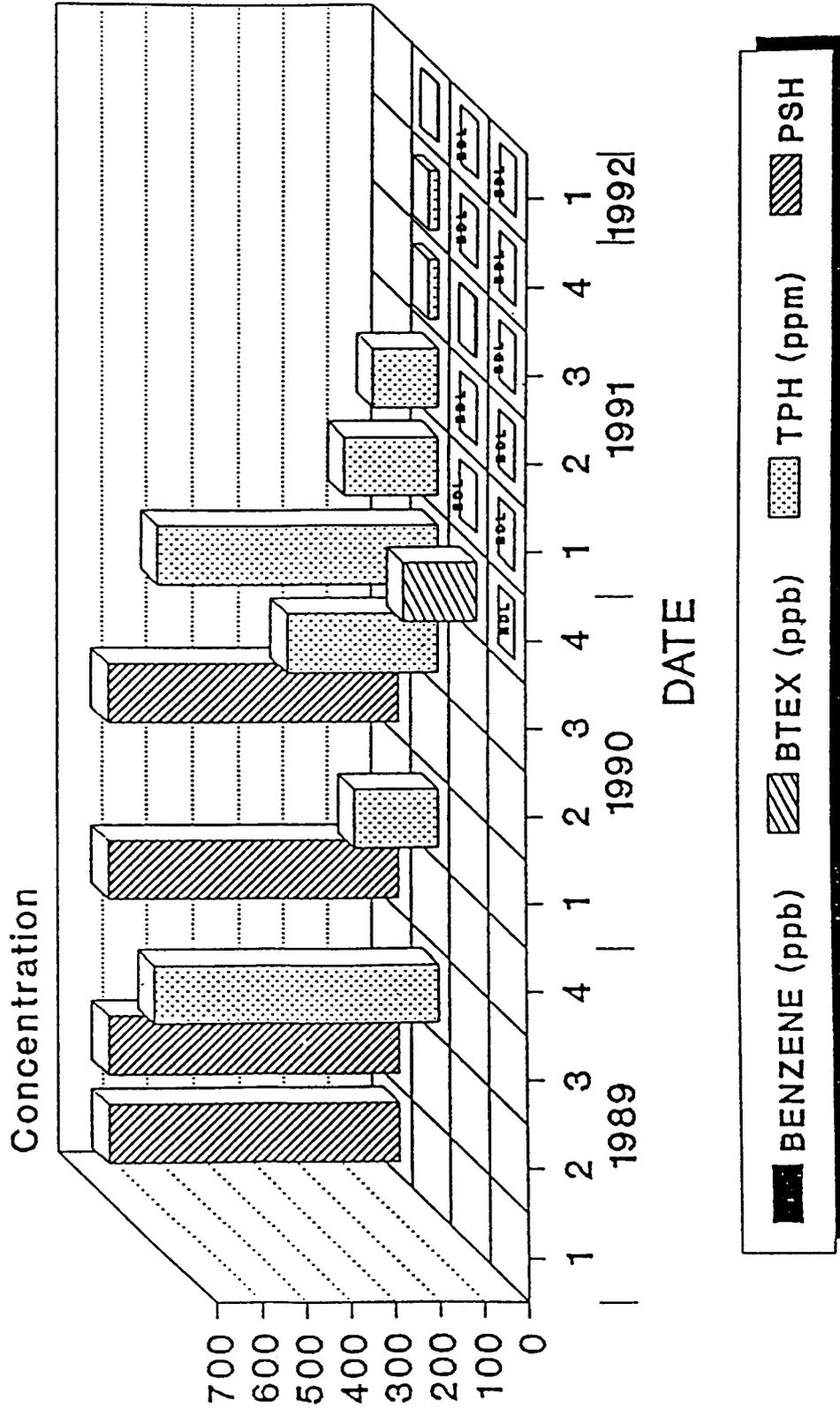
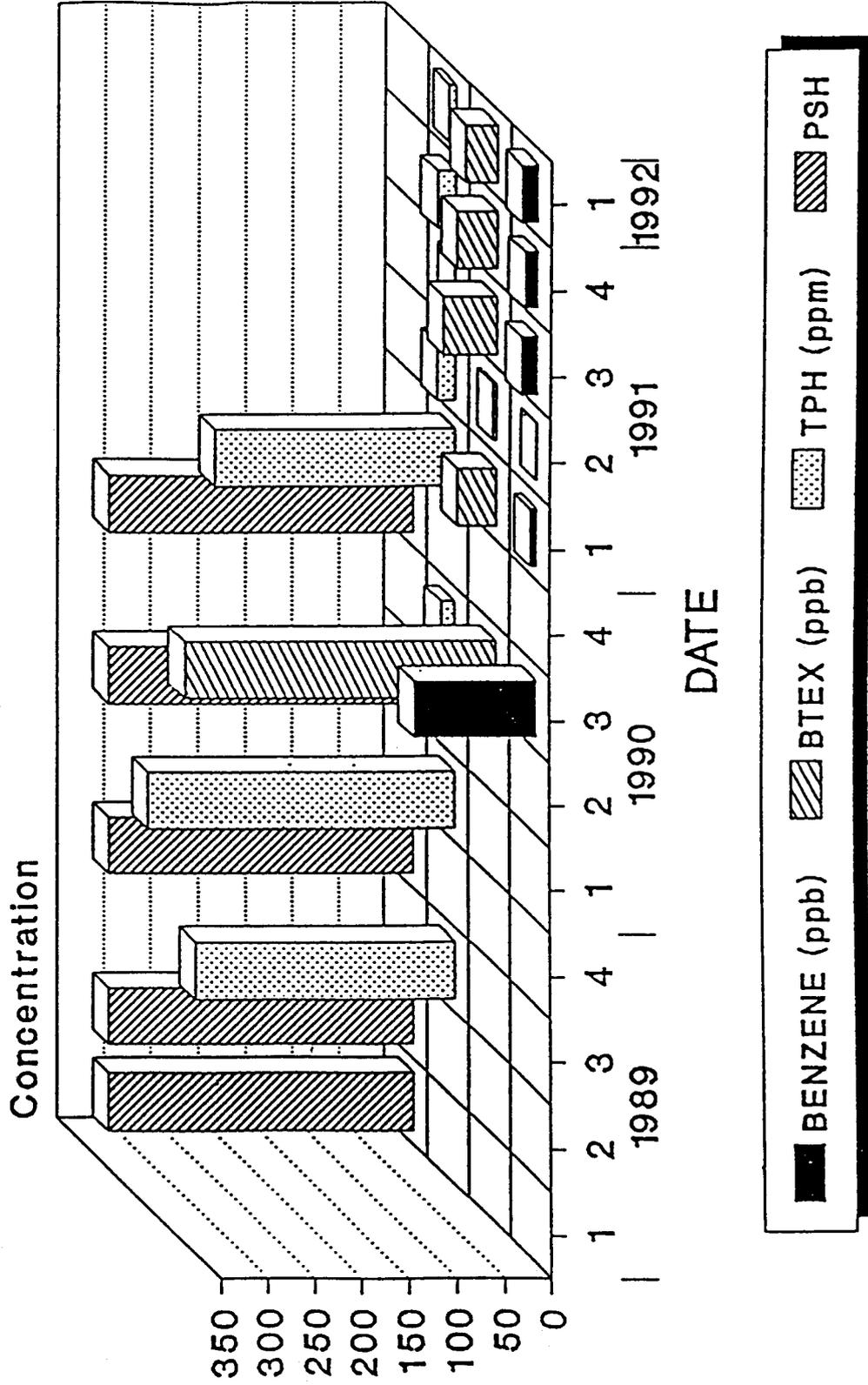


