ISSN 0111-6851

N.Z. GEOMECHANICS NEWS

No. 24

JUNE 1982

A NEWSLETTER OF THE N.Z. GEOMECHANICS SOCIETY

N.Z. GEOMECHANICS NEWS

No. 24, June 1982

A Newsletter of the N.Z. Geomechanics Society

CONTENTS

Persons interested in applying for membership of the Society are invited to complete the application form at the back of this newsletter. The basic annual subscription rate is $15.00 and is supplemented according to which of the International Societies, namely Soil Mechanics ($6.00), Rock Mechanics ($8.50), or Engineering Geology ($4.50) the member wishes to be affiliated. Members of the Society are required to affiliate to at least one International Society.

EDITOR'S NOTES

1. Articles in this Issue

This issue contains two articles. The first by Ian Smalley poses the question whether loess should be considered as a sensitive soil, and compares the mechanisms of collapse of loess and quickclay particularly when saturated. The second article by Peter Millar outlines the principles of the statistical analysis of triaxial results and how this approach can be of great benefit to the designer.

2. Draft Method of Soil Description

Unfortunately the subcommittee has not been able to complete the extension of the method of description to include rocks. The circulation of the soil and rock description method has consequently been delayed, for which the committee apologises.

3. List of Members

The International Societies (ISSFME, ISRM and IAEG) periodically issue membership lists - the last being ISSFME in 1981. To assist the Society in the preparation of these lists could members please fill out the form at the back of this issue and return it to the Management Secretary. The opportunity will also be taken to update the Geomechanics Society membership list, so members' co-operation would be greatly appreciated.

4. Membership Application

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. Prospective members are requested not to send subscription fees with their applications.

5. 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.

6. 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,
N.Z. Geomechanics News,
C/- N.Z. Geomechanics Society,
P.O. Box 12-241,
Wellington North.

S.A.L. Read
Editor

PUBLICATIONS OF THE SOCIETY

The following publications of the Society are available:

(a) From the Secretary, IPENZ, P.O. Box 12-241, Wellington North:

- Proceedings of the Palmerston North Symposium "Geomechanics in Urban Planning", April 1981. Price $20.00.
- "Stability of House Sites and Foundations - Advice to Prospective House and Section Owners". (Published for the Earthquake and War Damage Commission.) Price $0.50.
- Proceedings of the Third Australia-New Zealand Conference on Geomechanics, Wellington, May 1980. Price $90.00 for the three volume set.
- Proceedings of the Hamilton Symposium "Tunnelling in New Zealand", November 1977. Price $18.00 to members, $20.00 to non-members.
- Proceedings of the Second Australia-New Zealand Conference on Geomechanics, Brisbane, July 1975. Price only $25.00.
- Proceedings of the Wanganui Symposium "Using Geomechanics in Foundation Engineering", September 1972. Price $8.00 to members, $10.00 to non-members.
- Proceedings of the Christchurch Symposium "New Zealand Practices in Site Investigations for Building Foundations", August 1969. The last copies of a limited reprinting are available at $8.00 to members, $10.00 to non-members.
- Copies of all back-issues of "New Zealand Geomechanics News" are available to members at a nominal price of $2.00 per copy.
- The following back issues of the IAEG Bulletin are available. Price $3.00 to members.

Issue	No. available
14	1
15	10
21	1

(b) From Government Bookshops:

- "Slope Stability in Urban Development" (DSIR Information Series No. 122). Price $2.00.

The following publications of the Society have been sold out:

- Proceedings of the Nelson Symposium "Stability of Slopes in Natural Ground", 1974.
- Proceedings of the Wellington Workshop "Lateral Earth Pressures and Retaining Wall Design", 1974.

T.J. Kayes
Publications Officer

LOESS AS A SENSITIVE SOIL

I.J. Smalley

Introduction

At first glance there appear to be many similarities between loess and quickclay. They are both composed largely of primary mineral particles and they both, as a consequence of the mechanisms of sedimentation, have open structures. They are both, at least in the northern hemisphere, associated with glacial conditions and appear to require the cold phases of the Quaternary period for their formation; and they appear to share certain geotechnical hazards. Most of the world's loess and most of the quickclays (very sensitive soils) could be grouped into a class of 'collapsing soils'. In other words they present problems to the engineer because the soil structure collapses - they would both fit comfortably into the field of study relevant to the IAEG Working Committee on 'Soil Properties'- as a result of their genesis (Chairman: Victor Osipov of Moscow State University). But how similar are they? Can they both be considered as sensitive soils? This is probably the most important geotechnical 'defect' from which they could suffer - and a unifying factor may give us a clearer look at two problem soils.

Loess Sensitivity

These thoughts on loess sensitivity have been provoked by a discussion by Alan Lutenegger of the Geotechnical Research Laboratory at Iowa State University. Lutenegger (1981) suggests that, in the classical Terzaghi sense, loess soils - which are composed predominantly of silt particles - would probably not be considered sensitive soils, in that the ratio of undisturbed to remoulded strength, at constant moisture content, is usually around 3, depending on clay content, and therefore would generally fall into the category of medium sensitivity. If, however, sensitivity is taken as the ratio of undisturbed to saturated strength (in unconfined compression) as indirectly suggested by Feda (1966), then some loess soils would have to be considered quick. Remember that Lutenegger is writing about the classic loesses of the Mid-Western USA and not the compact materials of New Zealand.

What did Feda actually say? In the paper referred to by Letenegger, Feda states that: "The most sensitive, i.e. the most structurally unstable soils are quick clays. These are illitic clays with low plasticity index (Ip = 10-15%), whose typical feature is the natural water content, which is higher than their liquid limit (Rosenqvist 1953). Although the subsidence of loess soils differs in other ways from the liquefaction of quick clays, high porosity and low plasticity index values are typically common for both types of structurally unstable soils. These types differ in their degrees of saturation; quick clays are saturated, while subsident soils are unsaturated." (Feda 1966, p.210).

Collapse of Loess

The collapse of a loess is accomplished by wetting (while under load); this is shown clearly in Figure 1 which comes straight from Feda. The loess in the oedometer undergoes a structural collapse when it is wetted - if it is of the collapsing variety. New Zealand loesses tend not to do this. Thus a saturated loess could be very like a natural quickclay: both may collapse on loading. This touches on an interesting point raised by Lutenegger - he suggests that spontaneous liquefaction would help to explain the extent of the landslides observed during the 1920 earthquake in Kansu Province, China. He sees these as landslides in saturated, sensitive loesses but the normal interpretation appears to be that these occurred in essentially dry soils - this is the way the slides were represented by Varnes (1958) in his famous

HRB landslide chart, and the way they are still represented in the new edition (Schuster & Krizek 1978).

