N.Z. GEOMECHANICS NEWS

No. 16

JUNE 1978

A NEWSLETTER OF THE N.Z. GEOMECHANICS SOCIETY

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Persons interested in applying for membership of the Society are invited to complete the application form at the back of this newsletter. Members are required to affiliate to at least one of the following international societies: Soil Mechanics, Rock Mechanics or Engineering Geology.

EDITOR'S NOTES

1. Hamilton Symposium

The proceedings of the Geomechanics Society Symposium on "Tunnelling in New Zealand" will be available shortly. Those who attended the symposium already have a bound copy of the papers and these people will be mailed a further volume containing a summary of the discussion. A single volume containing the papers and the discussion will also be on sale at a cost of $18 to Society members and $20 to non-members. Enquiries regarding this publication should be made to the Secretary of N.Z. Institution of Engineers.

A review of the symposium is published in this issue.

2. Article on Clay Shales

Mr I. Brown, an employee of the N.Z. Geological Survey and a member of the Society is carrying out post-graduate study at the University of California, Berkeley. This issue of Geomechanics News contains an article by Mr Brown, submitted as a term project at Berkeley. The article deals with aspects of the behaviour of North American Clay Shales, with particular reference to their performance in underground openings. These materials are similar to the soft sedimentary rocks (papa) which are found over large areas of New Zealand.

3. 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.

4. Geomechanics Society Representation at International Meetings

The following item is reprinted from ISRM News No. 43, 1977:

"ISRM Council Meeting

The Council of the Society met in Stockholm on 1977 September 04, in conjunction with the 1st International Symposium on Storage in Excavated Rock Caverns... ... .
ARGENTINE, BELGIUM, FINLAND, GREECE, INDIA, MEXICO, NEW ZEALAND, POLAND and TURKEY were absent from the Council meeting.
However, participants from all these countries attended... ... .
This situation casts a shadow on the international image of the Society and should be avoided at all costs. On the one hand, National Groups of the Society should explore every conceivable possibility of being represented - at worst by proxy - at relevant ISRM meetings. On the other hand, every ISRM member intending to participate in an international conference connected with ISRM meetings should contact the National Group of his country, and tell them of his willingness to be a national representative at the Council meeting, eventually after adequate briefing by one of their officers".

Would members note that the same applies to ISSMFE and IAEG meetings. We understand that national representation overseas may result in tax concessions on some travel expenses.

5. Contributions wanted

Contributions to New Zealand 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/o New Zealand Geomechanics Society,
P.O. Box 12241,
WELLINGTON.

A.J. Olsen
Editor.

TWENTY YEARS ON - A HISTORY OF THE N.Z. GEOMECHANICS SOCIETY

J.P. Blakeley

(Taken from the Chairman's opening address at the Symposium on Tunnelling in N.Z. held at the University of Waikato - 17-19 November 1977)

Over the past two years there has been considerable growth in the activities of technical groups of the N.Z. Institution of Engineers. The N.Z. National Society for Soil Mechanics and Foundation Engineering (which was the forerunner of the N.Z. Geomechanics Society) was the first technical group of the N.Z.I.E. to be formed and hence has paved the way for other such groups.

The original impetus for the formation of the Society came in 1956 when the Second Australia-New Zealand Conference on Soil Mechanics and Foundation Engineering (which was a regional conference of the International Society for Soil Mechanics and Foundation Engineering) was held at Canterbury University College. As there was no organisation in New Zealand to represent the International Society, the organisation of the conference was undertaken by the University and it was a very successful conference.

Following on from this, Mr P.J. Alley, one of the pioneers of soil mechanics in New Zealand pressed for the formation of a New Zealand national committee. Mr Alley, who was an individual member of the International Society, was most concerned that New Zealand had no voice at executive meetings and was in effect represented by the Australian National Committee. In January 1958 he circulated a notice saying that he proposed that at the N.Z.I.E. Annual Conference in Wellington in February 1958 a resolution would be passed to form a national committee and that office bearers would then be appointed. This did not in fact happen but Mr J.W. Ridley, was appointed by the N.Z.I.E. Conference to convene a meeting in Wellington with the purpose of forming a national committee which would consist of representatives from each of the two university engineering schools, the D.S.I.R., the Ministry of Works, the N.Z. Railways, and two representatives of the N.Z.I.E. A meeting of interested people was duly held on 24 April 1958. A committee was appointed consisting of Mr (now Professor) P.W. Taylor from Auckland University, Mr Alley from Canterbury University, Dr R.D. Northey from the D.S.I.R. (who has served continuously on the committee ever since), Mr V.A. Murphy from N.Z. Railways and Mr Ridley from the Ministry of Works. The N.Z.I.E. representatives were Mr N.W. Collins from the Ministry of Works and Mr T.A.H. Dodd from R.G. Brickell, Consulting Engineer. Mr A.G. Hutchinson from Auckland City Engineer's Department was subsequently appointed as a third N.Z.I.E. representative.

The first meeting of the Committee was held on 17 July 1958. Unfortunately only four of the committee could be present, plus the N.Z.I.E. Secretary, Mr Bedingfield. Mr Ridley was elected Chairman and Dr Northey Secretary. Statutes for the Society were drawn up and the subscription was set at ten shillings per annum, and the International Society and the Australian National Committee were informed that the embryo group was under way.

The Society has continued to grow and expand its activities ever since. Mr Collins took over as Chairman in 1959 when Mr Ridley's duties as Project Engineer at Otematata made him unable to continue. The first annual meeting, held at the N.Z.I.E. Annual Conference in Christchurch in February 1959, was well attended and ratified the statutes of the Society.

During Mr Collins' three year term as Chairman, there was considerable controversy over whether the Fourth Australia-New Zealand Conference should

be held in Auckland in 1963. The fledgling society finally decided it did not have the financial resources to handle the undertaking and the conference was held in Adelaide. Subsequently the fifth conference was held in Auckland in 1967 and was an extremely successful occasion.

Mr O.T. Jones became Chairman in 1962 when the membership stood at 48, and held the office for five years until the end of 1966. He was ably assisted over these years by Mr R.O. Bullen as Technical Secretary, who had taken over from Dr Northey. During these years all the planning was carried out for the 1967 Auckland conference. Also the Society formally merged with the N.Z.I.E. to become its first technical group as a result of a ballot at the AGM on 10 February 1965. Also during Mr Jones' term as Chairman, the first national symposium of the Society was held in Hamilton on the subject of Roading Earthworks in August 1965. During the four year period 1962-1965 Mr K.S. Birrell of D.S.I.R. Soil Bureau served as the Australasian Vice-President of the International Society for Soil Mechanics and Foundation Engineering.

Mr R.M. Tonkin then became Chairman for the two years 1967 and 1968 with Mr C.M. Strachan as Technical Secretary. Mr J.H.H. Galloway became Chairman in 1969 and served for five years until 1973. Dr M.J. Pender took over from Mr Strachan as Technical Secretary in 1970-71 and Mr P.G.M. Imrie as Management Secretary in 1972-73.

During Mr Galloway's term as Chairman two further very successful symposiums were held; the Site Investigation Symposium in Christchurch in August 1969 and the Symposium on Using Geomechanics in Foundation Engineering in Wanganui in September 1972. Also, in November 1970 the first issue of the Society's newsletter "N.Z. Geomechanics News" was published with Mr J.P. Blakeley as Editor and this has been produced regularly twice a year ever since.

However, the most significant development during Mr Galloway's term of office was in 1972 when the Society changed its name to the N.Z. Geomechanics Society and became the official body in New Zealand representing the International Association of Engineering Geology and the International Society for Rock Mechanics as well as the International Society for Soil Mechanics and Foundation Engineering. During the ten years 1962-72 membership had grown from 48 to nearly 200.

From 1970-74 Mr L.E. Oborn served as Vice-President for Australasia of the International Association for Engineering Geology and from 1973-77, Professor P.W. Taylor served as Vice-President for Soil Mechanics and Foundation Engineering.

Mr D.K. Taylor succeeded Mr Galloway as Chairman and served in this position for the three years 1974-76 with Dr G.R. Martin as Management Secretary in 1974-75 succeeded in 1976-77 by Dr J.M.O. Hughes. Dr I.M. Parton took over as Editor of "N.Z. Geomechanics News" for the four year period 1974-77.

During this period a very successful Symposium on the Stability of Slopes in Natural Ground was held in Nelson in November 1974 and this was followed up by the publication of the booklet: "Slope Stability in Urban Development" which was prepared by the Society and published by the D.S.I.R. in January 1977. Also the First N.Z. Geomechanics lecture by Mr J.W. Ridley was held in Auckland, Wellington and Christchurch in March 1974 and the Second N.Z. Geomechanics lecture by Dr C.P. Wroth of Cambridge University was held in the same centres in August 1975.

