N.Z. GEOMECHANICS NEWS

No. 17

NOVEMBER 1978

A NEWSLETTER OF THE N.Z. GEOMECHANICS SOCIETY

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CONTENTS

THIS IS A RESTRICTED PUBLICATION

"N.Z. Geomechanics News" is a newsletter issued to members of the N.Z. Geomechanics 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 this newsletter. The annual subscription varies depending on which International Society the member wishes to be affiliated to. The basic subscription rate is $6.00, and affiliation fees to the International societies are $2.25, $6.20, $2.00, for Soil Mechanics, Rock Mechanics and Engineering Geology respectively. Members of the Society are required to affiliate to at least one International Society.

EDITOR'S NOTES

1. Australian Geomechanics Society

The Chairman of our Society, Mr J.P. Blakeley has recently been trying to establish better and more regular communications between the Society and both the Australian Geomechanics Society and also the Australian Tunnelling Association.

As a first step towards improving ties between the Society and our Australian counterparts, issues of "N.Z. Geomechanics News" will be sent to them on a regular basis. For their part, the Editorial Panel of the Australian Geomechanics Journal have indicated that they would be happy to consider papers from our members for publication in the Journal.

Members interested in submitting a paper for publication in the Journal should do so through the Management Secretary, N.Z. Geomechanics Society, P.O. Box 12241, Wellington North.

2. Membership Applications

To assist Society members in recruiting new members, an application form can be found at the back of this issue. Please note that to facilitate the management committee's task of scrutinising the applications, prospective members are required to be nominated by existing financial members of the Society.

3. Change of Address

Members are reminded that changes of address should be notified to the Institution Secretary, using the form provided in the back of this newsletter.

4. Contributions Wanted

Contributions to N.Z. Geomechanics News may be in the form of technical articles, notes of general interest, letters to the Editor, or book reviews, and may cover any subject within the fields of Soil Mechanics, Rock Mechanics and Engineering Geology. Articles on site investigations, construction techniques or design methods which have been successfully used in New Zealand, and which would be of help to other members, would be particularly welcome.

All contributions should be sent to:-

The Editor,
New Zealand Geomechanics News,
c/- New Zealand Geomechanics Society,
P.O. Box 12241,
Wellington North.

A.J. Olsen
Editor.

THE AOKAUTERE SCIENCE CENTRE

J.G. Hawley

The National Water and Soil Conservation Organisation (NWASCO) has over the last few years, set up three Science Centres, one in Hamilton, one at Aokautere (near Palmerston North) and one in Christchurch. Each of the three is a national centre for a particular group of research and survey activities. At the Hamilton Science Centre (on the Waikato University campus) projects are related to water quality issues (eg Pollution of lakes and rivers), at Christchurch (in Westminster House) water quantity sediment transport and alpine erosion processes are the central theme, while at Aokautere projects relate chiefly to land instability and land resources issues. Of the three centres therefore, only the one at Aokautere has direct links with geo-mechanics.

The Aokautere Science Centre is 11km east of Palmerston North (5km north of Massey University) and has a 32ha campus. The reason for this large area is that the National Plant Materials Centre is a part of the Science Centre and most of the hectares are used for propagating plants for erosion control. It is here that hundreds of different clones of poplars and willows and other species are assembled, tested, selected, and propagated before release to catchment boards and other organisations for soil stabilisation/conservation planting throughout the country.

Until recently the plant materials people (scientists, technicians and supporting staff - 27 in all) had the campus to themselves. However, six months ago a three man Catchment Condition Survey group moved onto the site, followed shortly afterwards by a soil mechanics technician. He was joined in September by a scientist (P. Luckman). These two together with the scientist in charge of the Centre (the writer) are at present the only representatives for soil mechanics on campus. When some staff currently elsewhere in the country are brought "home" and others are redeployed, there should be a group of five (excluding the writer) working on projects with a significant soil mechanics content.

The Catchment Condition Survey group are currently evaluating remote sensing techniques (aerial photography using four different wavebands, separately and in combination) for rapid and accurate surveys of catchment condition eg plant condition, erosion, ground moisture patterns, stream bed levels etc. They use a nest of 4 Hasselblad cameras in a modified Cessna 206 aircraft for taking their own photographs, and they are also evaluating UE satellite images for catchment condition survey and land resource purposes.

A fourth group yet to move from the city onto the campus is the Land Resource Survey group, a team of 8 scientists, two draughtsmen and two data processors, currently engaged on the production of the NZ Land Resource Inventory Work-sheets. A new office/laboratory building now nearing completion will make it possible not only for this Land Resource Survey team to come onto the campus but also for soil mechanics to have the laboratory space it deserves. This will be a soil mechanics/soil physics laboratory for making measurements which will not only characterise soils by their mechanical properties (Atterberg limits, permeability, strength etc) but will provide the data necessary to link transpiration rates and root strength as measured on the plants, to the soil strength characteristics. This can be done via soil physics (measure-ments of pore size distributions, soil suctions, available water content etc). A vacancy exists for a soil physicist to take charge of this work in the laboratory and in the field.

The 46 scientists and technicians at the Centre include geologists, engineers, geographers, botanists, agricultural scientists, soil scientists and (shortly) soil physicists. The bringing together of the many different disciplines relevant to land stability is a particular feature of the Centre.

Not all of the research and survey work of concern to the Organisation (NWASCO) is done by its own staff. Many projects are better tackled as MSc or PhD research topics. At present six PhD and two MSc students are being supported by the Organisation for studies in topics which fall within the Aokautere Centre's band of responsibilities (ie excluding water quality and hydrology). These students are at Auckland, Massey, Victoria, Lincoln and Edinburgh (the Edinburgh student is a staff member on study leave). Other projects are undertaken by university staff on contract, other government research organisations, and (a very few) private firms.

In addition to staff on campus, the Centre has (because it is a national centre) some staff in other places, - one in Whangarei, two in Gisborne, three in Napier, two in Christchurch and two in Alexandra. Finally, a group of nine field hydrologists based in Wanganui, though directed on technical matters from the Christchurch Science Centre are administered as part of the Aokautere Science Centre because they and Aokautere are both in the Wanganui MWD District.

What has the MWD got to do with this? The National Water and Soil Conservation Organisation is serviced by MWD - in much the same way as the National Roads Board is. Both NWASCA* and NRB are chaired by the Minister of Works; each has a line to Cabinet which though through the same person, is an independent line, ie the opinions of NWASCO and NRB are not necessarily the opinions of the Ministry of Works and Development.

The above account of organisation is given here because many members of the Society, when asking about the Centre, have clearly been as interested in its organisational background as in its geotechnical activities.

Details of particular projects with major geomechanics components could be the subject of some future articles in Geomechanics News. In general geomechanics concepts and techniques will be used to improve understandings of the basic mechanisms of soil and rock slope instability. It is to be hoped that the application of geomechanics will put tree planting, the construction of graded banks, under-drainage, special land management and all other actions aimed at reducing land instability and rates of erosion, on a more rational basis.

Historically, the central disciplines of geomechanics (soil mechanics, rock mechanics and engineering geology) have been developed largely in response to engineering demands. This is certainly true of soil mechanics. Only occasionally have the concepts and understandings developed in soil mechanics been applied to problems of widespread rural land instability.

While laboratory soil mechanics/soil physics studies await the completion of a new building, field studies already begun include the installation of inclinometer tubes in unstable areas which have been, or are about to be, planted. Neighbouring "similar" areas which are not to be planted have also been instrumented as a control. It is hoped that this will show the depths and types of movements and that it may improve understandings

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* The group, of representatives of other bodies, which directs NWASCO is called the National Water and Soil Conservation Authority.

of the depths to which different types of plants are effective at different times of the year. Parallel with this, measurements are being made of transpiration rates of trees. Critical State Soil Mechanics concepts will be applied in studies of how and at what rates the strengths of different soils change during the year. This school of soil mechanics is appropriate because it models the pre-failure stress/strain conditions rather than just the conditions at failure. It is this pre-failure situation which must be influenced by plants, underdrains etc, if instability is to be averted. Because the onset of instability is so obviously related to rainfall and the seasonal conditions generally, the most important measurements for relating the critical state theory to water uptake rates by plants will come from field instruments rather than from the laboratory.

S T O P   P R E S S

THIRD N.Z. GEOMECHANICS LECTURE

The Management Committee of the Society has invited Dr R.D. Northey of the Soil Bureau, D.S.I.R. to present the Third N.Z. Geomechanics Lecture, in 1979. The title of this lecture will be:

"The Acceptability of Geotechnical Risk"

The lecture will be delivered in 3 centres at a joint meeting of the local Geomechanics Group with the N.Z.I.E. Branch in each case. The venues and dates are as follows:

Auckland	:	21 March 1979
Wellington	:	5 April 1979
Christchurch	:	18 April 1979

The lecture will undoubtedly be one of the highlights of next years Geomechanics Society's activities in New Zealand. Society members are urged to publicise the lecture as widely as possible.

LETTERS TO THE EDITOR

The following items of correspondence have been received by the Editor:

Sir,

There appears to be considerable variation throughout the country when describing and logging soils for engineering purposes. Soil descriptions range from subjective descriptions to the more comprehensive schematic methods which attempt to take into account the engineering properties of the soil.

The 1972 report by the Geological Society Engineering Group Working Party (The preparation of maps and plans in terms of engineering geology, Q.Jl. Engng. Geol. 4 (4) : 293-382) adopted the following scheme of description by prefixes and suffices:

Prefixes

Colour
In situ strength and structure (including discontinuities)
Weathered state
Alteration state
Minor lithological characteristics and additional descriptive terms

SOIL NAME

Suffixes

Estimated mass behaviour to groundwater flow
Other terms indicating special engineering characteristics

Each section has its own defined terms. An example is:

Dark grey, stiff, closely fissured, CLAY, of high plasticity, slightly permeable, slakes slowly on exposure.