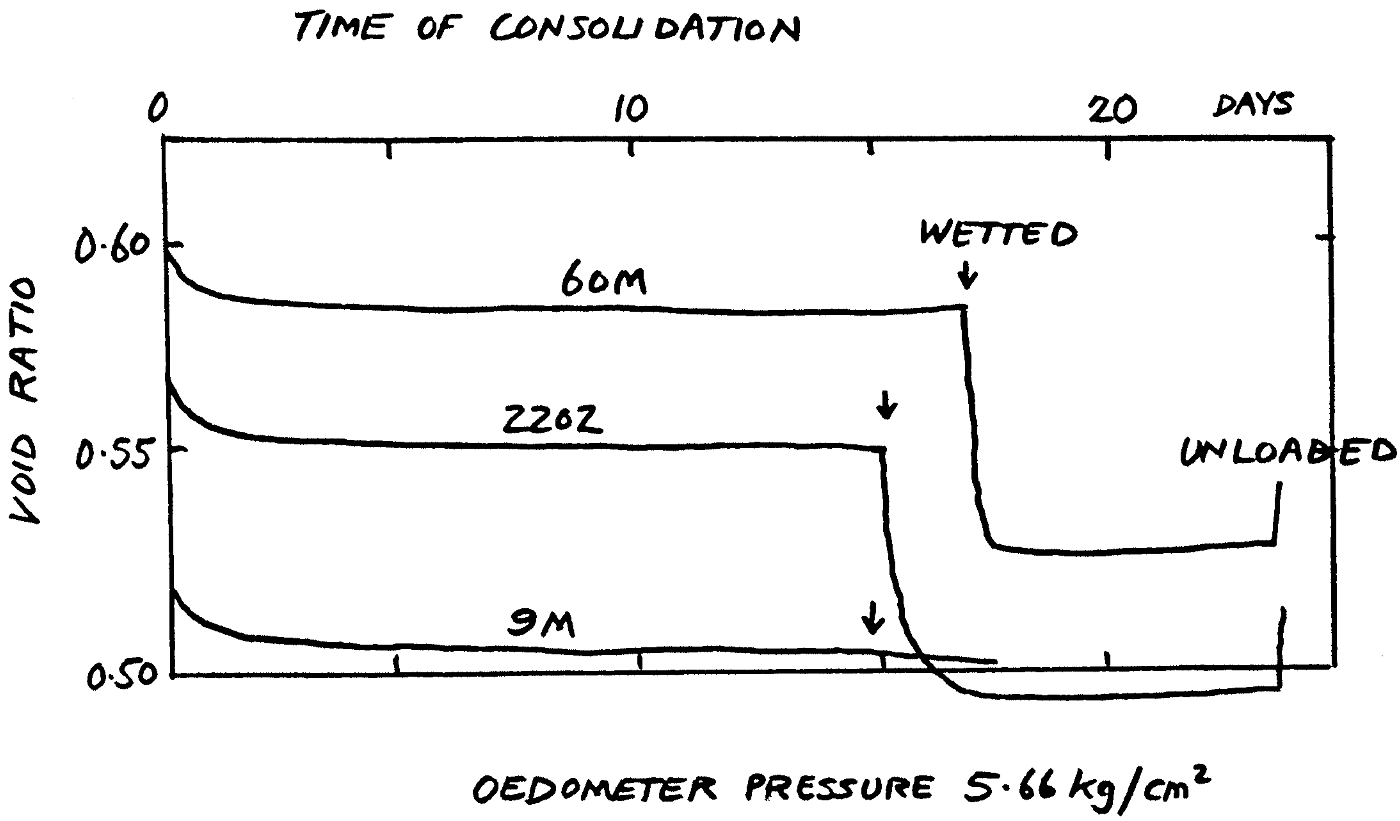


Figure 1. Oedometer tests on loess from Prague (Feda 1966) showing structural collapse on wetting. Samples from a depth of 2.5 m; 60M and 2202 are calcified loess; 9M is uncalcified loess loam emplaced by solifluction (and appears to behave rather like a New Zealand loess).

Reference to the great Kansu loess-slide is usually via the paper of Close & McCormick (1922) and it was also described by the great Russian loess expert V.A. Obruchev (1924) and this may be a superior description. This is such an important landslide that we could do to be aware of all the possible data. The evidence for a dry slide is not great - it could have been a wet slide as envisaged by Lutenegger; the Close & McCormick paper is a popular account and not too much attention was paid to reporting soil conditions. In Schuster & Krizek (1978, p.20) the slide is described as follows:

"Apparently the normal, fairly coherent internal structure of the porous silt was destroyed by earthquake shock, so that, for all practical purposes, the loess became a fluid suspension of silt in air and flowed down into the valleys, filling them and overwhelming villages. The flows were essentially dry, according to the report."

Two further studies are critical to our discussion, those by Denisov (1963) and Handy (1973). The Denisov work is in Russian and as a consequence of this not widely appreciated in the English speaking world. Denisov states (in a rather rough translation) that: "An extremely sensitive soil is subsident (uncompressed) loess, even in a state saturated with water. Such loess, when saturated with water in the absence of a possibility of swelling, its moisture (35-37%) is substantially above the boundary of fluidity (25-27%).

However loess in this state preserves some strength, which is demonstrated when it maintains the vertical edges of samples and is stable in the rather steep slopes of canal walls and pit sides. As a result of deformation (jarring), the thinning of these soils occurs with a drop in the shear resistance to zero." Surely a description of a classically sensitive soil.

Handy (1973) investigated collapsible loess in Iowa and concluded that the extent of collapsible loess may be defined and mapped using the criterion that the saturation moisture content must equal or exceed the liquid limit, because of the systematic increase in the liquid limit and decrease in saturation moisture content with distance from a loess source. Handy also observed, very significantly, that it was the loesses with the low clay mineral content which tended to collapse - an observation which parallels the suggestion that it is the quickclays (northern hemisphere variety) with the very low clay mineral contents which have the very high sensitivities. Which brings us back to Luttenegger who emphasises Handy's points:

"In recent investigations throughout the midwestern US, in-situ stability of loess has been related to liquidity index, that is when the in-situ moisture content reaches the liquid limit, usually on saturation, stability is all but lost and can readily be identified by isolated flow in boreholes. Because liquid limit is related to clay content, and saturation moisture is a function of density, this instability only occurs in special circumstances, typically low density and low clay content". (Lutenegger 1981, p.360).

Conclusion

Thus it appears that we do indeed have two similar materials. Up to now the major difference observed by the engineer encountering the materials in their natural state is that the water content of a quickclay is high (close to the liquid limit) whereas the normal loess has a much lower water content. But when a loess has a high water content the similarities are very marked and both could well be described as sensitive soils. It is interesting to note that similar methods have proved successful for stabilisation. Rosenqvist (1977) has described how a quick clay near Oslo was stabilised by salt wells (using KCl) and there are many descriptions in the Soviet literature of well methods being used to stabilise subsequent loess - and piles are used to achieve the same effect.

Denisov provides a suitable last word: "Summarising what has been said, it may be concluded that the basic reason for the appearance of highly sensitive quick clays is their preservation under natural conditions of the uncompressed state." This is also a requirement for loess; both systems require high water contents - and the particles should be connected by short range bonds (Smalley 1971).

References

Close, U. & McCormick, E. 1922: Where the mountains walked. An account of the recent earthquake in Kansu Province, China, which destroyed 100,000 lives. National Geographic Magazine 41(5), 445-464.

Denisov, N. Ya. 1963: The highly sensitive nature of quick clays. Osnovaniia, Fundamenty i Mekhanika Gruntov 5(5), 5-8 (in Russian).

Feda, J. 1966: Structural stability of subsident loess soil from Praha-Dejvice. Engineering Geology 1, 201-219.

Handy, R.L. 1973: Collapsible loess in Iowa. Soil Science Soc. Amer. Proc. 37, 281-284.

Lutenegger, A.J. 1981: Stability of loess in light of the inactive particle theory. Nature 291, 360 only.

Obruchev, V.A. 1924: Uber das grosse Erdbeden in der Provinz Kansu (China) am 16 December 1920. Zeit. Ges . f. Erdkunde zu Berlin 340.

Rosenqvist, I. Th. 1977: A general theory for quick clay properties. Proc. 3rd European Clay Conference Oslo 2-5 June 1977; I. Th. Rosenqvist editor, 258p. pp215-228.

Schuster, R.L. & Krizek, R.J. editors 1978: Landslides: Analysis and Control. Special Report 176, National Academy of Sciences, Washington DC.

Smalley, I.J. 1971: Nature of quickclays. Nature 231, 310 only.

Varnes, D.J. 1958: Landslide types and processes. In Landslides and Engineering Practice ed. E.B. Eckel. Highway Research Board Special Report 29, National Academy of Sciences, Washington DC, pp.20-47 (and a chart at the back).

1982 NZIE CONFERENCE

The Geomechanics session was held on the afternoon of Wednesday, 10 February, and there was an audience of about 50. Four papers were presented, dealing with theoretical and practical approaches to the problems of working with dispersive soils.

The papers were:

R.D. Northey - Engineering Characteristics of Dispersive Soils.

G.J. Schafer - Identification of Dispersive Soils.

D.H. Bell - Chemical stabilisation of Dispersive Soils Including Case Histories from the Christchurch Area.

T. Sameshima - Chemical Stabilisation of Roading Aggregates - a Clay Mineralogical Approach.

In his paper R.D. Northey outlined that dispersive soils are fine grained erodible soils whose clay fraction disperses readily in water with the expenditure of minimum mechanical effort. Characteristically erosion is underground leading to tunnel gully erosion of landscapes and to piping failure of water retaining earth structures. The degree and permanence of dispersion of a clay in water is strongly dependent on the amount and type of ions in solution or absorbed on the surface of clay particles. If sodium is the dominant ion, if the percolating water is relatively low in dissolved salts, and if the clay soil contains a crack or other defect which allows water to flow to an exposed surface at a much higher velocity than through the bulk of the soil material, then dispersive failure is a distinct possibility which must be considered in engineering design.

Since the results of conventional soil engineering classification testing such as water content/density/particle size distribution or Atterberg limits are not good discriminators of dispersive soils, recourse must be made to more direct measurements of erodibility and dispersibility.

G.J. Schafer placed the emphasis in his paper on erodibility of soils. In the first part he described field observations of erodible landscapes, which occur in New Zealand most notably on Christchurch's Port Hills, and on Marlborough's Wither Hills. Where there is a lack of thick vegetation erosion patterns may be easily seen (as the effects of tunnel gullying). The erosion may also be set off by altered drainage patterns, or by the stripping of top soil.

In the second part of the paper he described the various laboratory tests which have been devised to measure erodibility and (hopefully) dispersivity. He concluded that the pinhole test had the greatest potential use for assessing both dispersibility and erodibility.

