N.Z. GEOMECHANICS NEWS

No. 21

NOVEMBER 1980

A NEWSLETTER OF THE N.Z. GEOMECHANICS SOCIETY

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CONTENTS

THIS IS A RESTRICTED PUBLICATION

"N.Z. Geomechanics News" is a newsletter issued to members of the N.Z. Geomechanics Society. It is designed to keep members in touch with recent developments. Authors must be consulted before papers are cited in other publications.

Persons interested in applying for membership of the Society are invited to complete the application form at the back of this newsletter. The basic annual subscription rate is $10.00 and is supplemented according to which of the International Societies, namely Soil Mechanics ($4.50), Rock Mechanics ($7.00), or Engineering Geology ($3.00) the member wishes to be affiliated. Members of the Society are required to affiliate to at least one International Society.

EDITOR'S NOTES

1. Newsletter from Hong Kong

Mr J.C. Rutledge, an active member of the Geomechanics Society while he was in Wellington, is presently working with the Geotechnical Control Office of the Public Works Department in Hong Kong. This issue contains "A Newsletter from Hong Kong" written by Mr Rutledge. The article gives an interesting insight into the geotechnical work that is carried out in Hong Kong.

2. Letters to the Editor

One of the functions of Geomechanics News is to give members the opportunity to convey their opinions on current points of interest in Geomechanics, - a recent example being TELARC. As the newsletter is printed only twice a year it can take over a year for replies to be printed. With the aim of stimulating more active commentary on topical points, replies to specific letters will be encouraged to be printed in the same edition. Clearly the success of such a procedure depends on the early receipt of letters and members' cooperation in this would be greatly appreciated.

3. Australian Geomechanics News

The Australian Geomechanics Journal has now ceased to exist. The Australian Geomechanics Society is currently proposing to print an Australian Geomechanics News as its medium of disseminating information to the Australian Geomechanics community. The publication would appear twice a year and the first issue is scheduled for November 1980. People who are interested in making a contribution to that newsletter to give it a bit of kiwi flavour, please contact the Editor of N.Z. Geomechanics News for further details.

4. Draft Method of Soil Description for Engineering Use

As indicated in Volume 20 (June 1980) a draft method of soil description for engineering use is attached to this issue. The comments by members are vital to the preparation of a soil description method which is generally acceptable for New Zealand conditions. Comments will be accepted by the Management Secretary until June 30 1981, and will then be reviewed by a committee selected for that purpose.

5. 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.

6. 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.

7. 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.

MISSING MEMBERS

The Secretary of N.Z.I.E. does not have a current address for the following people:

P.J. Thompson   J.J. Chapman

Would members of the Society who know these people please inform them that they have been taken off the mailing list until such time that their present address is received.

PUBLICATIONS OF THE SOCIETY

The following publications of the Society are available:

(a) From the Secretary, N.Z.I.E., P.O. Box 12-241, Wellington North:

- Proceedings of the Third Australia-New Zealand Conference on Geomechanics, Wellington, May 1980. (These will be available when the Third Volume is printed by the end of 1980. Cost $90 for the three volume set.)

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

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

- Proceedings of the Wanganui Symposium "Using Geomechanics in Foundation Engineering", September 1972. Cost $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. A limited reprinting is 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 cost of $2.00 per copy.

Proceedings of the Nelson Symposium "Stability of Slopes in Natural Ground", November 1974 has been sold out. This will be reprinted according to demand. Please order through the Secretary, N.Z.I.E.

(b) From Government Bookshops:

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

T.J. Kayes
Publications Officer

BOOKLET

"Stability of House Sites and Foundations"

Enclosed with this edition of Geomechanics News all Society members will receive a copy of the third edition of a booklet which was prepared by Society members in Auckland some years ago. The two previous editions were sold out through distribution from the Auckland Building Centre. Some 21,000 copies of the current booklet have been sent to all Local Bodies in New Zealand; the following is a transcript of the circular which accompanies them.

Stability of House Sites and Foundations

The Earthquake and War Damage Commission is funding the publication of a small booklet entitled "Stability of House Sites and Foundations - "Advice to prospective house and section owners" which, it is hoped, will be distributed as widely as possible to people needing advice in simple non-technical terms.

The booklet is directed principally at private owners, or prospective owners, of building lots and it may be of some use to building inspectors, and to those architects and engineers who have no specialised knowledge of the topic.

It was written and now has been revised in this, its third edition, by The New Zealand Geomechanics Society which is a technical group of the New Zealand Institution of Engineers. The final chapter in this edition, dealing with small scale site filling, has been added at the instigation of a subcommittee of The New Zealand Standards Association.

The Commission is concerned that so many of the slips brought to its attention, while triggered off in unusually wet weather, have their root cause in ignorant or ill-advised actions of property owners. The booklet is intended to help property-owners to avoid much expensive and distressing damage.

This printing of the booklet will be sent to you free of charge in the hope that you will display it and make it available on your public counters.

While no accounting is required to be made to the Commission, a charge of 50¢ per copy should be made to the public, so that they will attach some value to it and not simply waste copies of it; money received could be held for subsequent orders should you require them.

This delivery to you is the total available for you in this free printing.

If there proves to be a continuing demand for the booklet then there may have to be a charge to you for subsequent printings. When your stocks of the booklet are running low, an indication of your requirements of further copies for further printings should be sent to:

The Secretary,	or	The Secretary,
N.Z. Counties Association,		The Municipal Association of NZ (Inc),
P.O. Box 5034,		P.O. Box 1214,
WELLINGTON		WELLINGTON

When a sufficient demand is so indicated then costs will be investigated and communicated to you before you make a firm order.

Geomechanics Society members knowing people who need the advice offered in the booklet should direct them to the public counter of their local authority.

The Society holds the copyright to the booklet.

D.K. Taylor

A NEWSLETTER FROM HONG KONG

J.C. Rutledge

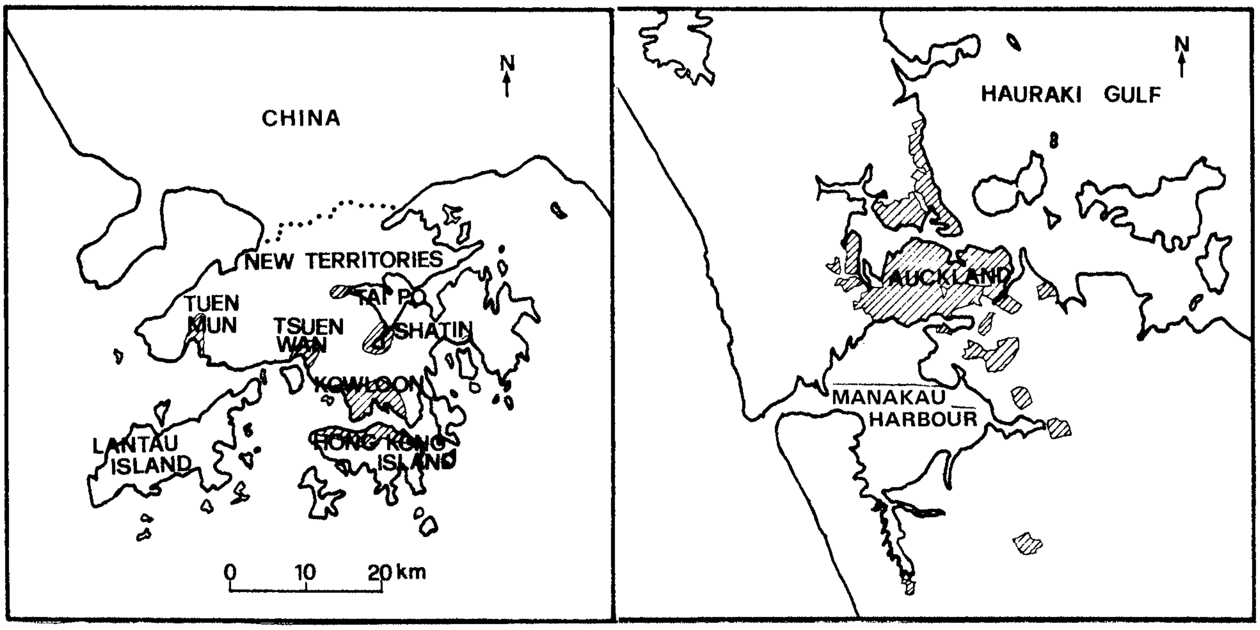
Introduction

Hong Kong, with its rugged weathered topography, an area of 1,061 square kilometers and a still rapidly expanding population of 5 million people, presents many interesting and challenging geotechnical problems.

In recent years the main civil engineering projects involving geotechnical work have been the development of building sites by excavation and reclamation, particularly in the New Territories; the provision of communication links such as roading, railways and the mass transit railway, which amongst other things include extensive tunnelling; and thirdly, the water supply projects involving large dams and tunnelling.