In New Zealand soils are commonly described using a variation of terms relating from the USBR "Earth Manual" unified soil classification chart. This often tends to produce subjective descriptions and further confusing terminology. The NZGS and project personnel of the MWD are using a standard range of pre-defined terms which are used in a recommended sequence. The system is explained in a NZGS publication "A systematic method of soil description". The standard sequence of terms are:

Main Paragraph

Visual Field Characteristics

Colour

Structure

Weathering

Soil Name

SUBORDINATE FRACTION

DOMINANT FRACTION (preceded by Particle Size Range)

Minor Fraction

(UNIFIED Soil Symbol)

Qualifying Paragraph

Soil Mass Qualifications

Strength

Moisture Content

Plasticity

Grading Qualification

Bedding:
Attitude
Thickness

Soil Fraction Qualifications

Dominant Fraction:
Particle Shape
Mineral or Rock Type

Subordinate Fraction:
Particle Size Range
Particle Shape
Particle Weathering
Plasticity
Mineral or Rock Type

Minor Fraction:
Particle Size Range
Particle Shape
Particle Weathering
Plasticity
Mineral or Rock Type

Additional Structures:
(Unified Soil Symbol)

This system can be used in a selectively condensed version and an example could be:

Blue grey, faintly bedded, slightly weathered, SILTY CLAY with very rare gravel (CL)

- Soft, moist, slightly plastic; gravel, fine, angular, unweathered sandstone.

To the unsuspecting recipient of a soils report a full description following the format above may be regarded as unnecessarily complex. To appendicise all the pre-defined terms can be impractical in a small report. However the system does, unlike most others, adequately differentiate between certain types of soil which have significantly different engineering properties. However the system does have flaws and some examples are:

1) The system does not always read well because of a lack of uniformity in the tenses of pre-defined terms.

2) The use of the suffix (....)y after certain pre-defined terms of the subordinate fraction of the particle size does produce some problem words:

e.g. a COBBLY GRAVEL
or COBBLEY GRAVEL
or perhaps a COBBLE GRAVEL

Similarly with CLAY

3) The term moisture content is probably not consistent with present day overseas usage.

Soil descriptions for engineering purposes should have a limited degree of flexibility for the individual observer but I feel further attempts should be made to standardise the usage of an acceptable method for New Zealand conditions.

Perhaps the Geomechanics Society could take responsibility for:

a) the review of existing methods used by members and comments on those methods,

b) formulation of an acceptable standard method(s),

c) the subsequent publicising of the resulting method(s) to ensure better understanding and more uniformity in soil descriptions for engineering purposes.

Yours faithfully,

G.W. Borrie

Sir,

With respect to the article "Slope Stability in Urban Planning" N.Z. Geo. Mech. News No. 16; I would like to make the following comments:-

1) Mr Taylor's conclusions that the design of a subdivision to reduce apparent stability risks comes mainly from judgement and experience with little calculation involved - is to my mind so very true.

2) Mr Taylor's comments regarding the need for the community to be realistic about expectations of assurance of land stability and how not all risk can be eliminated - is again correct. However on this aspect, there appears to be a wide range of opinion as to exactly how far design and construction on a subdivision by the developer <u>prior</u> to sale of sections should go. So often, in the case of application for subdivision approval, objectors expect the developer to allow for all possible eventualities that they (the objectors) have highlighted. Refining estimation of potential problems to an order of probability is rarely entertained by the objectors. I suggest that it is the very realm of probability which should be the aim of engineers/scientists in establishing when dealing sensibly with applied engineering problems. The local bodies also have an obligation to see that the information required of a proposed development is in the nature of probability and not merely in the semi-fantasy world of possibility. It may be worth remembering that nothing is assured in life other than death at the end of it, therefore reasonable risk is a necessity in all human endeavour.

3) It is my personal opinion that the whole question of land development, planning, zoning, hearings, appeals etc, etc, in regard to proposed subdivision and potential instability is becoming such a legal paradise that a long hard look at the whole system is necessary. Presently the only logical outcome of it

all appears to be very, very expensive land for building. Several aspects worry me in respect to zoning of blocks of land for planning purposes as unstable to build upon - blanket! Based upon my understanding of many of the problems in the Wellington Metropolitan Area - the zoning of any sizeable lump of land as being unsuitable for residential development based purely upon stability would only show a complete lack of appreciation of the prime physical components which contribute to unstable land i.e. soil cover (nature and depth); fossil gullies; natural drainage-paths both surface and subsurface, (and their man-made variations) slope and surface cover. Such variable conditions exist to a greater or lesser degree over all the greater Wellington area.

More often than not the problem areas are extremely localised and cannot possibly be defined by a Town Planner's tar brush. Most however, if not all of these factors can be modified by appropriate design based upon an understanding of these factors involved. This in effect then requires appropriate expertise and design for any given development proposal in steep terrain. The present method of local body handling of application for development shows little if any appreciation of economic development. Whether local bodies and objectors realise it or not, everyone (not only the developer and his agents) included in the process of community development must be concerned with economics. This of course assumes that socially we consider people other than existing property owners, have the right to purchase a section and build a house upon it!

All too obviously, the current attitude is that the Developer is the only person responsible for economics and this has the obvious result of fuelling internal development costs which must be ultimately paid for by the purchaser.

One way I can see that the present situation may be somewhat eased is by putting the insurance cover against instability back into the lap of private insurance indemnity. Mr Taylor suggests that professional behaviour will be worse if too much reliance is placed upon insurance. I would agree with this if too much reliance is placed upon insurance, but this does not necessarily have to follow. If the insurance indemnity had say a three step scale of increasing risk, i.e. low risk, moderate risk, high risk and they had their own engineering assessors (from suitably qualified consultants) to inspect the individual properties when cover was being sought, the standard of professional behaviour need not necessarily drop. With such a system, Local Bodies should still try to maintain a reasonable standard as presently exists for subdivision control through N.Z. Standards of earthworks and the involvement of appropriate expertise in the scheme. But in the "grey zones" where instability problems are considered to be a potential problem (which surely cover all hill country in the Wellington region!) many of the planning approval arguments currently rife could be reduced by individual property assessment.

Yours faithfully,

A.G. Mahoney

LOCAL GEOMECHANICS ACTIVITIES

WELLINGTON GROUP

Four formal meetings have been held this year and have attracted attendances of between 20 and 30.

On June 14 Mr P. Bartlett of MWD Central Laboratories gave a talk on filter clothes and the results of tests on strength and filtering properties of some clothes carried out at Central Laboratories. The different types of woven, felted and "welded" fabrics were demonstrated using samples of various commercially available clothes and the equipment used to determine permeability and "effective apperture size" of clothes was exhibited and explained. The current methods of selecting filter cloth characteristics for filtering against a design soil were explained and the need for testing of the selected cloth against the soil was emphasised. It was explained that in some cases the cloth acts mainly as a barrier against which a "graded" filter cake is formed as the soil is washed through the cloth.

For the July meeting Dr J.Berrill of Canterbury University and Mr L. Oborn of NZGS were scheduled to present a talk on the "Uncertainties in determining possible earthquake shaking at a site". Unfortunately Mr Oborn was unable to be present as a result of being required to make an overseas visit at short notice. However Dr Berrill presented a very interesting talk on the transmission of earthquake source energy and the associated ground excitation, illustrated by examples from the San Fernando earthquake. The effects of focussing of earthquake energy due to fault propagation and the effects of local site conditions on the prediction of local ground shaking were discussed. Dr Berrill was involved with the processing of acceleration records from the San Fernando earthquake and his comments on the record obtained at a large number of sites were of interest. In addition to members of the Society, a number of geophysicists and structural engineers were present and this resulted in a lively discussion ranging from the difficulties of applying Californian experience in New Zealand conditions to the difficulties facing practising engineers.

At a meeting on 16 August, Mr R. Preston and Mr T. Hinkley of MWD reported on the "International Tunnel Symposium 1978" held in Tokyo in June which they attended. Mr Preston briefly discussed the papers presented at the Symposium and reported on the International Tunnelling Association meeting held in conjunction with the Symposium. Mr Hinkley showed a series of slides taken during visits to a number of tunnel construction sites throughout Japan. New methods of construction including the use of curved tube steel sets, which are filled with concrete for additional load capacity where necessary, were illustrated. The slides illustrated the problems being encountered by the Japanese in constructing both beneath congested urban areas and beneath the sea.

A meeting with the subject of the "Wellington Storm of 20 December 1976" held on 19 September attracted a large attendance of 55. Dr Lewis of N.Z. Oceanographic Institute showed an excellent movie taken during and immediately after the storm which showed graphically the magnitude of the run off and the consequent damage and problems which faced civil defence staff. Dr Eyles of the Geography Department, Victoria University followed with a discussion of the distribution of rainfall and slope failures during the storm. He emphasised that the storm was not unusual but one of a number that occurs regularly. Fortunately most of these storms do not occur in heavily built up areas and hence the consequential slope failures have less impact and are fewer since the failures involve predominantly natural slopes. Dr Eyles then discussed work he is carrying out to relate slope failures to rainfall. He postulated that a surplus of 60mm in the 24 hr Water balance appears to indicate the onset of instability for man made slopes or natural slopes effected by excavation. For natural slopes a surplus of around 100mm may be required for the onset of instability. Examination of meteorological records, newspaper and other reports of instability appear to support his theory and he is now examining methods of determining return periods for occurrence of the threshold water balance surplus. Finally Mr Gillespie of Brickell Moss Rankine and Hill discussed work his firm has been involved in, related to property damage from slope instability. He noted that damage was most prevalent on the cheaper marginal sections and questioned whether owners of such properties should be subsidised by local and regional government in improving their sections with respect to stability. Mr Gillespie also pointed out that slope stability problems on sections tended to be concentrated in periods approx. 6 months, 7 years and 40-50 years after the sections are developed. In discussion the point was raised that while structures such as retaining walls require a local body building permit, major excavations and slope steepening operations can be carried out without a permit. The need for better control over the selection and excavation of sections to ensure proper engineering was expressed by a number of the contributors.