D.H. Bell's paper summarised the soil factors which contribute to dispersion of clays, then reviewed the available methods for stabilisation of soils. These include improvement of the mechanical properties of the soil by stabilisation with cement, lime or bitumen; modification of the electrochemical behaviour of the soil by treatment with inorganic chemicals such as sodium or calcium chloride, phosphoric acid, or gypsum; waterproofing of soil particles by treatment with resins. Also there are relatively minor techniques such as thermal stabilisation by heating the soil in situ, electrolysing the soil to promote electrochemical hardening, and "chemical compaction" by treatment with quicklime.

A large section of the paper was devoted to actual cases where dispersive soils had successfully been used both in New Zealand and overseas for construction of earth dams and other water-retaining structures. He concluded by outlining the problems caused by dispersive soils on hillside building sites, the precautions that must be taken to prevent uncontrolled erosion of the soil and suggesting methods for stabilising the backfill in service trenches.

T. Sameshima described experiments he has conducted into chemical stabilisation of roading aggregates which contain appreciable amounts of expandable clay minerals, as in the Auckland area. Conventional stabilisation techniques are unsuitable for such soils, which must first be treated to deactivate the expandable mineral content.

Laboratory tests were made to compare the efficacy of various inorganic additives for deactivating the expandable minerals in six samples of greywacke or andesite aggregate from Auckland quarries. The results showed potassium chloride to be superior for reduction of both plasticity index and clay index.

Field tests were then made, by spraying heaps of aggregate with solutions of selected additives. These showed that potassium chloride solution was the most successful in altering the smectites present, provided its concentration was 5% or greater. The author recommends it as worthy of further study. He pointed out that potassium chloride is not stocked as an industrial chemical but its manufacture is not difficult.

Discussion on these papers was disappointingly sparse.

The AGM of the Society followed, being attended by only about eight members. The formal business was disposed of quickly, and the results of the postal elections for the incoming National Committee were announced. No contentious matters were raised, and the meeting concluded about 5.20 p.m.

A field trip was held on Friday, 12 February, and about 20 attended. Four sites were visited on the hill slopes of Paparua County.

1. The Paparua County Reservoir site was on dispersive erodible soils, and the reservoir base, pipeline, and access road were constructed with the addition of 2% of slaked lime supplied in bags and mixed in place with a rotavator. When the tank construction was complete, the excavated bench was backfilled with soil to the original profile, with the top 300 m lime stabilised to prevent erosion.

2. The N.Z. Electricity road in Hoon Hay Valley was built about 15 years ago to give access to a power pylon line, and had eroded badly. It was repaired using lime-stabilised soil to fill the badly-scoured water tables, and to restore the road surface. The road was surfaced by rolling in a layer of 30 mm crushed stone before the stabilised soil dried.

3. The Worsleys Spur (Westmoreland) sub-division began with large scale earthworks in early 1974. Wind and water erosion caused problems almost from the beginning, and controls had to be applied to the work by local authorities, to minimise erosion of the slopes, and to prevent damage to the Heathcote river from eroded silt. Topsoiling and grassing eventually stopped the sheet erosion of subdivision slopes, but erosion continued to be a problem in service trench backfills over several years, as a result of storms. The North Canterbury Catchment Board now has an inventory of the relative soil stability over the area, and this was applied from early 1978; it should give the

local authorities adequate control over future earthworks in similar soils.

4. The Christchurch City Council's reservoir on Worsley Road has down-sloping outlet pipes which were threatened by tunnel erosion in their trenches. These tunnels were successfully backfilled by pumping in a lime stabilised soil slurry.

T.A.H. Dodd

NEWS FROM THE MANAGEMENT SECRETARY

1. Management Committee

The Management Committee for 1982 is:

I.M. Parton	(Chairman)	Auckland
G.G. Grocott	(Secretary)	Auckland
J.H.H. Galloway		Wellington
T.J. Kayes	(Publications Officer)	Wellington
P.J. Millar	(Vice Chairman, Rock Mechanics)	Wellington
R.D. Northey		Wellington
B.R. Paterson	(Vice Chairman, Engineering Geology)	Christchurch
S.A.L. Read	(Editor, Geomechanics News)	Wellington
G.J. Schafer	(Vice Chairman, Soil Mechanics)	Wellington
D.K. Taylor		Auckland

2. Chairmen for Local Branch Activities

Auckland	P. Riley	Beca Carter Hollings & Ferner
Wellington	D. Jennings	MWD, Head Office
Christchurch	B.R. Paterson	N.Z. Geological Survey

3. New Local Group

A new local group of the Geomechanics Society has recently been formed in Dunedin to be known as the Otago/Southland Group. The local convener of group activities for 1982 is Mr W.J. Henderson.

Two meetings for the year have been arranged generally covering activities of particular local interest. These are:

21 June - "Slope stability problems of the Kilmog" (an area just north of Dunedin). Speakers from N.Z. Geological Survey, Ministry of Works and N.Z. Railways will present papers on the subject. The meeting will be held in conjunction with IPENZ (Otago Branch).

September/October - "Tunnelling in Schist". Papers will be presented on tunnelling projects currently being carried out in Otago.

The Committee is also involved in arranging a programme for the "Slope Stability Problem" session at the Pacific Science Congress to be held in Dunedin 1-11 February 1983.

4. New Members

The following people have recently been admitted to the Society:

W.R. Miller	B.L. Mehappy	S.A. Practer
B.G. Nancekivell	D. Geopprey	O.R. Colin
H.B. Alldred	A. Brickell	

5. IPENZ 1983 Conference

The conference is to be held in Hamilton from 14-18 February. As in past years, the Geomechanics Society will contribute to the conference which this year has the theme "The Engineering Profession - Its Place in National Development".

Papers are still required for nomination to the Geomechanics session at the conference. Intending authors should submit synopses of their papers to the Management Secretary by 31 August. The deadline for submission of draft papers for pre-printing will be 1 December 1982.

The Annual General Meeting of the Society will take place during the conference.

6. Advertising in Geomechanics News

Engineering Publications Limited (Publishers of N.Z. Engineering) have recently indicated that it is possible for the Geomechanics Society to sell advertising space in Geomechanics News. It would be appreciated if prospective advertisers would express their interest to the Management Secretary.

7. Australasian Geomechanics Computing Newsletter

The Australasian Geomechanics Computing Newsletter (AGCN) is presently circulated to Society members who have contacted the Management Secretary (Geomechanics News No.22).

Members should now contact the Publications Officer to receive the AGCN. Copies of the AGCN received from Australia will be circulated with each issue of Geomechanics News. Members who have requested AGCN should have received No.7 with this issue of Geomechanics News.

G.G. Grocott

FORTHCOMING CONFERENCES

01-06	August	1982	2nd International Conference on Geotextiles, Las Vegas, Nevada, USA.
23-27	August	1982	11th Australia Road Research Baord Conference. Melbourne.
25-27	August	1982	23rd US Symposium on Rock Mechanics. University of California Berkeley, USA.
05-11	September	1982	4th International Conference on Shotcrete for Underground Support. American Concrete Institute, Columbia.
13-17	September	1982	International Symposium on Numerical Models in Geomechanics. Zurich, Switzerland.
22-26	November	1982	7th South East Asian Geotechnical Conference. Hong Kong.
10-15	December	1982	4th International Congress, IAEG. New Delhi, India.
	December	1982	Soil and Rock Improvement Techniques, A.I.T. Bangkok, Thailand.
01-11	February	1983	Solid Earth Sciences. 15th Pacific Sciences Congress. Dunedin.
14-18	February	1983	IPENZ Annual Conference, Hamilton, New Zealand.
	April	1983	7th Asian Pacific Regional Conference on Soil Mechanics and Foundation Engineering, Haifa, Israel.
10-15	April	1983	ISRM 5th International Congress on Rock Mechanics, Melbourne, Australia.
27-29	April	1983	Speciality Conference on Geotechnical Practice in Off Shore Engineering, ASCE. Austin, Texas.
10-12	May	1983	South Pacific Regional Conference on Earthquake Engineering. Wellington, New Zealand.
18-20	May	1983	Symposium on Soil and Rock Investigations by In situ Testing. Paris, France.
19-24	June	1983	Geotechnical Engineering in Resource Development. VII Panamerican Conference on Soil Mechanics and Foundation Engineering. Vancouver, Canada.
15-19	August	1983	New Zealand Roading Symposium. Wellington, New Zealand.
12-15	September	1983	International Symposium on Engineering Geology and Underground Construction. Lisbon, Portugal.

Further information on these conferences may be obtained by writing to the Management Secretary.

G.G. Crocott

GEOMECHANICS : IN SITU TESTING SEMINAR

The seminar on in situ testing in geomechanics held at the University of Canterbury on 10-11 May 1982 was jointly organised by the Departments of Extension Studies and Civil Engineering in association with the Department of Geology. Forty-five people from a variety of organisations participated.