Figure 6
MW-1
ANALYTICAL RESULTS



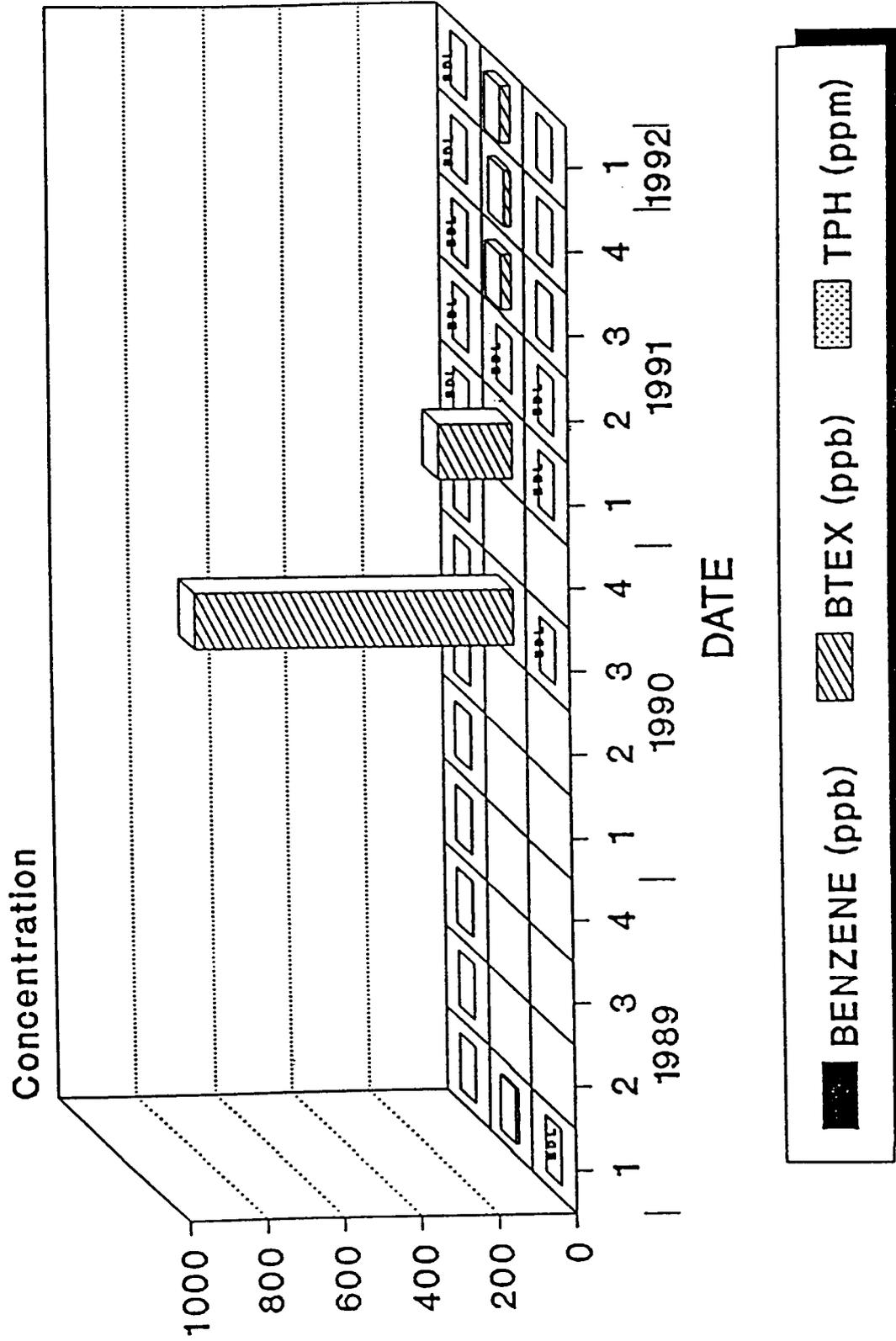
BDL - Below Detection Limits
PSH - Phase Separated Hydrocarbons,
Well Not Sampled

Figure 7
MW-8
ANALYTICAL RESULTS



PSH = Phase Separated Hydrocarbons,
Well Not Sampled

Figure 9
 MW-3
 ANALYTICAL RESULTS



BDL - Below Detection Limits

"GEOMECHANICS IN A CHANGING WORLD"
Adelaide, Australia, July 1-5, 1996

Organized by the Australian Geomechanics Society in association with the New Zealand Geotechnical Society and endorsed by the International Society for Soil Mechanics and Foundation Engineering (ISSMFE), the International Association of Engineering Geology (IAEG) and the International Society of Rock Mechanics (ISRM).