Settlement

Since its earliest years, Hong Kong has been beset by a lack of suitable building land largely due to its rugged topography. A map of Hong Kong, with Auckland at the same scale, is given at the foot of the page. The original settlements along the north side of Hong Kong Island soon expanded up the easier slopes and ridges of the surrounding hills, and then to land reclaimed from the shallower areas of sea. On the Island the topography rises to heights of more than 480 m with steep slopes exceeding 30^o. Many roads have substantial portions constructed in cuttings with slopes up to 75^o, or on part cut part fill slopes with fill slopes of 30^o - 35^o. The northern side of Hong Kong Island is heavily developed with many small sites which have high 45^o to 75^o back slopes. For the dense development in Kowloon new land has been created by cutting into borrow areas on hills, the spoil being used for extensive reclamation in the sea. Only a few isolated hills with heights up to 100 m now remain but along the north boundary of the urban development the Kowloon foothills rise to over 480 m. Major roads along the northern boundary and extensive industrial housing developments



TERRITORY OF HONG KONG AND AUCKLAND NZ AT SAME SCALE cuttings, large scale platforming and substantial fill embankments. The New Territories, although largely steep hilly country, contain limited areas of flat land around the older settlements which remain agricultural. Development in the New Territories was largely hindered by the Kowloon foothills which provided a physical barrier to easy road access, and also by a lack of public utility services. Thus, although Hong Kong Island and Kowloon contain some of the world's highest population densities, 80% of Hong Kong's 1061 square kilometers is rural.

Geology

The territory of Hong Kong is underlain by two major rock types: extrusive igneous rocks consisting of rhyolitic lavas and pyroclastic rocks commonly referred to as the volcanics, and intrusive igneous rocks consisting of granites, granodiorites and minor dolerite dykes, commonly referred to as the granites.

The volcanic rocks have a fine to coarse grained crystal texture and are generally closely jointed, joint spacing being of the order of 150 mm. More widely spaced jointing is found, however, in the coarser grained varieties. On weathering, the volcanic rocks decompose to a residual soil to vertical depths rarely exceeing 15 m. The transition from the residual soil mantle to rock is frequently sharp and well defined. The rock near the interface is often moderately permeable whereas both the overlying residual soil and underlying fresh rock have lower permeabilities.

The granitic rocks have a coarse grained crystal texture except at the contact with volcanic rocks where the texture is finer grained. Typically the rocks are coarsely jointed with joint spacing of the order of 1 to 1.5 m. Decomposition to residual soil may be found to vertical depths of about 30 m although 20 to 25 m is more typical. Core boulders occur frequently in the residual soil mantle whereas this is rarely the case in the residual soil which develops on the volcanic rocks.

Sheeting joints, which result from stress relief associated with the erosion of valleys and cliffs and are generally parallel to the surface of the rock, are a common feature in the granitic rocks when they are exposed at the surface and may also be found in the more massively jointed volcanic rocks. In many places the appearance of rock faces suggests that slabs of rock have failed along sheeting joints giving rise to the boulder strewn areas at the foot of the cliffs.

Relict joints can still be seen within the weathered mantle of soil, and in some instances original material such as kaolin, talc, chlorite or other minerals may be found coating the joint surface. Such relict joints may form weaknesses within the otherwise homogeneous soil.

In some areas there has been considerable mass movement in the form of colluvial debris from old slips and lower slopes of hills are commonly blanketed by colluvial fans.

Rainfall and Slope Instability

The rainfall in Hong Kong in the wet season, which lasts from May to October, averages about 2000 mm and most of that rain occurs during very heavy rainstorms lasting several days.

Records show that landslides in man-made and natural slopes, boulder falls and retaining wall collapses have been a problem in Hong Kong since the early days of the Territory, and that such failures are strongly correlated with periods of heavy rainfall. For example, in a severe rainstrorm in June 1966, when over 500 mm of rain fell during an 18 hour period, more than 500 landslips and washouts occurred. The failures result from the unusual combination of intense development, geology, topography and rainfall pattern. There is evidence that slips are more common in volcanic and colluvial soil areas than in granite soil areas. The consequences of failure are often not serious but there have been some major landslides which have resulted in many deaths and extensive property damage.

In 1925, 73 people were killed on the northern side of Hong Kong Island in an area called the Mid Levels when a group of three retaining walls situated one above another failed, destroying five three-storeyed houses. Failure occurred along a sheared surface between colluvium and the underlying residual soil.

In June 1972, after six weeks of continually wet weather culminating in three days in which each day received more than 200 mm of rain, there was a massive failure in a colluvium slope in the Po Shan area of the Mid Levels. Approximately 50,000 cubic yards of saturated colluvium, core stones and decomposed volcanics completely demolished a 12-storey occupied apartment block killing 55 people, all in a matter of approximately 5 minutes. During the same rainstorm there were 185 slips with a total of 138 deaths. Of the other slips several were located at Sau Mau Ping where high fill slopes liquified and flowed into occupied low cost housing blocks. Similar failures at Sau Mau Ping occurred in 1976, the death tolls being 71 and 18 respectively.

Geotechnical Control Office

Largely because of these disasters a Geotechnical Control Office was established within the Hong Kong Public Works Department. The Geotechnical Control Office (G.C.O.) is concerned with a wide range of geotechnical activities with particular emphasis on the stability of slopes and on the geotechnical aspects of slope related projects. It has an establishment of 83 geotechnical engineers and geologists and 50 technicians. It checks the designs of slopes for public and private developments, is responsible for investigating the stability of all existing slopes and retaining structures of both natural and man-made origin and, where appropriate, arranges for the design of remedial and preventive works. Because more than 10,000 distinct slopes and retaining walls have been catalogued and classified a lengthy programme of investigation lies ahead. Priority has been given to unsatisfactorily compacted fill slopes in order to ensure that disasters such as Sau Mau Ping do not occur again.

The G.C.O. carries out site investigations for all government projects and runs the Public Works Department Laboratories. Also within the G.C.O. there is an engineering geology and aerial photographic unit which as part of its role is carrying out a terrain evaluation of the whole territory and preparing geotechnical land use maps for selected areas.

In general, slope failures in Hong Kong are shallow and occur rapidly as a result of infiltration from heavy rainfall and not from a rising groundwater table. Many long standing cut slopes in Hong Kong, when analysed by conventional means using effective stress parameters, have factors of safety of less than one. In general we still have much to learn about the shear strength behaviour of unsaturated soils in the low stress range, the separate roles of pore water pressures and soil suction, and how they change with infiltration from rainfall. Conventional methods of slope stability analysis are not properly related to the actual failure mechanisms that occur. Long term programmes to study the shear strength behaviour of the residual Hong Kong soils and to measure *in situ* soil suctions are important additional activities in the Geotechnical Control Office.

These comments are also relevant to many of the slope stability problems experienced in deeply weathered rocks and residual soils in New Zealand. Much of the shear strength testing that has been carried out in such materials in the past is probably not appropriate to the problem to be solved and in fact provides misleading information.

Mass Transit Railway

The construction of Hong Kong's Mass Transit Railway (M.T.R.) has been and continues to be a major geotechnical task. After 10 years of investigation, design and construction, a mass transit railway is now operational. The first stage of the system, which is now in use, links major urban centres in Kowloon with Hong Kong Island and cost NZ$1,200 million. An extension of the system to Tsuen Wah is now being built and will cost NZ$850 million. The construction of the railway is not only Hong Kong's largest-ever engineering project, it is very large by world standards.

The go ahead for the first stage, which is 15.6 kilometers long, was given in mid 1975 and trains were operating over the entire length by February 1980. The job was completed ahead of schedule and under budget, surely a record for a mass transit system. It was divided into 25 major civil engineering contracts and 10 electrical and mechanical contracts; tenders then being invited on a multi-contract basis. Although a design solution for the system was provided by the Mass Transit Railway Corporation's lead consultants, with the corporation itself responsible for supervising construction of the project, each tenderer was free to submit his own designs, subject to specifications. Because of the varied geological conditions and the fact that the civil engineering expertise came from many countries, nearly every form of construction was used.

The first stage of M.T.R. has 15 stations of which 12 are underground and three are elevated. The cut and cover stations are very large, being 30 metres underground, about 230 metres wide, with a maximum length of 380 metres. The crowded urban situation and diverse geological conditions of heavily decomposed granite, sold rock and reclaimed land called for a wide range of tunnelling and cut and cover techniques. In many cases compressed air was used.

The second stage of M.T.R., the Tsuen Wan extension which is due for completion in 1982, is 10.5 kilometers long and will have a further ten stations, one at ground level, six underground and three overhead. About half of the Tsuen Wan extension is being constructed in similar ground conditions to the first stage while the rest is through rock.

The Hong Kong Government is at present considering a third stage to the M.T.R. This is called the Island line and it would run east-west on the northern shore of Hong Kong Island.

