N.Z. GEOMECHANICS NEWS

No. 13

NOVEMBER 1976

A NEWSLETTER OF THE N.Z. GEOMECHANICS SOCIETY

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"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. 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. Election of Management Committee by Postal Ballot

In Geomechanics News No.12 (May 1976), details of the proposed election of the Management Committee by postal ballot were presented. As stated in that issue, it has been decided to change to a postal ballot to give every member of the Society an opportunity to participate in the election of the Management Committee.

Section 6.2 of the rules of the Society states: "The Management Committee..... shall comprise ten members of the Society. Eight members of the Committee shall be elected by all members of the Society, and two shall be appointed by the Council of the Institution. At the time of calling for nominations it shall be brought to the attention of the Society membership that the representation on the Committee should be maintained as broad as possible with respect to the field of interest, occupational and regional classification."

Ballot papers are included with this issue of Geomechanics News. Members of the Society are asked to exercise their vote wisely in electing a Management Committee for 1977.

2. Slope Stability Handbook

As a result of the 1974 Nelson symposium "Stability of Slopes in Natural Ground", and an awareness by the Geomechanics Society of the need for a small, informative, booklet summarising considerations relevant to slope stability in urban development, a publication has been prepared and will go to press shortly. It is not intended to be a code of practice nor can it serve as a substitute for professional advice: rather it seeks to indicate many (but not all) of the situations where such advice should be sought.

Further notification will be given to members when copies of the handbook become available for purchase.

3. N.Z.I.E. Annual Conference, Christchurch, 1977

Time has been allotted for the Geomechanics Society to hold technical sessions on Wednesday, February 16th from 9 - 10.15 a.m. and 10.45 a.m. - 12 noon. The A.G.M. of the Geomechanics Society will be held on the evening of Tuesday 15th February.

Contributions to these sessions are welcomed. Tentative proposals include the forthcoming NRB recommendations for construction of highway batters (R.G. Brickell), railway and highway stability problems along the Kaikoura coastline (D.H. Bell et al) and proposed amendments to the Town and Country Planning Act relating to land use development.

4. Symposium on 'Tunnelling in New Zealand'

The Society is to hold a symposium on 'Tunnelling in New Zealand' on 17-19 November 1977 at the University of Waikato, Hamilton. The aim of the symposium is to review and discuss the role of Geomechanics in the investigation, design and construction of underground excavations in New Zealand.

The programme for the two day symposium will include sessions under the following broad headings:

(i) History of tunnelling in New Zealand
(ii) Site Investigation
(iii) Design
(iv) Construction
(v) Tunnel logging and instrumentation
(vi) Case studies

It is hoped to arrange a field trip to a site of relevance to the theme.

An invitation is extended to both members and non-members of the Society to contribute papers on the above topics. The success of the symposium will depend on participation from Society members.

5. Ground Vibrations - Part Two of a Series

This issue includes the second and final article on ground vibrations. Mr P.C. Whiteford of Geophysics Division (D.S.I.R) is the author of this most informative account of the manner in which safe charge sizes can be determined for varying site conditions.

6. IV International Congress for Rock Mechanics, 1979

The Int. Soc. for Rock Mechanics has approached the Geomechanics Society asking for subjects or topics which may form the basis of technical sessions or discussions at the IV International Congress in Switzerland in 1979. Any member of the Society who has topics he wishes to put forward should forward these to the Management Secretary.

7. The Inclinometer Monitoring System

This issue also contains a factual description of the uses and shortcomings of the inclinometer. Mr Olsen, the author of the article, is a geotechnical engineer at MWD Central Laboratories, and has had three years' experience with this particular instrument.

8. Contributions to New Zealand Geomechanics News

Contributions to New Zealand Geomechanics News may be in the form of technical articles, notes of general interst, 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:

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C/- New Zealand Geomechanics Society,
P.O. Box 12241,
WELLINGTON.

I.M. Parton
EDITOR

LOCAL ACTIVITIES

AUCKLAND GROUP

On 2 September 1976 the Auckland Group were addressed by Prof James K. Mitchell of the University of California at Berkeley on the topic

"GEOTECHNICS - 1776 - 1976 - ?"

Prof Mitchell has been a member of the Berkeley Faculty since 1958 and has received a number of awards for his research, particularly in areas related to soil stabilisation and physico-chemical principles of soil behaviour. He was a member of Apollo 11 and 12 soils investigation teams and was the principal investigator for the soil mechanics experiments of Apollo missions 14 - 17. He has recently been elected to the U.S. National Academy of Engineering.

Prof Mitchell began by defining technology as the conquest of materials and hence geotechnology as the conquest of earth materials. With the use of slides he traced the growth of geotechnology through recorded history. He made particular reference to the Romans and their roads which were built on the two fundamental principles of solid foundations and good drainage.

He then described the work of Charles Augustus Coulomb which was published in France in 1776. (Prof Mitchell said that the work was written in 1773 and hence took three years to publish. This shows that publishing times have altered very little in the last 200 years!) Coulomb's work represented a great step forward in the use of analytical techniques in soil mechanics.

In the 150 years from 1776 - 1925 there was a slow but constant growth in soil mechanics theory and the construction related to it. He quoted the construction of the Panama Canal which was cut through heavily over-consolidated clay shale. About 40 years after construction the banks started to fail. Prof Mitchell briefly described a number of prominent figures in the development of soil mechanics in the era from 1926 to 1950. These included Fellenius (Swedish landslips), Karl Terzaghi, Moran (caissons), Hvorslev (shear strength and sampling), A. Casagrande, D.W. Taylor (shear strength and slope stability) and Peck.

By the early 1950s it was apparent that although a large advance had been made in analytical techniques in soil mechanics there were still real deficiencies in our understanding of soil behaviour. Large contributions were made in the 1950s by A.W. Skempton and L. Bjerrum, who studied soil properties as well as mechanics.

A revolution was brought about in the early 1960s by the use of the digital computer. By about 1964 static and dynamic analyses using the finite element method were being developed and it then became possible to analyse complex structures. As an example, the Oroville Dam is a 780 ft high rock fill dam and complex cross-sections of the dam were analysed. By the end of the 1960s analytical techniques for static problems were well advanced, but the problem remained in defining the properties to go into the analysis. During the 1960s dynamic analysis also advanced greatly. Examples were - the analysis of the Turnagain landslide which occurred during the Alaskan earthquake, and also the studies of the Niigata earthquake. In 1971 there was a very near disaster when the San Fernando Dam almost collapsed. If there had been another few seconds of shaking the dam would have discharged all its water into an area containing 80,000 people. The near failure of this dam has been very carefully studied. Computational procedures have now developed to the point where it is possible to make reasonable judgements regarding complex problems. Also, prediction of the likely damage during earthquakes has advanced significantly, particularly as a result of the studies made of the Caracas earthquake.