The first day was split into four lecture/discussion sessions covering:

1. A review of the fields for which in situ tests have been developed (Tom Dodd).

2. Engineering applications of geophysical methods (Jarg Pettinga).

3. Standard penetration, Dutch cone and surface plate bearing tests (Murray Petherick).

4. Pressuremeters and downhole plate bearing tests (Tom Dodd).

The second day opened with a "general review of in situ testing methods appropriate for rock mass investigations, including stress relief techniques" (Peter Pillar). This was followed by a laboratory session and finally by field demonstrations.

The stated intention of the seminar was to present practical aspects of in situ testing of soils and rock to provide design parameters for foundations, underground works etc. However, the main emphasis of several speakers was placed on listing and/or very briefly describing various in situ test methods without providing any real information on the interpretation or application of results obtained. Only two contributors (Pettinga, Millar) appeared to have planned their presentations to fully utilise the time available - others seemed to expect that discussion would fill up the excess time allocated, which it did with some effort. Similarly, both the laboratory session (in which miscellaneous apparatus was laid out on benches for inspection) and the field demonstration of standard penetration and Dutch cone testing could have been completed in much less than the allocated time.

It is felt, at least by the writer, that the seminar failed to live up to expectations. Most of the speakers pitched their contributions at too low a level (? second year undergraduate) resulting in a very basic and superficial treatment of their subjects. Neither "practical" session allowed the direct involvement of participants (although admittedly this would have been difficult to organise) and hence neither contributed greatly to the seminar.

Properly planned and organised as a comprehensive state-of-the-art review of in situ test methods, and in particular the interpretation and application of results, this seminar could have been of enormous value to practising engineers and geologists. Unfortunately this potential was not realised.

D.F. Macfarlane

GEOMECHANICS RESEARCH IN THE DEPARTMENT OF CIVIL ENGINEERING, CANTERBURY UNIVERSITY

Current research interests in geomechanics in the Department of Civil Engineering fall into the following fields:

Constitutive models
Liquefaction of sands
Snow avalanches
Seismic risk
Seismic behaviour of retaining walls
Behaviour of large (offshore) piles
Disaster impact studies
Pressure-meter testing

Below is a list of publications and research report abstracts for work completed during the past two years.

Publications:

J.B. Berrill and R.O. Davis, "Maximum Entropy and the Magnitude Distribution", Bull. Seismological Soc. Am., Vol. 70, pp. 1823-1831, 1980.

J.B. Berrill, M.J.N. Priestley and H.E. Chapman, "Design Earthquake Loading and Ductility Demand", Bull. N.Z. Nat. Soc. Earthq. Eng., Vol. 13, pp. 232-241, 1980.

M.B. Matthewson, J.H. Wood and J.B. Berrill, "Earth Retaining Structures", Bull. N.Z. Nat. Soc. Earthq. Eng., Vol. 13, pp. 280-293, 1980.

R. Peek, J.B. Berrill and R.O. Davis, "A Seismicity Model for New Zealand", Bull. N.Z. Nat. Soc. Earthq. Eng., Vol. 13, pp. 355-364, 1980.

J.B. Berrill, M.J.N. Priestley and R. Peek, "Further Comments on Seismic Design Loads for Bridges", Bull. N.Z. Nat. Soc. Earthq. Eng., Vol. 14, pp. 3-11, 1981.

R.O. Davis and J.B. Berrill, "Assessment of Liquefaction Potential Based on Seismic Energy Dissipation", Proc. Conf. Recent Advances in Geotechnical Earthquake Eng., St Louis, pp. 187-190, 1981.

D.G. Elms, J.B. Berrill and D.J. Darwin, "Appropriate Distribution of Resources for Optimum Risk Reduction", Proc. Conf. on Large Earthquakes, Napier, N.Z., pp. 69-75, 1981.

G. Mullenger and R.O. Davis, "A Unified Yield Criterion for Cohesionless Granular Materials", Int. J. Numerical and Analytical Methods in Geomechanics, Vol. 5, pp. 285-294, 1981.

R.O. Davis and J.B. Berrill, "Energy Dissipation and Seismic Liquefaction in Sands", Earthquake Eng. and Structural Dynamics, Vol.10, pp. 59-68, 1982.

Research Reports:

P.N. Jacobson. Translational Behaviour of Gravity Retaining Walls during Earthquakes.

ABSTRACT: The translational behaviour of gravity retaining walls during earthquakes is examined using two models - Richards and Elms' simple sliding block model and Zarrabi's double block model. These models are compared to shaking table tests on small retaining walls. It is concluded that Zarrabi's model provided a better estimate of the translational behaviour although both models gave conservative results.

Department of Civil Engineering, University of Canterbury Civil Engineering Research Report No.80-9, 1980.

R. Peek. Estimation of Seismic Risk for New Zealand: A Seismicity Model and Preliminary Design Spectra.

ABSTRACT: The present knowledge of New Zealand seismicity is reviewed. Seismological, geological tectonic and geodetical data are used to estimate the spatial and magnitude distribution of seismic activity.

Three empirical studies of the relation between response spectra, characterising ground motions, and magnitude and distance are reviewed and compared.

A modified version of the results of one of these studies is used to establish a procedure by which response spectra corresponding to various return periods may be obtained for any site.

This procedure is used to obtain such spectra for the Haywards and Bunnythorpe sites, and a method by which spectra for other sites may be found approximately is given.

Department of Civil Engineering, University of Canterbury Research Report No. 80-21, 1980.

K.J. Simcock. Cyclic Loading of Sands with Precise Measurement of Dissipated Energy.

ABSTRACT: Results of 32 cyclic triaxial tests on New Brighton sand samples are presented. The tests were conducted to investigate the pore water pressure to energy input relationship. A theoretical relationship is suggested and the comparison between the recorded and predicted theoretical results is discussed.

Department of Civil Engineering, University of Canterbury Master of Engineering Report, 1981.

W.M. Mulholland. Estimation of Design Earthquake Motions for New Zealand.

ABSTRACT: A method of estimating seismic risk, using a seismicity model and an attenuation model is detailed. An attenuation model for response is modified and verified against New Zealand data. Three seismicity models are reviewed. An approximate method by which risk spectra may be obtained for any site is given.

Department of Civil Engineering, University of Canterbury Research Report No. 82/9, 1982.

G.H. Aitken. Seismic Response of Retaining Walls.

ABSTRACT: Shaking tests were conducted on small gravity retaining walls with sand backfill. For sliding failure wall displacements were sensitive to soil state and the Richards-Elms model gave a sufficiently good description of displacements. Soil failure zones were shown. Tests on tilting failure showed qualitative results, but were inconclusive.

Department of Civil Engineering, University of Canterbury, Research Report No. 82-5, 1982.

J.B. Berrill

NEWS FROM THE INTERNATIONAL TUNNELLING ASSOCIATION

REPORT FOR 1981 : NEW ZEALAND

Below is a precis of the 1981 report for New Zealand submitted recently to the International Tunnelling Association.

General

New Zealand does not have a formal national group or association.

1. List of Members

There is no formal membership.

2. List of Names and Addresses of Officials

The staff members of MWD to liaise with the ITA are:

(a) Mr J.B.S. Huizing

Chief Civil Engineer, who represents MWD on the ITA and effectively holds the position of President of the New Zealand group.

(b) Dr G. Ramsay

Who acts as Secretary and who corresponds with the ITA working groups on "Research" and on "Maintenance and Repair on Underground Structures".

(c) Mr A.T. Hinkley

Who corresponds with the working groups on "Contractual Sharing of Risk" and "Safety in Work".

(d) Mr R.J. Sneddon

Who corresponds on "Catalogue of Works in Progress".

Address: For all four representatives is:

Ministry of Works and Development
Head Office
P.O. Box 12041
Wellington North
New Zealand

3. Activities

There were no formal meetings or activities within Ministry of Works and Development.

4. Activities of Working Groups

There are no national committees corresponding to the ITA working groups. Representatives on the ITA working groups respond to requests for information from the leaders of these groups.

5. Tunnelling Activity in New Zealand

Tunnelling activity in New Zealand has declined significantly in recent years. This has resulted from the completion of a number of major projects and a fall off in the number of new projects commissioned. This is a direct consequence of the downturn in the New Zealand economy.

Some unusual tunnelling work may arise from current proposals to enlarge or replace five tunnels on New Zealand's North Island Main Trunk Railway to allow electrification of that line.

6. Literature

The following paper relating to New Zealand tunnelling was published in 1981:

Newsome, Brian, "Construction of the Terrace Tunnel", Transactions of New Zealand Institution of Engineers, Vol. 8, Number 1/CE, March 1981.

7. Film Library

There is no library of films.

G. Ramsay

LOCAL GROUP ACTIVITIES

1. AUCKLAND GROUP

No meetings have been held to date. Three meetings have been scheduled: 7 July on the Grey Lynn landslide; 18 August on the Ruahihi Canal Failure; 14 October on Residential slope failures: who carries the can?