Development of Shatin, Tuen Mun and Tsuen Wan

Another major geotechnical task has been the construction of new cities in the New Territories. The then new Governor of Hong Kong said in 1972 "If environmental standards are to improve, the bulk of new housing must be provided in the new towns in the New Territories ... For such a programme to succeed and to be acceptable to the potential inhabitants, three things seem to me essential. First, good communications with the old urban area ... Secondly, the housing in the new towns must be accompanied by a full ration of what is essential to modern life : medical, and secondary as well as primary educational facilities, parks and playgrounds, police stations, markets, fire and ambulance stations, community centres and much else. Thirdly, there must be work, and so sites for private commercial and residential development. These towns in fact must be built as a whole." The three major new cities are at Shatin, Tuen Mun and Tsuen Wan. The Government's decision to develop new cities in the New Territories was the first real planned attempt to breach the physical barrier of the Kowloon foothills. The aim is to provide new cities to accommodate 1.8 million people by the mid 1980's. The infrastructure of roading, water supply, sewerage and stormwater drainage is being built in about five years. The difficult topography means that the land for new cities has had to be formed by massive borrow areas in the hillsides, the fill being dumped in the sea to form large areas of reclamation. For example, at Tuen Mun there has been 240 hectares of reclamation and at Shatin 350 hectares. Since Hong Kong was founded in 1841 over 1850 hectares of land have been won from the sea. There are many geotechnical problems to be solved in the borrow areas and the economic pressures to quickly start multi-storey building construction on new deep reclamation present interesting and difficult foundation and settlement problems.

Other Geotechnical Developments

The list of major geotechnical projects is long. Besides the M.T.R. there are two other major tunnelling jobs : one is a twin two lane road tunnel from the north to south side of Hong Kong Island and the other a major new tunnel on the railway line to China. Future major geotechnical projects which may start soon include the development of the north side of Lantau Island. This would include a new offshore international airport replacing the existing Kai Tak Airport in Kowloon.

The rapid growth in geotechnical work has meant that an increasing number of geotechnical engineers and geologists have come to work in Hong Kong. A Geotechnical Group started this year within the H.K. Institution of Engineers and has a membership of 362. Attendance at meetings varies between 150 and 200. It is estimated that the total number of professionals working in the geotechnical field in Hong Kong is approximately 500 excluding contracting staff.

Concluding Remarks

There is no doubt that at the present time Hong Kong is a challenging and interesting place for a geotechnical engineer to work in. The total volume of civil engineering work, when compared with the population, must be amongst the highest in the world. Hong Kong's standard of living, housing and communication standards are improving rapidly and the Territory is a financial, manufacturing and communication centre for Asia. Its population is industrious and well-educated. Such a place attracts capital and individual projects are big. Finance is being made available for projects to go ahead after investigations are complete and the deadlines that have to be achieved are tight. However, the present boom has created strong inflationary pressures in the building area where at present there is over-employment. From July 1978 to June 1979 there was an increase of 38% in the construction cost index.

The favourable economic growth in Hong Kong and the large number of projects at present underway and being planned means that the future outlook for civil and geotechnical engineering in Hong Kong is very bright.

Note: This newsletter does not describe in any detail the geology or slope stability problems of Hong Kong. For those who would like to read further on the subject, the following brief bibliography may be of interest. Lumb (1975) is a very good introduction to the problems. Ruxton (1960) provides a geological viewpoint to slope stability. In the more general context Deere & Patton (1971) provide a 'state of the art' on slope stability in residual soils and De Mello (172) discussed geomechanics in residual soils.

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LETTERS TO THE EDITOR

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

Sir,

NZS 4402, TELARC and GEOMECHANICS

I am pleased that my coat trailing letter which you so kindly printed in your November 1979 issue has provoked John Wydenbach to reply. He has given a far better exposition of the merits of the TELARC system than I could ever hope to do. It should now be clear to all your readers that it is indeed an excellent tool, suitable for use in geomechanics.

What remains to be done is to educate people to the fact that geomechanics, like other technologies, is not merely an array of tools wielded blindly or arbitrarily. The wise selection, application and even adaptation of the available tools to the job in hand is what matters. A scalpel is useful in surgery, a paving breaker in road works. Before they reach for the TELARC scalpel, people must look to see whether it is road works that they are about.

Yours faithfully,
J.H.H. Galloway.

Sir,

The colloquism 'papa' is used widely when referring to soft sedimentary Tertiary rocks of the North Island. The term is used, even in some geotechnical circles, to describe rocks ranging from older weathered Waitemata Group around Auckland to the younger sediments of the Wanganui Series in the south. Hence ideas on excavation, construction and slope performance vary from district to district depending on the various local lithologies involved.

Attempts to clarify and standardise the usage of this term should be encouraged and actively publicised by the Geomechanics Society. Comments from society members on the origin of 'papa' and their thoughts on restricting or replacing the term would be of particular interest.

Similar problems have occurred with the use and misuse of geological terms such as greywacke, argillite, etc. Discussion and debate, encouraged by the Geological Society of New Zealand, has resolved these issues and perhaps the Geomechanics Society could foster a similar response to the use of the term 'papa'.

Yours faithfully,
G.W. Borrie

[Gage (1980, Legends in the Rocks - An Outline of New Zealand Geology) states that "Tertiary marine ... blue-grey sandstones and siltstones" are commonly known as "papa". Thus defined, the term thus has a relatively specific, if informed and colloquial geological meaning. Since "papa" can include a range of lithologies, clearly it is advisable in geomechanics to make accurate lithological descriptions. Editor]

FORTHCOMING SOCIETY CONFERENCE ACTIVITIES

(a) Geomechanics in Urban Planning

The symposium which is organised jointly by the N.Z. Geomechanics Society and the N.Z. Planning Institute will be held in Palmerston North from 29 April - 1 May 1981.

The purpose of this symposium is to examine how the geotechnical characteristics of different areas of land may be taken into consideration in the urban planning process.

The programme will include:

1. A paper on what the hazards are (landslip, settlement, soil dispersion, soil shrinkage, flooding, coastal/riverbank erosion, active faulting, seismic and volcanic activities, etc.)

2. Consideration of what field/laboratory/analytical work it is reasonable to expect shall be done (in view of costs) at each stage of urbanisation - from regional scheme preparation to the issuing of building permits.

3. Consideration of where the different hazards are likely to occur and what should, and should not, be done in order that they may be overcome rather than exacerbated.

4. A review of some known problem situations.

5. Consideration of what local authorities (and other parties) have done, and could do.

6. A paper and discussion on the Abbotsford report.

7. A guided field trip around the Manawatu Urban Growth Strategy study area.

Although the programme will include one session on Abbotsford, the symposium will be concerned with the common situations rather than the exceptional.

Persons interested in receiving Bulletin No. 1 should write to:

The Organiser
"Geomechanics in Urban Planning"
C/- Aokautere Science Centre
Ministry of Works and Development
Private Bag
PALMERSTON NORTH

J.G. Hawley

(b) 1981 N.Z.I.E. Conference

The Conference is to be held at the School of Engineering, University of Auckland from 9 to 12 February 1981. The Society's involvement will be with two technical sessions on the afternoon of Wednesday, 11 February.

The first session will contain two papers:

"House Foundation Failures due to Clay Shrinkage
Caused by Gum Trees"
by Michael A. Wesseldine

"Geotechnical Investigations of Claverley-Oaro
Section of South Island Main North Line"
by David H. Bell and Paddy J. Luxford

The second session will consist of a paper:

"Pressuremeter Tests" by Peter R. Goldsmith

This paper will be supplemented by a display of pressuremeter equipment and comments will be made by people who have used the various types of pressuremeters.

Whereas the second session may be of special interest to geotechnical designers and also those involved with in situ testing and investigation techniques, the first session may be of more general interest to a wide number of conference registrants.

The Annual General Meeting of the Society will take place at the conclusion of the Geomechanics sessions.

A.J. Olsen

FORTHCOMING CONFERENCES

1 - 5 December 1980	International Symposium on Problems and Practice of Dam Engineering. Bangkok, Thailand.
26 - 30 January 1981	International Symposium on Erosion and Sediment Transport in Pacific - Rim Steeplands. Christchurch, New Zealand.
16 - 18 March 1981	4th Australian Tunnelling Conference. Melbourne, Australia.
26 April - 2 May 1981	Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics. St Louis, U.S.A.
3 - 7 May 1981	TEAM Productivity. RETC forum on new developments in Tunnelling, Excavation and Mining. San Francisco, U.S.A.
11 - 15 May 1981	Cost Cutting Research in Tunnelling. Nice, France.
1 - 3 June 1981	Third International Conference on Stability in Surface Mining. Vancouver, Canada.
11 - 12 June 1981	Norwegian Geotechnical Institute Open House. Oslo, Norway.
15 - 19 June 1981	10th International Conference of the International Society for Soil Mechanics and Foundation Engineering.
8 - 10 July 1981	Environmental Engineering Conference 1981. Townsville, Australia.
14 - 21 September 1981	Engineering Geological Problems of Constructions on Soluble Rocks. Istanbul, Turkey.
21 - 24 September 1981	International Symposium on Weak Rock. Tokyo, Japan.
October or November 1981	Engineering and Environmental Geology Symposium. Sydney, Australia.
7 - 11 June 1982	Tunnelling '82. International Symposium on Tunnelling. Brighton, U.K.
1 - 6 December 1982	4th International Congress of IAEG. New Delhi, India.