Mr J.P. Blakeley took over from Mr Taylor as Chairman of the Society in 1977 and in 1978 Dr I.M. Parton has been elected Management Secretary and Mr A.J. Olsen Editor of "N.Z. Geomechanics News". The Symposium on Tunnelling in N.Z. in November 1977 was another milestone in the history of the Society.

Planning is now proceeding for the Third N.Z. Geomechanics lecture to be presented by Dr R.D. Northey early in 1979 and also for the Third Australia-New Zealand Geomechanics Conference to be held in Wellington in May 1980 with Mr J.H.H. Galloway as Chairman of the organising Committee.

This article was made possible by using early records of the Society made available by Mr N.W. Collins and his help is gratefully acknowledged.

REVIEW OF THE GEOMECHANICS SOCIETY SYMPOSIUM ON TUNNELLING IN NEW ZEALAND

P.J. Wilcox

I had the pleasure of attending the Geomechanics Society Symposium entitled "Tunnelling in New Zealand" held at the University of Waikato, Hamilton in November 1977.

The programme was a full one and we were certainly kept at it, though by careful selection of topics and speakers, interest remained high. Certainly comments overheard at coffee and meal breaks supported this.

While most people involved in any way with tunnelling would, I feel sure, tend toward the view that it is more an art than a science, it was apparent from the difinitive technical papers that the scientific approach to tunnelling has made significant inroads into the art and has an increasingly important part to play.

The introduction given by Mr A.F. Downer was astonishing. Here was a man who has probably forgotten more about tunnelling than most of us know, certainly in New Zealand, who spoke for about 60 minutes without referring to his notes on "Historical Aspects of Tunnelling in New Zealand". It was a fascinating account of those early tunnels, full of interesting side-lights and showing quite clearly why he should be regarded as the grand old man of tunnelling in this country.

The sessions on investigations gave us two papers by Messrs Prebble and Pender with the true stamp of the professional; clear and careful introductions to their topics with completely accomplished presentations.

In the design section, Dr Fama showed clearly what can be achieved by a parametric study using the finite element technique to choose suitable mine roadway spacings at Huntly while Mr Rutledge introduced two papers, one on rock classification systems and the other on tunnel portal practice. The first paper was a most interesting one and certainly left me with the feeling that a classification system represents the best approach in achieving successful predictable tunnel support requirements.

The session on construction saw two papers by Messrs Flynn and Newsome covering the topics of tunnelling machines and contracting aspects. My conclusion here was that the full face machines in New Zealand have not been and are unlikely to be very successful due to our extremely variable geology. More use is likely to be made of the much less expensive and more flexible machines known as roadheaders. The paper on contractural aspects showed that where work is to be undertaken in the ground the constructors and the designers must be able to communicate with each other and this is particularly true of tunnels where ground conditions nearly always change without warning and do not always favour the designer's intent.

Three papers were presented in the session on data recording and instrumentation. Mr Osborne covered aspects of the recording of geological and physical data. The paper presented by Messrs Bryant and Olsen gave everyone a very useful description of the latest instrumentation available and its application. Mr Osborne described the use of some of these instruments in the Terrace Tunnel. This was a very useful session which clearly showed the part that science has to play but that it must be tailored to fit the circumstance if it is to be used and trusted.

The last session on case studies was the logical conclusion to the symposium where much of what had gone before was shown being put to use in the particular

job. The jobs included Kaimai, the Western Diversions of the Tongariro Power Development and Rangipo Powerhouse. The last session emphasised for me the importance of geology in tunnelling and the fundamental requirement of geological advice in all stages of tunnelling. Here at this symposium we had engineering geologists, contractors, designers, scientists and engineers all showing by their presence and contributions in discussion that to be truly successful in tunnelling one has to use an amalgam of skills.

I believe that the success of this symposium can be judged from the full and interesting discussions which followed the papers. This symposium was every bit as successful as the last organised by the Society on "Slope Stability in Natural Ground" and I congratulate the Society in their organisational efforts and careful choice of topics and speakers in presenting a most enjoyable and stimulating symposium. I look forward to the next one.

LOCAL ACTIVITIES

AUCKLAND GROUP

At a meeting of the Auckland Group Committee held on 11 April 1978 Mr J.P. Blakeley retired as Convener of the group after several years in this position and was succeeded by Dr M.J. Pender. Other members of the Committee are T.J. Kayes (Secretary), A.P. Codling, G.R.W. East, B.C. Hadfield, Dr I.M. Parton, W.M. Prebble and M.A. Wesseldine.

It was decided that a general discussion regarding the future of the bore hole register for the Auckland metropolitan area would be held in conjunction with the combined meeting with the N.Z.I.E. Auckland Branch to be held in September 1978. This register has received very little use in recent years, nor has it been updated with details of site investigations carried out over about the past five years and to do so now would require a major effort. The register was originally set up due to the enthusiasm of Professor Searle of the Geology Department of the University of Auckland and since his retirement little work has been done on updating it. The Committee members feel that the main reason why it is not used is that it only contains very limited information and the detailed information is held by the organisation who carried out the investigation. It is up to that organisation or their client (who is the owner of the information) whether or not this can be released on request. The discussion in September should be valuable in indicating whether the concept of having such a borehole register in our larger cities should be pursued or abandoned. The matter is particularly relevant in that groups in both Wellington and Dunedin are at present considering whether to institute such a borehole register.

A programme of meetings for the remainder of 1978 was agreed as follows:

> Tuesday 11 July - Talk on "Vibro Processes" by Mr B.C. Hadfield of the Gilberd-Hadfield Pile Co. Ltd.
>
> Wednesday 20 September - A combined meeting with the NZIE Auckland Branch to be addressed by the Secretary or Assistant Secretary of the Earthquake & War Damages Commission.
>
> Tuesday 14 November - A panel discussion on Auckland aggregates at which about six speakers will be given five minutes to express their point of view in an informal manner followed by general discussion.

The meeting then proceeded to the topic for discussion "Slope Stability in Urban Planning" which is reported later in this issue.

- J.P. Blakeley

WELLINGTON GROUP

So far this year one meeting, convened at very short notice on 14 March, has been held. Mr Hugh W. Nasmith, an engineering geologist from Thurber Consultants in Victoria, British Columbia, gave a case history of flow slides that had damaged a logging town. The problem was solved with the use of model studies in which different deflection embankment arrangements were tested so that the flows could be deflected past the town. The flows

were similar to some experienced in Wellington during the storm of 20 December 1976.

The meetings planned for the year are:

June 14 — Mr Peter Bartlett of MWD Central Laboratories will talk on "The Filtering Properties of Filter Cloths". Mr Bartlett has been carrying out tests on various commercially available filter cloths with an emphasis on the problem of clogging.

July — Dr John Berrill of the University of Canterbury Civil Engineering Department and Mr Les Oborn, Head of the Engineering Geology Section of the N.Z. Geological Survey, will talk on "The uncertainties in determining possible earthquake shaking at a site". Both Dr Berrill and Mr Oborn have a strong interest in engineering seismology.

August — Mr Roger Preston and Tony Hinkley of Ministry of Works & Development will talk about the "International Tunnel Symposium 1978" which had a theme of "Tunnelling Under Difficult Conditions" held in Tokyo in June. The associated site visits will be illustrated with slides.

The meetings for September, October and November will be as follows, but not necessarily in the order given. The final order is dependent on the availability of speakers.

1. A meeting will be held on the effects of the 20 December 1976 storm that caused widespread damage in the Wellington area. Dr Keith Lewis, a geologist with the N.Z. Oceanographic Institute will show a short film that he made about the storm. Dr R.J. Eyles of the Geography Department at Victoria University will talk on:

   a. the distribution of slope failures in the storm;

   b. the context of the event in the long term geomorphology of the Wellington area; and

   c. threshold levels of rainfall at which problems occur.

   The final speaker will be Mr Keith Gillespie, a partner with the consulting practice of Brickell Moss Rankine and Hill. Mr Gillespie has a detailed knowledge about many of the problems that resulted from the storm and the remedial work that was required.

2. A presentation of the paper "A design method for heavy duty flexible pavements" by John P. Blakeley, Harold R. Green and Dr Do van Toan all from the consulting firm Beca Carter Hollings and Ferner. This paper was previously presented at the N.Z.I.E. conference held in Hamilton in February 1978 where it was awarded the Fulton-Downer gold medal.

3. Dr John Hawley from the Ministry of Works and Development Science Centre in Palmerston North will discuss aspects of work he is carrying out on slope stability.

The topic, speaker, venue and time of each meeting will be advertised in the N.Z.I.E. Wellington Branch newsletter and notices will be posted

to all members of the Society who live in the Wellington area. Alternatively members may ring John Rutledge on 729-929, ext 664, to find out about forthcoming meetings.

- J.C. Rutledge

CHRISTCHURCH GROUP

At a joint meeting with NZIE Canterbury Branch on 1 June 1977, a Christchurch Group of the N.Z. Geomechanics Society was formed. A committee of three was elected, as follows:-

D.H. BELL - Senior Lecturer, Geology Department, University of Canterbury

G.L. EVANS - Consulting Engineer, Christchurch

B.R. PATERSON - Engineering Geologist, N.Z. Geological Survey, Christchurch.