Two further meetings are scheduled this year:

On October 19, Dr J. Hawley, Scientist in Charge of the Water and Soil Conservation Organisation's Aokautere Science Centre will present a talk entitled:

"Aokautere Science Centre: Research Responsibilities and Selected Projects."

The centre is involved in work on land stability, erosion control and on the North Island land resource survey. Dr Hawley will discuss the function of some of the geomechanics projects being undertaken.

On November 2nd, Mr J. Blakeley of Beca Carter Hollings and Ferner will present the paper "A design method for heavy duty flexible pavements" by Blakeley, Green and van Toan. This paper was awarded the Fulton Downer Gold Medal when first presented at the 1978 NZIE Conference.

Venues and times for the meetings will be advertised in NZIE Wellington Branch newsletter and notices will be posted to members of the Society who live in the Wellington area. Any members who have not received notices of earlier meetings this year, who wish to have their name added to the mailing list should contact Dr Ramsay, Ph. 729-929 Extn. 349.

Mr J. Rutledge, who organised this year's programme of meetings departed on 13 September for Hong Kong to take up an appointment with Hong Kong Government. The success of the meetings held this year results largely from the effort put in by Mr Rutledge in organising the meetings and effectively advertising them.

G. Ramsay

CHRISTCHURCH GROUP

Two further meetings have been held since the last issue of Geomechanics News, as follows:-

27 July: About 20 people attended a meeting on "Compaction Control and Construction Practice for Earthworks", which was addressed by Dr P. Seddon,

Civil Engineering Department, University of Canterbury; Mr B. Gunderson, British Pavements Ltd, Christchurch; and Mr B. Lennon, Christchurch City Council. The speakers discussed both theoretical and practical aspects of compaction control for roadworks, and most of the subsequent discussion centred on subgrade and pavement problems. The hoped-for discussion on cut slopes and fill batters did not eventuate, but there will be other meetings in the future.

20 September: A joint meeting with NZIE Canterbury Branch was attended by some 30 people. The subject for discussion was "Urban Planning in Christchurch", and speakers were Mr J. White, Canterbury Regional Planning Authority; Mr J. Annan, Paparua County Council; and Mr T. Lucas, Christchurch Estates Ltd. The sharply contrasting views of the urban planner, the local body engineer, and the land developer provoked lively discussion.* It was an indication of the success of the meeting that three hours after it started argument and discussion was still going on in the supper room.

One further meeting is planned for 1978 in mid to late November. This will probably be linked to a one-day field trip to examine some slope stability problems in the Canterbury area.

D.H. Bell

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*A full report on this meeting may be found elsewhere in this issue.

NEWS FROM THE MANAGEMENT SECRETARY

1. FORTHCOMING CONFERENCES AND SYMPOSIA

Listed below are forthcoming Conferences and Symposia which have been brought to our attention. Further details can be made available on request.

1978

December	20-22	Conference on Geotechnical Engineering, Indian Geotechnical Society, New Delhi, India.

1979

January	22-26	ANZAAS Symposium on Geological Hazards, Auckland.
March	20-22	International Conference on Soil Reinforcement: Reinforced Earth and Other Techniques, Paris.
March	21-22	Conference on Recent Developments in the Design and Construction of Piles, London.
June	18-21	4th Rapid Excavation and Tunnelling Conference, Atlanta, U.S.A.
July	24-27	Sixth Asian Regional Conference on Soil Mechanics and Foundation Engineering, Singapore.
September	10-13	Seventh European Conference on Soil Mechanics and Foundation Engineering, Brighton, England.
October		Symposium on Bearing Capacity of Rock, Australia.

2. PUBLICATIONS OF THE SOCIETY

The following publications of the Society are available:-

(a) From the Secretary, N.Z.I.E., P.O. Box 12241, Wellington North:

- Proceedings of the Hamilton Symposium "Tunnelling in New Zealand", November 1977. Cost $18.00 to members, $20.00 to non-members.

- Proceedings of the Nelson Symposium "Stability of Slopes in Natural Ground", November 1974. Cost $15.00 to members, $18.00 to non-members.

- Proceedings of the Second Australia-New Zealand Conference on Geomechanics, Brisbane, July 1975. Cost $25.00 but as a special offer for a limited period this is discounted to $15.00.

- Proceedings of a Workshop on Lateral Earth Pressures and Retaining Wall Design, February 1974. Cost $1.30.

- Copies of most back issues of "N.Z. Geomechanics News" are available to members at a nominal cost of $1.00 per copy.

(b) From Government Bookshops:

- Slope Stability in Urban Development (D.S.I.R. Information Series No. 122). Cost $2.00.

3. NEW MEMBERS

The following new members have been admitted to the Society since publication of the last issue of Geomechanics News:

J.W. Gumbley
I.C. Thompson
M.N. Collen

I.M. Parton
Management Secretary

GEOMECHANICS RESEARCH AT THE UNIVERSITY OF AUCKLAND

P.W. Taylor, H.R. Green, J.M.O. Hughes and M.J. Pender

Introduction

This is the third in a series of reports on Geomechanics research at the University of Auckland. Previous articles appeared in the issues of Geomechanics News for November 1970 and November 1974. Projects completed since then and work currently in progress are briefly described here. Research in Engineering Geology at the University of Auckland was covered in a separate article by W.M. Prebble in the June 1977 issue of Geomechanics News.

The course work for B.E. (Civil) includes Geomechanics I and Introductory Geology in the second professional year. Geomechanics IIA is taken in the first semester of the final year. Geomechanics IIB and Engineering Geology are available as electives in the second semester of the final year.

The programme for the M.E. offers several options. The degree is equivalent to 8 papers and takes from 12 to 18 months to complete. The course requirements are flexible so that the options are many. Four subjects of specific geomechanics content are offered: Geomechanics Seminar, Applied Geomechanics, Earthquake Engineering and Earth Structures. In any one year three of these are normally offered. A range of M.E. courses (other than Geomechanics) in the Civil Engineering Department and by the Department of Theoretical and Applied Mechanics are also available. In addition one and two paper projects are available, or a research thesis equivalent to five papers. Thus it is possible to gain an M.E. with in depth specialisation in Geomechanics, or Geomechanics supplemented with other aspects of civil engineering.

The Ph.D student is required to take three M.E. papers, in addition to undertaking full time research into a chosen topic for about 2½ years.

Staff Changes

In 1974, Dr J.M.O. Hughes joined the staff of the Civil Engineering Department as Senior Lecturer, having completed his Ph.D studies at Cambridge, where he developed the Camkometer. He is now supervising research on soil-pile interaction described in more detail below.

Dr G.R. Martin, who had been on the staff since 1966, and who had just been made Associate Professor, left the department early in 1977. He has joined Fugro and Partners, international consultants in the geomechanics field based at Long Beach, California, where he heads a team of eight people dealing with soil dynamics problems.

Dr M.J.Pender joined the staff in 1977. He had completed his Ph.D at Canterbury, then was in charge of the Geomechanics section of the MWD Central laboratories. He spent 18 months in Cambridge engaged on post-doctoral research, extending the 'critical state' theories of soil mechanics to include preconsolidated materials.

A full-time Research Fellow, Mr H.R. Green, was appointed in April, 1977, and is engaged in work on roading aggregates and pavements, including field studies.

Earthquake Engineering

A. Dynamic Properties of Soils

The fundamental research on stress-strain properties of soils under dynamic loading, carried out over a number of years, is being continued. Three types of test equipment have been developed: stress-controlled and strain-controlled dynamic triaxial apparatus, and the free vibration torsion test. Stress-controlled triaxial tests have been used to determine the susceptibility to liquefaction of foundation soils under earthquake conditions. Investigations have included several local sites, and one in Indonesia for a major LNG installation.

The free-vibration torsion test (designed initially by I.M. Parton) was improved by T.J. Larkin and the output fed into a PDP 12 computer for analysis. The records define the non-linear properties of the soil, over a wide range of amplitudes, down to shear strains as low as one microstrain. One of the apparent disadvantages of the test (that strain is non-uniform) has been considered theoretically, and a correction can readily be made to overcome the problem. This is described in:

"Interpretation of Dynamic Torsion Tests on Soils" by P.W. Taylor, School of Engineering Report No. 120, University of Auckland, 1975.

The non-linear, hysteretic soil model (used in site response analysis, section B) provides a good description of the dynamic characteristics of soils. Better methods of determining the parameters of such a model, from the results of free vibration torsion tests are being investigated:

"Non-Linear, Hysteretic Soil Model"
(Current M.E. study by T.L. Mead, supervised by P.W. Taylor).

An entirely different model of a non-linear hysteretic soil has been developed by Dr M.J. Pender. It is of considerable interest that this model gives very similar predictions of dynamic soil properties to that developed by Professor Taylor. Work is continuing on the further development of the model to cover the phenomena of sensitivity and cyclic mobility. The application of the model to the soil structure interaction problem is described below in section F.