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

A.J. Olsen

LOCAL GROUP ACTIVITIES

1. AUCKLAND GROUP

1.1 Rock Socketed Piles

On 28 May 1980, Dr Ian W. Johnstone, a Senior Lecturer from the Department of Civil Engineering Monash University, gave an address on the subject "Rock Socketed Piles". Dr Johnstone was visiting New Zealand in connection with the 3rd Australia-New Zealand Conference on Geomechanics, and kindly agreed to address the Auckland Group before his return home.

In his introduction, Dr Johnstone described the difficulty encountered in the greater Melbourne area of founding structures on good bearing stratum. This is caused because mudstone of the Silurian era forms a major part of the geology of the entire Metropolitan region and it is this layer which underlies the poorer quality near surface soils. He commented that, in brief, the Melbourne mudstone could be described as a soft rock with unconfined compressive strengths (q_u) varying between 0.6 MPa at 18% moisture content to 8 MPa at 5% moisture content. The mass modulus (Em) varied between 100 to 1500 MPa.

With visual aids and slides Dr Johnstone described the formation of the socketed piles by hand auger or machine drilling and their variable length from 2 to 15 metres. The talk was particularly interesting with respect to the degree of instrumentation for the pile testing programme. It was found that the two most important parameters in pile design were pile geometry and roughness of sides. The testing indicated from the load-displacement results that strength or load carrying characteristics was less important than settlement considerations - in particular the establishment of a criterion for maximum settlement.

Dr Johnstone ended his lecture by describing the procedure to be used in the design of socket piles.

He concluded his address by answering questions from the small but extremely attentive and appreciative audience.

M.A. Wesseldine

1.2 Trench Stability and Safety

On 24 September 1980, a panel of three speakers - Mr D.M. Graham, Mr J. Cozens and Dr L.D. Wesley, each gave an informative talk on the practical, theoretical and safety aspects of trench stability.

Mr Don Graham, drawing from his experience and knowledge gained in his association with Green & McCahill, spoke on the contractors difficulties (a) at the tendering stage and (b) in the execution of the work.

At the tendering stage, experience and judgement are important factors in pricing, but local knowledge of subsoil conditions and geology are the best guide towards achieving a satisfactory tender. To a large extent the contractor is reliant in his pricing on the information available from the Engineer and particularly any special circumstances which should be provided for, within the tendered price. The contractor is often left to guess the condition of the subsoil with consequent erratic pricing.

The present economic conditions have resulted in a large number of claims from contractors who have been involved in unforeseen conditions. An inexperienced contractor may seek professional advice and assistance in the preparation of his tender.

The successful tenderer relies on a wide variety of specialised equipment and techniques for the economic excavation and support of trenches. For the excavation of rock, the use of hydraulic breakers, rippers and powerful hydraulic back hoes in combination with pre-shooting with explosives is now commonplace. The method of trench support depends largely on the nature of the rock and may not always be necessary, although quite often problems occur in what was thought to be good stable ground. Apart from the various timbering techniques, mobile steel shields which can be moved from one area to the next very quickly are available for a variety of conditions.

For weak and unstable ground, such as peat and sands, a knowledge of the ground water table and possible seasonal changes in level is important. Relatively expensive support systems including steel sheet piling, well pointing and possibly ground freezing are necessary for this type of subsoil.

Mr Graham stressed the importance of a good relationship between the Engineer and Contractor and the need for free communication both ways. The proposed method of excavation and support should be available from the Contractor at all times; while the Engineer should specify an end result rather than a method and be prepared to make known any unusual conditions disclosed from other adjacent previous work or investigations.

Mr Cozens, who has been with the Department of Labour for over 20 years, gave a resumè of the background experience, qualifications and function of a Construction Safety Inspector and his duties under the Construction Act 1959.

A Construction Safety Inspector is usually recruited from the construction industry and is qualified by examination to administer the Construction Act which, Mr Cozens emphasised, is very wide ranging particularly since there are up to 38 other Acts and regulations that can be associated with construction work. The Inspector's main functions are:

1. Advising employers and workmen on safe methods of work.
2. Investigation of accidents and prevention of recurrences.
3. Promotion of safety, health and welfare.

In particular reference to trenching excavation, it is evident that most accidents occur in relatively shallow excavations of 1.4 metre to 2.4 metre depth and the ratio of fatalities to accidents is much greater than for any other construction work.

Some of the problems in trenching leading to accidents and a poor safety record are caused by:-

Lack of Communication: either between workmen and job management or job management and Engineer.

Failure to use Safeguards: such as, not using available timbering; not backfilling as soon as possible; not wearing safety helmets; not using transformers or access ladders.

Insufficient Planning: not making inspections at the time of tendering; ignoring available information and local knowledge; tendering for work outside the scope of available labour and equipment.

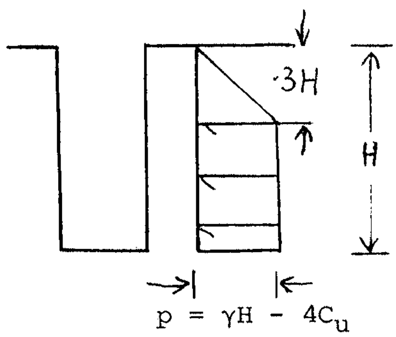
"Job at all costs" Approach: usually inadequately equipped and serviced or use of incorrect equipment.

Other facets: such as the lack of proper protection with fencing and lighting for the safety of the general public, in particular children.

In conclusion, Mr Cozens referred to a fatal accident in a trench only 1500 mm deep which was caused by the proximity of a power pole to the excavation and emphasised the need for good supervision and due care in what would appear to be a low risk job.

Dr L.D. Wesley commented briefly on the various theoretical approaches which can be used to determine the critical height H_c, to ensure stability of excavation. Using the formula $H_c = \frac{4C_u}{\gamma}$, a clay subsoil with an undrained shear value C_u of 50 kPa has an unsupported vertical height of approximately 12 metres or, with a factor of safety of 3, 4 metres. He then pointed out that it would be difficult, in the face of practical experience, to recommend an unsupported trench depth of even 2 metres in a subsoil of such low strengh and suggested that available theory was not always of great help and that some reliance should be put on local geological knowledge.

For braced and supported trenches in medium to soft clay, the basis of design frequently used is the theory described in Terzaghi and Peck which assumes a uniform intensity of pressure, $p = \gamma H - 4.C_u$ acting from a depth of 0.3 H below the surface. This approach contrasts to Rankines earth pressure theory which assumes an increasing intensity of pressure proportional to the depth of H.



The discussion which followed, brought forward the suggestion that one of the reasons for theory not matching practice in regard to the stability of vertical excavations in clay was the extensive cracking often occurring very soon after excavation. The introduction of surface water into localised areas also tended to further weaken the shear strength of these clays.

B.C. Hadfield

2. WELLINGTON GROUP

2.1 Landfill Development (with special reference to the Happy Valley Landfill)

This meeting was held on Tuesday, 12 August with a presentation by the following speakers:

Peter Barker, Engineering Section, Soil Bureau, D.S.I.R.
Gary Huish, Engineer, Wellington City Council.
John Hunt, Divisional Engineer, Wellington City Council.

Introduction

Mr Hunt indicated the extent of refuse disposal requirements in Wellington City, totalling some 230,000 cubic metres (solid) annually. He outlined the changes over the years from open tips with high faces, with all their problems of smell, smoke, rats and health hazards, etc., to the current high standards developed in "landfills".

He described possible alternatives and the costs involved before a decision could be made to negotiate and purchase a site. The long lead times involved in satisfying Town Planning requirements was emphasised (3 years plus). He described the various requirements made in this regard, especially relating to improved access, route cleaning, leachate control, etc.

Landfill Layout

Mr Hunt described the planning involved in major earthworks for roading access and the layout for the landfill itself with development in several stages. He described the leachate collection systems, using a "Christmas Tree" pipe collection system with gravel "chimneys", together with proposed methods of placing and compaction of refuse.

Main Stream Diversion

Mr Huish then described the problems with choice of type of diversion, control of water from side gullies, surface water disposal and the securing of water rights.

A number of colour slides and diagrams were shown covering details of pipe design, induced trench method of design, specification on a design and build basis for pipe manufacture, preparation of tender, and testing procedures.

Installation of Testing Equipment

Mr Barker described the way in which special gauges were installed (stress gauges and vibrating wire gauges) so as to be able to determine future stress build up in the pipe itself and in the surrounding ground in order to prove the efficacy, or otherwise, of the assumptions made during the design. He described some of the practical difficulties as well as some of the theory behind the decisions made.