Subsequently, DR J.B. BERRILL has been coopted to give the committee greater balance. Current membership of the Christchurch Geomechanics Group is 50, although a majority of these are not (as yet, at least) members of the N.Z. Geomechanics Society. Nevertheless, there is much to be gained at the local level from the involvement of people with only a peripheral interest in geomechanics: Our main problem is, in fact, to gain the interest and support of members of the engineering and related professions who are involved directly with geomechanics.

At 1 June 1977 meeting two papers were presented, the first by Guy Evans titled "Earthworks and erosion on the Port Hills", and the second by David Bell on "Geological aspects of tunnel erosion": D. McConchie, a post-graduate Geology student assisted with the latter talk. On 22 June 1977 a joint meeting was held with the Christchurch Section of the Geological Society of New Zealand, at which DR A.J. PEARCE, Forest Research Institute, Christchurch, talked on "Geology and hill-slope erosion in relation to forest management in New Zealand". Both June meetings had attendances in excess of 40, and the topics generated lively discussion.

The 1977 programme concluded with Guy Evans talking on his attendance at international geomechanics conferences in Bangkok and Tokyo earlier in the year. Attendance was disappointing (only about 10 were present), but this could probably be attributed to the choice of a December date for the meeting.

The main event so far in 1978 has been the two-day seminar on "Slope Stability and Urban Development" held at the University of Canterbury on 24 & 25 February (and reported elsewhere in this volume). Although this was organised by the Department of Extension Studies, the local Geomechanics Group was active both in initiating the seminar and in organising its technical content. On 26 April Dr R.O. Davis, Civil Engineering Department, University of Canterbury, addressed the local Group on "Post-Terzaghi Soil Mechanics". His was a stimulating and lucid presentation, especially of the critical state concept, and the attendance was about 20. The programme for the remainder of 1978 has yet to be finalised, although we are hoping for about three more evening talks, and a one-day field trip later in the year.

The success or otherwise of the Christchurch Geomechanics Group is certainly dependent on the enthusiasm of the local committee, but much more important is the active support of those with an interest and involvement in geomechanics problems (of which there are no lack around Christchurch). However, it is still too early to predict the future of the local Group with any confidence, and there remains a wide gap between geomechanics theory and practice, at least in Christchurch.

- D.H. Bell

SLOPE STABILITY IN URBAN PLANNING

J.P. Blakeley

(Proceedings of a meeting of the Auckland Geomechanics Group)

1. INTRODUCTION

A meeting of the Auckland Group of the Society was held on 11 April 1978 on the above subject which was attended by about 50 people including a number of planners who had been invited as guests of the Group. The first speaker was Mr D.K. Taylor of Tonkin & Taylor, Consulting Engineers, and one of the authors of the book "Slope Stability in Urban Development". Mr Taylor began by stating that in the development of land for urban purposes the "community" has to decide what cost it will stand for an acceptable standard of safety. Relatively few building lots suffer slope failure but those that do fail are of great consequence to the owners, especially those of modest means. Much of the easiest land in our cities has already been developed and the risks of slope failure are increasing as steeper land is developed. The Earthquake and War Damage Commission has come under political pressure to extend their cover from building damage and contents only to include reinstatement of failed ground or the provision of a new house on another site to an equal standard to that on the site where the failure occurred. The Commission is aware that many slope failures which have happened could have been avoided by relatively extra little care. In August 1976 the Commission therefore reminded Local Authorities of their existing obligation to check land stability. This was done in an effort to ensure that a better standard of care is exercised by Local Authorities to reduce the risks borne by the Commission down to acceptable proportions. At about the same time, some Court judgements brought home to Local Authorities their possible liabilities in this regard and exposure to legal action. These two factors seem to have been combined in attempts by Local Authorities to obtain professional opinions and statements that are more definite than the present state of the art permits and are hence unrealistic.

2. STEPS IN THE INVESTIGATION

Mr Taylor said that the present state of the art is described in the handbook "Slope Stability in Urban Development". Any investigation of slope stability should start by covering a broad area and be gradually narrowed down to each individual house site.

Step 1 - Surface Evidence

An initial examination of the ground surface should be made by an experienced geologist or engineer. Aerial photographs and available geological maps are also useful in this regard in indentifying areas of possible instability but at this stage any judgement must be a qualitative one. The cost of such an investigation would be of the order of a few dollars per hectare. It may be complemented by minor selective drilling or excavation carried out at modest cost where exposures are lacking. Although some sample testing may be carried out at this stage, the data produced would be far short of that needed for a quantitative analysis. Evaluations at this stage must be based largely on precedent, i.e. the performance of similar slopes in similar geology.

Step 2 - Subsurface Examination Related to Specific Development Proposals

This may consist of bores or pits at specific critical localities to determine

the type and attitude of strata. It will refine the qualitative appreciation of stability and can indicate the appropriate physical development to maintain or improve stability but it is still a qualitative judgement.

Step 3 - Detailed Stability Analysis

If Step 2 is extended to sample testing and quantitative analysis of stability with any chance of being conclusive, another order of cost is involved, i.e. at least several thousands of dollars for one locality with uniform soil conditions which may be less than one hectare in area. This kind of analysis for every building lot is out of the question and even for only one or a few building lots requires very special circumstances.

Conclusion

Successive steps in the investigation improve the quality of the judgement of stability but certainly not in proportion to the increase of expenditure involved and never to reach the same degree of certainty as for example in the analysis of a building frame or even the definition of a flood plain for a given frequency of flooding. Costs may vary from a few dollars per hectare for general geological and topographical appraisal to some thousands of dollars per hectare for quantitative analysis but the degree of certainty has by no means improved a thousand times.

3. STATEMENTS BY REGISTERED ENGINEERS

Mr Taylor then made reference to the various forms (known as the EWD forms) originally prepared by the Earthquake & War Damage Commission and subsequently modified by a combined Committee of the Municipal and Counties Association. The three formats for the statements have been given on pages 24-28 of N.Z. Geomechanics News No. 15, November 1977. Mr Taylor said that there are four stages of geotechnical examination of land stability of which the last three correspond to the formats given on these forms.

First Stage - At the Zoning Stage

Format 1 (6/77) states that it is necessary to complete this form when there is some prior reason to suspect a stability problem; this implies that either a broad appraisal has already been made and taken account of in the Town Plan preparation or that some particular failure has come to notice of the Local Authority. Such a broad appraisal should be made when land is first zoned for urban development and therefore must be carried out by qualified people selected by the Local Authority. At the present time in N.Z., engineers are the only professionals registered in this field although there are some moves towards the registration of geologists as is the case in California.

Second Stage - At the Scheme Plan Stage

Format 1 (6/77) is intended to be used at this stage. Prior to the use of this form, scheme planning was very often carried out by a surveyor without special training in geomechanics. The use of this form now requires that a registered engineer be involved in this work who claims specialist experience in the field of soils engineering and more particularly land slope and foundation stability.

Third Stage - Subdivisional Construction

Format 2 (6/77) requires a registered engineer (but not a specialist) to certify that he has inspected the works during construction to ensure that they were carried out in accordance with the contract requirements and that the earthworks were carried out in terms of NZS 4431P and hence that there is on each residential section a site suitable for a residential building not

requiring specific design.

Mr Taylor made the point that in both the second and third stages above the professional advisers are selected by the owner or his subdivider and engagement can be in different ways.

(i) Partial advice - no authority

(ii) Observation and testing - no authority

(iii) Partial authority - some phases only

(iv) Total responsibility and control over constructor and owner.

Only the Local Authority can enforce a "total responsibility" engagement if they want professional people to accept responsibility for the end result. The design of a subdivision to reduce apparent stability risks comes mainly from judgement and experience. Little calculation is usually involved.

Fourth Stage - Building Permit Application

At this stage the land is subdivided, subdivision construction is finished and the building lots are privately owned. Format 3 (6/77) should normally only be required for a building site which is an area previously defined as having problems of known potential, or suspected land slope or foundation instability, or for a section in a subdivision where final plans were approved subject to specific investigation and engineering design for that section. Format 3 requires a registered engineer with specialised experience as for Format 1. Before Format 3 came into use, owners might go anywhere for geotechnical advice, perhaps even to engineers who are not civil engineers. At the building permit application stage, the registered engineer will come under pressures that the house should be built and it is not easy to be objective. An investigation which is to be very much more conclusive than that required in Stage 2 becomes too expensive for private owners. A better qualitative judgement will cost some hundreds of dollars but a quantitative judgement will cost some thousands of dollars.