B. Effects of Site Characteristics on Earthquake Motion

Methods of analysis of site response to earthquakes have, in the past, used a linear elastic characterisation of soil properties, with viscous damping. The actual, non-linear behaviour could not be adequately allowed for. Computer programs have now been developed which utilize the non-linear soil model, mentioned above. These are believed to give a much more exact picture of the real dynamic behaviour. The material properties must, however, be obtained from laboratory tests. Even with high quality sampling methods, some disturbance occurs, which reduces the shear modulus. The magnitude of this reduction of modulus has been investigated by comparing results from in situ shear wave velocity measurements with laboratory tests at low strain amplitudes. The "down-hole" method for shear wave velocity measurement has been successfully used at depths of up to 50 m and is described in:

"Comparison of Laboratory and Down-hole Shear Wave Velocities" by T.J. Larkin and P.W. Taylor, School of Engineering Report No. 168 (March 1978).

Based on down-hole velocity measurements, the laboratory values may be corrected, before the parameters for the non-linear soil model are obtained. This, then, is the input data for the site response program. The complete process is outlined in a recent paper:

"Seismic Site Response of Non-linear Soil Media" by P.W. Taylor and T.J. Larkin, Journal of the Geotechnical Engineering Division, ASCE v 104, No. GT3 (March 1978) (also published as School of Engineering Report No. 135, September, 1976).

The work on which the procedures described in the paper are based, including the computer programs used is:

"The Propagation of Seismic Shear Waves through Non-linear Soil Media" by T.J. Larkin (Ph.D Thesis, 1976, supervised by P.W. Taylor) (also published as School of Engineering Report No. 144, University of Auckland, September, 1976).

Another aspect of this work has been the assembly of three-component accelerometers and tape recording equipment to record earthquake aftershocks. Two sets of equipment are available so that, if there is a sizeable earthquake within the North Island in the near future, it will be possible to install these at the site, one on hard ground, and another where there are soft soils near the surface, to enable comparisons to be made, during the expected after-shock sequence.

C. Slope Stability during Earthquakes

Failure, by spreading and cracking, of road and railway embankments is common in earthquakes, as is the settlement of bridge approach fills. A detailed historical review of such events has been compiled, and an investigation made of the mechanisms involved. This work included model tests on a shaking table, and computer analyses. This is described in:

"The Seismic Stability of Highway and Railway Embankments Founded on Soft Ground" by A.H. Kent (M.E. Thesis, 1976, supervised by P.W. Taylor) (also published as School of Engineering Report No. 145, University of Auckland, November, 1976).

D. Liquefaction of Sand during Earthquakes

This work was initiated by Dr G.R. Martin. The joint project with the Universities of British Columbia and California (Berkeley) was to develop improved methods of analysis of the susceptibility of sands to liquefaction during earthquakes. Several major advances have been made towards a more fundamental understanding of the underlying mechanism of liquefaction. These are described in:

"Fundamentals of Liquefaction under Cyclic Loading" by G.R. Martin, W.D.L. Finn and H.B. Seed, Journal of the Geotechnical Engineering Division, ASCE, v. 101, No. GT5 (May, 1975).
"Seismic Response and Liquefaction of Sands" by W.D.L. Finn, P.M. Byrne and G.R. Martin, Journal of the Geotechnical Engineering Division, ASCE, v. 102, No. GT8, (August, 1976) and in
"Dynamic Effective Stress Analysis of Sands" by W.D.L. Finn, K.W. Lee and G.R. Martin, Proc. 9th Int. Conf. SMFE, v. 2 (Tokyo, 1977).

Further work is being done at Auckland to investigate the recoverable deformation characteristics of sands during one-dimensional cyclic (compression) loading. Low amplitude cyclic shear tests, at constant vertical stress are also being carried out, in a pneumatically-loaded shear apparatus. This is part of the project:

"A Fundamental Study of Sand Liquefaction under Cyclic Loading" (Current Ph.D study by R.C.K. Alexander, supervised by P.W. Taylor).

E. Earthquake Risk

The necessity to design building structures to resist earthquakes has been recognised in New Zealand since the early 1930's. The Seismological Observatory has an excellent network of tele-seismic stations, with records extending back several decades, and a more recently installed system of strong motion instruments. It is surprising, that not until very recently has any detailed study been made of the available data, to provide methods of assessing seismic risk in this country.

Using a computer file of N.Z. earthquakes, statistical methods have been developed for assessing the probable return periods of earthquakes of a particular intensity for any site in New Zealand. This provides a logical basis for the selection of criteria for the earthquake resistant design of civil engineering works (other than buildings, which are covered by the Code). In addition, attentuation relationships based on observed diminution of earthquake intensity with epicentral distance, are being developed using the existing records. This is included in:

"Seismic Risk Analysis" (Current Ph.D study by T. Matuschka, supervised by P.W. Taylor).

F. Soil-Structure Interaction

Having devised a realistic model for the non-linear hysteretic stress-strain properties of soil under dynamic loading it is of interest to apply this to the soil-structure interaction problem. Preliminary work indicates that the soil behaviour introduces a beneficial base isolation effect. This work is continuing in:

"Application of a Non-linear Soil Model to Soil-Structure Interaction" (Current M.E. study by C.J. Graham, supervised by M.J. Pender).

Another aspect of soil-structure interaction is the rocking of spread footings. Making simplified assumptions, moment-rotation relationships for spread footings on clay have been developed, including partial uplift of the footing, and soil plasticity. These relationships are found to be highly non-linear. Using a 500 mm x 250 mm test foundation, the predicted relationships have been confirmed in practice. Analysis of the effects of such foundation compliance on structural response indicates that the natural period is increased and internal moments and shears are generally reduced. This is described in:

"Foundation Rocking on a Clay Soil" by P.E. Bartlett (M.E. Thesis, 1976, supervised by P.W. Taylor) (also published as School of Engineering Report No. 154, University of Auckland, November, 1976).

The work is now being extended to spread footings on sand. The computer simulation is more complex, but the work done so far is very promising. The same laboratory equipment is being modified to use sand as a foundation material. This must, of course, be placed at a known, uniform density. This is the work undertaken for the project:

"Foundation Rocking on Sands"
(Current M.E. study by P.R. Weissing, supervised by P.W. Taylor).

The generous support of the Ministry of Works and Development for both Mr Bartlett and Mr Weissing is acknowledged.

Road Research

In recent years a wide range of pavement materials testing equipment has been developed in the School of Engineering. Also, some sophisticated computer programs, to estimate stresses and deformations in pavement structures are in use. It is expected that the programme of pavement research will be continued and expanded. Three of the pavement research projects current in 1974, funded by the National Roads Board, have since been completed.

The first of these showed that pavement deformation may be 100 times greater for a saturated pavement than for an unsaturated pavement, emphasising the importance of pavement drainage, and of selecting free draining materials for the base layers. This is described in:

"The Effect of Saturation on the Behaviour of Granular Basecourse Layers under Traffic Loading", Ph.D Thesis by Do Van Toan, supervised by G.R. Martin, (School of Engineering Report No. 125, University of Auckland, September, 1975).

In another project, four basecourse materials from the overlay test strips on Quarry Road, Drury, including lime modified and bitumen treated aggregates, were tested in the dynamic triaxial apparatus (developed for the previous project). An equation for the resilient modulus under experimental conditions was derived and used in a computer analysis to compute surface deflections. These deflections were compared with Benkelman Beam deflections measured on the test strips. This work is outlined in:

"Resilient Moduli of Selected Basecourse Materials"
M.E. Thesis by N.A. Bradley, supervised by G.R. Martin, (School of Engineering Report No. 143, University of Auckland, February, 1977).

A device has been developed to apply shearing deformations to basecourse aggregates under compressive stress to simulate more closely in the laboratory the compacting action experienced by road aggregates during field construction. A standard compaction test for the equipment was developed and shear modulus tests were carried out:

"The Development of a Simple Shear Compactor for Basecourse Aggregate Studies", M.E. Thesis by R.J. Maurice, supervised by G.R. Martin and P.W. Taylor, (School of Engineering Report No. 153, University of Auckland, August, 1977).

Currently there are three projects being carried out with financial assistance from the National Roads Board. The first is a comparison of the shear modulus values for basecourse materials obtained from the simple shear compactor and the dynamic triaxial apparatus, and consideration of the effect of anisotropy on the properties of compacted basecourse:

"The Shear Moduli of Basecourse Aggregates, and the Effects of Anisotropy", Current M.E. study by V.K.T. Lee, supervised by M.J. Pender.

Another project is concerned with lime-stabilised soils. Suitable techniques for measuring fatigue strength and modulus are being investigated. It is intended to test soils with various lime contents, and after a range of curing periods:

"Properties of Lime-Stabilised Soils" (M.E. study by D.O. McCarthy, under the supervision of M.J. Pender).

It is of little value to perfect laboratory testing methods of road pavement materials unless the results can be related to field performance. An extensive study is in progress to establish correlation between measured deformations of test pavements under known traffic loading, and the basic physical characteristics of the pavement materials, determined from laboratory tests. Such work will, it is hoped, lead to improved design methods:

"A Comparative Study of Field and Laboratory Performance of Pavement Material", (Current research project by H.R. Green).

To provide reliable field data on the permanent deformations occurring in pavements, a road profile recorder is being developed. This comprises a portable stiff beam, which, when in use, is supported at three permanent points on a road test strip. An instrumented wheel transverses the pavement and causes a cross-section to be drawn on an X-Y plotter. By repeating the measurement at some later date, permanent deformations occurring in the intervening period are accurately determined. The profile recorder is being developed by Mr B.H. Cato and Mr G.C. Duske.