Construction of Main Pipeline

Mr Huish then described, with the aid of slides, etc., some of the more interesting aspects of the construction involving delivery of pipes, earthworks for temporary access, temporary stream diversions and culverts, together with main pipe laying and equipment use therein. Some special construction features were adopted as regards bedding methods and under drainage. He also described in further detail the leachate collection system, slope drains from mid contour drains to intercept runoff from adjacent hillsides, the energy dissipator at the lower end of the main pipeline, compaction and excavation of the induced trench and associated problems.

Operation of Landfill

Mr Hunt then described the normal methods of operation of the landfill and compaction of incoming material, as well as methods for control of low density windblown material, the progressive raising of gravel chimneys and outer face material as well as the need for adequate maintenance of low level side drains and main contour drains. He also described some problems arising from development of (sewer fungus) Leptomitus and Beggiatoa, following some leaks which were discovered in the pipeline arising from joint design and the correction methods adopted involving chemical grouting etc.

Test Results

Mr Barker described the results of tests taken to date showing that generally the induced trench method of design was achieving the purpose to the extent that the pipe was remaining totally in compression and loading was generally following expected parameters.

There had been several practical difficulties which had been overcome, as well as a fairly high level of ground water build up, probably as a result of insufficient internal drainage system capacity in the upper part of the landfill.

Conclusions

Mr Hunt concluded the presentation by advising of some of the lessons learned as a result of the special investigations undertaken, particularly regarding future joint testing procedures, leachate drainage and cut off systems and the sequence of placing refuse, working from the upstream end of the catchment rather than the reverse.

The considerable number of questions asked in the final half hour indicated the degree of interest by those present.

T.J. Kayes

3. CHRISTCHURCH GROUP

On 15 October Dr R.D. Northey gave an excellent talk on "Geotechnical Aspects of the Abbotsford Landslip and some Implications for Urban Development". The talk, attended by 30 people, stimulated a great deal of interest among the audience.

D.H. Bell

FROM THE ROCK MECHANICS VICE-CHAIRMAN

(a) I have a copy of the minutes of the ISRM Council meeting held in Montreux in September last year. Any member wishing to look at these is invited to contact the Vice Chairman.

(b) 5th ISRM Congress, Melbourne 1983

This is the first time a big congress or conference for one of the three international societies has come to our part of the world. Hopefully it will mean that the NZ Geomechanics Society will have better representation than usual. Start planning now!

It is proposed that the main theme of the Congress will be related to Resource and Energy Development and/or Utilisation as most congresses in the past have been mainly involved with Dams and Tunnelling.

The current proposals for the programme are:

(i) Main Theme - Two whole days of common sessions

Title: Rock Mechanics and Resource Development

Topics suggested:

Permanent Underground Storage of Radioactive Wastes

Nuclear Power Plants in Underground Caverns

Future Developments and Directions in Rock Mechanics

Optimisation of Geomechanical Data Prior to Development

Shale Oil Extraction

High Steep Rock Slopes. e.g. in deep open-cut mines

(ii) Minor Themes - Two days of sessions run in parallel with interest specifically related to:

(a) Deep Mining and Hard Rock

(b) Near Surface Structures and Sedimentary, Weathered and Soft Rocks

There will also be pre- and post-congress tours. It is planned that one of these be in New Zealand.

(c) Commission on Swelling Rocks

The announcement on the work of their commission which appeared in the Int. Jour. Rock Mech. and Mining Science recently is duplicated below. Anyone who would like to contribute to the work of the commission could either send information to the Vice Chairman or alternatively contact the commission members directly.

"

Swelling Rocks

The International Society for Rock Mechanics has formed a Commission on Swelling Rocks. The members of this Commission have determined its Tasks to include the following:

(A) Characterization of swelling rocks

(1) Phenomenological definition. Identify various time-dependent phenomena in behavior of intact rock and rock masses (including gouge material). Define swelling in this context and attempt to distinguish from other phenomena (like squeezing).

(2) Underlying mechanisms. Evaluate state of knowledge on swelling mechanisms and identify areas that need further investigation. (Mechanisms that should be considered involve stress relief, pore pressure and water content change, chemical change and combinations.)

Task A has to be coordinated with Tasks C and E.

(B) Classification

Review existing classifications and determine their ranges of application with particular emphasis on their limitations. Determine the need for additional or revised classifications and suggest guidelines for the development of such classifications.

Task B has to be coordinated with Tasks A and E.

(C) Identification of problem areas

Identify and categorize the problems that occur in swelling rock. The categorization will be done with regard to rock type and behavior of engineering structures, and correlated with the mechanisms established in Task A.2. Case histories will be used to identify problem areas; in addition guidelines will be formulated for a review and cataloguing of case histories.

(D) Analysis and design of structures in or on swelling rock

(1) Review of existing approaches. Analytical and empirical approaches relating rock characteristics with behavior of engineering structures will be reviewed. Design approaches that reduce, eliminate or accommodate the effects of swelling rock will also be reviewed. Analytical and empirical as well as design approaches will be evaluated with regard to their ranges of application and effectiveness. A promising approach seems to be the examination of several representative case studies.

(2) Suggestions for improvements of analytical, empirical and design approaches. Based on the determination of underlying mechanisms (Task A.2), the identification of problem areas (Task C) and the review of existing approaches (Task D.1) need for improvements will be established. The areas where improvement is most important will be defined and suggestions for necessary work will be made.

(E) Laboratory and field testing

(1) Laboratory tests. Review existing laboratory tests; determine their advantages and limitations and establish for what purpose(s) the tests can be used. Determine the need for new tests; suggest criteria for and coordinate the development of such tests. (Laboratory testing includes index, mechanical and chemical-mineralogical testing.)

(2) Field tests and monitoring instrumentation. Review field testing equipment and procedures as well as monitoring instrumentation and techniques that have been used or that can potentially be used. Evaluate and categorize techniques and equipment. Determine the need for standardization and for new field testing and monitoring procedures, field testing and monitoring techniques and equipment.

The goals of the recommendations to be worked out by the Commission include:

- To make the geomechanics profession aware of problem(s).
- To provide ideas of how to identify problems; (to provide means or guidelines enabling users to determine if swelling will occur or not).
- To provide descriptions of 'tools' that are necessary to identify and deal with the problem, i.e. describe exploration and testing procedures necessary for problem identification and design procedures for dealing with the problem.

Permeating all the above, the Commission's policy will be to include appropriate summaries of cases illustrating problems, i.e. showing how to apply the above-mentioned tools.

The work of the Commission would be greatly enhanced by contributions from practitioners and researchers who have encountered and/or studied swelling rocks. Comments, papers and case histories relating to any of the tasks would be greatly appreciated, and may be sent to any of these Commission members:

W.E. BAMFORD
Mining and Metallurgy Department, University of Melbourne,
Parkville, Victoria 3052, Australia

H.H. EINSTEIN
1-330, Civil Engineering Department, M.I.T., Cambridge,
MA 02139, U.S.A.

M. GYSEL
Motor-Columbus, Parkstrasse 27, CH-5401 Baden, Switzerland. "

M.J. Pender

FROM THE ENGINEERING GEOLOGY VICE CHAIRMAN

Below is a summary of the IAEG Council meeting held in Paris during the 26th International Geological Congress. I have a copy of the full minutes and any member wishing to look at these is invited to contact the Vice Chairman.

Summary Report of IAEG Council Meeting, 7 July 1980

The meeting was opened on 7th July, 1980 by the President, Professor E.M. Sergeev and continued under the Chairmanship of Professor Arnould, Past President. Most of the meeting time was occupied with routine matters and only the more significant aspects will be mentioned in this summary.

MEMBERSHIP

There has been an encouraging increase in membership to 40 National Groups and over 4,000 members.

COMMISSIONS

The following Commissions have completed their reports or are very close to completion - Teaching of Engineering Geology, Site Investigation, and Landslides.

It has been decided to revitalise the Commission on Building Stone and its probable new name will be Commission on Building and Ornamental Stone.

FUTURE EVENTS

1980	Third International Congress, I.A.E.G., Madrid, 1978. Printed papers of this Congress will be distributed.
1981	International Symposium - Engineering Geological Problems of Construction on Soluble Rocks. Istanbul. September 14-21.
1982	Fourth International Congress, I.A.E.G. New Delhi. December 1-6.
1983	International Symposium - Geology and Environmental Problems. Poland. Prior to July.
1983	International Symposium - Engineering Geology and Underground Construction. Lisbon. September.
1984	International Symposium - Aggregates. Paris. Date to be fixed.
1986	Fifth International Congress, I.A.E.G. Probably in Argentina.

AN ENGINEERING GEOLOGY BOOK

A proposal for a specialist book on engineering geology was adopted and an editorial board consisting of Prof. Sergeev, Prof. Arnould, Dr Wolters and Prof. Dearman was appointed. The form and contents will be determined by postal votes of National Group.

ENVIRONMENTAL GEOLOGY

The International Union of Geological Science, and the International Union of Geology and Geodesy are about to embark on a new international study programme on the "Lithosphere".