Also since 1960, rock mechanics has developed greatly. The failure of an abutment of the Malpasset Dam in France was a result of a lack of knowledge in rock mechanics and gave a great impetus to further studies in this subject. A very recent abutment failure in a dam occurred in Idaho and the reasons for this failure are still being studied.

As a result of the development of rock mechanics it is now possible to cut high rock slopes with a much greater degree of confidence than previously. Also there has been a great advance in the use of underground rock cavities for power house construction. In the early 1960s such cavities could not be constructed with nearly as much confidence as is now possible. However, for the successful engineering of projects involving the use of rock mechanics, good sites and competent geology are required in order to come up with a good end result.

Prof Mitchell then went on to discuss recent challenges in geotechnics, and then looked into the future. He said that the main challenges at present were into the areas of previously unexplored environments and particularly space, the sea and underground.

SPACE

Prof Mitchell described his experiments in connection with the Apollo missions. He described how the footprints of astronauts in the moon's surface were carefully analysed as they form a type of plate bearing test. Also the observational method was used to good effect and the astronauts were trained to give as much information as possible in their comments on what they were doing on the moon's surface. Also a vehicle was designed to operate on the moon using soil data obtained from previous missions and the vehicle was then used to obtain further soil data. Slides were shown on the landing pads of the space vehicle sinking slightly into the ground and of a recording penetrometer which was used to probe into the moon's surface. Prof Mitchell said that the moon's surface is basically a silty fine sand.

DEEP SEA EXPLORATION

Prof Mitchell said that the deep sea environment has some similarities to the environment of the moon (except that on the moon if a space suit leaks the astronaut would explode, whereas in the deep sea the diver would implode). He said that a lot of deep sea work relies heavily on the use of anchors. Also good use has been made of instruments to obtain data on deep sea exploration.

UNDERGROUND CONSTRUCTION AND MINING

In the use of rock mechanics for underground works the study of rock behaviour is now becoming very important. In the 1950s there was emphasis on rock behaviour but this was replaced in the 1960s by emphasis on methods of analysis, and we are now getting back again into behaviour. A slide was shown of a study of the squeezing in of a tunnel and Prof Brekke successfully used a model to study this underground activity and to determine ways in which the problem could be overcome.

CHALLENGES AT THE PRESENT TIME

Prof Mitchell said that he would regard soil mechanics as now being in the stage of early maturity whereas rock mechanics is still moving along and growing rapidly. His recent work on the Apollo missions and deep sea exploration and with underground work had convinced him that the basic principles of geotechnics apply in all these environments as well as on the earth's surface, and the basic problem is still to be able to define the soil properties involved.

Prof Mitchell saw the main challenges at the present time as being the following:

1. The evaluation of in situ properties of sands.
2. The proper definition of site conditions.
3. The measurement of soil properties in situ.
4. Determination of dynamic pore pressures.
5. Damage caused by earthquakes.
6. Engineering construction in soft rock.
7. Composition and properties of ocean sediments.
8. Properties of residual soils.
9. Properties of expansive soils.
10. Remote sensing of soil properties.

RECENT ADVANCES IN GEOTECHNICS

Finally Prof Mitchell mentioned the advances in techniques for tunnelling and other underground works. He showed pictures of tunnelling machines and mentioned the use in the laboratory of an electron beam for breaking out rock and the future potential of this process. He believed that underground nuclear reactors would be used more often in the future to further reduce the earthquake and other hazards of these reactors. He also mentioned that underground storage of materials in very large cavities would be used more commonly in the future. He also believed that the methods of geotechnics would be applied much more deeply to environmental enhancement. Also he believed that mining is in a stage of resurgence and there is a shortage of qualified people in this area around the world. At present, advances are taking place in using the principles of geotechnics in solid waste management and utilisation and in the development of marginal soils and sites.

At the end of his address Prof Mitchell answered questions from the audience, and he was thanked by the Chairman, Mr Blakeley, for a most stimulating address.

OTHER MEETINGS

LEGAL ASPECTS OF GEOTECHNICAL WORKS

A meeting held in April 1976 on this topic is fully reported elsewhere in this issue.

SYMPOSIUM ON POLE HOUSE FOUNDATIONS

A decision was made to invite the public to attend this symposium (held from 5 - 7 p.m. on Tuesday 10 August) by means of a short article in the Auckland Star. The result was phenomenal with an audience conservatively estimated at 320 in the 250 seat lecture theatre and about 150 people were turned away. As a result, the entire symposium was repeated on Tuesday 14 September, and again a large audience of over 200 people were present. This must surely indicate the extent of public interest in pole houses at the present time. Although due emphasis was given to foundation requirements the symposium covered all aspects of pole house construction.

The symposium began with a 30 minute colour movie produced on pole houses in New Zealand (kindly provided by Hicksons Timber Impregnation Co). This was followed by addresses from the three speakers and then discussion. The speakers were Mr Peter Norton, architect, Mr Ernie Lapish, structural engineer and Mr Rodney Melville-Smith, geotechnical engineer. Both sessions were very capably chaired by Mr Michael Wesseldine, a committee member of the Auckland Group who was also convener responsible for organising the symposium.

SYMPOSIUM ON THE GEOLOGY OF THE AUCKLAND REGION

This symposium is to be held from 4 - 7 p.m. on Tuesday 12 October with a panel of five speakers and is being convened by Mr Warwick Prebble of the Geology Department, University of Auckland. A report on the symposium will be included in the next issue of N.Z. Geomechanics News.

J.P.B.

WELLINGTON GROUP

To date four of the six meetings planned for the year have taken place.

In June Mr W. Partel, of the Mines Department, spoke about "Coal Mining in New Zealand - History and Future Development". Firstly Mr Partel outlined the extent of New Zealand's coal reserves and projected production to meet likely demand. He then went on to talk about the planning and development involved in bringing on stream a large mine such as the new Huntly No. 1 mine. Methods of mining employed overseas to provide high extraction rates, and their application to New Zealand conditions, were also discussed.

In July Mr J.C. Rutledge of the M.W.D. gave an account of his recent overseas trip. Mr Rutledge toured through the United States, Europe and finally attended the "Tunnelling '76" conference in London. In a particularly well presented and illustrated talk he covered three broad topics.

Firstly he discussed the various classification schemes used to predict support requirements and performance of underground structures. These classification approaches are designed as a means of extrapolating data from past experience to new sites with differing conditions. The condition of the rock is assessed by rating a number of factors separately in terms of common procedures, e.g. joint spacing, degree of weathering etc. The overall rating is then arrived at by combining the individual figures. Secondly, Mr Rutledge reviewed construction methods and equipment. He noted that European contractors were having a considerable impact in the U.K. The so-called "New Austrian Method" of providing tunnel support was described. The principle is to provide continuous support for the newly exposed rock as soon as possible after excavation. This is done by the application of shotcrete. Mr Rutledge explained how difficult places such as crush zones and wet areas are handled. Finally Mr Rutledge made some observations about the reinforced earth retaining walls he had seen. It seems that detailing may be a source of bother and raises questions about the long term viability of the walls. The response to earthquakes was also suggested as an area of concern.