4. PRACTICAL MACHINERY OF CONTROL OVER USE OF LAND

Mr Taylor said that the community must be realistic about expectations of assurance of land stability. There will always be some risk of instability and any other belief is unrealistic. A statement of professional opinion tending towards a guarantee is likely to be so conservative that many existing developments would be excluded. Responsible and experienced professional opinion would be stifled by unrealistic demands and fear of legal retribution. It would only need one house sliding down a hill for many professional engineers to be bankrupted. Time will tell whether the EWD Formats 1, 2 and 3 (6/77) are the answer to this problem. Also it remains to be seen whether judgements based on geological and topographical evidence in Stages 1 and 2 above can survive District Scheme objections.

Finally Mr Taylor asked whether it is economic to grapple with progressively more expensive stages of investigation which are not proportionately more certain regarding risk of stability failure. Also, who should carry the insurance for the residual risks once a registered engineer with specialist experience has done his professional best. Should it be on the personal assets of the professional consultants or on the Local Authority Engineer's personal assets, or on privately arranged insurance or on a community insurance? In conclusion Mr Taylor said that unrealistic demands must be resisted but professional behaviour will be worse if too much reliance is placed on insurance.

5. THE PLANNER'S POINT OF VIEW

The meeting was then addressed by Mr Glen Rees, a planner with the Waitemata City Council. Mr Rees said that many planners were only just becoming aware of the existence of the EWD (6/77) forms. He contrasted the experiences in his own area of Waitemata City where there was pressure to develop difficult sites within areas which had already been zoned for urban purposes with a rapidly developing area such as Manukau City where there is a need to define areas of instability and zone them accordingly.

Mr Rees said that of recent times there has been a great deal of focus on urban development in unstable areas. This has been triggered off by so many instances of slipping in hilly country following heavy rain. Also, recent instances of erosion by the sea is a similar problem from the planning viewpoint. Both these problems have quite catastrophic results for the unfortunate land owners involved. To look at such disasters after the event and say that the causes were obvious is relatively easy compared with the task of foreseeing the event. Increasing pressure is being levied at Local Authorities to identify problem areas and Mr Rees suggested that the District Scheme should be used for this purpose to put on the necessary controls. The Town and Country Planning Act gives directions in this respect using in part the 1977 Act and in part the 1953 Act and the regulations based thereon. The following matters are declared to be of national importance - the conservation, protection and enhancement of the physical environment; the wise use and management of NZ's resources; the preservation of the natural character of the coastal environment. District Schemes shall have for their general purposes the wise use of management of the resources in such a way as will most effectively promote and safeguard the health, safety, convenience and general welfare of the people and the amenities.

Mr Rees said that he had been unable to examine the copy of the regulations relating to the 1977 Act but with reference to the 1960 regulations, these gave a very clear direction to Local Authorities, particularly in regulation 16 which deals with the subject matter of District Schemes and has a section on the suitability of land which reads "Every District Scheme shall provide as far as is practicable against land being used for purposes for which it is not suitable having regard to earthquake fault lines, the liability to flooding, erosion and landslip; to stability of foundations; and to safety of amenities." However very little indication or guidance is given as to how to include these considerations into the District Scheme, and in particular how to make provision for not building on certain areas within a Scheme.

Hence the problem is to get into a District Scheme some provisions regarding land stability. It is possible to identify a large area of land and areas within it which may be subject to instability but it cannot exclude areas for development. Another problem is that small scale maps cannot identify individual house sites which may have a stability problem.

Mr Rees said that in his experience many prospective purchasers through their legal advisers seek information from their Local Authority regarding the provisions of the District Scheme relating to a particular piece of land. Hence it would be a relatively simple matter to convey any information in the District Scheme relating to land stability of individual sites. Once Format 1 (6/77) comes into general use it may become relatively easy to get such information from the District Scheme but it will be very difficult in the case of land already zoned for urban purposes.

Mr Rees said that in the case of land already developed and with pressure to use less suitable building sites, he believed that the solution is for the Local Authority to go out and identify areas in which there may be instability problems and then to record these on some document. He believes

that the District Scheme is the ideal vehicle to bring to public attention how best to use a piece of land. If problems of land instability are becoming more and more serious, then obviously a much greater effort is now required, before building permits can be issued by Local Authority if expensive claims are to be avoided in the future.

6. DISCUSSION

It was pointed out that regulations and laws do not always take into account the needs of the community. Every site has its own requirements and legal requirements cannot be made flexible enough to allow for all factors affecting land stability to be considered properly and to allow the land to be used to the best effect. By restricting the use of land, this may eliminate its development whereas by suitable measures it could be developed safely as a housing subdivision.

Mr Taylor agreed that laws and regulations are not the complete answer but that something needs to be done to bring people's attention to the fact that there must be certain limitations on the use of particular areas of land and in many cases the best thing to do is to avoid using land which may not be stable for subdivision (and possibly use it as a reserve). Mr Rees said that the problem is that there is strong and increasing pressure in the community to use desirable land which is close to the city.

It was pointed out that a restrictive covenant on the title can define the type of house which can be built on land but that this is not the right vehicle to draw attention to a stability problem with the land.

Mr Rees agreed that if stability problems of particular areas of land could be dealt with through the District Scheme (probably by referring the inquirer to some other source of information) the Local Authority could provide information to land owners or purchasers much more easily than through a restrictive covenant on the title.

A question was asked as to how far a qualitative report on land stability can be taken. If an area is graded into various degrees of stability, and certain areas are said to be satisfactory, then obviously the specialist concerned will have to be very sure it is satisfactory or later purchasers will claim that they were not warned of any problem.

In reply to this, it was pointed out that it is not possible to quantify land stability in the same way as the strength of foundation soils can be quantified.

The question was asked that if a client goes to see his lawyer to ask if he should buy some land, should the lawyer then search not only the title but also the District Scheme? In reply Mr Rees said that the solution may be for solicitors to have a standard letter seeking various information from the Local Authority including information on land stability. To implement this the District Scheme should refer to some other document which will give more detailed information on the stability of land in that Scheme.

Concern was expressed that registered engineers are now being asked to sign documents and that land is then supposed to be stable because an engineer has signed that it is. Perhaps it would be better if all land was regarded as being unstable unless proved otherwise. The speaker commented that he felt there was a huge communications gap between engineers and planners on land stability. To this Mr Rees replied that planners have no intention in getting involved in the details of evaluation

of land stability but only in the making available to enquirers of information on stability which has been prepared by engineers.

The question was asked whether protection against flooding and earthquake as well as land instability is to be incorporated in the District Scheme when it is drawn up or whether it comes later in a more detailed plan. The full investigation into the design of a subdivision will not proceed until after the District Scheme has been drawn up and land has been zoned for urban development. Mr Rees replied that the District Scheme on a small scale plan cannot record areas of land instability etc., but could provide that at some later stage information can be detailed on stability and other considerations in a much larger scale plan.

Another speaker commented that land which is regarded as being stable at the present time will not necessarily always remain stable. An unprecedented storm which can cause large scale land slips cannot be forecast and hence much land could not be developed if the possibility of such storms was fully taken into account.

It was pointed out that the key to making the right decisions regarding land stability was good engineering judgement and the person best equipped to do this is one with experience in this field who is able to give a professional opinion which can be relied upon without warranty. The EWD formats do not require a person to be a specialist but to have experience in the field. The EWD formats are now more correctly Territorial Local Government formats as Local Authorities desired to have such formats prepared as they were confused about what steps they should take in giving building permits in areas where previous landslips had occurred. The key issue is what standard of guarantee a Local Authority should reasonably expect from a professional person and Local Authorities are now in agreement with the basic philosophy in the current formats.

A discussion then followed on the role of the engineering geologist in slope stability evaluation. One view was that he is one of a professional team and is well equipped to give such advice. The amount of his input will depend on the type of problem but the final jugement must be an engineering one. A differing viewpoint was that the role of scientists other than engineers is to assist engineers where they need assistance but also to give comment on problems when by doing so they may avoid further need to carry out expensive engineering investigations. Such scientists can also delineate problems and hence avoid the need for widespread investigation. To suggest that the initiative should always come from an engineer might be an outmoded attitude. In some other countries scientists are the first people to be consulted. In reply to this it was pointed out that at the present time in N.Z., engineers are the only professionals working in this field who have legal registration.

A comment was made that the nature of the present format can cause difficulty and should separate out house foundation problems from slope stability problems. The format should basically be concerned only with slope stability as it is always possible to find a satisfactory foundation for a structure if enough money is spent. The formats appear to have mixed up slope stability with foundation design.

The final question regarded the availability of the format (7/66). These are now being promulgated by the Municipal Association and the Counties Association but can also be found in N.Z. Geomechanics News No. 15. Some Local Authorities may be using an earlier version of the formats (which have now been superseded) but can usually be persuaded to accept the latest format when this is pointed out to them.

The meeting concluded with the Chairman, Dr Pender, proposing a vote of thanks to the speakers which was carried with acclamation.