In connection with this new programme, Prof. Sergeev drew attention to the increasing need for engineering geology to be concerned with the environment, which includes the sub-surface, and to the need for recognition of this interest by other specialists and laymen.

It was decided that moves would be initiated for the word environment to be included in the statutes of the Association.

The Council decided that, rather than form another Commission, interest in environmental geology should be developed at National Group level where positive involvement by members of the Association could be achieved. A programme to encourage and co-ordinate such activity will be initiated by the Executive, but for positive results activity must be generated and maintained by the National Groups.

C.L. ADAMSON
Proxy for Prof. D. Stapledon
Vice-President, Australasia

D.H. Bell

CODES OF PRACTICE IN GEOTECHNICAL ENGINEERING

P.W. Taylor

Of all the fields of engineering practice, the geotechnical area is, perhaps, the most difficult to codify. With soils that can range from soft peats to igneous rocks, subsurface profiles that can be uniform over a site or grossly variable, and many solutions available for the ingenious designer to every geotechnical problem that arises, this is hardly surprising.

This has not deterred the British Standards Institution, which has produced codes on the following aspects:

CP 2001 (1957) Site Investigation
CP 2003 (1959) Earthworks
CP 2004 (1972) Foundations
CP 2012 (1974) Foundations for Machinery
Part I Foundations for Reciprocating Machines
Civil Eng. Code of Practice No. 2 (1951) Earth Retaining Structures (I.Struct.E.)

The 'Foundations' code (CP 2004) is a 158 page document of A4 size, mainly describing construction practices. Rather than being specific, it tends to be written in very general terms. It makes interesting and worthwhile reading - rather like a down-to-earth textbook.

The position in New Zealand is that we have a provisional standard, NZS 4205P : 1973 'Code of Practice for Design of Foundations for Buildings' which has been under review by a committee of SANZ, of which the present author is chairman. Initially, the committee considered that a few revisions of the provisional code were all that was necessary to make this code fully acceptable. Input from various sources indicated, however, that considerable revision was desirable. At that stage, it was thought that a new start should be made, and the code completely rewritten. The difficulties in doing this soon became obvious.

Firstly, what topics should the code cover? Should it attempt to deal, in a few pages, (as the provisional code does) with site investigation and earth-works as well as the design of foundations? Should it be written in a very general way (as in CP 2004) or should it be specific? If it is to be specific, then it will tend to limit the scope of engineers to exercise their ingenuity, and so limit innovation. If it is to be general, then we could adopt the British code. But is there really any point in doing that, when it may merely serve as a background reference book? It can be used as that without our adopting it as a code, both by design engineers and by engineers in certifying authorities who have to approve proposals.

These considerations bring one to the quesion; Do we need a code at all? If there were indications that standards of design and construction of foundations in this country were unsatisfactory, there would be a clearer need for a code, but that is not the case. Certainly, there may be occasions when better design, or better construction practices could be adopted. Strict adherence to a code would not, however, obviate such occasional lapses.

Here, let me quote John Burland, (Geomechanics News, No. 18, p 9): "I do, however, believe that some Codes inhibit thought and judgement. There is no room for such Codes in ground engineering. The behaviour of the ground and its occurrence in nature are too complex to permit the formulation of detailed design and construction procedures."

There is one area in which guidance for the New Zealand designer is necessary; that is with regard to the choice of suitable factors of safety for bearing capacity of foundations for earthquake resistant structures. At the moment, design loadings are given in the Loadings Code (NZS 4203) and suitable safety factors are recommended in commentary clauses. (Clause C3.3.6.1 deals with factors for 'design earthquake' loading and C3.3.6.2 for 'capacity' loading for ductile structures.)

The SANZ Foundations Committee has now recommended that the Loadings Code (NZS 4203) be amended to include these minimum factors of safety in the code itself, rather than in the commentary section. This change will be considered by the Code Revision Committee for NZS 4203. The Foundation Committee has also decided that, provided these amendments are made, the existing provisional code on Foundations should be withdrawn, and not replaced.

This decision will, I expect, be received happily enough by most people engaged in geotechnical engineering, but there will no doubt be a few who staunchly believe, "We must have a code on Foundations".

My own personal view is that good codes are written when there is a clearly-discerned need for them. An example is the New Zealand "Code of Practice for Earth Fill for Residential Development". This document was produced initially in 1973 when increasing use was being made of mass earth fills for housing development. It was couched in terms broad enough to include a wide range of acceptable local practices and yet overcame some of the difficulties (such as certification) which had arisen. It was later confirmed as NZS 4431 : 1978.

One area which has been debated in recent issues of N.Z. Geomechanics News concerns soil description. From this discussion it appears that there are differences in opinion,yet it would be clearly to everyone's advantage to have an agreed system. There are special local descriptive problems, related to volcanic and weathered rocks, and some "interdisciplinary" misunderstandings arising from the fact that engineers and geologists are now working together more closely than before. 'Soil Description' appears to me to be an aspect of geotechnical engineering where some standardisation is appropriate and desirable.

DRILLHOLE ALIGNMENT DETERMINATION USING AN INCLINOMETER

N.D. Perrin

1.0 Introduction

Inclinometers have been used on several projects within New Zealand to monitor horizontal subsurface ground movements, particularly in landslides. A less common use of the instrument is to survey the alignment of drill-holes where it is necessary to know if deviation from the intended direction has occurred.

The suitability of the inclinometer for this purpose was clearly demonstrated during construction of the Rangipo Tailrace Tunnel, Tongariro Power Development, where a 116 m deep vertical hole of 254 mm diameter was drilled from the batching-plant site down to the tunnel line. The hole was to deliver concrete for lining of the 5.9 m diameter tunnel.

The hole, which was drilled before the tunnel excavation had reached that point, was intended to intersect the tunnel 0.6 m to the right of the centre line so as to avoid the ventilation line along the left-hand side (Figure 3). When it was suspected that the hole was not vertical, a survey of its alignment was made using a Pajari instrument* which indicated that the hole might be up to 2° away from the vertical, the direction of deviation being uncertain.

Such a deviation from the vertical would have been enough for the hole to miss the tunnel completely (Figure 3, inset), so the contractor, Downer and Company, asked the Engineering Geology Section of the New Zealand Geological Survey to try to determine the position of the bottom of the hole using an inclinometer.

This paper initially describes the inclinometer used for the survey (Soiltest C-350 Slope Meter), its principles of operation and methodology of usage and concludes with an account of the survey of the Rangipo hole. The survey indicated that the hole at tunnel level was 2.4 m on a South-East bearing from the collar. With the tunnel alignment at 139°52'25", this indicated that the hole would intersect the tunnel close to the centre line. The tunnel later intersected the hole within 280 mm of the predicted position (Figure 3).

2.0 The Inclinometer

The Soiltest C-350 Slope Meter (Figure 1) consists of a transducer (also known as a probe or torpedo), which is similar to that described by Olsen (1976), containing an oil-immersed, cantilevered weight on a leaf spring. Electrical resistance strain gauges mounted on this spring measure the strain in the spring as the weight attempts to maintain a vertical orientation when the transducer is inclined.

The transducer has an overall length of 380 mm, and the distance between the guide-wheel axles is 220 mm. It is permanently connected through a waterproofed gland-coupling to 76.2 m (250 feet) of earth-screened four

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*A Pajari is an inclination measuring plumb-bob and magnetic compass which is locked by a clockwork mechanism after being placed at the desired depth.