2. WELLINGTON GROUP

2.1 Electronics in Geotechnical Engineering

On Thursday, 11 March, people expecting to hear Stuart Read speak about mining activities in Bougainville and Queensland received a talk on electronics - Stuart finishing up at hospital. Congratulations to Stuart and Rosalind on the safe arrival of your son Christopher.

Peter Millar stepped in to help us out of a spot and he discussed the role of "Electronics in Geotechnical Engineering" to a small but interested audience. Those present were rather curious as to what was happening when Peter turned up with just about every electronic gadget available. The presentation was arranged around some of the equipment currently being used by the MWD Central Laboratories Geotechnical Section. Both the field and laboratory applications of electronics were discussed including:

* settlement measurement using hydraulic pressure sensitive transducers
* extensometers for measuring tunnel movements and plate bearing test deformations
* density measurements using nuclear densometers, including borehole equipment
* horizontal deformation measurement using inclinometers
* resistivity measurements
* seismic survey methods, including downhole developments
* vibrating wire piezometers and piezoelectric transducers
* consolidation test monitoring
* stress controlled triaxial testing with an HP85 mini computer.

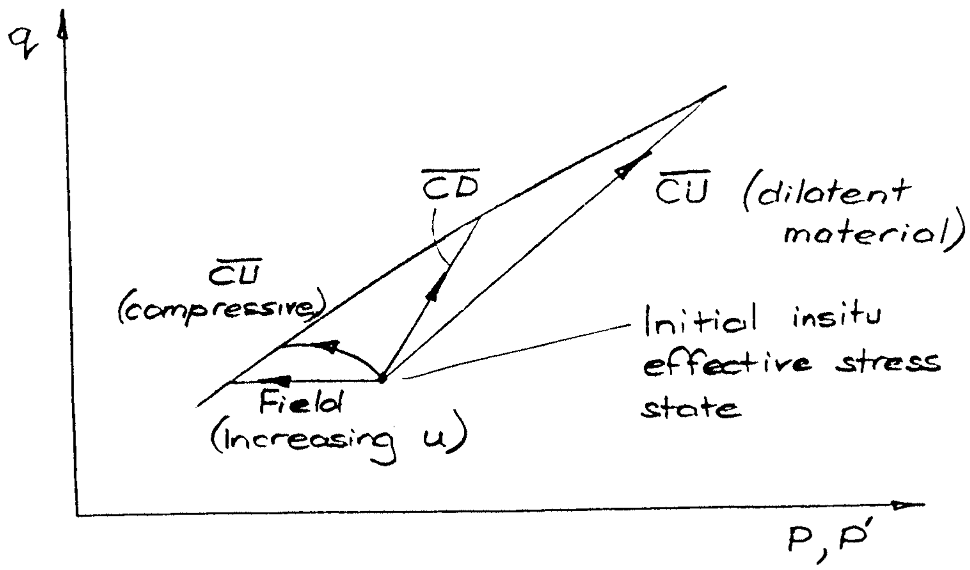
Demonstrations were given of the performance of some of the equipment which Peter had on display. After some lively discussion the meeting ended and the appreciative acclamation confirmed that the audience had not been disappointed by the change from the advertised programme. An article by Peter on the statistical analysis of triaxial test results appears later in this issue.

2.2 Geotechnical Engineering in Hong Kong

On Thursday 20 May John Rutledge talked to an audience of 25 about "Geotechnical Engineering in Hong Kong". This presentation was based on John's recent three year experience with the Hong Kong Geotechnical Control Office (GCO) and consequently the emphasis was on Hong Kong's extensive slope stability problems. The many slides which John had selected illustrated the nature and size of the problems most effectively. Much of the background of John's presentation has already appeared in the Geomechanics Newsletter in his article published in Number 22 (November 1980) of Geomechanics News. In that article John mentioned the problem of analysing rain induced landslides in residual soils. In his talk he discussed the normal 'classical' approach to analysis extended to deal with soil suction and then went on to discuss semi empirical (or modified precedent) methods and terrain evaluation techniques for dealing with the problems at a macro scale.

In the past conventional classical analysis methods using effective stress parameters have not explained the stability of many existing slopes. In the classical approach one mechanism is that of water infiltration from heavy rainfall causing a reduction in the pore suction in the partially saturated soil. This results in a decrease in the effective stress on the potential failure surface and a corresponding decrease in the soil strength to the point where equilibrium in the slope cannot be sustained. Failure takes place under conditions of almost constant total stress and increasing pore pressure (decreasing suction). This is not the stress path or stress range normally followed in triaxial tests.

Stress Paths
- Triaxial tests
- Field behaviour (rain induced slope failure)



John also described theories for the application of soil suction to the effective stress equations and the measurement of suction in the field. He commented that a tremendous amount of research is still required to define the mechanism of rain induced failure.

In addition to classic stability methods two other approaches are being used to assist engineers with design decisions:

* semi-empirical (or modified precedent) design methods
* terrain evaluation methods

Some attempts are being made to develop modified precedent design rules based on the knowledge of the performance of existing slopes in the relevant conditions. A study for cut slopes in the residual granites and volcanics is being carried out under the title "Cut slopes in Hong Kong - Assessment of Stability by Empiricism" - CHASE. Two hundred "extreme" cut slopes have been selected and the information is being collected under ten main headings:

- general data
- slope history
- slope geometry
- instability data
- protection/remedial works
- slope materials
- drainage
- vegetation
- relevant adjacent structures
- miscellaneous

The results are being analysed statistically to obtain relationships between the variables.

Terrain evaluation techniques are being developed, largely on the basis of aerial photographs, to classify landforms mainly from a stability viewpoint for the purposes of zoning areas in terms of risk or hazard. Two years ago the GCO embarked upon a Geotechnical Area Studies Programme (GASP) to provide systematic input for land use management and development planning purposes. This should shortly cover the entire land area of the territory at a scale of 1:20,000 and more difficult areas at a scale of 1:2,500. The zonation system employed is based on the <u>overall</u> geotechnical assessment of the land units, but because of the nature of Hong Kong's natural terrain considerations of stability are dominant. Each area study report is accompanied by a series of maps and transparent overlays which generally comprise:

- a terrain classification map
- an engineering data sheet
- a vegetation map
- a surface hydrology map
- an engineering geology map
- a geotechnical land use map (GLUM) (essentially a landslide hazard map)

The last two are particularly important as they represent a synthesis of the data collected.

John briefly described some other more general matters including hand dug caissons, problems with ground anchors, dynamic compaction of fill slopes etc.

Following some interested discussion those gathered expressed their appreciation to John for a most interesting presentation with acclamation.

(John included a list of References on geotechnical engineering in Hong Kong in his Newsletter of November 1980. In addition to those references he now mentions: recent issues of the Hong Kong Engineer, Journal of the Hong Kong Institute of Engineers, most copies of which have geotechnically related papers; and the Proceedings of the ASCE Conference on Engineering and Construction in Tropical and Residual Soils, Honolulu, Hawaii, January 1982, which had several good papers about Hong Kong particularly a state of the art paper by E.W. Brand "Analysis and Design in Residual Soils".)

D.N. Jennings

3. CHRISTCHURCH GROUP

No meetings have been held so far this year. However in the next month or so John Rutledge of the MWD, Wellington, will be presenting a talk on "Geomechanics in Hong Kong with an emphasis on slope stability", similar to that recently given to the Wellington group.

B.R. Paterson

FROM THE INTERNATIONAL VICE-CHAIRMEN

1. ROCK MECHANICS

1.1 Manuel Rocha Medal

A bronze medal and cash prize is to be awarded annually by the ISRM in memory of Manuel Rocha for doctoral theses in rock mechanics. Further information is available in ISRM News Number 60.

1.2 ISRM Congress, Melbourne May 1983

Only two synopses for papers from New Zealand were received by the Vice Chairman for the above Congress. This is a disappointing response in view of the amount of large scale tunnelling and excavation projects and also the close proximity of the venue. It is hoped that more members take the opportunity to attend the congress.

1.3 Council Meetings

A report has been received from Mr S. Read on the Tokyo Council Meeting in September 1981. This report can be made available to members on request.

Mr W. Bamford of the Australian Geomechanics Society, and Australasian Vice President for Rock Mechanics, represented New Zealand at the Aachen Council Meeting on 29 May 1982.

P.J. Millar

2. ENGINEERING GEOLOGY

2.1 4th IAEG Congress, New Delhi, 1-6 December 1982

No papers have been submitted from New Zealand and as far as I know there will be no New Zealand participants at the congress.

2.2 IAEG Secretariat 1982

Following the death of Dr Wolters in March 1981, the Treasurer of IAEG, Prof Langer, became the interim Secretary General. At the IAEG Council Meeting in Istanbul, September 1981, the secretariat changed to France. The new Secretary General is: Dr L. Primel, Lab. Centr. Ponts et Chaussees, 58 bd Lefebvre, 75732 Paris Cedex 15, France.