In August Mr G.J. Lensen and Mr P.R. Wood of the Geological Survey spoke about New Zealand Earth Deformation Measurements.

Firstly Mr Lensen explained by means of slides many of the historic movements in the Wellington area. This was followed by a survey of the current measurements underway in New Zealand and around Wellington in particular. Triangulation in the Wellington area has revealed a relative horizontal movement across the Wellington Fault of approximately 17cm in the 40 year period 1926-1969. Finally Mr Wood described the most impressive array of sophisticated surveying equipment that is being employed for the current measurements.

In September Mr L.E. Oborn, also of the Geological Survey, told of his experiences during a six month sojourn with a consulting firm in California. The firm, Woodward, Clyde and Associates, has a professional staff in excess of 700. Mr Oborn explained how the firm was organised and operated.

The final half of Mr Oborn's talk was taken up with an interesting account of the geotechnical investigations undertaken for a nuclear power station site in the State of Washington. The initial phase of this investigation was a thorough reconnaissance of a 200 mile radius about the site in an attempt to locate active faults. A large range of techniques was used, many of them conventional and many more unconventional. Only when the site is passed as acceptable from this overview is a more detailed investigation of the region surrounding the site undertaken and finally the detailed investigation of the foundation conditions of the site undertaken.

The work required in this investigation was vast. One wonders if there is any site in New Zealand that would be regarded as acceptable for a nuclear power station if such stringent investigations are required.

M.J.P.

LEGAL ASPECTS OF GEOTECHNICAL WORKS

In April 1976 the Auckland Group of the N.Z. Geomechanics Society was addressed on this topic by Mr D.F.G. Sheppard, an Auckland barrister and solicitor. Set out below is a summary of Mr Sheppard's address and the discussion which followed.

Mr Sheppard said that for an engineer to be liable in negligence it does not just mean that he has made a mistake. The law recognises that a man can make mistakes and errors of judgement and therefore a professional man is not necessarily going to be held liable for every mistake which he makes. However, he may be required to make reimbursement for damage which is caused in certain cases.

An engineer who is consulted by a client in a normal professional relationship has a duty of care, either to a person of a group of persons in this way. That is, the engineer has an obligation to his client to be careful in using his skill.

Also, the engineer has an obligation in tort to a wider range of people who might be affected by his actions. He owes these people a duty of care but any loss which they may suffer is not necessarily a legal liability on the engineer. He will only be held liable if he was careless. The first test which the courts will apply as to carelessness is to enquire whether other engineers of skill and experience in their profession would have acted in the same way in similar circumstances. Engineers of some experience and repute within their profession will be asked what they would have done. If they would have acted in the same way, this is strong evidence against there having been any negligence.

But any breach of duty must be reasonably clear and self-evident to result in legal liability. To show that better methods might have been used does not necessarily mean that the methods in fact employed were so unprofessional or unskilled as to amount to negligence. But it is evidence, though not conclusive evidence, of ignorance or unskilfulness for a professional man to act contrary to the established principles which are universally recognised by members of his profession. However, the question whether a professional man has failed to reach the required standard is in the end determined by the Court and not by his professional colleagues' general practice. The Court may come to the conclusion that the standards described by his fellows do not reach the standard required by law -namely that of a reasonable, prudent engineer.

In summary, a civil action for professional negligence can be brought against an engineer "in contract" by his client or employer or "in tort" by any other person to whom he owes a "duty of care". (A test for whether or not there is a duty of care is whether the other person can reasonably be foreseen to suffer a loss if the engineer fails to exercise the requisite care). Whether the action is in contract or in tort, the case will probably proceed on the basis that as a professional man undertaking a professional task, the engineer has assumed an obligation to perform that task in a manner appropriate to his qualifications and status.

The law does not ask for perfection but a general standard of care and skill by a professional man of the same standard as would be supplied by his colleagues in the profession. To illustrate this, Mr Sheppard then made reference to a number of recent court decisions.

Bognuda v. Upton and Shearer (1971)

A wall of a service station on the boundary of a property was damaged by excavation of soil of a poor type in a trench immediately adjacent to the boundary. The Supreme Court held that the excavator was not liable for his actions as it was the weight of the wall which had caused the collapse. (Refer N.Z. Geomechanics News, No. 2, p.3). The owner of the service station appealed to the Court of Appeal who ruled that he was owed a duty of care by the excavators who were hence liable for the consequences. (Refer N.Z. Geomechanics News, No. 5, p.16).

In making this decision the court said that they would not expect the required standard of care to be at an unreasonable level, and certainly not to absolute liability, but in this case the excavating contractor had failed to take even elementary precautionary measures.

Gabolinsky v. Hamilton City Council (1974)

An area had been used as a gravel pit and sand pit from 1928. After World War 2 transit houses were constructed on the area and these were removed in the late 1950s and the Hamilton City Council made a residential subdivision out of the land. Sections in the subdivision were leased by the Council, one of the conditions being that houses had to be built within two years of taking up the lease.

Mr and Mrs Gabolinsky built a house on the land and lived in it for ten years before settlement occurred at one corner of the house and repairs were carried out which cost $3000 plus engineer's fees. The Gabolinskys sued the Hamilton City Council to recover this money. The history of the area came out during the court hearing. It was found that beneath the ground surface there was 3 ft of good soil, although plainly fill material. Below that there was found poor quality soil (rubbish) which was gradually decomposing and as it did so the ground settled and the fill subsided, the house dropped and the damage was caused. It was established that the rubbish must have been placed on the site during ownership of the land by the Council as it had owned the land since 1928 and should have known the quality of the material being placed there. The Judge referred to the Dutton v. Bognor Regis Council case (discussed later in this article).

The Hamilton City Council had specified that all house foundations were to be taken down to original solid ground but the Judge found that any reasonable builder who did not know that underneath the ground surface there was poor material would have assumed from inspection that the ground was satisfactory. The Judge held that the Council had failed to take proper care in preparing the subdivision and awarded the full costs of repairs to the Gabolinskys plus $500 general damages.