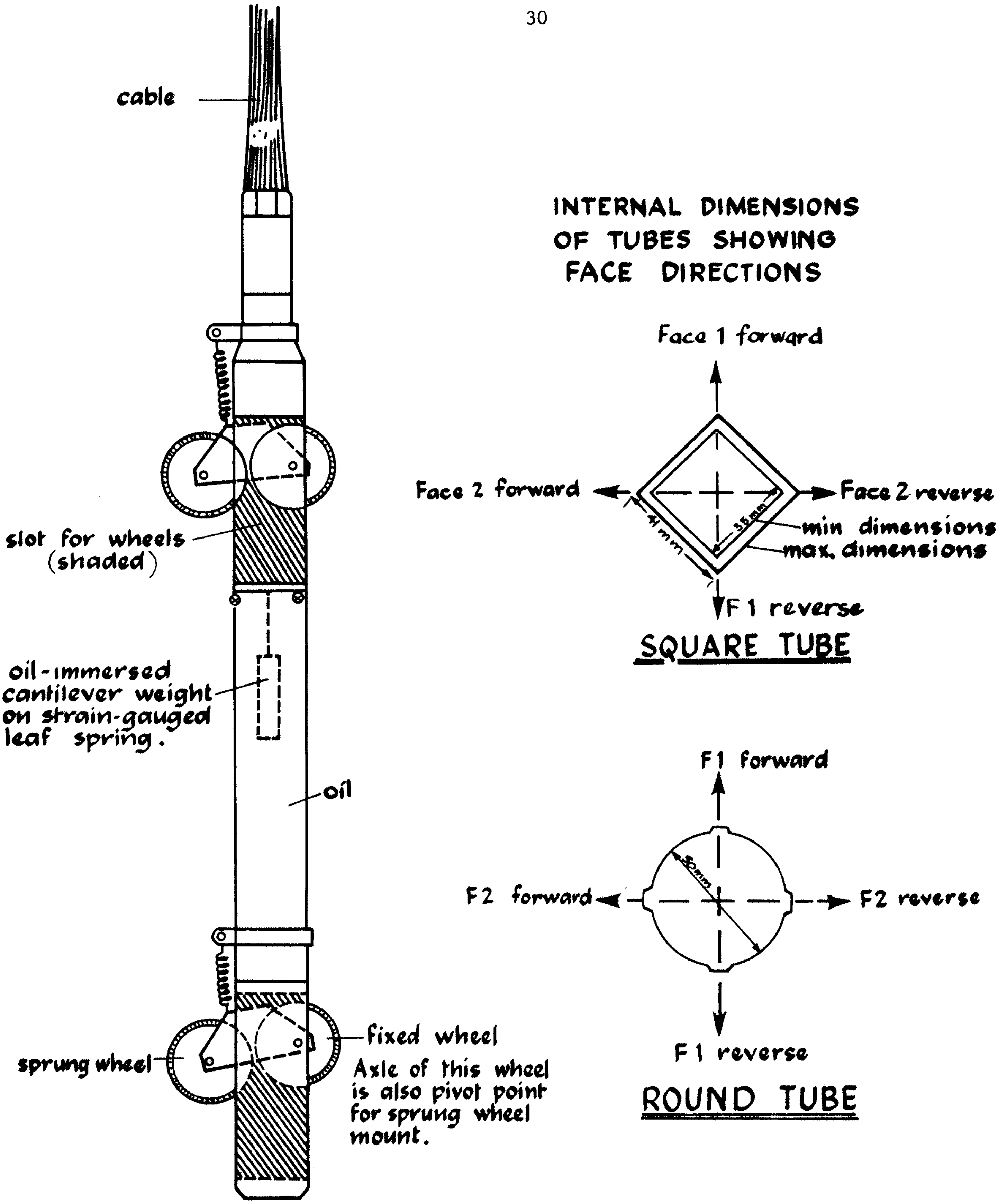
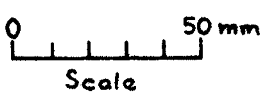


FIG. 1 SOILTEST C-350 INCLINOMETER TRANSDUCER



core cable, graduated at 0.61 m (2 foot) intervals. This cable is attached to the terminals of a Vishay P-350A digital strain indicator which acts as the power supply for bridge excitation at 1.5 volts R.M.S., 1000 H_z and provides the readout.

The guide-wheels which orient the transducer can either be positioned diagonally across square-section tube, or in keyways in round-section tube (Figure 1). In the example at Rangipo, square-section tube was used.

3.0 Principles of Operation

The change in resistance of the strain-gauges which are mounted on the leaf spring in a Wheatstone full-bridge configuration, is measured at the readout unit, to give strain recorded with the inclination of the transducer. As the strain-response is assumed to be linear with the angle of inclination, the strain recorded gives the angle of the transducer from the vertical.

The inclinometer measures in two directions perpendicular to each other with two readings being taken in each direction. These two readings are known as the forward and reverse; the forward taken with the fixed wheels in one direction, and the reverse with the transducer rotated through 180^o.

The difference between the forward and the reverse reading at a point in the tube represents twice the angle of the transducer (and therefore the tube) from the vertical. The sum of the forward and reverse readings is a constant which should be checked by the operator in the field to verify the proper operation of the instrument, or its precision. This procedure also detects mistakes in reading or recording, and temperature effects caused by a change in resistance in the lead wires. The latter is seen as a steady increase or decrease in the value of the sum of forward and reverse readings. The apparent strain induced by temperature effects can exceed the magnitude of the strain being measured, a common problem in Wheatstone bridge circuits.

The calibration of the transducer is performed with it in a piece of wall-mounted tube which is tilted through a series of angles from the vertical. The strain readings are noted for each angle of tilt at a range of gauge factors* of the readout instrument. For each gauge factor setting, an instrument factor, (I.F.) is derived from:

$$I.F. = \frac{180 \times \text{strain units per } n^o \text{ rotation}}{n^o \times \pi}$$ (for strain readings at n^o increments of rotation) Eq1

The instrument constant, (I.C.), for the transducer and readout unit which is in strain units per radian is given by:

$$IC = GF \times IF$$ Eq2

The displacement from the vertical of one end of a known length of tube can be shown to be given by:

$$\text{Displacement} = \frac{(\text{forward reading} - \text{reverse reading})}{2} \times \frac{\text{length}}{IF}$$ Eq3

*Gauge factor, G.F., relates the electrical sensitivity of a strain gauge to strain, e.g. a gauge factor of 2 means the gauge changes 2 micro-ohms per ohm of initial resistance for a change in length of 1 micro-metre per metre.

When measuring the profile of a drillhole, readings are taken at a series of depths known as stations, and the distance between stations is substituted for "length" in Eq. 3 above. As the instrument factor (IF) derived from Eq. 2 gives different units of readout by altering the gauge factor, the selection of an appropriate gauge factor allows the reduction of Equation 3 to:

$$\text{Displacement} = \text{forward reading} - \text{reverse reading} \qquad \text{Eq4}$$

Thus for any selected station interval, the readout* can be adjusted to give direct readings of displacement in terms of any units desired.

Readings should be taken from the bottom of the hole upwards after allowing the transducer sufficient time at the bottom of the hole to temperature stabilise. The transducer is raised to the first station above the bottom of the hole which ensures that it is not resting on the bottom, and readings are taken at the selected station interval up the hole. After reaching the top of the hole the transducer is rotated through 180^{o} and the procedure repeated.

4.0 Use of the Inclinometer

In the monitoring of landslide movements, the initial configuration of the hole is unimportant (Olsen 1976), although it has been recommended elsewhere (I.S.R.M. 1977) that the two initial profiles of a hole should be plotted.

For an initial set of readings in landslide monitoring it is sufficient to leave the results of the forward minus reverse readings tabulated against their depths. When subsequent readings are taken, the difference between the forward and reverse readings at each station are subtracted from those initially obtained to give the changes in displacement from the vertical. The summation from the bottom upwards of the changes is then plotted for each axis to show the deformation of the tube resulting from landslide movement and is irrespective of the initial configuration of the tube.

To determine the alignment of a drillhole, the four sets of readings are made (forward and reverse on each axis) as for the initial survey for landslides, but in this case the summation of the differences between forward and reverse readings is done from the top downwards. The profiles obtained for each axis are plotted, and the direction and magnitude of the run-off of the hole away from the vertical can then be derived.

5.0 Rangipo Tailrace Tunnel Concrete-Delivery Shaft

A square-section steel tube consisting of butt-welded 15 m lengths was placed in the hole with packers at several levels to stabilise it and keep it centred, and the tube axis directions were determined by surveying.

After the calibration of the instrument was checked on the site, especially for verification of the sign-convention relationship to direction of displacement, the top 73 metres of the hole was surveyed at a station interval

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* The survey at Rangipo used a 3.05 m (10 feet) station interval with an instrument factor of 1524 giving readout in 0.1 mm units of displacement.