Object

This four-yearly meeting of the Australian Geomechanics Society and the NZ Geotechnical Society is aimed at providing a forum for geotechnical engineers and geologists, active in the field through research and practice, to present and discuss their work.

Venue

The Conference will be held at the Adelaide Convention Centre, in the heart of Adelaide, the capital city of South Australia.

Keynote Speaker

The keynote speaker will be Prof. M. Jamiol Kowski, President ISSMFE, and Chairman of the Committee currently assessing rehabilitation works to the Leaning Tower of Pisa.

Technical Program

The technical program will consist of the keynote address, the John Jaeger Memorial Lecture, to be given by D. H. Stapleton, the NZ Geotechnical Society Lecture, to be given by M. J. Pender, 3 theme addresses on the topics of Analytical and Numerical Modelling.

Paper Presentation

To maximize the number of papers which can be accepted, theme session reporters will summarize papers for general discussion. A small selection of papers will be presented in each session. Poster sessions will be available for the authors of the remaining papers.

Technical Exhibits and Sponsorship Opportunities

A technical exhibition will be run at the conference and will allow either single day exhibiting or continuous exhibits throughout the week. In addition, opportunities exist to sponsor various aspects of the conference at a number of different levels.

Field Trip

A day has been set aside for technical visits which will provide delegates with the chance to see South Australian developments and the State's local attractions.

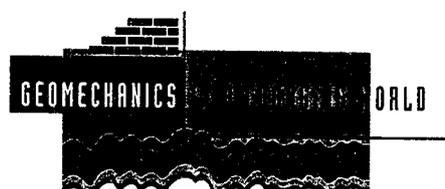
Registration Fees (after 31 May 1996)

Members of AGS, NZGS, ISSMFE, IAEG or ISRM (\$650)
Non Members (\$700); Students (\$350); Daily rates also available.

CONFERENCE SECRETARIAT

Ms Angela Schaeffer
Conference Manager
ICMS Pty. Ltd
Adelaide Convention Centre
North Terrace
Adelaide, South Australia, 5000
Telephone: (618) 210 6776
Fax: (618) 212 5101

Dr Mark Jaksa
Chairperson of the Organizing Committee
7th ANZ Conference on Geomechanics
Dept. of Civil and Environmental Engineering
The University of Adelaide
Adelaide, South Australia, 5005
Telephone: (618) 303 4317
Fax: (618) 303 4359
E-mail: mjaksa@aelmg.adelaide.edu.au





1997 IPENZ Conference - Wellington "Engineering our Nation's Future"

Call for Papers for presentation at the 1997 IPENZ Conference
by Members of Technical Groups and Members of IPENZ.

The IPENZ 1997 Conference Committee calls for papers for presentation at the Conference to be held in Wellington from Thursday 7 February until Sunday 9 February, 1997.

Papers for formal presentation (up to 12 sides) or poster display (up to 6 sides) must be submitted in the format and to the timetable required by the Conference committee and the papers must be presented personally on Saturday 8 February or Sunday 9 February, 1997. All papers presented will be published in the Conference Proceedings prior to the conference and these will be supplied to all delegates free as part of their registration fee. Paper format details will be provided to all authors accepted for the Conference. The papers may be submitted through a technical group, or direct to the Conference Technical papers secretary.

The theme of the conference is "Engineering our Nation's Future" The conference is being set up with special feature sessions and keynote speakers to mark a number of important issues such as:

- Our future townscapes with particular reference to the Wellington region
- Managing resources in a sustainable way
- Better custody and stewardship of our built and natural environment
- Use of sophisticated " high tech " solutions to deal with real problems
- The impact of tourism on engineering and technological skills
- Significant political issues that have an impact on the way we are using technology.

We invite technical groups and individuals to submit papers on any of these issues.

The Institution is made up of members from a wide range of groups involved in every aspect of engineering and allied disciplines. The Annual IPENZ Conference provides an ideal opportunity for your group to conduct sessions which enable those in other fields of activity to see and hear what are the key issues, developments, challenges and exciting advancements in the future in your field. Participation in the conference will give each group an opportunity to provide a "window" on the activities of its members which will be of interest and benefit to others.

We can accept papers up to 10 January 1997 for publication but only papers received on or before 2 December 1996 will be submitted to the IPENZ Awards Committee for assessment for the 1997 Conference Awards. Technical groups may wish to referee their Technical Group papers and they may set an earlier deadline for the receipt of papers for this purpose.

We require a title and 50 word abstract and author details of each paper to include in the conference programme and registration brochure which will be issued with the November issue of New Zealand Engineering. These abstracts will be required by 28 August, 1996 in both hard copy and floppy disc forms or they can be Emailed to the Technical papers secretary.