McLaren Maycroft & Co v. Fletcher Development Co Ltd (1971)

This case concerned a subdivision in Lower Hutt. The developers had 39 acres and a firm of consulting engineers were engaged by them to do the subdivision scheme for 195 building lots. A contract was let to an earthworks contractor with the consulting engineers supervising. Part of the ground area of the subdivision consisted of swampy material which was unsuitable for compaction and was excavated out and removed and replaced with a controlled compacted fill material. The subdivision was put on the market and a brick veneer house was built for a Mr H. by a builder, Mr C. Subsidence occurred at one end of the house and Mr H. sued Mr C. and also sued the developers who joined the consulting engineers and the earthworks contractor as defendants. The real issue turned out to be between the consulting engineers and the developers. This was whether the developers could pass on their liability to Mr H. to their consulting engineers. As reported in N.Z. Geomechanics News, No. 2, p. 3, the consulting engineers had requested the standard additional percentage fee for full supervision of construction work but this request had been declined by the developers. Consequently only limited supervision of construction work was carried out. However, at the end of the work the consulting engineers issued a certificate stating that all unsuitable material had been removed from the site before placing of fill began. Evidence was presented by a soils engineer (acting for Mr C.) who had dug a pit which revealed that beneath a surface layer of gravel fill there was a pocket of unsuitable material - peat - at the corner where the house had subsided but it could not be established whether this peat had been exposed during the excavation work prior to placing of the fill. The Supreme Court Judge said that the critical phase of the operation was when the decision was made as to whether enough unsuitable material had been removed. Therefore, given that detailed supervision had not been required by the developers or the consulting engineers, the Judge ruled that the work needed special supervision only at that stage. In his evidence the soils engineer said that in his opinion in order to ensure that all unsuitable material had been removed the consulting engineer should have dug test pits over the area. However, the consulting engineer had relied on observation of the passage of a heavy wheeled vehicle over the whole site to detect any soft areas. The Judge ruled that the contractor was not to be held liable for any of the damage. He apportioned 75% of all the damages against the consulting engineers. The other 25% was apportioned against the developers who should have appreciated the limited nature of the supervision provided for under the consulting engineer's terms of engagement.

However, in 1973 this case was taken to the Court of Appeal where the consulting engineers were exonerated and the developer had to pay the full costs involved (as reported in N.Z. Geomechanics News, No. 8, p. 10). The consulting engineers claimed that the Supreme Court Judge had interpreted their duty in such a way as to make them virtually a guarantor of proper performance of the contract. In the Supreme Court the evidence had not established that the method of digging test pits was a general practice on the part of engineers.

The fact that the soft material was not discovered by the test with a wheeled vehicle indicated that the test may not have been made in this particular area, which suggested some failure on the part of the contractor. The Court considered that the duty of the consulting engineers extended no further than establishing at the beginning of the work that the contractor was using methods of a reasonable kind and making personal observations from time to time and particular visits at certain stages of the work to check if the work was being carried out in a satisfactory manner. The developers maintained that a higher standard of supervision was required if a completion certificate was required at the end of the work, which meant that the contractor was relieved of his responsibility by the employer. Therefore this could be a situation where a higher degree of care was called for by the consulting engineer. However, this viewpoint was not upheld by the court in its findings.

English Case (Greaves Contractors Ltd v. Baynham Meikle and Partners 1975)

This case concerned the design of a building used to store oil. The first floor was damaged by vibration of vehicles. A note in the Code of Practice being used warned the designer to satisfy himself that no unsatisfactory vibrations would be caused by imposed loadings.

At the court hearing there was a divergence of views as to what the ordinary competent engineer would have done in this situation, but it was agreed that engineers should have known what was expected of their design. Because of the warning contained in the Code of Practice the court held that in this situation a higher duty was imposed on the engineer than the law in general imposes on a professional man.

Bevan Investments Ltd v. Blackhall & Struthers (1972)

This case, concerning the building of a recreation centre and squash courts in Porirua, went to the Supreme Court. It was established that the design was not entirely in accordance with the existing Codes of Practice and there was a difference of opinion between engineers on what was good practice, but it was established that the consulting engineer, Mr S., had failed to comply with the Code. He said the profession would generally expect compliance with the Codes as they not only provided a guide to safety, but also there are no really extravagant provisions in them and that he would generally follow them. In evidence Dr P. said that the Code should be followed unless it is shown by analysis that the engineer can do otherwise. In evidence, Mr F. said that if all engineers were required to follow the detailed requirements of all codes this would stifle all advances in the engineering profession. The Judge ruled that a design which substantially departs from codes is a faulty design unless it can be demonstrated that it conforms to accepted engineering practice by rational analysis. Accordingly he awarded damages and costs against the engineer, Mr S.

Hence it appears that an engineer who fails to follow the appropriate code of practice (whether or not he is required to follow it by local authority bylaws) abandons one of his best defences against action based on "professional negligence".

NEGLIGENT MISSTATEMENT

Mr Sheppard then went on in his address to describe the engineer's liability for negligent misstatements with several examples of court rulings in other professions. He did not have any examples of court cases involving engineers in negligent misstatements as engineers by the very nature of their work were generally careful people.

Liability for negligent misstatements would not necessarily be to the engineer's client (with whom he would have a contractural arrangement) but would arise if somebody else had relied on a statement made by the engineer carelessly and as a result the person who had relied on this statement suffered a loss. The cases quoted by Mr Sheppard were as follows.

Auditor

Shares were sold on the basis of a balance sheet which had been audited. It was claimed that on the balance sheet the assets had been overstated and the liabilities underestimated and the purchaser of the shares sued the auditors although he had no contractual relationship with them.

In the Supreme Court it was held that the auditors had no reason to foresee that their certificate would be relied upon by purchasers of shares and so they were not liable. However, the Court of Appeal held that although the auditor did not have any liability from signing the certificate on the account, the fact that the statement of accounts was made available by him to the purchaser and that the auditor had failed to exercise proper care in the checking of at least one of the accounts meant that he was liable in this case.

Real Estate Agent

The real estate agent showed a client a property in Blockhouse Bay, Auckland, and was asked about a mushroom on the property and whether this indicated that the property was on a septic tank rather than on a main sewerage system. The agent told the client that it was on a main sewerage system, as he had been previously told this by the owner of the property. The client relied on this information and sued the real estate agent when he later found that the property was still on a septic tank. In the Magistrates Court it was held that the agent was not expected to exercise any special care in this matter. However, the Supreme Court held that the agent had failed to use reasonable care in that he did not make any check on the information which had previously been given to him subsequent to the pointint out of the mushroom and the specific enquiry by the purchaser. He was thus held to be liable even though he had no contractual relationship with the purchaser but only with the seller of the property.

Architect

This case concerned a block layer who stopped work on a project until he was paid for his work. The architect arranged this payment and assured him that ample funds were available to pay for the balance of his work. When the blocklayer finished work this was found not to be so and hence he was not paid for the balance of the work. The blocklayer then sued the architect and the court held that the architect had a duty of care, more particularly since he had a financial interest in the finishing of the property so that he could claim his fees.