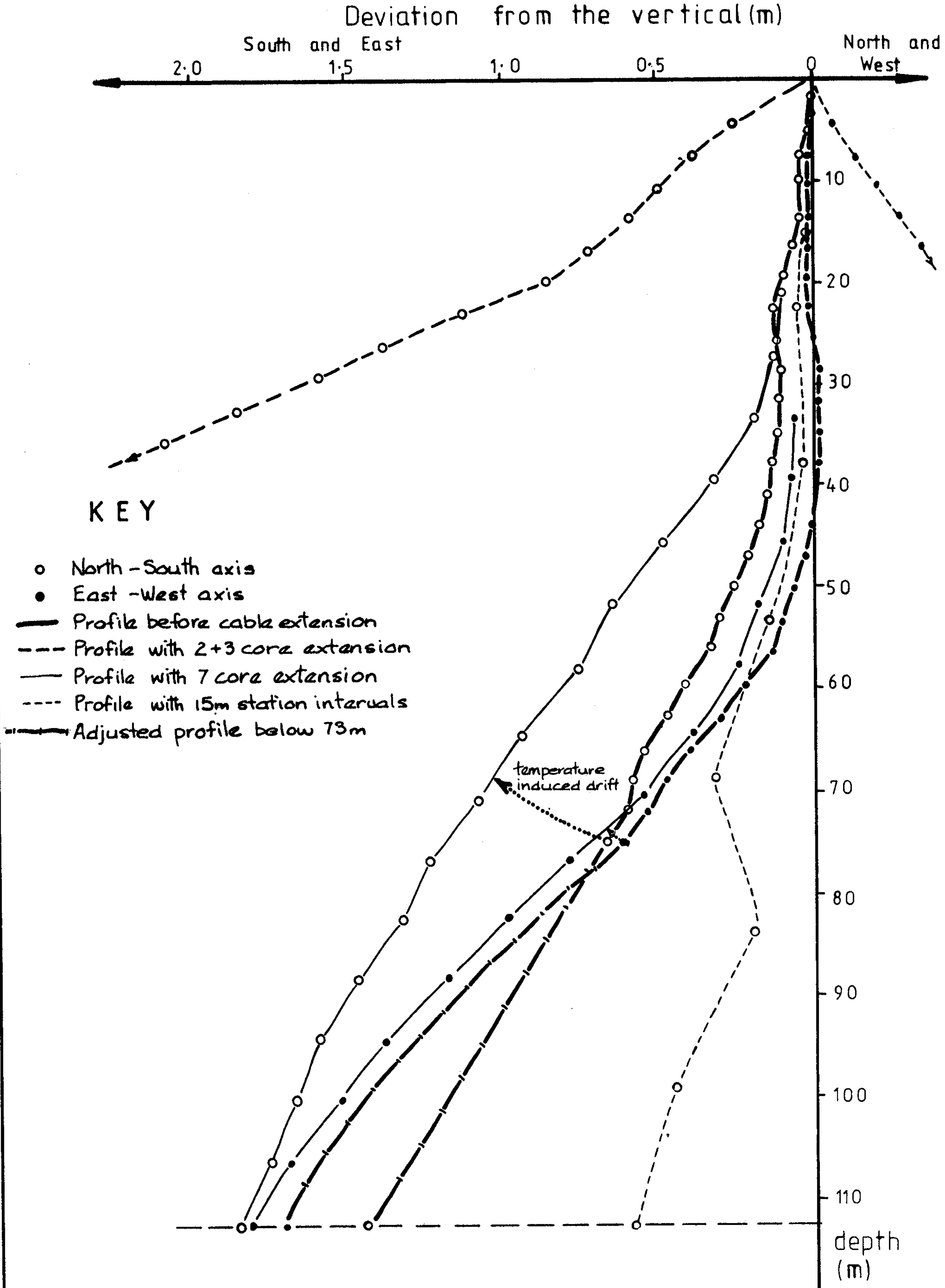

FIGURE 2

PROFILES OF TUBE AXES

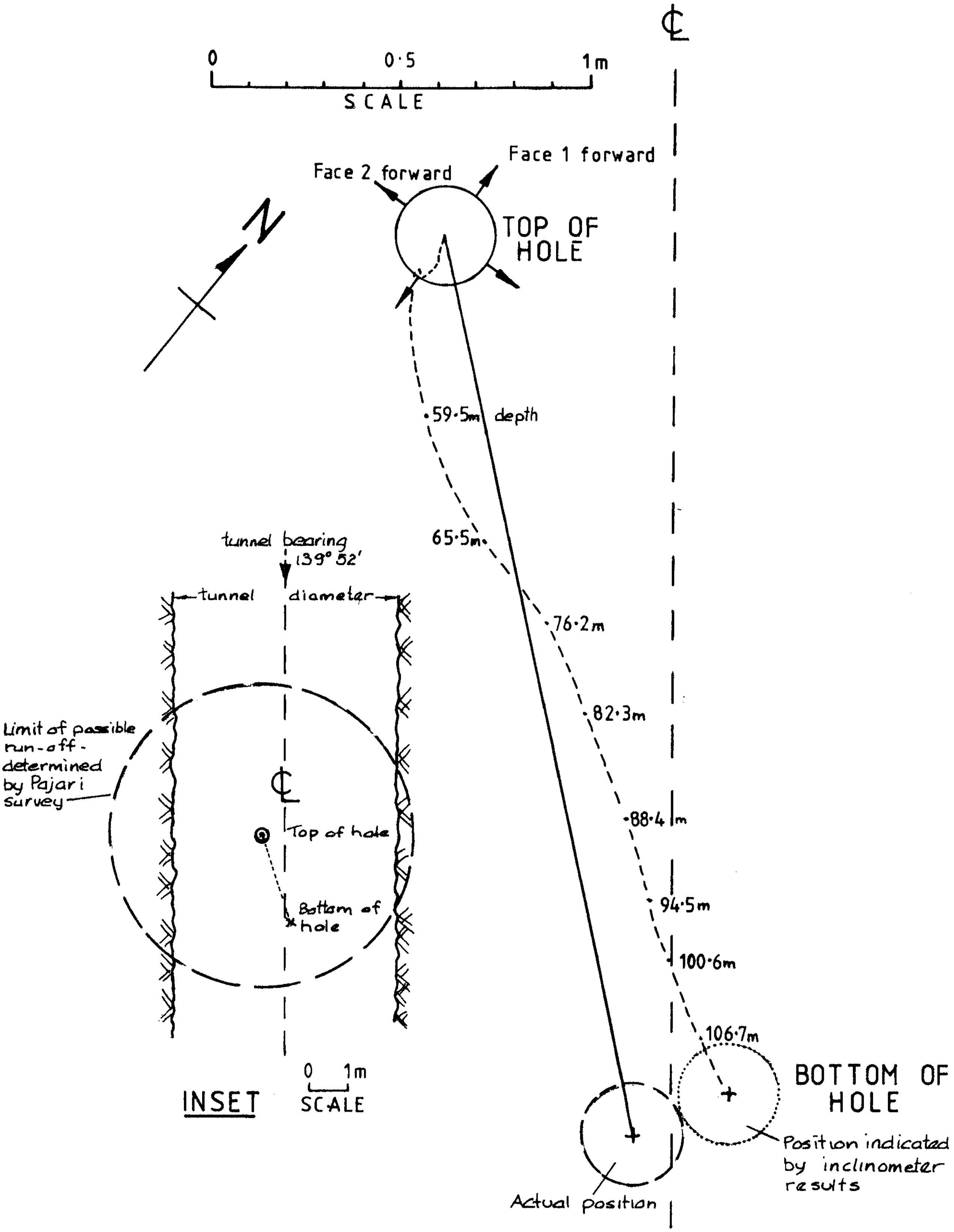

FIGURE 3

PLAN OF BOREHOLE RUN-OFF RELATIVE TO TUNNEL of 3.05 m. The mean angle from the vertical down to this depth was found to be 0.73° (i.e. 0.93 m of deviation approximately to the South-East).

As the instrument was supplied with only 73 m of cable, a cable extension of 45 m was required to reach the bottom of the hole. The contractor initially provided a 3-core cable with a 2-core cable taped to it for this purpose. This was connected between the readout unit and the end of the cable supplied with the instrument. (The instrument was again re-calibrated, and the I.C. was found to be unchanged.) However, during readings, as this cable was withdrawn from the hole into the warmer air outside, the difference in temperature effects on the two cables led to a drift in readings more than 5 times greater than the strain being measure (Figure 2). Consequently this cable was discarded.

An improved result was obtained using a 7-core cable extension (5-cores only were needed), although temperature associated drift was noted as more of the cable extension was exposed to the ambient air temperature outside the tube as the transducer was pulled up. However as this effect was most marked above 50 m the readings below 73 m were adjusted by subtracting the difference between the displacement indicated at 73 m depth in the original survey and the survey with the 7-core cable extension.

A repeat survey was made on one axis using a 15.24 m (50 feet) station interval to verify the direction of deviation. This survey verified the direction but indicated less displacement as many of the variations in the tube had been missed (Figure 2).

The profiles of the hole obtained from these surveys are given (Figure 2) and the direction of deviation (Figure 3). After the hole was intersected by the tunnel, the error in the position of the bottom estimated by the inclinometer was 6° of bearing and 30 mm distance i.e. the difference between actual and estimated positions was 280 m, the hole actually deviating 2.4 m from the vertical.

6.0 Conclusions

The exercise demonstrated that inclinometers can be used to define effectively the orientation of deep drillholes, and despite the temperature-drift problems, the results obtained by the inclinometer were accurate enough for the contractor's purposes.

In addition, inclinometers using readout units with adjustable gauge factors, such as the Vishay P-350A, are extremely versatile. This is because the readout can be so adjusted to give displacement for different station intervals which results in simple data reduction and enables results to be calculated quickly in the field.

7.0 References

- Olsen, A. 1976. The Inclinometer Monitoring System. N.Z. Geomechanics News 13: 25-30.

- International Society for Rock Mechanics, 1977. Suggested Methods for Monitoring Rock Movements Using Inclinometers and Tiltmeters. Rock Mechanics 10: 81-106.

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 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 $10.00.

I wish to affiliate to:

International Society for Soil Mechanics and Foundation Engineering	(ISSMFE)	Yes/No	($4.50)
International Society for Rock Mechanics	(ISRM)	Yes/No	($7.00)
International Association of Engineering Geology	(IAEG) ($7.00 with Bulletin)	Yes/No	($3.00)

Signature of Applicant ______________________________

Date ______________ 19__

PLEASE DO NOT SEND FEES WITH THIS APPLICATION, AS 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,
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 ________________________