1997 IPENZ Conference - Wellington
 “ Engineering Our Nation’s Future ”

Timetable for Papers, Conference Theme Award and Technical Group Programme

- | | |
|--------------------|--|
| 23 August, 1996 | Deadline for abstracts and author details to be provided to the Technical papers Secretary, 19 Richmond Ave, Nelson. Poster papers will also require abstracts. |
| 14 September, 1996 | Conference brochure material sent to publisher for printing and distribution with NZ Engineering, November issue. |
| 1 October, 1996 | Nominations of Technical Group papers for awards should be sent to the Institution’s National Office for the attention of the Awards Committee. Please specify which award the papers are nominated for. |
| 2 December, 1996 | Deadline for the receipt of conference papers wishing to be eligible for the IPENZ 1997 conference awards. Papers to be sent to the Conference technical papers secretary, A Winwood & Associates Limited, 19 Richmond Ave, Nelson |
| | Deadline for Conference Technical programme for inclusion in the Conference handbook. |
| 10 January, 1997 | Deadline for the nomination paper from each group for Best on Conference Theme Award. Send the nomination and copy of paper to the Conference Director, Robert Norman,
P O Box 12 241, Wellington. |
| 10 January, 1997 | Deadline for receipt of papers for publication in the conference proceedings.
Note, these papers will not be assessed for any 1997 conference awards. |
| 17 January, 1997 | Finalisation of Conference Technical Programme for publication in the Conference Handbook. Nomination by Technical groups of the session chairpersons for all Technical group sessions. Send to Alan Winwood |

All enquiries to:
 The IPENZ 1996 Conference Technical Papers Secretary,
 Alan Winwood,
 19 Richmond Ave, Nelson.
 Ph (03) 546 6973 - Fax (03) 546 6972
 e mail address - awinwood@nelson.planet.org.nz

1. The New Zealand Geotechnical Society wishes to recognise and encourage student participation in the fields of soil mechanics, rock mechanics, and engineering geology. It has therefore agreed to present annually two merit awards, each for a book of the value of \$250* which shall be known as the "New Zealand Geotechnical Society Student Prize". (* the value of the prize is subject to review at the next NZGS annual general meeting).
2. The award shall be made to the bona-fide full-time student of a recognised Tertiary Institute in New Zealand who makes the adjudged best presentation on any aspect or topic in the field of geomechanics to the designated Local Group Meeting in either Auckland or Christchurch. The award is open to both undergraduate and postgraduate students, but the same student is not eligible for more than one award.
3. In May of each year students shall be invited to submit a Synopsis of their topic to the Local Group convenor in either Auckland or Christchurch, and the due date for receipt of synopses will be 30 June of that year. The Synopses shall not exceed 1,000 words or two A4 pages typed.
4. Students whose synopses are accepted shall be invited to present their topic verbally at a Local Group meeting specially designated for that purpose, and this will usually be held in the following September. The Local Group convenor shall be responsible for the format and timing of the meeting, but students should normally be required to speak for 20 minutes followed by 5 minutes of questions.
5. The Prize shall be awarded to the student who is judged to have made the best presentation in terms of clarity, and who is considered to have dealt with questions most competently. The composition of the judging panel is a matter for the Local Group convenor, and the judges' decision shall be final.
6. The Local Convenors in Auckland and Christchurch are expected to liaise through the National Activities Officer regarding the timing, format and venue for the annual Student Prize Meeting in each centre. they are also to ensure that the awards are made each year under generally similar conditions, and that invitations to participate are extended to students at institutions outside Auckland and Christchurch.

THE DEADLINE FOR SYNOPSES IS 30 JUNE 1996 *NOTE: Students wishing to submit a paper for the 1996 NZGS Student Prize should contact:*

Alexei Murashev
c/o Beca Carter Hollings & Ferner Ltd
P O Box 3942
Wellington

Phone: (04) 473 7551
Fax: (04) 471 5501

Dunedin, 25-27 November 1996

The organising committee has opted for a 3-day mid week meeting with field trips at either end. We hope to make a special feature of the poster session. The circular and registration form will come with the July Geological Society Newsletter. Deadline for receipt of abstracts is likely to be mid September.

Geological Society meetings are characterised by papers on a wide range of topics and we will be encouraging this valuable feature. In addition, we will also invite contributions to several symposia which may include:

- An engineering geology topic
- Deformation along active plate boundary in NZ
- Paleogeographic maps of NZ, Cretaceous - Recent
- Jack Bradshaw Memorial Symposium on Western Province basement

Possible field trips include two to three day trips to:

- Manapouri - Deep Cove, Fiordland basement with Jack Bradshaw symposium?
- Alpine Fault, Haast to Hokitika
- Products Creek, Permian to Jurassic stratigraphy and terrane boundaries
- Clyde - Beaumont; Clutha power development, landslides, neotectonics

and one day trips to:

- Clyde, upper Clutha power development, landslides, neotectonics
- Miocene Dunedin intraplate volcanics
- Macraes - Strath Tairei, Au mineralisation and mine
- Gabriels, Gully, alluvial gold and Cretaceous-Cenozoic tectonics of Tuapeka fault zone
- Akatore Fault-Crystalls Beach, neotectonics and Caples melange
- North Otago Cenozoic stratigraphy
- Otago peneplain, Cretaceous-Cenozoic erosion

Preliminary notification of your interest in any of the above themes or field trips, or suggestions for other trips, would be welcomed by the committee.