GENERAL DISCUSSION

After Mr Sheppard's address the following matters were raised during the general discussion.

The question of standards which are promulgated by the Standards Association of New Zealand and adopted by local authorities was raised. The question was asked as to what the legal situation is with provisional codes of practice which set out methods of design or construction as the basis of a way to proceed, but which have not yet been formally adopted. Mr Sheppard said that if an engineer is aware of the existence of a provisional code of practice but decides rather to use his own method, the mere fact of failing to follow the code will not make the engineer liable. However, failure to use the practices which would be adopted by the majority of his engineering colleagues in the same situation could make the engineer liable. Mr Sheppard said that he did not regard codes as the ultimate answer. If an engineer had departed from the code for reasons which are valid and cogent he should have no greater liability than the engineer who designed by the code.

A question was asked about the general standard of care which would be required of a specialist in geomechanics (foundation engineering). Would a higher standard of care be required in a foundation design by a person who considers himself to be a specialist? Also, what is the position of a general engineer who undertakes work generally carried out by a specialist? In reply Mr Sheppard said that the court and the public would expect a higher standard of skill by a specialist engineer within his particular speciality, but not a higher standard of care than a general practitioner. If asked to prepare a foundation design for a building, a general practitioner would be expected not to overlook any matter which a specialist would have considered in exercising his skill on the foundation design. If the general run of the profession would have called in a specialist engineer for a particular problem then if the general practitioner does not, he could be held not to have exercised a sufficient standard of care.

The point was made that in the case of the subdivision in Lower Hutt the developers were not held to be negligent but were liable because they had a contract with the purchaser of the section. In fact, the issue of any professional liability on the part of the developers was not tested in the court action.

The question was raised as to whether an engineer can limit his liability. To this Mr Sheppard replied that an engineer cannot effectively limit his liability in tort as in this case the person suing him is not a party to a contract and is not restricted by a term in the contract of engagement limiting liability. However, the chances are that as engineers do not generally tell people who are not their clients that buildings or land are safe, they do not run a high risk of becoming liable in tort. If his client or a Local Body shows to other people a report written by the engineer, there is a possibility of liability in tort but as long as the engineer has exercised the standard of care required of him he will not be held liable. If in preparing any reports an engineer is relying on the statements of other people, he usually will say so in his report, i.e. he will make statements such as "on the assumption that ....".

The question was raised whether if the estate agent who was found liable for a negligent misstatement had gone back and asked the owner again and had still received the answer that the house was on a main sewer line, he probably would not have been held to be negligent. If he had made an enquiry of the local Council and had still be misinformed then he would almost certainly have been held not to be negligent.

A question was raised as to whether the limit on time for liability had been exceeded in the Gabolinsky v. Hamilton City Council case. To this Mr Sheppard replied that a party would not usually be held to be liable after a time of six years had expired, but as the Hamilton City Council was held to have known that poor fill had been placed on the land prior to its subdivision on their behalf, this was an exception to the normal limitation of six years. Fraud does not necessarily only apply to statements actually made, but failure to make statements to inform people can also be regarded as fraud. Although the limits to liability under a contract is six years (i.e. of an engineer to his client), under tort the period of liability can be held to run for six years after the defect is first discovered. Therefore in some cases, although an action may not be possible under a contract, it may be possible to take an action under tort.

Finally, the question was raised as to the powers of a local authority building inspector in overruling the recommendations which may have been made by a registered engineer regarding foundations for a house. This was also related to the Dutton v. Bognor Regis (1972) case in England (described in N.Z. Geomechanics News, No. 6, pp 25-27). In reply to this Mr Sheppard made the following points:

1. The law regarding standard of care applies to a building inspector as to an engineer. However, the standard of care required from a building inspector may in fact be rather different to that from an engineer because of their different qualifications.

2. It is not yet clear whether the ruling in the Bognor Regis case will be found to be applicable in New Zealand. Litigation is at present coming up which should make this clear. (The decision of the Supreme Court in Hope v. Manukau City, given since the address, established the application of the Bognor Regis principle in New Zealand. This discussion may be the subject of an appeal to the Court of Appeal).

3. When a building inspector checks the work of an engineer it may

be that he believes that he has knowledge regarding a certain area or site which the engineer may not have been aware of when he made his decision.

4. Unless a building inspector feels that a certificate provided by a registered engineer allows him to pass his responsibility on, he will still feel that he has an obligation to do his job.

5. Certain obligations are mandatory to building inspectors and they may not feel they can waive them under any circumstances.

Finally it was pointed out that the standard of care which was required of the building inspector in the Bognor Regis case was not very onerous as it was very apparent that the site was a rubbish tip. However, in some cases it would not be so easy to tell if the ground was good or not by the usual type of inspection made of the foundations by a building inspector and hence in such cases the exercise of the normal standard of care expected of a building inspector would not necessarily be expected to reveal the problem.

In conclusion, as long as a man's work is carried out with the standard of skill expected of one of his training and knowledge, he should not be held to have exercised an insufficient standard of care.

J.P.B.

IAEG SYMPOSIUM ON LANDSLIDES AND OTHER MASS MOVEMENTS

1. Date and place

The Symposium will be held in Prague at the Intercontinental Hotel on September 15 -16, 1977. The IAEG Council meeting will be held at the same place on September 13 -14, 1977. The participation in the Council meeting will be free of charge.

2. Themes

The themes have been chosen in accordance with our proposal submitted at the Council meeting at Krefeld. Theme No. 1 has been completed according to the suggestion of Professor Arnold. The themes are the following ones:

1. Systematic reconnaisance mapping and registration of slope movements, estimation of risks due to landslides.
2. Deep-reaching gravitational deformations of mountain slopes.
3. Assessment of the effectiveness of corrective measures in relation to geological conditions and types of slope movements.
4. Modern methods used in study of mass movements.

3. Program

Every theme will be treated in a half day technical session. This session will consist of:

- The presentation of the general report,
- The presentation of the panel members contributions,
- The discussion on the main problems raised by the general reporter and panelists.

Two excursions are being prepared. A two-day excursion will be organised before the Symposium, a four-day excusion will follow the Symposium.

4. General Reporters and Panelists

The following experts have been invited to act as general reporters and panelists.