Railroads, with rails fixed to sleepers on a ballasted formation, have tended to follow traditional practices. Here, after an extensive review of methods of design currently in use, and considering local conditions (track gauge, train speed and frequency, axle load, rail size and sleeper system) a method of determining the required thickness of ballast for New Zealand conditions has been developed. The work was supported by N.Z. Railways:

"Rationalised Railway Ballast Depth", M.E. Project Report, by K.H. Tay, supervised by P.W. Taylor (School of Engineering Report No. 159, University of Auckland, February, 1978).

Rock Slope Behaviour

The earlier work on rock slope stability has been continued. The National Roads Board provided a Study Award and other financial assistance for the following project:

"The Stability of Slopes in Soft Rock", by I.R. Brown (M. Phil. Thesis, supervised by P.W. Taylor) (also published as School of Engineering Report No. 112, University of Auckland, 1975).

Another project, funded by the N.R.B., was completed just before Dr Martin departed for the United States:

"Methods for the Investigation and Design of Cut Slopes in Fractured Rock", by I.R. Brown and G.R. Martin, (Report No. 158, University of Auckland, 1977).

In addition a paper by M.J. Pender on rock slope design will be presented at the N.R.B. Bridge Design Seminar in November, 1978.

Consolidation Settlement

In some settlement problems 'delayed compression' (that is, secondary consolidation, not accounted for by the Terzaghi theory) is responsible for a substantial proportion of total observed settlement. A computer program was developed, using finite difference methods, to calculate such settlements. This can deal with a multi-layered soil and allows for changes in permeability and compressibility with changes in voids ratio or effective stress. A controlled-gradient consolidometer was developed to determine soil parameters. With assistance from MWD, the method was applied, with reasonable success, to the Gloucester Park motorway embankment. The work is described in:

"Consolidation Settlements of Roading Embankments" by B.G. McLister (M.E. Thesis, 1975, supervised by P.W. Taylor) (also published as School of Engineering Report No. 113, University of Auckland, February, 1975).

This was also the subject of a combined paper:

"Embankment Settlement including Delayed Compression" by P.W. Taylor, B.G. McLister and G.R.W. East, Proc. 2nd Australia New Zealand Conf. on Geomechanics (Brisbane, 1975).

This work was supported by the award of an NRB Postgraduate Scholarship to Mr McLister.

Lateral Loading of Piles

This study was commenced in 1976 with the ultimate objective of examining the behaviour of piles subject to seismically induced lateral loads. As this is a new area of research for Auckland, considerable effort has been devoted to developing experimental techniques to enable repeatable and reliable experiments to be conducted. Special photographic and radiographic techniques have been developed to examine the behaviour of the soil surrounding the pile. To date all the studies have been on laboratory models with piles driven into sand. Single pile and two pile systems are currently being investigated. The lateral loads have all been applied slowly either as "static" or slow cyclic tests. When this static study is completed the research will be extended to cover rapid cyclic loading tests approximating more closely to seismic loading. It is hoped to extend the model studies to cohesive soils and to larger full scale tests. Since 1977, this work has been supported by the National Roads Board:

"Lateral Loading of Piles", (Current Ph.D study by P.R. Goldsmith supervised by J.M.O. Hughes).
"Behaviour of Pile Groups under Lateral Loads", (Current Ph.D. study by H.D.W. Fendall, supervised by J.M.O. Hughes).

Publications related to these studies are:

"The Uniform Placement of Laboratory Sand Samples" by P.R. Goldsmith (School of Engineering Report No. 171, University of Auckland, 1978).
"A Qualitative View of Lateral Displacement of Poles and Piles in Sand" (School of Engineering Report No. 140, University of Auckland, September, 1978).

A condensed version of this paper was presented at the 9th International Conference SMFE, in Tokyo (1977) in the Specialty Session on the Effect of Horizontal Loads on Piles due to Surcharge or Seismic Effects.

"A Borehole Displacement Gauge" by P.R. Goldsmith and J.M.O. Hughes, Geotechnique, v. 27, No. 2 (June, 1977).
"The Behaviour of Piles subject to Lateral Loads" by J.M.O. Hughes, P.R. Goldsmith and H.D.W. Fendall (School of Engineering Report No. 178, University of Auckland, September, 1978).

Here also, the contents of the Report have been condensed, and submitted as a paper for the NRB Seminar on Bridge Design, to be held in Auckland in November, 1978.

Field Instrumentation

It is now becoming widely recognised that geomechanics investigations must rely more on field measurements rather than entirely on laboratory tests. Various developments are being made in this direction.

Arising from the work described under 'Lateral Loading of Piles' above, the borehole displacement gauge is now being used in field investigations. When used in conjunction with a quick response piezometer this provides a useful method of monitoring natural slopes.

Another type of field measurement entails the use of pressuremeter. The self-boring type, developed by Dr Hughes at Cambridge (1968-73) may be used to measure in situ horizontal stress, soil modulus and strength. While developed initially for use in soft clays, their application to soft rocks is under consideration.

It is hoped to combine this technique with the down-hole seismic method mentioned previously, to extend the range of field determination of modulus values.

Recent publications include:

"Pressuremeter Tests in Sand" by J.M.O. Hughes, C.P. Wroth and D. Windle, Geotechnique, v. 27, No. 4 (December, 1977).
"In Situ Testing of Soils using a Self-boring Pressuremeter" by J.M.O. Hughes, N.Z. Engineering, v. 33, No. 7 (July, 1978).
"Undrained Stress-Strain Properties of Clays from In-Situ Expansion Tests" by J.M.O. Hughes (School of Engineering Report No. 179, University of Auckland, September, 1978).

SMS Series Reports

Each report is prepared by a graduate student as a project within the postgraduate course "Geomechanics Seminar". The reports are the result of library research and the object, in addition to providing a valuable exercise for the student, is to provide information in a concise form which it is hoped will be of use to the practising civil engineer. Each report briefly outlines the topic and includes a comprehensive list of references.

Previous lists were published with the November, 1970 and November, 1974 articles. Listed below are reports prepared since 1974.

Copies may be obtained on request from:

The Secretary,
Civil Engineering Department,
University of Auckland,
Private Bag,
AUCKLAND.

SMS 7601 "Ground Anchors"
by N.A. Bradley.
The design of anchors for use in foundation construction is covered (41 pp, 12 references).

SMS 7602 "Reinforced Earth"
by R.C.K. Alexander.
Reinforced earth construction techniques are reviewed and design methods available in 1976 discussed (54 pp, 12 references).

SMS 7603 "Vertical Sand Drains and Stone Columns"
by T. Matuschka.
The effect of sand drains and stone columns on the rate of settlement of a soil deposit is discussed (36 pp, 19 references).

SMS 7604 "Pressures in Bins and Silos"
by P.R. Goldsmith.
The principles involved in assessing pressures exerted by granular media on silos and bins are discussed (47 pp, 12 references).

SMS 7605 "Ground Freezing in Construction"
by D.C. Boyce.
The history, applications and design of ground freezing are discussed (27 pp, 10 references).

SMS 7606 "Foundations for Offshore Structures"
by R.J. Maurice.
Various types of foundations for offshore structures are considered (42 pp, 13 references).

SMS 7701 "Statistical Analysis of Settlements"
by H.W. Fendall.
The possibility of incorporating the uncertainty in soil property values into settlement predictions is reviewed (12 pp, 7 references).

SMS 7702 "Limit Analysis in Geomechanics"
by T.L. Mead.
The techniques and theoretical background to limit analysis are discussed (28 pp, 12 references).

SMS 7801 "The Rate of Consolidation of Layered Soil Strata"
by C.J. Graham.
The effect of a number of layers with differing properties on the rate of consolidation of a soil deposit is reviewed (34 pp, 17 references).

SMS 7802 "Settlement of Pile Foundations"
by V.K.T. Lee.
Elastic methods of predicting pile settlements are described (50 pp, 16 references).

SMS 7803 "Electro-Osmosis in Soils"
by T.H. Nguyen.
The physics of electro-osmotic effects in soils are discussed (20 pp, 20 references).

SMS 7804 "Flexible Pavement Design Methods"
by S.C. Lee.
Design methods used for flexible pavements are compared (64 pp, 14 references).

SMS 7805 "Pile Foundations for Offshore Structures"
by M.E.S. Hii.
Piles foundations for offshore structures are discussed from both the design and construction viewpoints (53 pp, 15 references).

School of Engineering Reports

A number of these reports, prepared in the Civil Engineering department, are listed with reference to research developments. Unless out of print, these may be obtained on request from the departmental secretary.

URBAN PLANNING IN CHRISTCHURCH

(Notes from a Meeting of the Christchurch Geomechanics Group)

D.H. Bell

Introduction

On 20 September 1978 a joint meeting of the Christchurch Geomechanics Group and the NZIE Canterbury Branch, was attended by some 30 people. Although organised by the Geomechanics Group, attention was deliberately focussed away from "geomechanics" to the very much wider field of urban planning itself. (It must be remembered that a 2-day seminar on "Slope Stability and Urban Development" was held at Canterbury University in February of this year - see NZ Geomechanics News No. 16, pp 34 and 35.)

The meeting was addressed in turn by John White of the Canterbury Regional Planning Authority; by John Annan, County Engineer, Paparua County Council; and by Terry Lucas, of Christchurch Estates Ltd. Predictably the planner, the engineer and the developer had somewhat different approaches to the subject, and their comments generated a lively response from those present. What long-term benefits, if any, will emerge from the meeting is less certain - but it was a salutary lesson to be reminded that urban planning is not just slope stability or geomechanics!!