2.3 IAEG Newsletters

There were no IAEG newsletters in 1981 because of the death of Dr Wolters.

2.4 Australasian IAEG Vice President

Prof D.H. Stepledon has served as Australasian IAEG Vice President since 1978 and will vacate the position this year - IAEG stipulate that a new candidate is elected. According to the arrangement between the Australian and New Zealand Geomechanics Societies the 1982-86 term will be taken by New Zealand. Mr D.H. Bell has been nominated.

B.R. Paterson

3. SOIL MECHANICS AND FOUNDATION ENGINEERS

3.1 Technical Subcommittees

The ISSFME has 18 technical subcommittees as listed below.

1. Information Advisory Committee
2. Site Investigation (pending more recent information from 1977-81 Subcommittee, extended)
3. Penetration Testing
4. Research Cooperation
5. Geomechanical Computer Programs
6. Sampling and Laboratory Testing:
   6.1 Residual Soils
   6.2 Soft Rocks
   6.3 Sand gravels
   6.4 Soils of Volcanic origin
7. Policy on standards, manuals, specifications and codes
8. Symbols, units, definitions and correlations
9. Landslides
10. Centrifuges
11. Allowable deformations of buildings, and damages
12. Tropical soils, laterites and tropical saprolites
13. Filters and filter criteria
14. Hydraulic fill dams, tailing (awaiting confirmation)
15. Penetrability, drivability of piles
16. Preservation of Old Monuments and Cities
17. Constitutive Laws and Equations
18. Professional practice, responsibilities, ethics, etc.

Nominations for membership of the subcommittees are being sought. Would Society members who are interested in becoming a member of any of the subcommittees please contact the Vice President.

R.D. Northey

GREY LYNN LANDSLIP INVESTIGATION

A synopsis of Tonkin and Taylor's report into the landslip is reproduced below.

Following a large landslip affecting 1 to 5 Herringson Avenue, Grey Lynn, on 3 December 1981, Tonkin and Taylor Limited were engaged by the Auckland City Council to undertake an investigation to establish the causes of the landslip and to provide advice to Council on types of remedial work.

The investigation work consisted of detailed soil explorations including core drilling, sampling, testing and stability analyses, as well as a review of aerial photographs, historical records and a number of other factors which could possibly have been related to the landslip.

The underlying geology of the area consists of weathered sandstones and siltstones, but the slip has apparently not originated within these rocks.

From historical records and aerial photographs a history of development in the Herringson Avenue area has been complied. Herringson Avenue is situated on what was originally quite a narrow spur with a broad steep gully and natural watercourse extending in a southwesterly direction from near the present junction of Rona and Herringson Avenues. A large amount of filling was placed in the gully prior to subdivision of the Herringson Avenue area in 1948. A high, dry stone wall was also constructed across the face of the filling at the rear of 1 to 5 Herringson Avenue. All houses in Herringson Avenue were built by 1951 and Nos. 1, 3 and 5 were built either partly or entirely on the filled ground.

In 1951 a fairly large landslip occurred behind 1 and 3 Herringson Avenue, demolishing part of the stone wall and damaging the sewer line behind these properties. The Council replaced the damaged section of sewer with a steel pipe placed on piles. Ground movements continued for several years after the 1951 landslip causing the sewer to bend and to suffer minor leakage which required repair.

In 1958 a major quarrying operation was carried out below the end of Rona Avenue, but did not extend below 1 to 5 Herringson Avenue and thus had no apparent influence on the bank stability behind these properties. In the early 1960's the Shirley Road area was developed below and to the west of Herringson Avenue. Substantial excavation of parts of the bank below Herringson Avenue were carried out, but were apparently of only small extent below the landslip area and excavations are not thought to have significantly influenced the stability of the bank below the slip area. Since the early 1960's no significant development activities appear to have been undertaken which could be related to slope stability in the immediate area of the 1981 landslip.

Stability analyses of the landslip, using reconstructed ground contours and assessments of the extent and strength properties of the old filling, derived from the investigations, have shown that the hillslope was in a very marginal state of stability prior to the landslip.

The cause of the landslip is seen as a combination of factors; the primary ones being:

(i) the presence of an extensive area of deep filled ground placed in the broad, steeply sloping gully one side of which extended beneath the houses involved in the landslip,

(ii) the fact that the outer (western) face of the filling behind 1 to 5 Herringson Avenue was excessively steep and inadequately supported,

(iii) The occurrence of a previous landslip in the same area in 1951 and subsequent continued ground movements,

(iv) the existence of a high natural groundwater table in the area and the apparent concentration of underground drainage along the old filled gully and through the area of the recent failure.

A number of other factors, which have been suggested as contributing to the failure, were considered. These factors included: possible leakage from both main and branch sewers; possible ground vibrations from blasting at the Western Springs motorway construction site; excavation of the toe of the bank to the west; rainfall; earthquake; and traffic vibrations from the motorway. The investigations have indicated that all these factors have had an insignificant effect on the ground stability at Herringson Avenue.

No definite 'trigger' for the landslip was identified, but in view of the marginal state of stability of the bank none is seen as necessary for the failure to have occurred. Under such conditions only very small changes in ground conditions would be needed to precipitate failure and such changes may be imperceptible. In a technical sense 'failure' of the ground could be considered to have started in the early 1950's at the time of previous ground movements and shortly after subdivision development was completed.

Thus, the factors which brought about the critical slope stability, have been present for a long time and it is concluded that the Herringson Avenue landslip was due to a combination of factors, in particular, the presence of a large amount of inadequately retained, relatively loose filling placed on a steep slope, and which has been subject to saturation over a long period of time.

An area of hazard has been defined around the perimeter of the landslip, within which future landslips could conceivably occur. The only building which this area affects is No.1 7 Herringson Avenue located close to the edge of the slip.

In addition to initial remedial works carried out by the Council, permanent remedial work is recommended to reduce the hazard area around the landslip perimeter and to assist in stabilisation of the earthflow. These remedial works consist mainly of various types of surface and subsurface drainage measures and the retaining of the bank below No. 7 Herringson Avenue.

INTERNATIONAL SEMINAR ON LANDSLIDES AND MUDFLOWS

UNESCO convened an international seminar on landslides and mudflows (debris flows as it turned out) which was held in Alma Ata, USSR, on 12-17 October 1981. Two New Zealanders (Dr M.J. Crozier and Dr A.J. Pearce) were invited to the seminar which was jointly organised by UNESCO, UNEP and the USSR Commission for UNEP in cooperation with the Kazakh Board for the Protection against Mudflows.

Twenty-seven scientists from sixteen countries presented papers, held discussions and attended field trips, along with a large group of Soviet and local Kazakh scientists and engineers.

Alma Ata, situated on the colluvial outpourings of the Alitau Mountains, was an appropriate venue as it had a history of inundation and loss of life from catastrophic debris flows, not to mention the periodic earthquakes experienced in these areas bordering the highest alpine massif in the world. Engineering control measures rather than 'prevention' or 'avoidance' measures had been adopted against the debris flows. Visits were made to two huge debris dams that form the main part of an extensive control and warning system. The dam on the Great Almatinka River consisted of a 40 m high monolithic reinforced concrete, cellular dam, with a debris reservoir capable of receiving catastrophic debris flows up to 14.5 million m^3. The other dam was a larger, 150 m high, rockfill dam designed to withhold debris flows exceeding 12.5 million m^3 in volume.

One highlight of the seminar was the spectacular and instructive films of landslides in action. Notable amongst these was one on the Norwegian sensitive clay flows, and a couple on the massive Kazakh and Uzbeck debris flows. Papers that attracted my interest besides polished performances from David Varnes, Robert Schuster and Earl Brabb from USA were Stanislav Novosad's (Czechoslovakia) paper on the successful application of geophysical methods for establishing slope failure geometry and John Hutchinson's theoretical model to account for seepage erosion in sandy strata as a mechanism for landslide failure. The Scandinavian delegates, Tor Løken (Norway) and Ingemar Cato (Sweden) gave excellent papers on landsliding in quick clay complemented by Pierre La Rochelle (Canada) accounting for the Canadian counterparts and Georges Pilot's (France) report on landslides in overconsolidated clay.

The Soviets tended to produce theoretical (almost philosophical) papers e.g. Prof. Sheko (Moscow) which contrasted with the more technical papers of the Japanese (Masami Fukuoka) and Chinese (Li Gonghou). Other delegates who have been seen in New Zealand over the last few years were Ernesto Marquez (Peru) and Raj Bhandari (India).

Andy Pearce (Christchurch) gained a lot of interest with the N.Z. Forest Service films and his paper on the lithologic and tectonic controls of mass movement in the east coast, North Island. My paper on the prediction of critical groundwater conditions for climatically triggered landslides was facilitated greatly by having learnt the Russian words for "next slide please" which so stunned the Russian projectionist that he proceeded to jam the projector.