Updated information on the conference will be posted on the OU Geology Department's web home page-http://www.otago.ac.nz/Web_menus/Dept_Homepages/geology/index.html

November

Mon 24	Tues 25	Wed 26	Thurs 27	Fri 28	Sat 29	Sun 30
1-day field	Papers	Papers	Papers	1-dayfield		
		Posters		2 or 3 day	field trip(s)	
		AGM				
DinnerInformal meal						

Andy Tulloch (Convenor)
 Institute of Geological & Nuclear Sciences
 Private Bag 1930
 Dunedin
 e-mail: a.tulloch@gns.cri.nz

1996

JUNE 17-21, 1996

Trondheim, Norway
7TH INTERNATIONAL SYMPOSIUM ON LANDSLIDES

Topics: Analysis of landslides inventories; Landslide investigations; Monitoring and instrumentation; Stability analyses and geotechnical parameters; Shoreline stability and submarine slides; Assessments of landslide risk and hazards; Stabilisation and remedial works; Open-pit mine slopes and mine tailings; Slope instability in tropical and seismic areas; Landslides in sensitive soils. Language: English and French

JULY 1-5, 1996

Adelaide, South Australia
7TH AUSTRALIA-NEW ZEALAND CONFERENCE ON GEOMECHANICS - GEOMECHANICS IN A CHANGING WORLD
Call for papers: April 1995 with synopses required by July 1995 and final papers by January 1996. (See article earlier in this issue of Geomechanics News).

AUGUST 4-14, 1996

Beijing, China
30th INTERNATIONAL GEOLOGICAL CONGRESS

Topics: Wide ranging programme includes symposia on structural geology and geomechanics; Engineering geology; Hydrogeology and environmental geology.

AUGUST 27-29 1996

Sydney
IX AUSTRALIAN TUNNELLING CONFERENCE: "BREAKING NEW GROUND"

The Conference will focus on key issues confronting the development of underground space in Australia and the Asian region. Of interest to planners, builders, developers, financial institutions and specialists in underground construction and mining.

SEPTEMBER 2-5, 1996

Torino, Italy
EUROCK '96, ISRM INTERNATIONAL SYMPOSIUM - PREDICTION AND PERFORMANCE IN ROCK MECHANICS & ROCK ENGINEERING

Topics: Foundation of dams, bridges, oil field platforms and other large structures; Natural and excavated slopes; Tunnels, oil wells and caverns; Mining structures; Environmental engineering (including fluid-rock interaction, prediction of contamination radioactive waste repositories, subsidence above oil and gas fields, etc.)

SEPTEMBER 11-13, 1996

Orlando, USA
FIFTH INTERNATIONAL CONFERENCE ON THE APPLICATION OF STRESS-WAVE THEORY TO PILES

Themes: Wave mechanics and application to pile driving analysis; stress wave analysis, high and low strain dynamic pile testing; NDT methods applied to deep foundations; testing equipment and methodologies; and case histories.

Language: English.

SEPTEMBER 23-26, 1996

Gol, Norway
2ND INTERNATIONAL SYMPOSIUM ON SPRAYED CONCRETE - UNDERGROUND SUPPORT

Topics: Design of Support; Construction Aspects, Durability; Frost Loading; Case Histories

Language: English

Abstracts by 1 April 1996

SEPTEMBER 30 - OCTOBER 2, 1996

Maastricht, The Netherlands
EUROGEO 1. GEOSYNTHETICS CONFERENCE

Topics: Erosion control/Bank protection; Filter applications; Liners and landfill covers; Monitoring; Embankments/walls.

OCTOBER 16-18, 1996

Xuzhou, China
INTERNATIONAL SYMPOSIUM ON MINING SCIENCE AND TECHNOLOGY

Aims to provide a forum for experts to exchange information on pioneering research into mining and to promote scientific and technological co-operation.

OCTOBER 16-18, 1996

Santiago, Chile
INTERNATIONAL SYMPOSIUM ON SEISMIC AND ENVIRONMENTAL ASPECTS OF DAMS DESIGN.

Topics: Tailings dams - environmental aspects, monitoring and abandonment, seismic design and behaviour; Concrete and embankment dams - seismic aspects.

Papers: by April 1, 1996

OCTOBER (2 days), 1996

Naples, Italy
INTERNATIONAL SYMPOSIUM ON GEOTECHNICAL ENGINEERING FOR THE PRESERVATION OF MONUMENTS AND HISTORIC SITES

Topics: Investigations - history of the monument/site, structure, materials, buried remains and foundations soils; Monitoring; Intervention

CONFERENCES

DIARY

Techniques; Case histories - illustrating interplay between preservation and geotechnical engineering.

Abstracts: by 31 December 1995

Papers: by 30 June 1996

NOVEMBER 5-8, 1996

Osaka, Japan

2nd INTERNATIONAL CONGRESS ON ENVIRONMENTAL GEOTECHNICS

Themes: Site Investigation, Speciation and Characterisation; Modelling and Numerical Analysis; Geotechnics of Mines Waste Management; Geotechnics of Municipal Waste Management; Waste Disposal and Containment; Geotechnical Recycle or Reuse of Waste Materials; Remediation of Contaminated Ground; Dredging and Sediments; Geo-Environmental Risks: Assessment and Mitigation; Regulations: Trends and Vision for the Future.

Language: English

NOVEMBER 12-14, 1996

Fukuoka, Japan

2ND INTERNATIONAL SYMPOSIUM ON EARTH REINFORCEMENT (IS KYUSHU '96)

Topics: Construction practice on embankments, wall structures, foundations, slopes and excavations; Standardisation of testing methods; Standardisation of design methods; Numerical methods for design; Case histories; Monitoring systems.

Language: English

1 9 9 7

FEBRUARY 7-9, 1997

Wellington, NZ

IPENZ CONFERENCE: ENGINEERING OUR NATION'S FUTURE CALL FOR PAPERS

Abstracts Deadline: 23 August 1996.

FEBRUARY 9-12, 1997

St Petersburg, Florida, USA

INTERNATIONAL CONFERENCE ON CONTAINMENT TECHNOLOGY CALL FOR PAPERS

Topics: Barriers-Walls, Floors, Caps, Construction QA, Contaminant Transport Modelling, Permeable Walls, Long Term Performance Monitoring, Barrier Materials.

Abstracts Deadline: July 15, 1996.