The Regional Viewpoint

John White clearly expounded what may be termed the "philosophy of urban planning", stressing the need for a flexible approach based on the valuing of objectives and with continuing public involvement in the planning process. He outlined the recently published Canterbury Indicative Plan, and the various objectives underlying its preparation (conservation; transport; social and economic needs; etc.). It was not, however, until question time that it became evident that Christchurch could expect in the next 20 years a population growth between zero and 50% of its present level. How realistic planning for long-term urban development could be made on such an uncertain basis remained a mystery to most present, and certainly emerged as the dominant constraint on future urban planning for Christchurch.

The Local Body Viewpoint

John Annan suggested that the need for sound planning was now well recognised by local body members, whose aims were as far as possible to satisfy the requirements of individual freedom within the local community. However, he entered a plea for greater cooperation between planners at the national, regional and local levels; and argued that use of the perimeter surrounding existing development did not necessarily constitute urban sprawl. The role of the local body was still seen to be primarily its historic one of provision and upgrading of community services and facilities.

A Developer's Viewpoint

Involvement of the land developer in urban planning was suggested as essential, but the economic factors (especially population trends) were seen as dominating the future, at least in Christchurch. Terry Lucas suggested that it was certainly time to rationalise the "natural limits" to urban development in Christchurch (especially with regard to hillslope expansion), and urged instead limited "decentralisation" and expansion of many of the smaller towns beyond Christchurch. Considerable discussion centred on the recently proposed revision of the Heathcote County District Scheme, which allows for considerable expansion onto the Port Hills (and which reportedly provides sufficient sections for the next 150 years at the present rate of population growth in the County!!).

The Role of Geomechanics

It emerged from the discussion that population trends and economic factors will dominate future urban planning in Christchurch. The geomechanics problems associated with development on urban slopes (and especially on Port Hills loess) appeared to be well recognised - probably more so than those of the peat swamps on the flats, where development has been proceeding for over 100 years. However, given the probability of very low growth in demand for urban housing, and with inner city redevelopment in part offsetting the need for expansion of the urban perimeter, the slope stability problems of recent years on the Port Hills receded (but only temporarily) into insignificance.

Some other interesting points to emerge included:-

1. Should hillside sections continue to be made available (with their attendant stability problems), and if so should all ratepayers subsidise the risks involved? Or should some form of differential (risk = cost-related) rating system be devised?

2. There is a need for legislation and insurance whereby slope failures affecting urban land can be "prevented", rather than the existing situation where only remedial measures are really possible.

3. Should the developer be legally and financially responsible for the stability of his subdivision, rather than the local body as at present?

4. How much freedom can be allowed the individual to live where he likes, and do what he wishes with his section? And how far should the local body go in planning and legislating for "the community at large"?

POSTSCRIPT

The meeting closed with a brief resume by Malcolm Douglas, Consultant Town Planner, who thanked the three speakers for their contributions, and reiterated the basic question of rate of growth in demand for urban housing. The role of geomechanics in the future urban development of Christchurch was placed in reasonable perspective, and the airing of many different points of view was encouraging. A comment at supper was even more pleasing - "Three years ago such a meeting would not have been possible in Christchurch". If the Geomechanics Society can continue to act as a catalyst and (hopefully) unbiased commentator in the field of urban planning, then we may yet successfully bridge the gap between geomechanics theory and its practical applications (the "communication barrier" which I mentioned in Geomechanics News No. 16, p. 35)!

NEWS FROM THE INTERNATIONAL TUNNELLING ASSOCIATION

The International Tunnelling Association held its fourth annual meeting in TOKYO from 29th May to 2nd June 1978 in connection with the International Symposium on Tunnelling Under Difficult Conditions. It gathered 158 participants (delegates and observers) representing 18 out of the 24 member-nations of the Association, 8 nations interested to join the Association in the near future and 2 International Associations.

The following member nations were represented:-

South Africa, Federal Republic of Germany, Algeria, Australia, Austria, Belgium, Spain, United States of America, Finland, France, Italy, Japan, New Zealand, Norway, Netherlands, United Kingdom, Sweden, Switzerland.

Executive Council

The elected members of the Executive Council are:-

A.M. MUIR WOOD	United Kingdom	Honorary President	
H.C. FISCHER	Sweden	President	until 1980
W.N. LUCKE	United States of America	1st Vice-President	until 1979
T. SHINOHARA	Japan	2nd Vice-President	until 1980
G. GIRNAU	Federal Republic of Germany		
P. DUFFAUT	France	General Secretary	until 1979

Working Groups

The six previously established working groups held two working sessions each, and two new working groups have been established, one for Maintenance and Repair of Underground Structures, the other for Structural Design Models for Tunnels.

The working group on Standardization (Mr PLICHON, France) has approved a thesaurus to be used for indexation of all technical documents, issued by ITA as well as by national groups and journals devoted to Tunnelling and related matters. A lot of work is now being done on terminology,and four questionnaires willbe distributed about standardization problems to be studied.

The group on Research (Mr KIEFT, The Netherlands) acting on behalf of Mr GIRNAU (G.F.R.) has updated its report on the state of tunnelling research, which will be published, partly in English, partly in French. This report will be updated every three years. A discussion on shield tunnelling will be conducted at the next annual meeting.

The working group on Contractual Sharing of Risk (Mr LEMLEY, U.S.A.) acting for Mr NADEL (U.S.A.) submitted a recommendation ready to be published (from which emerge four chief points):

(i) use in all tunnelling contracts of "changed conditions" clause
(ii) give all available subsurface information
(iii) eliminate all disclaimer clauses
(iv) submit the choice of contractors to a pre qualification procedure

This recommendation will soon be published.

The group on Subsurface Planning (Mr JANSSON, Sweden), in addition to having arranged the open session, decided to concentrate its main activities on the problem of Human Beings underground in the future, while efforts to develop Planning Guidelines will continue.

The group on Catalogue of Works in Progress (Mr FUJITA, Japan), met for the first time and reviewed a lot of material received from a number of countries. A representative in every country is necessary in order to carry out the preparation at a national level, along the established format. A catalogue was planned to be printed every two years.

Mr KRIGE (acting on behalf of Mr WAGNER, South Africa) informed the group on Safety in Work, that the South African National group had appointed an engineer for preparation of a Safety Index. A document on safety signs conforming to the I.S.O. specifications will be presented. The group agreed on the aim of establishing central statistics on accidents in tunnelling works.

Open Session

The Open Session at this Annual Meeting attracted a large number of attendants, also from participants in the Symposium on Tunnelling Under Difficult Conditions, increasing the total audience to over 300. It constituted a general presentation of recent and future uses of underground space with the general title: TO GO UNDERGROUND - RIGHT OR WRONG? In his introduction Professor H.C. FISCHER, Sweden, stated that the aim of this session could be said to concern WHY to make tunnels and other subsurface constructions, as a supplement to the technical subjects of the Symposium which were concerned with HOW to make them. Thus the subject of the Open Session was intended not only for engineers, but also for decision makers and the general public.

The following papers were presented:

Mr B. JANSSON, Sweden : "Terraspace - a Resource in Human, Economic and Urban Development"

Mr M. BARKER, U.S.A. : "Building Underground for People ; Eleven Selected Projects in the United States"

Mr Y. WATANABE, Japan : "Planning for Subsurface Use from the Viewpoint of Comprehensive City Planning"

Mr M. BERGMAN, Sweden : "Low-cost Storage of Petroleum in Salt-domes, Mines and Rock Caverns" and a paper from Prof. C. FAIRHURST, U.S.A. : "Conservation of Energy and Environment - Energy Storage, Nature, Human Living"

Mr J. RYGH, Norway : "Energy Savings in Food Storage and in Buildings"

Mr L. LUPIAC, France : "Should we avoid Transportation underground?

The presentations contained a rich variation of illustrations of projects already constructed and being in use, in some cases with detailed data on performance. It was clearly demonstrated how underground constructions, and also earth-covered buildings can be used to conserve existing aesthetic values and introduce new ones. In transportation, underground installations should be avoided only under certain conditions, while they had important advantages under other conditions.

Detailed proceedings of this 4th Annual Meeting, including the Open Session, will be distributed to the member nations and to the participants at the Annual Meeting.

As reported elsewhere in this issue, New Zealand was represented at the Annual Meeting by Messrs Preston and Hinkley, both of M.W.D., Wellington.

LATERALLY LOADED PILES

T. Belshaw

1. INTRODUCTION

Methods are presented below for the design of piles subjected to horizontal loads. The piles are divided into two classes:

(i) "Short Piles" are strong stiff piles with relatively small embedment lengths, in which the ultimate lateral resistance is governed by the passive resistance of the soil.

(ii) "Long Piles" have large embedment lengths and the ultimate lateral resistance is governed by the yield resistance of the pile section.

The two types of piles may be either free at ground level, or restrained fully or partly by concrete pile caps, slabs or beams.

2. DESIGN OF SHORT PILES

Symbols:

- L = embedment length (m)
- e = height of lateral load above ground level (m)
- P = lateral load (kN)
- D = width of pile (m)
- Y = deflection at ground level (mm)
- S = passive resistance of the soil at a depth of 0.33L (kPa) (See Table I)
- c = cohesion (kPa)
- γ = bulk density of sand = 19 kN/m^3

The width of pile, D, is based on round piles, for square or rectangular piles use D = pile width x 1.2. The equation for embedment length, L, is based on a deflection at ground level of 12mm.

$$L = \frac{1.36P}{S \times D}\left[1 + \sqrt{\frac{D}{0.3} + \frac{2e \times S \times D}{P}}\right] \quad \text{(Eqn 1)}$$

$$Y = \frac{17P}{L \times S \times D}\left[1 + \sqrt{\frac{D}{0.3} + \frac{2e \times S \times D}{P}}\right] \quad \text{(Eqn 2)}$$

For a short free pile (see Fig. 1(a)), the equation for L, based on a deflection of 6mm at the bottom of the pile, is given by:

$$L = 2.1\sqrt{\frac{P \times e}{S \times D}} \quad \text{(Eqn 3)}$$

For a short pile restrained by floor slab (see Fig. 1(b)), values of L or Y may be taken as 1/3 those given by Eqns 1 and 2. The condition for a short fully restrained pile is shown in Fig. 1(c).