NEWS FROM THE MANAGEMENT SECRETARY

1. MANAGEMENT COMMITTEE 1978

J.P. Blakeley (Chairman)	Auckland
I.M. Parton (Management Secretary)	Auckland
J.H.H. Galloway	Wellington
D.H. Bell	Christchurch
A.J. Olsen (Editor, Geomechanics News)	Wellington
J.G. Hawley	Wellington
B.W. Riddolls (Vice-chairman Engineering Geology)	Wellington
M.J. Pender (Vice-chairman Rock Mechanics)	Auckland
R.D. Northey (Vice-chairman Soil Mechanics)	Wellington
D.K. Taylor	Auckland
J.C. Rutledge	Wellington

2. FORTHCOMING CONFERENCES AND SYMPOSIA

Listed below are Conferences and Symposia in the 1978-1979 period which have been brought to our attention. Further details can be made available on request.

1978

August 29 - September 1	First Colombian Geotechnical Seminar Bogota, Colombia.
September 4 - 8	Third International Congress of the Internation Association of Engineering Geology, Madrid, Spain.
September 4 - 10	Third Colombian Geotechnical Symposia, Bogota', Colombia.
September 13 - 15	Third Australian Tunnelling Conference, Sydney.
September 18 - 22	International Symposium on Water in Mining and Underground Works, Granada, Spain.
September 27 - 29	ISRM International Symposium on Rock Mechanics Problems Related to Dam Foundation, Rio de Janeiro, Brazil.
October 16 - 19	Symposium on Soil Reinforcing and Stabilizing Techniques in Engineering Practice, Sydney, Australia.
November	Conference - Clay Fills, London.
December 20 - 22	Conference on Geotechnical Engineering, Indian Geotechnical Society, New Delhi, India.

1979

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.

1979 cont'd.

September 10 - 13	Seventh European Conference on Soil Mechanics and Foundation Engineering, Brighton, England.
October	Symposium on Bearing Capacity of Rock, Australia.

3. PROCEEDINGS SECOND AUSTRALIA - NEW ZEALAND GEOMECHANICS CONFERENCE

The Society holds limited stocks of these Proceedings which are available to members at a cost of $25.00.

4. PROCEEDINGS, NELSON SYMPOSIUM ON STABILITY OF SLOPES IN NATURAL GROUND

Copies of the Proceedings are available from the Secretary, NZIE, at a cost of $15.00 to Society members and $18.00 to non-members.

5. BACK ISSUES NEW ZEALAND GEOMECHANICS NEWS

Copies of most back issues are available to members at a nominal cost of 50¢ per copy from the N.Z.I.E. Secretary.

- I.M. Parton
Management Secretary

N O T I C E

GEOLOGICAL HAZARDS: ANZAAS CONFERENCE, JANUARY 22-26, 1979, AUCKLAND

The Geology and Mining Section of the 49th Congress of the Australian and New Zealand Association for the Advancement of Science includes a Symposium on Geological Hazards.

This Symposium has wide scope - to include topics such as landslides, flooding, volcanic hazards, earthquake risk and microzoning, geothermal hazards, tectonic risks, coastal erosion, pollution and waste disposal, seawater intrusion of ground water fields, foundation failure - in fact any topic which has to do with naturally occurring or man-made geologic conditions that present a risk or are a potential hazard to life and property. Interpreted widely it is hoped that this Symposium will receive contributions from various disciplines such as engineering geology, ground engineering, hydrology, geomorphology and volcanology.

It is hoped that the papers presented will be published in a special issue of a suitable journal.

Any members of the Geomechanics Society interested in presenting a paper to the Symposium should contact one of the undersigned.

W.M. Prebble - Geology Dept., University of Auckland
Convener.

M.J. Pender - Civil Engineering Dept, University of Auckland,
Private Bag, Auckland.

ENGINEERING GEOLOGICAL MAPS

A.J. Olsen

The production of engineering geological maps of New Zealand, similar to those available in some other countries, is a matter which has been raised from time to time by members of the Society. The Management Committee of the Society has formed a sub-committee to liaise with the N.Z. Geological Survey of the D.S.I.R. on the question of the production of such maps.

At this stage the Survey has no plans for the preparation of engineering geological maps. The main reason for this is the lack of manpower resources. There is also concern that the demand for such maps may not warrant the enormous amount of work required to produce the maps. It has been suggested that there could be upwards of 50 man-years work in preparing engineering geological maps for the Auckland area alone.

The Geological Survey is currently preparing enginering geological commentaries which are appearing in the texts accompanying new geological maps. In addition, as resources permit, tables describing the geology in engineering terms will also be prepared to accompany the new maps. At this stage the commentaries and tables seemed to be the best way of presenting general purpose engineering geological data in New Zealand, and in fact may well be all that is required in this country.

The currently available geological maps are as follows:

(a) 1:250,000 scale, time stratigraphic covering all N.Z.

(b) 1:63,360 scale, some time and some lithostratigraphic, covering about 25% of N.Z.

(c) 1:25,000 scale, special purpose lithostratigraphic, a few only.

Those maps based on time stratigraphic units are considered to be of little use in the engineering context. The new geological maps are now being prepared at 1:50,000 scale rather than 1:63,360 scale.

THE DURABILITY OF CLAY SHALES AND THEIR PERFORMANCE IN UNDERGROUND OPENINGS

I.R. Brown

1. INTRODUCTION

Inorganic fine grained sedimentary rocks that have not been deeply buried and affected by regional metamorphism, occupy a significant portion of the earth's crust. These materials have properties that might be considered soil-like at some times, and rock-like at others. The low durability of these materials, i.e. their resistance to weakening and disintegration in the course of time, often causes difficulties in civil engineering situations.

The geotechnical literature contains many definitions and attempts to classify these rocks. The term "shale" is used by nearly all authors, either as a general term to include all weak sedimentary rocks such as siltstones, mudstones and claystones (e.g. Shamburger et al 1975), or as a more specific term requiring shales to possess laminations or fissility (e.g. Underwood 1967). In this definition, the non-fissile equivalents are then termed mudstone, siltstone and claystone. Classifications may also be used following geological nomenclature where the type of lithic particles are used to categorize the rock. Mechanical properties, such as unconfined strength, may also be used. This approach appears to have considerable merit as it distinguishes over-consolidated clays that are well known to soil mechanicians, and more rock-like materials that have been affected by diagenesis. Morgenstern and Eigenbrod (1974) have proposed a classification system that uses strength and reaction with water as a means of distinguishing argillaceous materials. For the purpose of this report, the term shale will be used in the general sense, and modified to include only materials with an unconfined compressive strength greater than 1.8 MPa.

The stability of natural and cut slopes in shales has been the subject of numerous published papers (e.g. Banks 1971). An even greater research effort has been directed towards the study of the performance of embankments constructed with compacted shales (e.g. Shamburger et al. 1975). Much of the work that has been done to characterize the near-surface behaviour of these materials is relevant to shale behaviour in underground openings. The excavation of a tunnel induces stress changes and changes in water content in the surrounding rocks, and in shales these changes cause a time-dependent volume increase. In tunnels, most deformation takes place as invert heave, which may be as high as 25 cm/year (Einstein and Bischoff 1977). The rate of heave may decrease with time, however rates of heave of 9.5 to 1.0 cm/year are not uncommon in tunnels 75 to 100 years old.

The problems caused by shales in an underground opening may be due either to swelling, slaking, creep, elastic rebound, or various combinations of these phenomena. A distinction between the various phenomena that cause ground deformation is difficult because of their interaction. It is therefore necessary to consider in detail the physical and chemical factors that promote the degradation of shales.

2. FACTORS THAT INFLUENCE THE DURABILITY OF SHALES

2.1 Mineralogy

Shales are composed mainly of particles finer than 0.06 mm corresponding to silt and clay size fractions. Clay minerals may comprise only a minor

proportion of a shale, intermixed with other common detrital minerals such as quartz and feldspar, however the clay mineralogy usually controls the engineering properties.

Because of the tendency for montmorillonites and vermiculites to undergo greater volume changes on wetting and drying than do kaolinites and hydrous micas, the relative abundance of these minerals can affect the bulk properties of shales. The chemical alteration of some minerals, by hydration, oxidation or carbonation, creates by-products that may occupy a larger volume than the original mineral. Such reactions, especially involving sulphides, may be caused by the addition of water.

The intensity of cementing, usually carbonate or authigenic quartz, will influence shale behaviour by resisting volume changes. However cementing is vulnerable to the effects of weathering, and cementing minerals may weather to form further clay minerals. The weathering of cement also increases the penetration of water, promoting general rock breakdown and the loss of grain to grain contact.

2.2 Pore Water

Pore water pressure measurements are difficult in shales because of the adsorptive forces of the clay platelets which produce negative internal pressures. When water is removed from shales, adsorptive pore pressures are developed. Chenevert (1970) performed tests on shales that showed that rock weakening by water adsorption is caused by a decrease in the effective confining stress of the rock. Conversely, the hardening effect obtained by drying out a shale is due to the net increase in effective confining stress.