(UK) SPRING, 1997

London, UK

INTERNATIONAL CONFERENCE ON GROUND ANCHORAGES AND ANCHORED STRUCTURES.

Topics: Site Investigation, Anchor Design and Materials Corrosion, Construction techniques, Monitoring, Field Testing, Laboratory Studies, New Development, Standards.

JUNE 23-27, 1997

Athens, Greece

INTERNATIONAL SYMPOSIUM ON ENGINEERING GEOLOGY AND THE ENVIRONMENT

Topics: Engineering geology and geomorphological processes; Natural and man-made hazards, Geological environment in urban and regional planning; Waste disposal; Impact from the exploitation of mines and quarries; Environmental aspects of the design and construction of large engineering works and schemes; Protection of historical and architectural heritage; Strategies and legislation related to geological conditions and processes affecting; Environmental courses in geological and geotechnical education.

Languages: English and French, Greek

Abstracts: by 30 December 1995

Papers: by 28 February 1996

SEPTEMBER 6-12, 1997

Hamburg, Germany

XIV INTERNATIONAL CONFERENCE ON SOIL MECHANICS AND FOUNDATION ENGINEERING

Themes:

Plenary Sessions:

- Soil Testing & Ground Property Characterisation
- Recent Developments in Foundation Techniques
- Retaining Structures and Excavated Slopes
- Underground Works in Urban Environment
- Soil Improvement & Reinforcement
- Waste Disposal and Contaminated Sites

Parallel Sessions:

- Recent Developments in Laboratory

Stress-Strain Testing in Geomaterials

- Ground Property Characterisation by Means of Insitu Tests
- Interplay between Physical and Numerical Models as Applied in Engineering Practice
- Soil Structure Infracture for Shallow Foundations under Static Dynamic Loadings
- Design and Performance of Piled Rafts
- Limit States Concept in Design of Shallow and Deep Foundations
- Design Construction and Performance of Anchored Walls and Strutted Excavations
- Large Excavations with Dewatering in Urban Environment
- Subsidence as Related to Various Tunnelling Techniques
- Performance and Monitoring of Underground Works

- Soil Improvements for Tunnel Works
- Deep in Place Mixing Methods including Jet-Grouting
- Use of Geosynthetics and Geotextiles in Geotechnical Engineering
- Pollutants Containment via Passive Barriers
- Active Pollutants Control and Remediation of Contaminated Sites
- Dredging Sludge and Tailings Impoundments
- Teaching and Education in Geotechnical Engineering

Manuscripts by 31 Dec 1996
Registration by 30 June 1996

OCTOBER 13-15, 1997

Seoul, Korea

**ISRM REGION SYMPOSIUM - 1ST ASIAN
ROCK MECHANICS SYMPOSIUM:**

Environmental & Safety concerns in underground construction.

NOVEMBER 2-7, 1997

Wuhan, China

**9th INTERNATIONAL CONFERENCE IACMAG
(INTL. ASSOCIATION FOR COMPUTER METHODS
AND ADVANCES IN GEOMECHANICS)**

Themes: Computer Modelling; Computer Aided Engineering; Geoenvironmental Engineering; Underground Works; Infrastructure Rehabilitation; Static and Dynamic Soil-Structure Interaction; Ground Improvement; Natural and Man-Made Hazards; 21st Century Geomechanics.

1 9 9 8

MARCH 25-29, 1998

Atlanta, Georgia, USA

**6TH INTERNATIONAL CONFERENCE ON
GEOSYNTHETICS CALL FOR PAPERS**

Abstracts due 1 Sept. 1996

APRIL 19-22, 1998

Atlanta, Georgia, USA

**1ST INTERNATIONAL CONFERENCE ON SITE
CHARACTERISATION - CALL FOR PAPERS**

Topics: Planning Site Investigations, Specifications, Standards, Drilling and Testing, Geophysical Testing, Case Histories.

Abstracts Deadline: Nov. 1, 1996.

Footnote: For further details on contacts or brochures for any of the above conferences or symposia please contact the Assistant Editor of NZ Geotechnical News.

The following publications of the Society are available from the Secretary, IPENZ, P.O. Box 12241, Wellington North. Some publications have been reduced in price to members to clear excess stocks. All prices exclude postage and GST.

	LIST PRICE	
	MEMBERS	NON MEMBERS
Australia-NZ Conferences on Geomechanics		
Proceedings of the Sixth Australia-NZ Conference on Geomechanics, Christchurch, February 1992	\$50.00	\$100.00
Proceedings of the Third Australia-NZ Conference on Geomechanics, Wellington, May 1980	\$ 10.00	\$ 30.00
Proceedings of the Second Australia-NZ Conference on Geomechanics, Brisbane, July 1975	\$ 25.00	\$ 25.00
Proceedings of the Second Australia-New Zealand Young Geotechnical Professionals Conferences, Auckland, December 1995	\$ 25.00	\$ 40.00
NZ Geomechanics Society Symposiums		
Geotechnical Issues in Land Development. Proceedings of Technical Groups. Vol.22, Issue 1G, Hamilton, 1996	\$ 20.00	\$ 35.00
Proceedings of the Auckland Symposium "Groundwater and Seepage", May 1990	\$ 10.00	\$ 45.00
Proceedings of the Hamilton Symposium "Piled Foundations", September 1986	\$ 10.00	\$ 25.00
Proceedings of the Alexandra Symposium "Engineering for Dams and Canals", November 1983 (a joint Symposia with NZSOLD)	\$ 10.00	\$ 50.00
Proceedings of the Palmerston North Symposium "Geomechanics in Urban Planning", May 1981	\$ 20.00	\$ 20.00
Proceedings of the Wanganui Symposium "Using Geomechanics in Foundation Engineering", September 1972 (xerox copy)	\$ 8.00	\$ 10.00
Other Publications		
Guidelines for the Field Description of Soils and Rocks in Engineering Use	\$ 10.00	\$ 13.00
"Stability of House Sites and Foundations - Advice to Prospective House and Section Owners"	\$ 1.00	\$ 1.00
IEA Guidelines for Provision of Geotechnical Information, etc.	\$ 10.00	\$ 10.00
Back dated issues of Geomechanics News	\$ 0.50	\$ 0.50