Recommendations for Short Piles

The equations for L have factors of safety of possibly 3 or 4. Repetitive loads due to wind or earthquake may reduce the strength of the soil around the pile. Therefore for clays and loose sands subject to repetitive loadings, use 0.5 x S. For medium to dense sands use 0.66 x S.

In clays, the maximum free pile bending moment $= P \times \left(e + 1.5D + \frac{P}{18cD}\right)$

In clays, max. B.M. for restrained piles $= P \times 0.6L$ (kN-m)

In sands and gravels, max. free pile B.M. $= P \times \left(e + 0.5\sqrt{\frac{2P}{\gamma_1 DKp}}\right)$

In sands and gravels, max. B.M. for restrained piles $= P \times 0.66L$. This value of P x 0.66L must not be greater than the yield bending moment of the pile. It is essential to check that the resisting moment of the pile section ($f_y Z$) is equal to or greater than the applied bending moment. Note that where the load is not occasional but permanent, consolidation will approximately treble the deflection, in time.

Ultimate Lateral Resistance for Short Piles

For cohesive soils:

(i) Not restrained, $P_u = \frac{1.5 \times L^2 \times D \times c}{e + 0.66L}$ (kN)

(ii) Restrained, $P_u = 4.5 \times L \times D \times c$ (kN)

(Eqn 4)

For sands and gravels:

(i) Not restrained, $P_u = \frac{0.5 \times \gamma_1 \times D \times L^3 \times Kp}{e + L}$ (kN)

(ii) Restrained $P_u = 1.5 \times \gamma_1 \times D \times L^2 \times Kp$ (kN)

(Eqn 5)

TABLE I: VALUES OF "S" FOR SHORT PILES IN COHESIVE SOILS

SOIL TYPE	COHESION c,(kPa)	VALUES OF "S" FOR VARIOUS DEPTHS				
		0.5m	1.0m	1.5m	2.0m	2.5m
Stiff Clay	100+	142	150	157	164	171
Firm Clay	50	90	95	104	109	116
Soft Clay	25	45	50	55	60	65
Very Soft Clay	15	25	28	31	34	37

TABLE II: VALUES OF "S" FOR SHORT PILES IN COHESIONLESS SOILS

SOIL TYPE	DENSITY (kN/m^3)	CO-EFF K1	VALUES OF "S FOR VARIOUS DEPTHS				
			0.5m	1.0m	1.5m	2.0m	2.5m
Dense sand and gravel	20		60	120	180	240	300
Medium sand	19		47	95	142	190	238
Loose sand	18		36	72	108	144	180

Notes on Tables I and II: For the appropriate soil, use the value of "S" at a depth of 0.33L. For repetitive loads, use 0.5S for clays and loose sands and 0.66S for other sands. Reduce S according to position of the water table in cohesionless soils. If water table is at ground level, reduce S by 50%; if water table is at L/2, reduce S by 25%.

TABLE III: COMPARISON OF CALCULATED AND MEASURE DEFLECTIONS

P (kN)	L (m)	D (m)	e (m)	c (kPa)	S (kPa)	Y Calculated (mm)	Y Measured (mm)
70	4.4	0.3	-	Sand	135	13.4	12.5
30	3	0.3	-	Sand	90	12.6	12.5
11	2	0.3	1	50	90	11.9	12.5
8.9	1.52	0.6	3	73	115	11.5	10
6.3	1.22	0.275	4.57	106	142	19.3	18
21.6	1.83	0.457	4.57	88	130	20.8	13
56.7	1.83	0.940	4.02	146	142	22.4	12

3. DESIGN OF LONG PILES IN COHESIVE SOILS

Symbols:
- k = co-efficient of lateral subgrade reaction for a long pile (kN/m^3)
- E = modulus of elasticity of pile material (kPa)
- I = moment of inertia of pile section (m^4)
- f_y = yield stress of the pile (kPa)
- Z = section modulus of pile (m^3)
- R = 1 for steady loads or 2 for repetitive loads

The pile reactions depend mainly on a dimensionless factor B x L in which

$$B = \sqrt[4]{\frac{k \times D}{4 E I}}$$

The pile length is assumed "long" when $B \times L > 2.25$ (free), or $B \times L > 1.5$ (restrained)

Deflections

For a long free pile ($B \times L > 2.25$) $$Y = \frac{2000PB(eB+1)}{kD} \quad \text{(Eqn 6)}$$

For a long restrained pile ($B \times L > 1.5$) $$Y = \frac{1000PB}{kD} \quad \text{(Eqn 7)}$$

Note that $k = \frac{\alpha 160c}{DR}$ where α varies from 0.3 for long steel piles in soft clay to 0.5 for timber piles in stiff clay. An average value of α would be 0.4.

Example

A steel H piles has L = 16.5m, e = 9.9m, D = 0.356m, P = 4.41 kN, free headed, $I = 0.000249 m^4$ in very soft clay (c = 10 kPa). Find the deflection at ground level.

$$k = \frac{0.3 \times 160 \times 10}{0.356 \times 2} = 675 \text{ kN/m}^3$$

$$B = \sqrt[4]{\frac{675 \times 0.356}{4 \times 51505}} = 0.185$$

Note k has been reduced for repetitive loads.

B x L = 3.05, therefore pile is long.

$$\text{Lateral defection at ground level} = \frac{2000 \times 4.41 \times 0.185\ (9.9 \times 0.185 + 1)}{975 \times 0.356}$$

$$= \underline{20\text{mm}}$$

The calculated Y = 20mm compares favourably with the measured deflection of 15mm for a single load.

Ultimate Lateral Resistance of Long Piles

Failure takes place in a long free pile when the driving moment $P\left(e + 1.5D + \frac{P}{9cD}\right)$ is equal to the moment resistance $f_y.Z$ of the pile section.

For a long free pile in clay (see Fig. 2):

$$P_u = \frac{f_y.Z}{e + 1.5D + \frac{P}{9cD}} \qquad \text{(Eqn 8)}$$

Divide P_u by 1.5 for repetitive loadings. Note that P_u (restrained pile) = 2 x P_u (free pile). A factor of safety of 2.5 or 3 would be necessary to obtain the allowable horizontal load.

Example

Calculate the probable P_u of the steel H pile in soft clay with the same L and e, etc as in the preceding example.

$$f_y = 31000 \text{ kPa}$$

$$Z = 0.0014 \text{ m}^3$$

$$P_u = \frac{f_y.Z}{e + 1.5D + \frac{P}{9cD}}$$

= 37 kN divide by 1.5 for repetitive loads

therefore P_u = 25 kN.

A factor of safety of 3 would give P(allowable) = 8 kN.

4. LONG PILES IN COHESIONLESS SOILS

Symbols:

n = constant of horizontal subgrade reaction for a long pile of width 1m at a depth of 1m (kN/m^3)

γ = bulk density of sand, average value 19 kN/m^3

L = dimensionless factor; pile is long for $\eta L > 4$

$\eta = (n/EI)^{0.2}$

$L_c = 2/\eta$ = critical length (m)

M_y = yield moment of the pile (kN-m)

M_p = maximum applied bending moment

K_p = 2 for loose sand, 3 for medium sand and 4 for dense sand

N = no. of blows from Standard Penetration Test.

The values of the constant, n, are given in Table IV.

TABLE IV: VALUES OF CONSTANT "n"

	Values of (kN/m^3) After Terzaghi						
"N" (S.P.T.)	4	7	10	20	30	40	50
Rel. Density	Loose			Medium		Dense	
Above W.T.	1000	2000	3000	7000	11000	18000	26000
Submerged	600	1200	2000	4000	7000	10000	15000

For repetitive loadings, use 0.33n for loose sand and 0.5n for medium and dense sand.

Deflections

For a long free pile,

$$Y = \frac{1600P\left(1 + \frac{1.33e}{Lc}\right)}{n^{0.6} \times (EI)^{0.4}} \quad \text{(mm)} \qquad \text{(Eqn 9)}$$

For a long fully restrained pile,

$$Y = \frac{600P}{n^{0.6} \times (EI)^{0.4}} \quad \text{(mm)} \qquad \text{(Eqn 10)}$$

Example

A large diameter bored pile, D = 1.8m, L = 30m, e = 17m, P = 1000 kN is founded in submerged sand (N = 10 blows). Find the deflection at ground level.

Table IV gives $n = 2000\ kN/m^3$

$E_{conc.} = 20{,}685{,}000$ kPa

$I = 0.515\ m^4$

$\eta = \left(\frac{n}{EI}\right)^{0.2} = 0.144$

$L_c = 2/\eta = 13.89$

For a long free pile, $Y = \dfrac{1600P\left(1 + \dfrac{1.33e}{L_c}\right)}{n^{0.6} \times (EI)^{0.4}}$ = 132 mm at G.L.

Deflection at top of pile = $\dfrac{132 \times (13.89 + 17)}{13.89}$ = 294 mm

Deflection at top of pile is 294 mm plus approximately 200 mm due to pile bending, making a total deflection of about 500 mm.