Conference organisation was everywhere and it was a little confusing for both hosts and guests to know who was in charge on any one day. The Soviets were magnificent hosts and to my surprise no restrictions were placed on our independent movements within either Moscow or Alma Ata nor was photography limited in any respect.

M.J. Crozier

STATISTICAL ANALYSIS OF TRIAXIAL TEST RESULTS

P.J. Millar

Introduction

Designers are often reluctant to invest in good quality testing of soils because they can see little economic advantage to their structures. They use the same design factors regardless of how the strength or deformation characteristics are obtained.

Calculation of confidence limits for test results provided the designer with the opportunity to make effective savings and gives an improved understanding of the foundation performance.

The method for determination of strength parameters and confidence limits for triaxial test data used by Central Laboratories, Ministry of Works and Development, is set out in the example below.

Strength Parameters

The method assumes the maximum shear stress at failure, q, for the specimens are normally distributed about the means and have a common variance. The mean principal stresses, p, are considered as controlled variables which are not dependent of shear stress.

The results of a triaxial test series carried out on a highly over-consolidated Clayey SILT are shown in Table 1.

The shear stress axis intercept, d and gradient tan β of the Kf line drawn through the points are determined by solving the equations

$$\sum_{i=1}^{n} qi = nd + \tan\beta \sum_{i=1}^{n} pi$$

i.e. $4460 = 5d + 7330 \tan \beta$

and $$\sum_{i=1}^{n} piqi = d \sum_{i=1}^{n} pi + \tan\beta \sum_{i=1}^{n} p2$$

i.e. $7649831 = 7330d + 129149 \tan \beta$

hence $d = \underline{141.0}$ and $\tan \beta = \underline{0.5123}$

NOTE: Many calculators include a regression analysis function giving d and tan β directly as well as determining the sums of the columns given in Table 1.

The strength parameters c and ϕ can be obtained using the geometric relationships between the Kf line and the Mohr-Coulomb failure envelope drawn in Figure 1.

Test No.	pi	pi^2	qi	qi^2	piqi
1	574.2		430.2		
2	954.1		636.1		
3	1466.9		886.9		
4	1916.0		1133.0		
5	2419.1		1374.1		
	7330.3	12914 909	4460.3	4548217	7649831
n = 5	Σpi	Σpi^2	Σqi	Σqi^2	Σpiqi

Table 1. Calculation of c and ϕ using the Method of Least Squares.

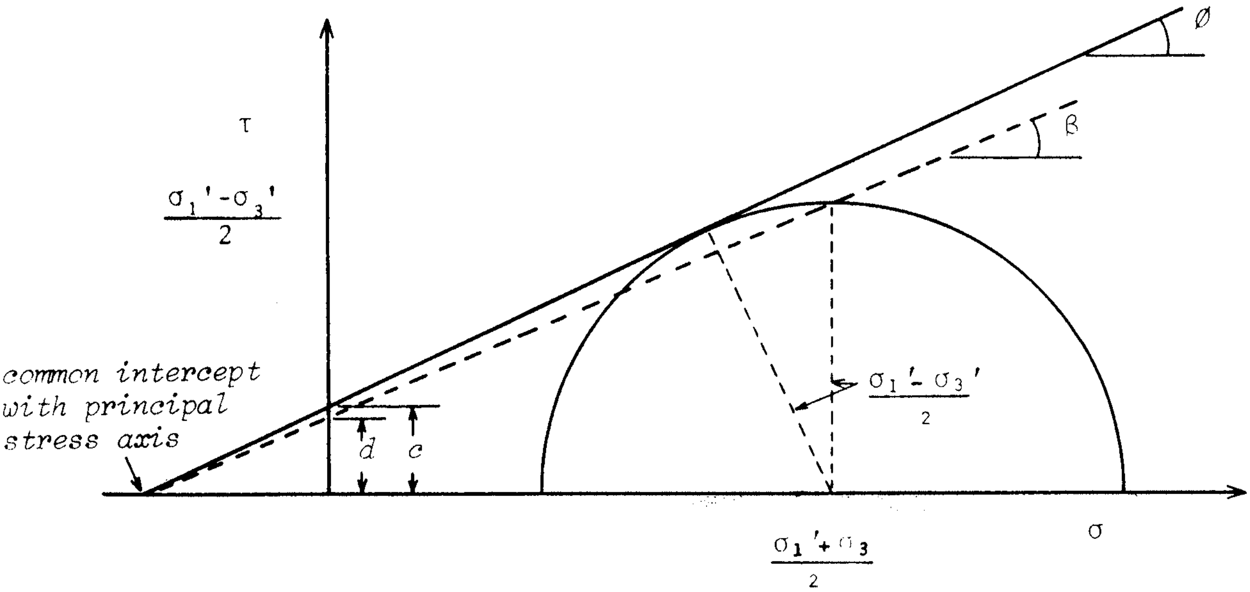


Figure 1. Geometric Relationships between the Kf Line (d and β) and the Mohr-Coulomb Failure Envelope (c and ϕ).

$$\phi = \sin^{-1} \tan \beta$$
$$= 30.8^{o}$$
$$c = \frac{d}{\cos \phi}$$
$$= 164 \text{ kPa}$$

The limits in terms of shear strength are defined as:

$$\tau = \tau_o \pm \tau_p$$

$$\tau_o = \sigma_o \tan \phi + c$$

and $$\tau_p = tc\ w \left[\frac{1}{n} + \frac{(\sigma_o - \bar{\sigma}^2)}{\sum_{i=1}^{n} (\sigma_i - \bar{\sigma})^2} + 1 \right]^{\frac{1}{2}}$$

tc = the t-distribution critical value of t at the required level of significance with (n - 2) degrees of freedom

$\bar{\sigma}$ = mean value of $\sigma_i = p - q \sin \phi$

σ_o = normal stress

$$w = \left[\sum_{i=1}^{n} \frac{(\tau_{Ai} - \tau_{Ei})^2}{n - 2} \right]^{\frac{1}{2}}$$

τ_{Ai} x τ_{Ei} are defined in figure 2

NOTE: Only the lower confidence is generally required for triaxial results. In this case use 0.5 (P + 100)% level of t. e.g. use (F(z) = 0.9 for 95% minimum confidence limit. For 5 specimens tc = 1.64.

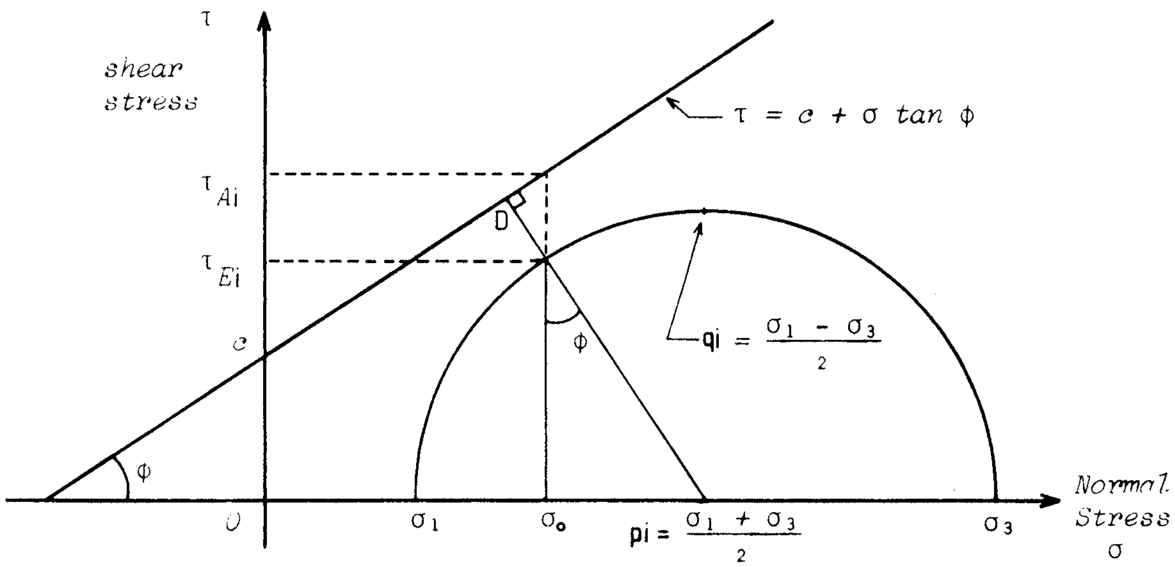


Figure 2. Mohr Circle and Theoretical Envelope

Confidence Limits

The confidence limits for the shear strength parameters are defined by:-

$$c \pm = \bar{c} \pm tc\, w \left[1 + \frac{\sum_{i=1}^{n} \sigma i^2}{n \sum_{i=1}^{n} \sigma i^2 - (\sum_{i=1}^{n} \sigma i)^2} \right]^{\frac{1}{2}}$$

$$\tan \phi = \tan \bar{\phi} \pm tc\, w \{ \sum_{i=1}^{n} \sigma i^2 - \frac{1}{n} (\sum_{i=1}^{n} \sigma i)^2 \}^{-\frac{1}{2}}$$

where $\sum_{i=1}^{n} \sigma i^2 = \sum_{i=1}^{n} (pi - qi \sin \phi)^2$

$$= \sum_{i=1}^{n} pi^2 - 2 \sin \phi \sum_{i=1}^{n} piqi + \sin^2 \phi \sum_{i=1}^{n} qi^2$$

and $(\sum_{i=1}^{n} \sigma i)^2 = (\sum_{i=1}^{n} pi - \sin \phi \sum_{i=1}^{n} qi)^2$