OBJECTS

- (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

Annual subscriptions, which include the newsletter are (for 1996)

<i>Members</i>	<i>(IPENZ members)</i>	<i>\$30.00</i>
	<i>(others)</i>	<i>\$45.00</i>
<i>Students</i>	<i>(IPENZ members)</i>	<i>\$15.00</i>
	<i>(others)</i>	<i>\$22.50</i>

Affiliation fees for International Societies are in addition to the basic membership fee:

<i>International Society for Soil Mechanics and Foundation Engineering (ISSMFE)</i>	<i>\$20.00</i>
<i>International Society for Rock Mechanics (ISRM)</i>	<i>\$20.00</i>
<i>International Association of Engineering Geology (IAEG)</i>	<i>\$15.00</i>
<i>(with bulletin)</i>	<i>\$42.50</i>

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
 The Institution of Professional Engineers New Zealand (Inc)
 P.O.Box 12-241
 WELLINGTON**

**NEW ZEALAND GEOTECHNICAL SOCIETY
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(A Technical Group of the Institution of Professional Engineers New Zealand (Inc))

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PRESENT EMPLOYER:

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EXPERIENCE IN GEOMECHANICS:

STUDENT MEMBERS:

TERTIARY INSTITUTION: SUPERVISOR:

SUPERVISORS 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 Foundation Engineering	(ISSMFE)	Yes/No
International Society for Rock Mechanics	(ISRM)	Yes/No
International Association of Engineering Geology	(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

Signed
 Date

ANNUAL BASIC SUBSCRIPTION: Due on notification of acceptance for membership, thereafter on 1st of January. Please do not send subscriptions with this application form. You will be 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:

(for office use only)

Received by the Society
 Recommended by the Management Committee of the Society
 Approved by the Council of the Institution

NZ Geomechanics News is published at least twice a year and distributed to the Society's 400 members throughout New Zealand.

This 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
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The deadline for advertising copy for the next issue is 5 November 1996. Arranging artwork for your adverts can be carried out at a reasonable additional cost if requested. However, advance notice is required for this additional service.

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

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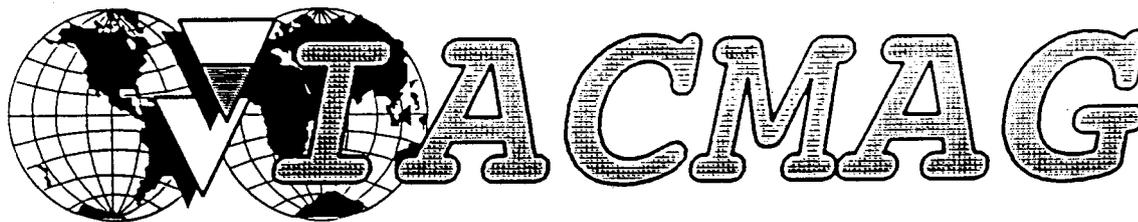
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INTERNATIONAL ASSOCIATION FOR COMPUTER METHODS AND ADVANCES IN GEOMECHANICS



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University of Arizona
Tucson, AZ 85721, USA

THE ASSOCIATION OBJECTIVES AND GOALS OF IACMAG

Based on the deliberations at the 6th International Conference on Numerical Methods in Geomechanics at Innsbruck, Austria, in 1988, the International Association for Computer Methods and Advances in Geomechanics (IACMAG) was established. This association grew out of the "International Committee on Numerical Methods in Geomechanics" that was established in 1976, and had organized successful international conferences every three years.

Geomechanics is an interdisciplinary area that involves study of natural and man-made systems with emphasis on the mechanics of various interacting phenomena. It comprises aspects of various engineering and scientific disciplines such as civil, mechanical, hydraulic, materials, and geological engineering and geophysics with appropriate bases of mechanics and physics. (Some of the specific subjects involved are: soil and rock mechanics, statics and dynamics of interacting structures and foundations, oil and fluid flow through porous media, environmental geotechnology, offshore and marine technology, geothermal energy and ice mechanics.)

Geomechanics covers both fundamental and practical aspects, and recognizes the need for a rational process of simplification through integration of theory, experiments and verification for the development of procedures for solution of practical industrial problems. Geomechanics, with emphasis on both basic and applied aspects, and its interdisciplinary nature, is capable of participation in and integration of emerging scientific and technological developments so as to contribute in a wide range of areas. These include: development and use of new materials; constitutive modeling of materials including deformation, damage and failure; verification of existing and new constitutive models; micro-macro correlation of material response including nondestructive testing; new techniques for material and site characterization; computer aided engineering and expert system; innovative construction using new

materials and computer methods; design and rehabilitation of infrastructure; use of system and optimization procedures; and remote sensing. Thus geomechanics has potential for developing innovative technologies, and for providing challenging careers to outstanding persons.

The objectives of the IACMAG are:

1. to engage in activities at international and national levels so as to promote and encourage basic and applied research, and industrial applications related to computer methods and other advances in the interdisciplinary area of geomechanics,
2. to promote and establish procedures for the introduction of geomechanics in undergraduate and postgraduate education,
3. to establish avenues for providing appropriate input to national and international agencies that have direct impact on the funding policies and encouragement of research and teaching in engineering and geomechanics,
4. to encourage such activities such as
 - (a) organization of international conferences every three or four years,
 - (b) organization and co-sponsoring of regional symposia on specific topics during the period between international conferences,
 - (c) initiation of publications such as journals, communications and newsletters,
 - (d) establishing awards and prizes to recognize and encourage outstanding contributions in research and application,
 - (e) establishing collaboration with other societies and organizations involved in related disciplines, and
 - (f) establishing avenues to promote active participation of younger individuals.