Theme 1 -	General reporter:	Prof. V. Cotecchia (Italy).
	Panel members:	Dr J. Bazynski (Poland)
		Dr D. Radbruch-Hall (USA)
		Dr J. Pasek (CSSR)
Theme 2 -	General reporter:	Prof. G.I. Ter-Stepanjan (USSR)
	Panel members:	Dr M. Humbert (France)
		Dr U. Zischinsky (Austria)
		Dr A. Nemcok (CSSR)
Theme 3 -	General reporter:	Dr J.N. Hutchinson (England)
		Prof. S. Yamaguchi (Japan)
		Dr D. Varnes (USA)
		Prof. K.J. Klengel (GDR)
Theme 4 -	General reporter:	Prof. V. Mencl (CSSR)
	Panel members:	Prof. G.S. Zolotarev (USSR)
		Dr A.G. Yague (Spain)
		Ing. S. Novosad (CSSR)

All invited general reporters have confirmed their cooperation. However, the Organizing Committee has not yet received the replies from six invited panel members, namely from Dr Bazynski, Dr Humbert, Dr Zischinsky, Dr Varnes, Prof. Klengel and Prof. Zolotarev. All named specialists have been asked once more to act as panel members or to suggest another IAEG member from their countries to this function.

5. Distribution of the Circulars

The first circular was distributed in April. Altogether 690 copies were sent to 243 individuals and organizations (including IAEG National Groups). All members of the Executive Committee have been informed by the letter enclosed to the circular that the IAEG Council meeting will be held on September 13 -14 1977 in Prague. The same information has been sent to all IAEG National Groups. All members of the Working Commission "Mass Movements" have been invited to participate in the session of this commission. The second (and last) circular will have been published and distributed by the end of Oxtober 1976. Altogether 700 copies will be printed.

6. Papers

Until July 20th 1976 altogether 50 papers bave been announced by 17 foreign authors and 33 by Czechoslovak authors. From this number 13 papers will deal with the theme 1, 10 with the theme 2, 5 with the theme 3 and 22 with the theme 4. All the papers will be published in the Bulletin of the IAEG prior to the Symposium. The general reports and the contributions of the panel members will be provisionally printed and distributed to the participants in Prague. The definitive version of the general reports and contributions of the panel members will be published in the Bulletin together with the discussion and conclusions.

ENGINEERING GEOLOGY AT THE 25TH INTERNATIONAL GEOLOGICAL CONGRESS, SYDNEY, AUGUST 1976

The Congress, which is held every four years, took place at Sydney University from 14-24 August. The scientific sessions were programmed in 17 simultaneous sections, and there were also several symposia, mostly sponsored by specialist international geological bodies.

Engineering geology was catered for in Section 13, which had as its theme "The contribution of geology towards management of the environment", and in Symposium 113.1, "Geological hazards and the environment", which was sponsored by the International Society of Engineering Geology.

The authors and titles of the papers presented are listed here. Abstracts of most were available at the Congress, and the complete papers are to be published in the Bulletin of the Association of Engineering Geology.

"The contribution of geology towards management of the Environment" Papers

Bell, D.H. - Slope evolution and slope stability, Kawarau Valley, Central Otago, New Zealand.

Knights, C.J.; Matthews, W.L. - A landslip study in Tertiary sediments, Tasmania.

Radbruch-Hall, D.; Varnes, D.J. - Gravitational spreading of steepsided ridges in western United States.

Solonenko, V.P. - Landslides and collapses in seismic zones and their prediction. (Not presented)

Denness, B.; Riddolls, B.W. - The influence of geological factors on the slope stability of the London Clay of Essex, England.

O'Loughlin, C.L.; Pearce, A.J. - Influence of Cenozoic geology on mass movement and sediment yield response to forest removal, North Westland, New Zealand.

Lomtadze, V.D.- The development of gravitational processes. (Not presented)

Kahl, R.W. - Laterites in road construction, Nigeria.

Whelan, T. et al - The occurrence of methane in Recent deltaic sediments and its effect on soil stability.

Ronka, E., Uusinoka, R. - The problem of peat upheaval in the man-made lakes of Finland.

Shibakova, V.A. - On the possibility of using microwave energy for soil stabilization.

Prokopovich, N. - Geological factors determining land subsidence.

Selby, J. - Engineering geology and subdivision in South Australia.

Stewart, R.M. et al. - The review process and the adequacy of geologic reports.

Albani, A.D.; Brown, G.A. - Geological contribution to environmental management of coastal lagoons at Gosford, New South Wales.

Buachidze, J.M. et al. - Engineering geological evaluation of current geological processes on the Caucasian Black Sea Shelf aiming at rational coastal development. (Not presented)

Goldsmith, V. et al. A shoreface process-response model for the New Jersey (USA) beaches adjacent to the planned AGS offshore nuclear power plant.

Shlemon, R.J.; Capacete, J.L. - Applications of Holocene geological data for siting nuclear plants: An example from Puerto Rico.

Hofmann, G.W. - Environmental mapping in southeast Queensland: A first approach.

Rockaway, J.D. - Impact of mapping scales and procedures on the relative cost and potential usefulness of engineering geologic maps.

Leith, C.J. et al. - Land use planning - geophysical investigation of archaeological sites.

Merla, A. et al. - Detailed engineering-geological mapping in selected Italian mountainous areas: Methodology and examples.

de Moor, G.; de Breuck - Preparation of semi-detailed lithological and hydrogeologic maps for land management by means of a geoelectrical survey.

Matula, M.; Dearman, W.R. - Environmental aspects of engineering geological mapping.

Altug, S. - The relationship between the geological setting and karstification in the Manavgat-Omapiner reservoir, Western Taurid, Turkey.

Anderson, O.L.; Grew, P.C. - Coal and water in the desert: Environmental geology of coal resources development near Lake Pavell, U.S.A.

Bowen, K.G. - A combined operating and reclamation scheme for a hornfels quarry, Victoria.

Burgess, P.J. - The role of engineering geology in developing Sydney's environment - past, present, and future.

Gordon, F.R. - The Coastal Limestone Formation of Western Australia and its environmental implications.

Kennedy, M.P. - The character and recency of faulting along the Elsinore fault zone in Riverside County, California, U.S.A.

Schmidt, R.A.M. - Environmental and geologic concerns in construction of the Trans-Alaska Pipeline.

DeBuchananne, G.D.; Stevens, P.R. - Problems in shallow land disposal of solid low level radioactive waste in the United States.

Langer, M. - Engineering-geological problems of underground disposal of wastes in salt caverns.

Angino, E.E. et al. - Antarctica - a potential international burial area for high-level radioactive wastes.

"Geological hazards & the environment" Papers

Fournier D'Albe, E.M. - Natural and geological hazards. (Not presented)

Campbell, I. - The influence of geological hazards on legislation in California.

Radbruck-Hall, D.; Varnes, D.J. - Landslides, cause and effect.

Barberi, F.; Gasparini, P. - Volcanic hazards.

Neal, V.E. - Lahars as major geological hazards.

Lensen, G.J. - Tectonic hazards and their effect on town planning.

Stapledon, D.H. - Geological hazards and water storage, past and future.

Arnould, M. - Geological hazards; legal, technical and general.