$\bar{C}$ and $\tan \bar{\phi}$ are the shear stress intercept and gradient of the M - C envelope respectively as determined previously

n is the number of test results

$$w = \left[\frac{nc^2 + 2c\sec\phi(\sin\phi \sum_{i=1}^{n} pi - \sum_{i=1}^{n} qi) + \sec^2\phi(\sin^2\phi \sum_{i=1}^{n} pi^2 - 2\sin\phi \sum_{i=1}^{n} piqi + \sum_{i=1}^{n} qi^2)}{n - 2} \right]^{\frac{1}{2}}$$

In the above example:

$$\sum_{i=1}^{n} \sigma i^2 = 6273314$$

and

$$(\sum_{i=1}^{n} \sigma i)^2 = 25466508$$

and $w = 12.283$

The 97.5% minimum confidence limit is found using F(z) = 0.95 with n-2 degrees of freedom, i.e. tc = 2.35.

hence

$$C_{97.5\ min.} = 164.2 - 2.35 \times 12.283 \left[1 + \frac{6273314}{(5 \times 6273314) - 25466508} \right]^{\frac{1}{2}}$$

$$= 122.7 \text{ kPa}$$

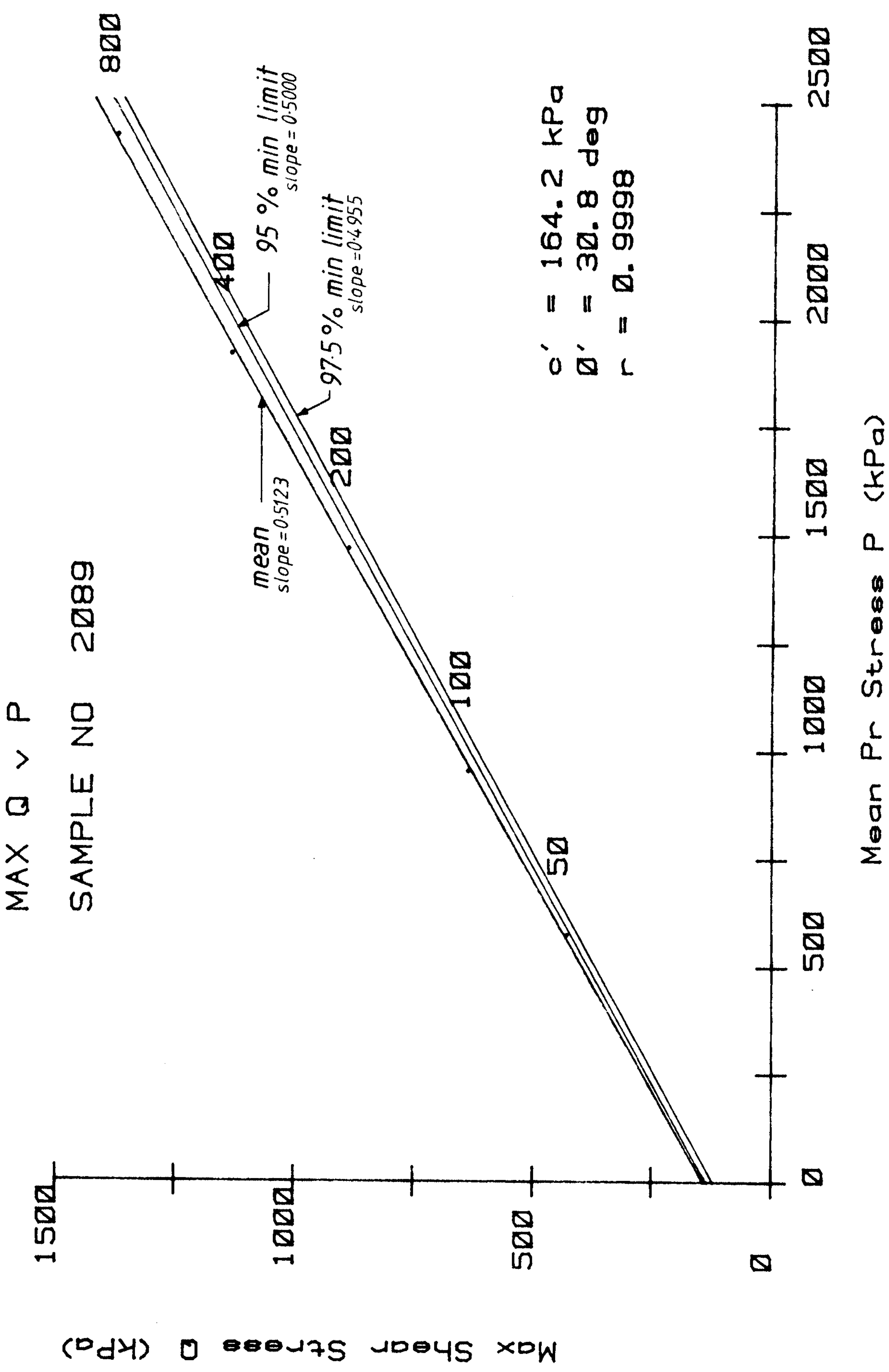


Figure 3. Example of Triaxial Test Results

and tan ϕ $= 0.5961 - 2.35 \times 12.283 \left[6273314 - \frac{1}{5} (25466508) \right]^{-\frac{1}{2}}$

$\phi_{97.5 \text{ min}} = 29.7^{o}$

These results have been plotted together with the 95% minimum confidence level in terms of the corresponding values of d and tan β in Figure 3.

References

Bajpai, A.C. 1977: Advanced Engineering Mathematics. Wiley & Sons.

Millar, P.J. 1982: The Triaxial Test Method. Ministry of Works and Development Central Laboratories Report No.2 - 82/8.

LIST OF MEMBERS

FOR INTERNATIONAL SOCIETIES

Surname First Name and Initials	______________________________
Title	______________________________
Profession	______________________________
Employer	______________________________
Address	______________________________
	______________________________
	______________________________
Telephone	______________________________
Telex	______________________________
Home Address	______________________________
	______________________________
	______________________________
Telephone	______________________________

Member of	ISSFME Yes/No	ISRM Yes/No	IAEG Yes/No

Normal Address for Correspondence — Work/Home

Please return to

N.Z. Geomechanics Society
Membership List
C/- Mr G.G. Grocott
Worley Downey Mandeno Ltd
P.O. Box 4241
AUCKLAND

APPLICATION FOR MEMBERSHIP

of

New Zealand Geomechanics Society

A TECHNICAL GROUP OF THE INSTITUTION OF PROFESSIONAL ENGINEERS NEW ZEALAND

The Secretary
The Institution of Professional Engineers New Zealand
P.O. Box 12241
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 N.Z. Geomechanics Society and supply the following details:

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

PERMANENT ADDRESS ______________________________

____

QUALIFICATIONS AND EXPERIENCE ______________________________

____

NAME OF PRESENT EMPLOYER ______________________________

NATURE OF DUTIES ______________________________

Affiliation to International Societies: (All members are required to be affiliated to at least one Society, and applicants are to indicate below the Society/ies) to which they wish to affiliate). Affiliation fees are in addition to the Geomechanics Society membership fee of $15.00.

I wish to affiliate to:

International Society for Soil Mechanics and Foundation Engineering (ISSMFE) Yes/No ($6.00)

International Society for Rock Mechanics (ISRM) Yes/No ($8.50)

International Association of Engineering Geology (IAEG) Yes/No ($4.50) ($9.00 with Bulletin)

Signature of Applicant ______________________________

Date ______________ 19 ___

PLEASE DO NOT SEND FEES WITH THIS APPLICATION. AN ACCOUNT WILL BE RENDERED ON YOUR ACCEPTANCE INTO THE SOCIETY.

Nomination:

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

NOTIFICATION OF CHANGE OF ADDRESS

The Secretary
The Institution of Professional Engineers New Zealand
P.O. Box 12241
WELLINGTON

Dear Sir,

CHANGE OF ADDRESS

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

____

____

____

Name: ____

Address to which present correspondence is being sent:

____

____

____

Signature ______________________

Date ______________________