A shale does not need to contain expansive clays to swell. The capillary tension in a shale is a function of the vapour pressure in equilibrium with capillary water. If the gas water vapour pressure is greater than the meniscus water vapour pressure, the water pocket will grow until equilibrium is reached and *vice versa*. Van Eeckhout (1976) reasoned that a liquid water phase, and hence capillary tensions, would not exist at vapour concentrations less than 35% relative humidity. As an example, if a shale that was fully saturated *in situ* is exposed to an atmosphere of less than 50% relative humidity, then saturated again, there are two possible responses. If the shale has very low porosity and permeability so that void openings are not created due to pressure instability, there will be contraction then expansion with no air allowed to enter. In shales where no air is able to enter, contraction exerts an overall confining pressure, hence strengthening the rock. If contraction and expansion occur with air allowed to enter, shale degradation will occur. This mechanism has been used to explain slaking (Taylor and Spears 1970). During dry periods, evaporation from the surfaces of rock fragments promotes high suctions, which in turn result in an increased shearing resistance of individual fragments by virtue of high contact pressures. With extreme desiccation, most of the voids will be filled with air, then on rapid immersion in water the voids become pressurized by the capillary pressures developed in the outer pores. Failure of the mineral skeleton along the weakest plane follows and an increased surface area is then exposed to a further sequence of events.

2.3 Electrolyte Concentration and Interparticle Force Fields

Ion concentration differences between the double layer water and the free water are considered to cause osmotic swelling (Einstein and Bischoff 1977). This type of swelling is distinguished from hydration swelling, where the polar water molecules are adsorbed at the exterior of the mineral and in an intracrystalline mode between the unit layers. Hydration swelling in constant

volume conditions produces pressures of several hundred MPa while osmotic swelling produces pressures of several MPa. However the distance at which water is affected is much greater in osmotic swelling and it is this kind of swelling that is of primary interest in engineering.

The electrolyte concentration during sedimentation affects the magnitude of swelling. A salt water enrironment during sedimentation leads to a relatively loose flocculated particle arrangement whereas a fresh water environment leads to a much denser arrangement. Hence swelling of clays that have been deposited in fresh water may be much stronger than similar clays deposited in salt water.

Van der Waals forces and intracrystalline electrostatic attractions tend to counteract hydration swelling, however Van der Waals forces and the effect of the negative electric field may favour osmotic swelling.

2.4 Fabric

Shales generally have an anisotropic fabric. Fabric anisotropy results in anisotropic permeability, strength and deformability. Chenevert (1970) found that the strain response of shales perpendicular to bedding was usually 3 to 4 times that found parallel to bedding. Fabric anisotropy may be caused by the effects of sedimentation, and in the case of a dispersed fabric, the orientation of clay minerals will cause fissility.

Lindner (1976) considered density was important in controlling the amount of swell *in situ*. Results from the testing of marls showed that an increase in density from 1.60 Tonne/m^3 to 1.90 Tonne/m^3 can result in an increase in maximum swell pressure from 0.6 MPa to 2.0 MPa.

2.5 Environmental Conditions

The amount of volume expansion, and the pressures developed in a shale, are dependent on the confining stress. Shales are either in a stable condition where only the reduction of *in situ* stresses leads to volume increases, or in a meta-stable condition where swelling is not completely counteracted by the present *in situ* stresses and only a lack of available water prevents swelling. High horizontal stresses are often found in shales. Lo and Morton (1976) measured K_o in the range of 10 to 40 for Ordovician shales in Toronto.

The availability of water affects the magnitude of swelling. During tunnelling, fracturing due to stress changes can increase the permeability of the rock mass. In many tunnels where significant swelling has occurred, the rock surface is often dry, indicating that the water is drawn away from the tunnel walls.

3. THE IDENTIFICATION OF SHALES WITH LOW DURABILITY

Prior to the construction of a tunnel in shale, it is necessary to establish whether ground deformations due to low durability shale are likely to occur. Conventional site investigation techniques (engineering geological mapping, core drilling) can provide data that may indicate likely behaviour. The rock type of formation name can serve as an initial guide - numerous published case histories report formations that have swelling or slaking problems. The clay mineralogy should also be determined. The slaking of natural exposures should be observed, also whether discontinuities in the shale have slickensided surfaces as are frequently found in swelling shales.

Core samples that are to be used in laboratory testing should be treated carefully. Moisture content changes must be prevented by sealing the sample as soon as it is removed from the core barrel. When a core is detached from the in situ rock by the drilling bit, stress release occurs. If the ratio of horizontal in situ stress to rock strength is low, cores may have numerous fresh fractures normal to the axis of the core. Conventional soil mechanics tests can be carried out on shales to determine strength and deformability. Special tests that have been devised to indicate the susceptibility of shales to slaking and swelling require further discussion.

3.1 Slaking Tests

Various laboratory slaking tests may be used to measure the response of a small shale sample to either an aqueous environment or a moisture laden air environment. Slaking tests are fundamental to many shale classifications (Morgenstern and Eigenbrod 1974, Chapman et al. 1976), and the particular test methods used will depend on which classification system is being used. All slaking tests expose the shale sample to one or more wetting cycles and the amount of material that disintegrates is then measured. Tests may vary as to whether the samples are air or oven dried, the number of cycles carried out, and the time required for each cycle.

Franklin and Chandra (1972) described a slake-durability test that reduces the time required for testing by combining the processes of slaking and sieving (to remove the material that disintegrates). A sample of oven-dried rock lumps is rotated for 10 minutes in a test drum made of standard sieve mesh, with the drum half immersed in a water bath at 20°C. During the test, the finer products of slaking pass through the mesh and into the water bath. The slake-durability index, I_d, is the percentage ratio of final to initial dry weights of the rock in the drum. Two cycles of slaking are normally carried out. This test has been standardised and appears to be the most widely accepted of the various slaking tests.

A rate of slaking test where a dried specimen is immersed in water for a 2 hour period is sometimes used (Morgenstern and Eigenbrod 1974).

3.2 Swelling Tests

Various testing techniques are used to assess the swell potential of a shale:

Free Swell Test - The specimen is oven dried, disaggregated and placed in a container. Water is added and the amount of volumetric expansion is recorded. In this test the original shale fabric is destroyed.

Modified Free Swell Test - An intact specimen is placed in water and allowed to swell. The swell is recorded as the change in volume of the system.

Unconfined Swell Test - The specimen is placed in a container with devices to measure displacements along one or more axes. Water is added and expansion is recorded.

Nominal Load Test - A specimen is inserted in a consolidometer, a nominal seating pressure is applied (generally 10 kPa) and water added. The volume change is recorded.

Calculated Pressure Test - The specimen is placed in a consolidometer and subjected to a calculated overburden pressure. Free access to water is permitted and the volumetric expansion is recorded. Modifications to this test include rebounding the specimen to the original void ratio.

Constant-Volume Test - The specimen is inserted in a consolidometer and a seating load is applied. Water is added, and pressure on the specimen is

increased such that the total volume change of the specimen is zero. The final pressure is taken as the swell pressure.

Double Oedometer Test - Two similar specimens are placed in separate consolidometers. One specimen is subjected to calculated overburden pressures and the deformation recorded. The other specimen is allowed free access to water, is permitted to swell and then is also subjected to overburden pressure. The difference in deformations or strain of the two specimens at the overburden pressure is considered the potential swell of the material.

Triaxial Test - A specimen is consolidated to the in situ stress, as evaluated by in situ stress measurements. The specimen is then allowed freee access to water and the swell is then recorded.

Huder-Amberg Oedometer Swell Test (Einstein and Bischoff 1977) - A specimen is placed in a consolidometer and subjected to a loading, unloading and reloading cycle in the axial direction and in a dry state. Water is then added to the system leading to a swell displacement. Reduction of the axial stress will give a swell curve.

The Modified Free Swell, Unconfined Swell, Nominal Load and Constant Volume tests do not represent in situ conditions, as confining pressure strongly influences the amount of swell that takes place. The Double-Oedometer and Calculated Pressure tests are more representative of field conditions, however in the consolidometer the horizontal stress is less than the vertical stress, which may not be true of in situ conditions. This stress field can only be reproduced using triaxial equipment. The load-reload cycle during the Huder-Amberg test serves to reduce the effect of stress relief during coring.

3.3 Atterberg Limits

The Atterberg Limits of a disaggregated shale have been widely used as an indicator of swell. Atterberg Limits have also been correlated with other parameters, but such relationships often show wide variations. Chapman et al. (1976) showed that the Atterberg Limits for a shale are a function of the energy input into sample preparation. Many of the shale characteristics that enhance durability (such as cementation, structure and fabric) are changed during remoulding. Atterberg Limits appear to have little relevance for materials that are not readily disaggregated, and results obtained from shales should only be used as simple indices; correlations with in situ behaviour should be used with caution.