A few papers involving geomechanics were programmed in other Sections of the Congress:

Rockaway, J.D.; Stephenson, R.W. - Physical properties of clayshales underlying coal seams.

Denness, B. et al. - Engineering evaluation of seabed sediments by cluster analysis.

Denness, B.; McQuillan, R. - Teotechnical evidence of cyclic depositional environments off Nova Scotia.

Montari, R. - Stratigraphic correlations of Plio-Pleistocene clays by means of technical properties.

The wide range of topics covered and usually vigorous discussion indicate the current awareness of the importance of geological and geomechanical studies for proper environmental management. Papers and dicussions on engineering geological mapping for land-use purposes were of particular interest. There was general agreement that the need for this in urban areas was still hardly appreciated outside the geological profession. This situation could be improved by closer liaison with planners, especially so that the data made available to them are presented in a form appropriate to their needs.

At the conclusion of the engineering geology sessions of the Congress, a spare hour was devoted to an informal discussion on "Field techniques in engineering geology". There was a brisk exchange of ideas on water pressure testing, and it was clear that a much longer period could have been used to discuss other topics.

B.W.R.

INVESTIGATION OF STRESS IN ROCK - ADVANCES IN ROCK STRESS MEASUREMENT

INTERNATIONAL SOCIETY FOR ROCK MECHANICS SYMPOSIUM, 1976

The symposium was held at Sydney University from 11-13 August, 1976. The purpose of the symposium was to outline significant developments in rock stress measurement which have taken place since the ISRM conducted its last rock stress symposium at Lisbon in 1969.

A wide variety of papers describing a number of stress measurement techniques were presented. Such techniques included;

C.S.I.R. triaxial strain cell
C.S.I.R.O. triaxial strain cell
cylindrical borehole jacks
hydraulic fracturing
overcoring of mechanically instrumented rock

Of particular interest was the development of the C.S.I.R.O. 'hollow inclusion' triaxial strain cell. This cell is a development of the original hollow cell used by Rocha in Portugal and has now been developed to a sophisticated state.

A field visit to the Appin Colliery (Wollongong) was arranged and registrants were able to see equipment monitoring stress changes in coal pillars and to observe strain cells under construction in the BHP/AIS rock mechanics laboratory.

Authors and titles of the papers presented are listed below. Copies of the conference proceedings are held by the Mines Department Library and at Ministry of Works & Development Central Laboratories.

P A P E R S

I.M.P.

LETTERS TO THE EDITOR

Dear Sir,

To our knowledge, guidelines for preparing engineering geological reports similar to the example from California reprinted in the last issue of "Geomechanics News", have not been proposed in New Zealand. There appear to be two issues which require consideration. Are guidelines such as those adopted in California for reports submitted to the Department of Public Works, County of Ventura, required in New Zealand, and if so, are the published guidelines relevant to our conditions?

The main purpose of such guidelines should be to ensure that geologists take full consideration of the kinds of information and recommendations that are necessary in civil engineering work. Few geologists working in the broad field of geology have a feel for engineering geology (an area of geology that has become increasingly quantitative, and a discipline in its own right) and report guidelines may be of assistance to such people. It may also be that some engineers who request engineering geological reports are not fully aware of the sort of information they should expect to receive. If an appropriate set of guidelines is followed in preparing engineering geological reports, it may ensure that the engineer at least sees all pertinent data, so that interpretations and recommendations can be critically reviewed by others. Reports prepared by the Engineering Geology Section of the N.Z. Geological Survey follow lines similar to the Californian ones. However, greater emphasis is placed on distinguishing engineering geology (e.g. the engineering properties of the rocks and their defects, and the influence of these on the particular engineering structure), from descriptions of regional geology (stratigraphy and structure).

It may not be practicable to prepare a list of headings that would cover the wide range of engineering or environmental matters for which engineering geological reports are written, but the Californian example could provide a starting pointfor similar guidelines for New Zealand. Perhaps the Geomechanics Society should take responsibility for formulating and publicising such guidelines.

I.R. Brown, B.W. Riddolls

A TALE OF TWO WALLS

I.M. Parton

Over the past two to three years there has been considerable public discussion and deliberation as to the lengths to which a local body should go in setting standards for subdivision work, and the standard of care and responsibility demanded of that local body in ensuring the stability of slopes and filled ground within subdivisions. Such standards formed the basis of much discussion at the symposium on slope stability organised by the Geomechanics Society in 1974. An awareness of the continuing need to educate the layman on aspects of slope stability in residential subdivisions has resulted in the Society preparing a small booklet on slope stability which will be available for distribution in the near future.

Two cases have recently been brought to the writer's attention involving construction of crib walling. While both were in the same metropolitan area, they were not in the same local body area, and construction of each wall was subject to different standards.

Mr M. purchased an existing dwelling several years ago in a hillside subdivision. The dwelling had a 4m high vertical clay bank approximately 1 m from one wall. During the winter of 1975 the slope failed and to prevent further instability endangering the dwelling, Mr M. decided to retain the slope with a crib wall. Not being familiar with the design aspects and fine details of crib wall construction Mr M. consulted privately, a registered engineer who was able to prepare drawings and give advice for a modest fee, and who liaised with the council on drainage, method of construction, type of backfill and surcharge angle. A permit was issued subject to inspection of the foundation material by a building inspector. Inspections were made, the wall was constructed, and has performed satisfactorily to date.

Mr B. purchased an existing dwelling in another hillside subdivision. The section was bounded on one side by a steep natural slope. The previous owner had benched this slope near the top, as if it might have been his intention to build a retaining wall on this bench. Mr B. decided to construct a crib wall approximately 3 m high and 25 m long on this bench and so increase the amount of flat space available for car parking, etc.

Mr B. decided to design and build the wall himself. Correspondingly, he submitted a plan to the local authority and obtained a permit for construction subject to inspection. The inspection was requested but not made, so Mr B. proceeded to build his crib wall. Mr B. was totally unaware of the need for adequate drainage behind his crib wall and the need to use a free-draining backfill. Furthermore, he was unable to determine whether his foundation was adequate and, in an effort to protect himself, constructed a concrete footing up to 375 mm thick.

As construction was nearing completion, the wall failed during a period of heavy rain. Initially the entire wall and footing slumped approximately 750 mm and Mr B. was advised independently to dismantle the wall and so retrive the crib units. Shortly afterward the slope failed during a further period of heavy rain. The failure has disfigured Mr B's property and resulted in landslip on an adjoining property. Reinstatement of the ground will be expensive.

At this point an examination of the engineering approach to the construction of each wall is relevant. Enquiries revealed that both local bodies advised the home-owner to design his own crib wall from information supplied by the manufacturer, although the adequacy of this design would be checked by the local body. In the first case (Mr M.) the local body was most thorough in its examination of the proposal, requiring a plan, elevation, footing details, drainage details and stipulated method of construction. An inspection was made, when requested, to prove the adequacy of the foundation material.