A great many individuals from all over the world have shown interest in the Association, and its past and proposed activities. The Association expresses its sincere appreciation to these individuals and others for their interest and input. ■



MEMBERSHIP FOR IACMAG

Membership Benefits

- Membership and certificate
- Newsletter: Current Events, and news on ongoing Research, Conferences, etc.
- Reduced registration fee for conferences, symposia, etc. sponsored/cosponsored by the Association and planned in the future.
- Special reduced subscription rates for collaborating journals such as Int. J. Numerical and Analytical Methods in Geomechanics.
- It is proposed to develop data banks on publications and computer codes; members will have access to these data banks.

REQUEST FOR NEWS ITEMS

IACMAG NEWSLETTER cordially invites its members and other interested persons to send news items to the co-editors or the IACMAG Secretariat by regular mail, electronic mail or fax mail.

The Newsletter also plans to publish short articles on (a) current research and educational activities at a given institution, (b) practical application at private organizations, and (c) technical aspects of research in a specific topic.

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Regional Editorial Representatives

It is proposed that we invite and appoint regional editorial representatives for the Newsletter. These individuals would identify and transmit to the Newsletter various items such as technical news, personal news, conferences and meetings, reports on technical developments, and other news of interest. If you are interested or you would like to nominate someone, please send name(s), including address, telephone, fax and e-mail numbers to Professor M.M. Zaman.

National Groups

The Association encourages formation of national or regional groups under the IACMAG; some such groups have already been formed, e.g., in Czechoslovakia. The minimum number of members needed for such a group is 10. Please write to Professor C.S. Desai with your suggestions. ■

IACMAG Board

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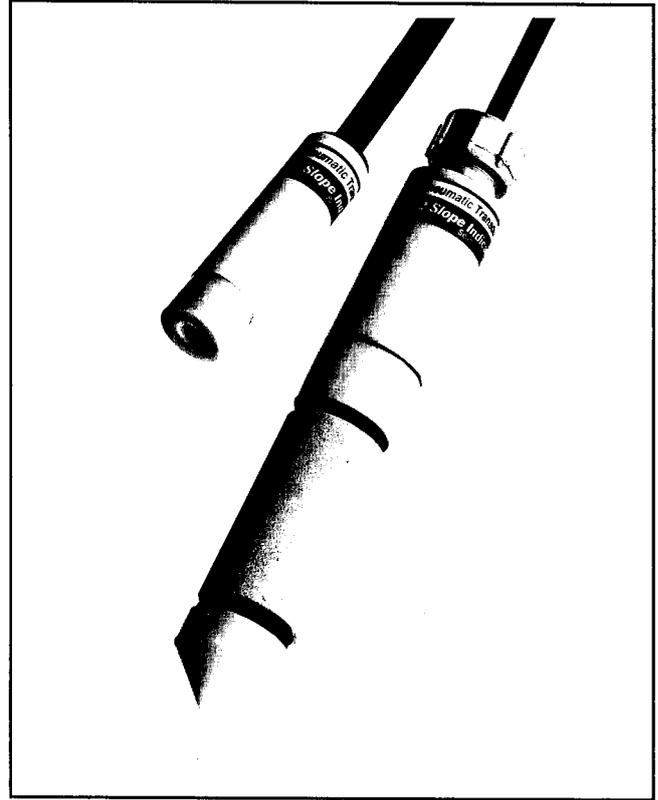
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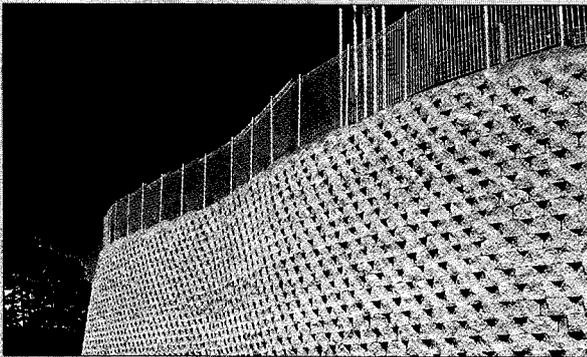
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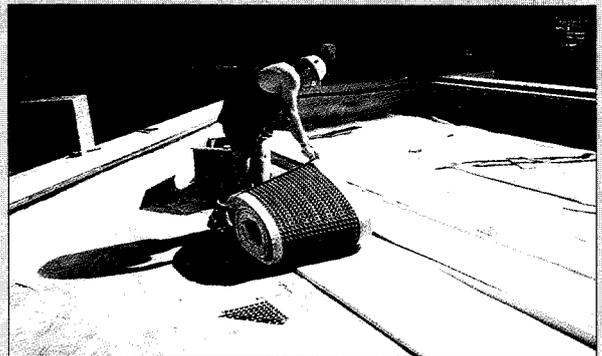
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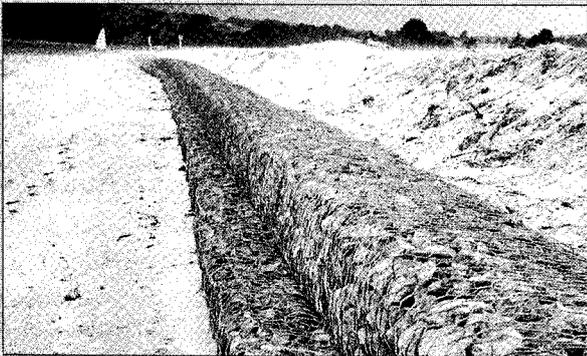
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