4. MECHANISMS THAT CAUSE GROUND DEFORMATION IN TUNNELS

4.1 Elastic Rebound

As fine grained sedimentary materials are consolidated due to overburden pressures and tectonic stresses, they acquire a considerable amount of 'locked-in' strain energy. A substantial amount of this energy is lost in the dislocation and permanent deformation of mineral grains and cannot be recovered. However a change in environmental conditions, such as excavation, will allow a portion of the locked-in energy to be released, giving the elastic response of the rock. The magnitude of this deformation is a function of the rock elastic properties (compliances), the amount of unloading, and the original stress field.

The elastic response of shale can be affected by changes in humidity. This is important in coal mine roof shales. If moisture is removed, the shale will tend to contract due both to increased elasticity and natural

contraction as it dries. The combined effects may be sufficient to break the shale in tension.

4.2 Creep

Delayed intergranular stress-strain readjustments that continue to take place following excavation, cause time dependent displacements or creep. The post-excavation release of strain energy (or 'rock squeeze') may occur over a long period of time, the rate is dependent on rock composition, stress history, boundary and unloading conditions. By considering the long term effects of strain energy release and using finite element modelling, Lee and Lo (1976) were able to calculate the high compressive stresses found in tunnel linings in Ontario.

4.3 Slaking

Slaking is best prevented by covering the exposed shale, if only with a thin layer of shotcrete. In some situations, such as coal mine drives, this may not be practicable, and slaking may cause continual maintenance problems.

4.4 Swelling

Swelling of shales, if unchecked, is capable of causing significant tunnel deformations. In simple terms, the swelling of shales can be considered to be due to the interaction of water content increase and stress change. Stress changes lead to adsorption of water that causes a volume increase. The volume increase due to a change in stress and the volume increase due to water adsorption may occur simultaneously or sequentially. The inverse of this may also occur. A time dependent increase in volume due to water adsorption leads to stress changes with further volume increase. Swelling can then be affected by the application of counter-stresses or the control of water content increase. Einstein and Bischoff (1977) have developed an analysis-design procedure for tunnels in swelling shales involving the follow-int steps:

- determination of *in situ* stresses
- determination of swell zones based on stress changes caused by excavation
- laboratory swell tests
- calculation of swell displacements
- swell-time computations
- *in situ* measurements of tunnel deformation

The results of this analysis can then assist in the selection of design features and construction methods.

5. CONCLUSIONS

The problems associated with low durability shales are complex. Several physical and chemical factors may influence the behaviour of a shale under a given set of conditions. Although these factors are reasonably well understood, their interrelationship and relative importance in controlling shale durability is not so clear. There are no laboratory tests that can be used to directly predict the *in situ* durability of shale. The laboratory tests discussed do not distinguish any fundamental property of a particular shale. They are basically index tests that provide a means of characterizing shale behaviour and are therefore useful for making empirical predictions.

From the literature available, there appears to have been no development of

field techniques for measuring in situ behaviour of clay shales. Presumably pressuremeter systems could be used to measure swelling pressures in a drill hole.

At present the prediction of deformation following tunnel excavation can only be approximate. Further research into the behaviour of shales should provide a more exact assessment of shale behaviour under various loading and environmental conditions.

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BOOK REVIEW

M.J. Pender

"SEEPAGE, DRAINAGE and FLOWNETS"
H.R. Cedergren, 2nd edition, J. Wiley 1977

I must confess to having missed the first edition of this book. Examination of this new edition reveals that I had indeed missed something very worthwhile. According to the dust jacket Cedergren has had nearly 40 years' experience in dealing with the effect of water on earth structures both man-made and naturally occurring. The breadth of this experience shines through the 500 odd pages of the book.

Although the practical application of the material is never far away, the text presents all relevant theoretical material in a clear logical manner.

The book opens with a discussion of the basic concepts of seepage (it is emphasized that of all the soil properties engineers utilise permeability covers the greatest range - in excess of ten orders of magnitude), the measurement of permeability and the construction of flownets. This part of the book is followed by a much more extensive section dealing with applications. The chapter headings cover: Filter and Drain Construction (Filter Fabrics are discussed), Seepage Control in Earth Dams, Foundations, Slope Stabilisation and Drainage, Roads and Airfields, Structural Drainage.

NEWS FROM THE INTERNATIONAL TUNNELLING ASSOCIATION

J.C. Rutledge

The International Tunnelling Association held its third annual meeting in Stockhold on 4th and 6th September 1977. It gathered more than 100 participants (delegates and observers) representing 18 from 24 member-nations of the Association, 4 nations likely to join the Association in the near future and 6 International Associations.

MEMBER NATIONS REPRESENTED

South Africa, Federal Germany, Australia, Austria, Belgium, Canada, United States of America, Finland, France, Iceland, Italy, Japan, Norway, Netherlands, United Kingdom, Sweden, Switzerland, Turkey.

MEMBER NATIONS NON REPRESENTED

Algeria, Denmark, Spain, Greece, India, New Zealand.

OTHER NATIONS REPRESENTED

Brazil, Columbia, Czechoslovakia, Poland.

INTERNATIONAL ASSOCIATIONS

Permanent International Association of Road Congresses
International Society of Soil Mechanics and Foundation Engineering
International Railway Union
International Commission on Large Dams
International Society of Rock Mechanics
International Association of Engineering Geologists.

The Executive Council of the Association was changed due to the President's resignation. A.M. MUIR WOOD has been appointed to important functions in United Kingdom and he has been replaced by the senior vice-president H.C. FISCHER (Sweden). W. LUCKE (USA) became senior vice-president and Dr SHINOHARA (Japan) was elected as second vice-president.

The General Assembly applauded President MUIR WOOD, whose personality and perseverance allowed the Association to be created and had gathered 24 nations in 3 years of operation.

The ITA special session on TUNNELS IN SERVICE : effects of age, construction and maintenance on underground works, gathered more than 120 participants. As a matter of fact, many participants to Rockstore joined the ITA participants.

As tunnels and caverns are increasingly being used for a variety of purposes - not only subways, railways and roads, but also for power plants, water and sewage transport and treatment, telephone exchange stations, storage of oil or food, shopping centers, offices, swimming halls and many other purposes - it is natural that their safe and reliable functioning is becoming ever more important to owners as well as users, including the general public.

The session included a survey of special risks and of special safety factors underground - protection against rain and snowstorms, temperature variations, earthquake disturbances as well as explosions, sabotage and war. A probabilistic treatment of safety was advocated and it was concluded that if available technologies and procedures for pre-investigation, design construction and maintenance are used, the underground alternative is safer than the corresponding installation on the surface, especially when indirect advantages are also considered. This standpoint was supported by decades of experience of tunnels and caverns in rock in Sweden.

Mr PERA from France gave a survey of methods for continuous monitoring of the conditions of tunnels, and presented experience of ageing of unlined as well as lined tunnels in various countries, including drainage of the surrounding ground.

Experience from more than 100 year old tunnels in clay were reported by Mr REED who showed examples of damage to the 1,000 km of tunnels for water mains and the 11,000 km of tunnels for sewers in the London area. He also presented the systematic procedures that have been developed for inspection, maintenance, reconstruction and renewal of these tunnels.

Safety could be improved and the need for maintenance reduced at the stage of design, as was pointed out by Professor DUDDECK from West Germany. After pointing out the important differences between design of tunnels and design of surface constructions such as bridges, he outlined the relevant steps in tunnel design including studies of the ground properties and interaction of ground and tunnel lining under various loads.

The presentations and the following discussion caused ITA to decide to continue the study of these questions by preparing future formation of one or two working groups for Safety in Service and Design for Safety. The preparations should include contacts with other international organizations who may be active in these problems.

The WORKING GROUPS of the Association held their meetings :

STANDARDIZATION (Mr J.N. PLICHON - FRANCE)

The Group set up a classification system based on a key-words list. It hopes to apply this system in the next months, in order it can be already used at Tokyo Symposium.

Regarding standardization itself, the situation is not completely clear, so further information is necessary and will be obtained through questionnaires sent to the different countries. These questionnaires concern the state of art of standaridization, the needs for circular tunnels and the methods to be applied.

A third task concerns terminology, its study being desired by a great number of participants. The first work will be the examination of what is already existing in the various member-nations.

RESEARCH (Professor G. GIRNAU - FEDERAL GERMANY)

The working group "Research" prepared a preliminary draft of a report on research works completed and in progress in 22 member-nations. Beside that a priority list for future research tasks was set up and discussed. The final report on these subjects will be completed by the end of 1977 and published in early 1978.

USE OF SUBSURFACE PLANNING (Mr B. JANSSON - SWEDEN)

The group concentrated on two items :

1. Human reactions in underground space. The Swedish report will be distributed for consideration among the countries.

2. Planning guidelines : compilation of factors which have led to choice of underground construction; a guidance may be derived from that.

The group is preparing to make a presentation in Tokyo.

The group thinks that ITA should take upon itself to work out a classification system for information on underground human occupancy.