Ultimate Lateral Resistance of Long Piles in Sand

For long free piles, max. B.M. $= P\left(e + 0.5\sqrt{\dfrac{2P}{\gamma_1 DK_p}}\right)$ (Eqn 11)

For long free piles, $P_u = \dfrac{M_y}{e + 0.5\sqrt{\dfrac{2P}{\gamma_1 DK_p}}}$ (Eqn 12)

For long restrained piles, $P_u = \dfrac{2M_y}{e + 0.5\sqrt{\dfrac{2P}{\gamma_1 DK_p}}}$ (Eqn 13)

Note that M_y will depend on the strength of the concrete specified and the amount of steel reinforcing used.

5. INTERMEDIATE LENGTH PILES

Broms gives piles in clay as "intermediate" between short and long when BL is between 1.5 and 2.25 for free piles and between 0.5 and 1.5 for a restrained pile. Piles in sand are "intermediate" when ηL is between about 2 and about 4 (for both free and restrained piles). It is essential in "intermediate" length piles to ensure that both the soil reactions and the moment resistance of the pile are adequate.

6. SUMMARY AND CONCLUSIONS

The nature of the top few metres of soil is predominant in determining the behaviour of the piles. For example if a sand fill of thickness $L_c/2$ is provided over a soft clay, an 'n' value pertaining to the sand can be used. Note that for sand, $L_c = 2/\eta$ (free and restrained) and for clay, $L_c = 1/B$ (free) and 2/B (restrained).

The design of laterally loaded piles is governed by the requirement that complete collapse should not occur even under the most adverse conditions, and that deflections should not be so excessive as to prevent the proper functioning of the structure. Where only small deflections can be tolerated the design is governed by the lateral deflections. While for structures in which large deflections can be tolerated the design is governed by the ultimate lateral resistance. In general the design should be based on the assumption of unfavourable soil conditions.

Short Piles. It is usual to design short piles by limiting the deflection at ground-line to 12 mm or less, and checking that the maximum B.M. in the pile does not exceed the yield or ultimate moment of the pile section. Where piles are designed to resist wind, earthquake or other cyclic loads, the values of 'S' should be reduced for repetitive loading.

Long piles in clay. For repetitive loads the coefficient of subgrade reaction 'k' is divided by 2 for use in the deflection formulae. While for ultimate lateral resistance P_u is divided by 1.5.

Long Piles in Sand and Gravel. For repetitive loads the constant of subgrade reaction 'n' is divided by 3 for loose sands and by 2 for medium and dense sands. No reduction is necessary for P_u since the cohesionless formulae are conservative.

Formulae. Some formulae have been slightly adjusted, mostly in the direction of safety, e.g. Equations 1, 2, 11, 12 and 13, while Equations 9 and 10 have been reduced to give more realistic realistic results.

Pile Groups. A reduction may have to be made for groups of piles when the pile spacing is less than 4 D.

Factors of Safety. The maximum stress in a laterally loaded pile does not increase linearly at high stresses, hence the maximum stress in a pile may reach 2.5 times the design stress when the applied load is only 1.5 times the design load, therefore even for high earthquake design loads a minimum factor of safety of 2.5 would seem to be indicated.

Pole Piles. Piles placed in bored holes should be encased with concrete not rammed earth.

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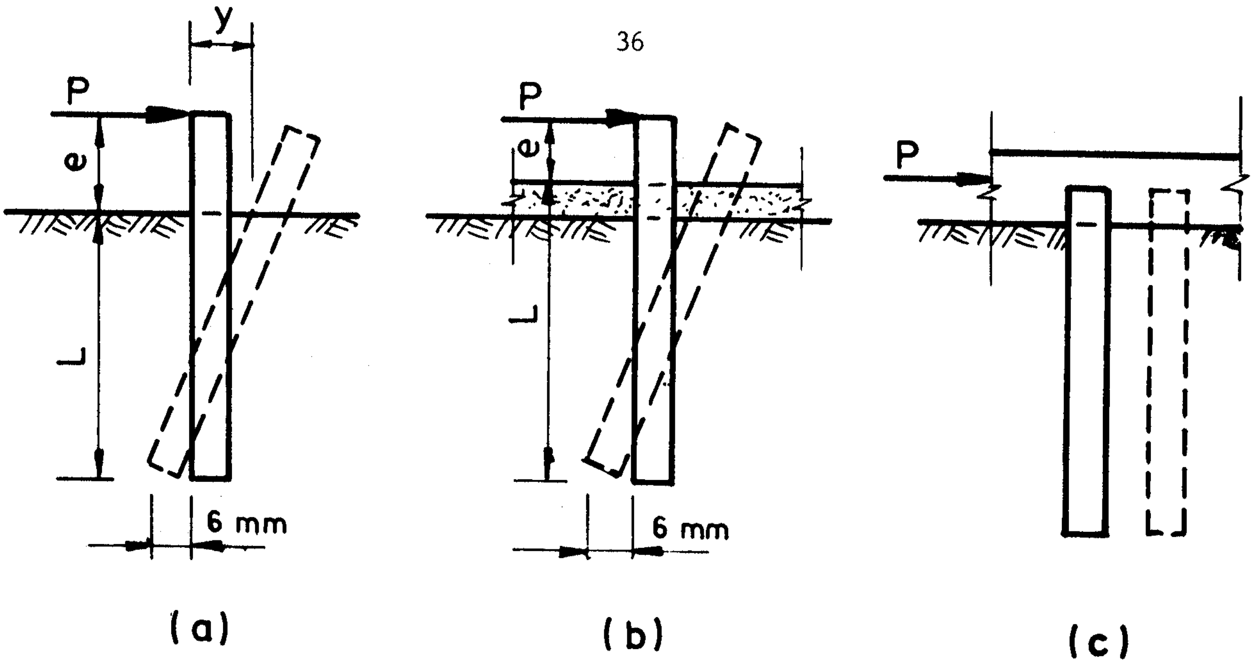

FIG. 1 SHORT PILES

(a) free
(b) restrained by floor slab
(c) fully restrained

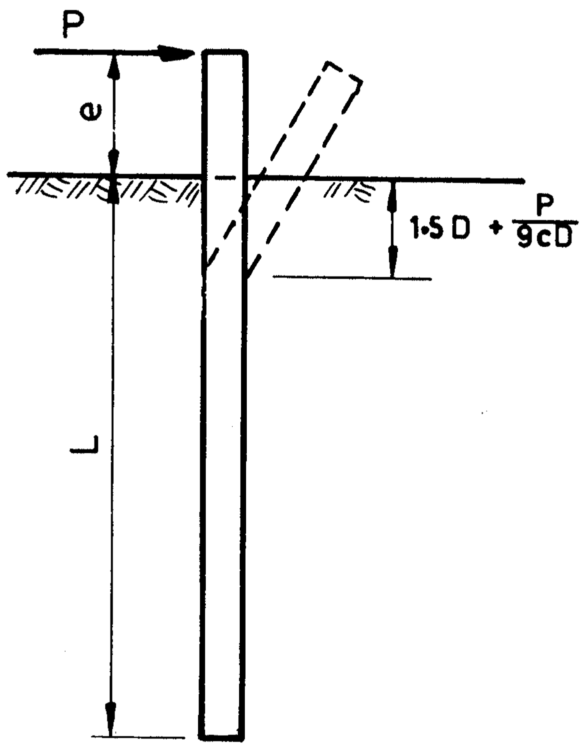

FIG. 2 LONG PILES

3rd AUSTRALIA-NEW ZEALAND GEOMECHANICS CONFERENCE

This joint Geomechanics Conference, the first to be staged in New Zealand, will be held at the Victoria University of Wellington from 12 to 16 May, 1980. The Organising Secretary will be accepting abstracts of 250 to 350 words for consideration up to 28 February, 1979. Provisional acceptance will be based on the contents of the abstract. Final manuscripts of not more than 10 pages (A3, to be reduced photographically) should be planned for submission not later than 31 October, 1979.

Enquiries should be directed to:

The Organising Secretary,
3rd Australia-N.Z. Geomechanics Conference,
c/- Barr, Burgess and Stewart,
P.O. Box 243,
WELLINGTON.

APPLICATION FOR MEMBERSHIP

of

New Zealand Geomechanics Society

A TECHNICAL GROUP OF THE NEW ZEALAND INSTITUTION OF ENGINEERS

The Secretary,
N.Z. Institution of Engineers,
P.O. Box 12-241,
WELLINGTON.

I believe myself to be a proper person to be a member of the N.Z. Geomechanics Society and do hereby promise that, in the event of my admission, I will be governed by the Rules of the Society for the time being in force or as they may hereafter be amended and that I will promote the objects of the Society as far as may be in my power.

I hereby apply for membership of the New Zealand Geomechanics Society and supply the following details:

NAME ____

(to be set out in full in block letters, surname last)

PERMANENT ADDRESS ____

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QUALIFICATIONS AND EXPERIENCE ____

____

NAME OF PRESENT EMPLOYER ____

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I wish to affiliate to:

International Society for Soil Mechanics and Foundation Engineering (ISSMFE) Yes/No ($2.25)

International Society for Rock Mechanics (ISRM) Yes/No ($6.20)

International Association of Engineering Geology (IAEG) Yes/No ($2;$6 with Bulletin)

Signature of Applicant ______________________

Date ______________ 19 ___

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I ______________________________ being a financial member of the N.Z. Geomechanics Society hereby nominate ______________________ ______________________ for membership of the above Society.

Signed ______________________ Date ______________ 19 ___

NEW ZEALAND GEOMECHANICS SOCIETY

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The Secretary,
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Dear Sir,

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Could you please record my address for all New Zealand Geomechanics Society correspondence as follows:

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Name: ____

Address to which present correspondence is being sent:

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Signature ____________________

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