CONTRACTUAL SHARING OF RISKS (Mr J.K. LEMLEY - USA)

There is substantial activity on the problem of contractual risk sharing in several countries. Reports from members participating included the disturbing news of a trend of increased assignment of risks by owner to contractor in the past two years. The endorsement of the following principles could be considered as good practice :

1. full disclosure of geotechnical data during prebid period
2. removal of disclaimer clauses from contracts
3. inclusion in contracts of clauses to allow accommodation of changed conditions
4. the prequalification of contractors performing underground construction.

SAFETY (Mr WAGNER, successor of Mr A.A.T. WILSON - SOUTH AFRICA)

The working group is preparing an index of relevant safety standards and codes so as to provide the basis for a comparison of existing safety codes on an international level. The working group reached consensus on the basic principles of an international system of standard colour coding and graphic safety signs for use in tunnelling.

The 4th General Assembly of the I.T.A. was held in Tokyo from 29 May to 2 June 1978, in conjunction with "Tunnel Symposium '78" on tunnelling under difficult ground conditions. The New Zealand delegates were Mr R.L. PRESTON and Mr A.T. HINKLEY, both of M.W.D.

FROM THE ROCK MECHANICS VICE PRESIDENT

1. FORTHCOMING EVENTS

4-8 September 1978, Madrid. 3rd Congress of the International Association of Engineering Geology.

13-15 September 1978, Sydney. 3rd Australian Tunnelling Conference.

18-22 September 1978, Granada. International Symposium on Water in Mining and Underground Works.

27-29 September 1978, Rio de Janeiro. International Society for Rock Mechnics Symposium on Rock Mechanics Problems Related to Dam Foundations.

16-19 October 1978, Sydney. Symposium on Soil Reinforcing and Stabilising Techniques in Engineering Practice.

22-26 January 1979, Auckland. Symposium on Geological Hazards (ANZAAS Conference).

12-16 March 1979, London. Tunnelling 79.

2-6 April 1979, Aachen. 3rd International Conference on Numerical Methods in Geomechanics.

18-21 June 1979, Atlanta. 4th Rapid Excavation and Tunnelling Conference.

July 1979, Singapore. 6th Asian Regional Conference on Soil Mechanics and Foundation Engineering.

September 1979, Montreux. 4th International Congress on Rock Mechanics.

September 1979, Brighton. 7th European Conference on Soil Mechanics and Foundation Engineering.

May 1980, Wellington. 3rd Australia-New Zealand Conference on Geomechanics.

1981 Tokyo. International Symposium on Weak Rock.

2. RECENT PUBLICATIONS

"Design Methods in Rock Mechanics" Proc. of the 16th Rock Mechanics Symposium, University of Minnesota 1975 edited by C. Fairhust and S.L. Crouch (cf. ISRM News July/Sept. 1977 p.10-11).

"Rock Slope Engineering" Hock, E. and Bray, J. 2nd edition 1977, Inst. of Mining and Metallurgy. (cf ISRM News July/Sept. 1977 p.11-12).

"Field Measurements in Rock Mechanics" Proc. of Int. Symposium, Zurich 1977 edited by K. Kovari. (cf ISRM News July/Sept. 1977 p.12-13).

"Proceedings of the First Conference on Acoustic Emission/Microseismic Activity in Geologic Structures and Materials" 1975 edited by H.R. Hardy and F.W. Leighton. (cf 14-15 ISRM News Oc./Dec. 1977).

"Anchoring in Rock" P.L. Hobst and J. Zajic, Vol. 13 Developments in Geotechnical Engineering, Elsevier. (cf p.15 ISRM News Oct./Dec. 1977).

LETTERS TO THE EDITOR

The following correspondence has been received by the Editor:

Sir,

I would like to obtain a copy of the following text which is now out of print:

"Fundamentals of Soil Mechanics" by D.W. Taylor

It was originally published in 1948 by J. Wiley and re-issued as a paper back in the mid-60's. I should be very pleased to hear from anyone interested in selling a copy second hand.

Yours faithfully,

M.J. Pender

Sir,

I am writing to comment on the article 'Landslip Insurance and Statements by Registered Engineers' (N.Z. Geomechanics News, No. 15) and the subsequent discussion on the subject recently held by the Society in Auckland.

Firstly I question the need for such formality in the way statements are prepared. To my mind this type of requirement will remove the responsibility from the Local Body Engineer to make sure fully comprehensive studies are completed on the proposed development. As the person dealing every day with problems in such development, the engineer is the person most able to assess what studies are necessary to show that the proposed development can take place or is being constructed in a satisfactory manner. I do not believe the proposed format will ensure that better investigations into land stability will be done.

Secondly the proposed formats require opinions from 'Registered Engineers'. This excludes scientists of whom there are a number in this country with considerable experience in the field of soil mechanics and slope stability. These statements exclude the use of these specialists even when their expertise is more applicable to a problem than that available from engineers.

Whereas format 2 (Engineers' opinion after works for residential subdivision) requires the use of engineering expertise and therefore can only be provided by an engineer, the other two formats (format 1 and format 3) are for opinions on land stability and thus, in many cases could well be provided by geotechnical experts other than engineers. I suggest that this is a move not in the best interests of providing better stability in subdivisions.

Yours faithfully,

S.J. Carryer

SEMINAR ON SLOPE STABILITY AND URBAN DEVELOPMENT

CHRISTCHURCH - FEBRUARY 1978

D.H. Bell

On 24 and 25 February this year a seminar on "Slope Stability and Urban Development" was held at the University of Canterbury, Ilam. Organised by the Department of Extension Studies at the University (with the active assistance of the recently formed Christchurch Group of the Geomechanics Society), this seminar was concerned ostensibly with loess stability problems on Banks Peninsula, although wider questions such as legal liability, local body administration and existing legislation were discussed. About 80 people attended, mostly from the Christchurch area but with a significant contribution from other parts of New Zealand. The seminar itself was aimed at local body professional staff, consulting engineers, surveyors and town planners.

The first day was devoted to a series of papers covering the following topics:-

1. Geological and geotechnical characteristics of loess, with particular reference to Banks Peninsula.
2. A brief history of urban development on the Port Hills and some case histories of slope failure in loess.
3. The legal aspects of slope failure: Appropriate regulatory powers and functions.
4. Mapping for urban land use zoning (I. Soil mapping and classification. II. Relative soil stability mapping).
5. Water movement, drainage, and appropriate construction techniques in loess.

Contributing speakers were:-

D.H. BELL	Geology Department, University of Canterbury
R.D. DICK	North Canterbury Catchment Board, Christchurch
T.A.H. DODD	Civil Engineering Department, University of Canterbury
G.L. EVANS	Consulting Engineer, Christchurch
M. HALLBERG	(representing J.L. GILL) Earthquake and War Damage Commission, Wellington
J.K. HILL	Geology Department, University of Canterbury
R.D. NORTHEY	N.Z. Soil Bureau, Lower Hutt
I.F. OWENS	Geography Department, University of Canterbury
D.M. PALMER	Barrister and Solicitor, Christchurch
B.B. TRANGMAR	N.Z. Soil Bureau, Lincoln

The second morning of the seminar was devoted to a field trip, which allowed inspection of housing developments, slope failures and loess instability problems in the Christchurch area. In the afternoon a panel discussion was held on "Practical Problems and Responsibilities - Existing and Proposed Legislation", with panel members from local body professional staff. The seminar concluded with a general discussion led by M. Douglass, Consulting Town Planner, and J.G. Hawley, Water and Soil Division, Ministry of Works and Development.

From an organisational viewpoint the seminar was an undoubted success, and

the wide-ranging discussions generated both by papers and by panel sessions suggested that most participants benefited from the two-day meeting. As with many such seminars and symposia, probably the greatest benefit was derived from personal contacts between the various professions represented. The technical papers presented highlighted the "state of the art" with regard to loess stability and construction problems, and areas for future research were clearly indicated. However, a very real gap emerged between the scientific and technological understanding of loess instability, and the highly practical problems faced by local body engineers in routine administration of existing legislation. It is this communication "barrier" which requires removal if geomechanics is to be any more than a specialist field.

A number of other points of interest emerged from the discussions. One of these was the suggestion by D.M. Palmer, in his stimulating paper entitled "Evolving Law and the Eroding Hills", that interpretation of the laws of negligence was changing rapidly, with the courts finding increasingly against the "negligent" adviser (and with the added benefit of hindsight). Another recurrent suggestion was that the powers of the Earthquake and War Damage Commission be widened to include prevention of landslip, although there was some dispute as to the practical implementation of such a policy. Discussion from all sessions has in fact been recorded, and the N.Z. Geomechanics Society is considering publication of a single volume comprising papers and discussion. Interest in such a volume from persons beyond the immediate Christchurch area would be a most useful stimulus to its preparation, and comments and suggestions are certainly invited.

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 _____

_____

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.)

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 ___

N.B. Affiliation fees are in addition to the Geomechanics Society membership fee of $6.00.

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,
N.Z. Institution of Engineers,
P.O. Box 12-241,
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 _____