In the second case the local body required only a plan, and if the owner indicated that the wall was to be founded on good ground, an inspection of the foundation would not necessarily be required. Mr B's permit was issued subject to an inspection which was never made.

Mr B's wall failed. Who was at fault? Should local authorities encourage home owners to design gravity retaining structures from manufacturer's pamphlets which do not detail drainage, foundation requirements, or type of backfill? Provided the engineering section of the local body is prepared to act in a consulting capacity, scrutinising proposals, discussing the design with the prospective builder, and recommending changes where required, the system may be workable - provided on-site control is provided by means of inspection visits.

Perhaps there is a need for local body by-laws to require that walls exceeding 1 m in height not only require a permit for their erection, but are designed and detailed by engineers experienced in that type of work. Without this requirement it is inevitable that local bodies must accept a greater degree of responsibility, not only for the amateur constructor, but also to his neighbours.

Obviously the engineering standards amongst local bodies differ. It is the opinion of the writer that under current by-laws local bodies have a responsibility to the home owner to ensure that, as with dwellings, revetments are constructed in a sound engineering manner.

THE INCLINOMETER MONITORING SYSTEM

A.J. Olsen

Introduction

After some three years experience at the MWD Central Laboratories with a Soil Instruments Mk 2 Inclinometer, it is perhaps opportune to describe a few important features of its installation and operation, and to comment on its effectiveness as a monitoring system for the particular applications for which it has been used.

The inclinometer monitoring system provides a method of measuring and recording horizontal subsurface ground movements, or horizontal structural movements, to a high degree of accuracy. The system consists of access tubing, a torpedo, and a read-out unit. The torpedo is capable of measuring angles to the vertical of the access tube which is positioned either in a borehole or within a structure.

ACCESS TUBE: The extruded anodised aluminium access tube has a nominal 50 mm bore, with four keyways at the circumference (see Figure 1.) The tubes, supplied in 3 m lengths, are joined by 150 mm long coupling sleeves, pop-riveted to adjoining lengths of access tubing.

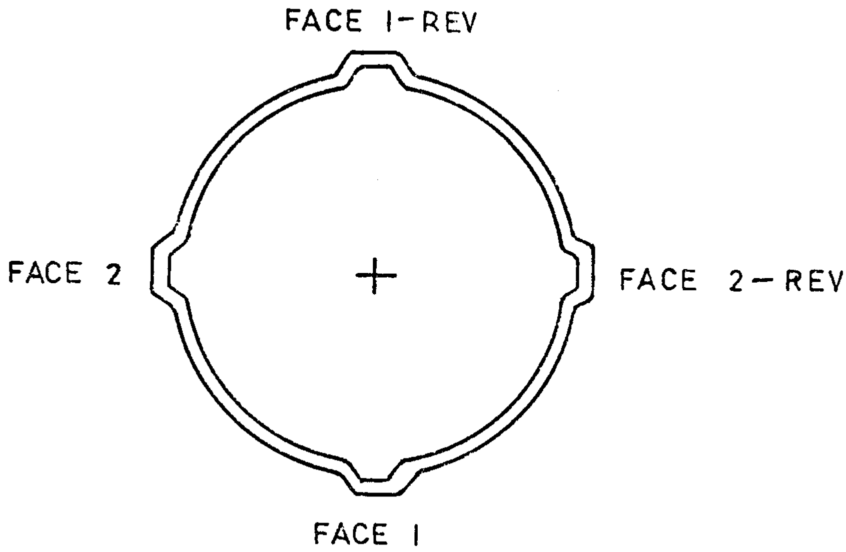


Figure 1. Section of Access Tube

TORPEDO: The torpedo contains a full bridge circuit of four temperature compensated resistance strain gauges, activated by a stiff cantilevered pendulum (see Figure 2). The power supply to the bridge is contained within the read-out unit.

Displacement of the torpedo from the vertical causes movement of the pendulum and hence a change in the output voltage from the bridge. The torpedo is connected to the read-out unit by a cable which carries conductors to the bridge circuit and is used to lower and raise the torpedo in the access tube. A stranded steel wire is incorporated within the cable to carry the weight of the torpedo. The cable is graduated in 0.5 m increments to enable the torpedo to be located at particular depths within the access tube.

The two pairs of wheels on the torpedo are designed to run in the keyways and thus locate the instrument in a fixed direction within the access tube. The sprung wheels on one side hold the fixed wheels on the other side firmly against the 'reading face' of the tube.

READ-OUT UNIT: Soil Instruments Limited market two types of read-out unit, viz, digital and meter read-outs. The digital unit displays both inclination in degrees and displacement in metres. It computes and stores displacements resulting from either 0.5 m or 1.0 m increments of measurement in the access tube. Both parameters are displayed on a 4 digit indicator with a positive or negative sign. The inclination and displacement ranges are $\pm$ 20^{o} and $\pm$ 10 m respectively, with readility of angles to within 0.01^{o} and displacements to within 0.001 m. It has the facility to output data to ancillary recording equipment, but applications of the instrument to date have not required the use of this capability. The unit is powered by internally mounted rechargeable batteries.

The meter read-out displays inclination on two different ranges (0 to 5 and 0 to 25) on a scale graduated in degrees. The unit is powered by internally mounted dry cell batteries.

INSTALLATION: Experience at Central Laboratories has so far been limited to borehole installations. The ideal borehole size is 150 mm diameter which affords adequate space for a grout tube or tremmie pipe to be lowered in beside the assembled access tube. The borehole should penetrate to a depth where no movement is expected. This is important since the bottom of the tube is used as a reference point and in most cases must be assumed fixed. The inclinometer access tube is sealed at its bottom end and is then built up, section by section, as it is lowered into the borehole. The position of the top of the tube should be accurately ascertained by conventional survey techniques. This will enable checks to be made at a later date as to the magnitude of the movement indicated by the inclinometer.

Connection is made between the sides of the borehole and the tube by backfilling with grout, which should be at least as deformable as the surrounding material. The manufacturers recommend a 3:1 bentonite: cement mix for soft clays and silts and a cement grout or pea gravel for stronger materials.

Design and testing for a suitable grout mix was undertaken at Central Laboratories. The following criteria were considered for design:

- the mix should be quite fluid for ease of placing
- it should be resistant to both segregation and bleeding
- it should retain some plasticity when it hardens.

A suitable mix was developed and has been used successfully for installation in both weathered greywacke and Tertiary siltstones. Proportions by weight are:

cement:	bentonite:	sand:	water
4 :	1 :	18 :	8

The sand should be clean and fine, e.g. plasterer's sand. Modifications to this mix may be required for other material types.

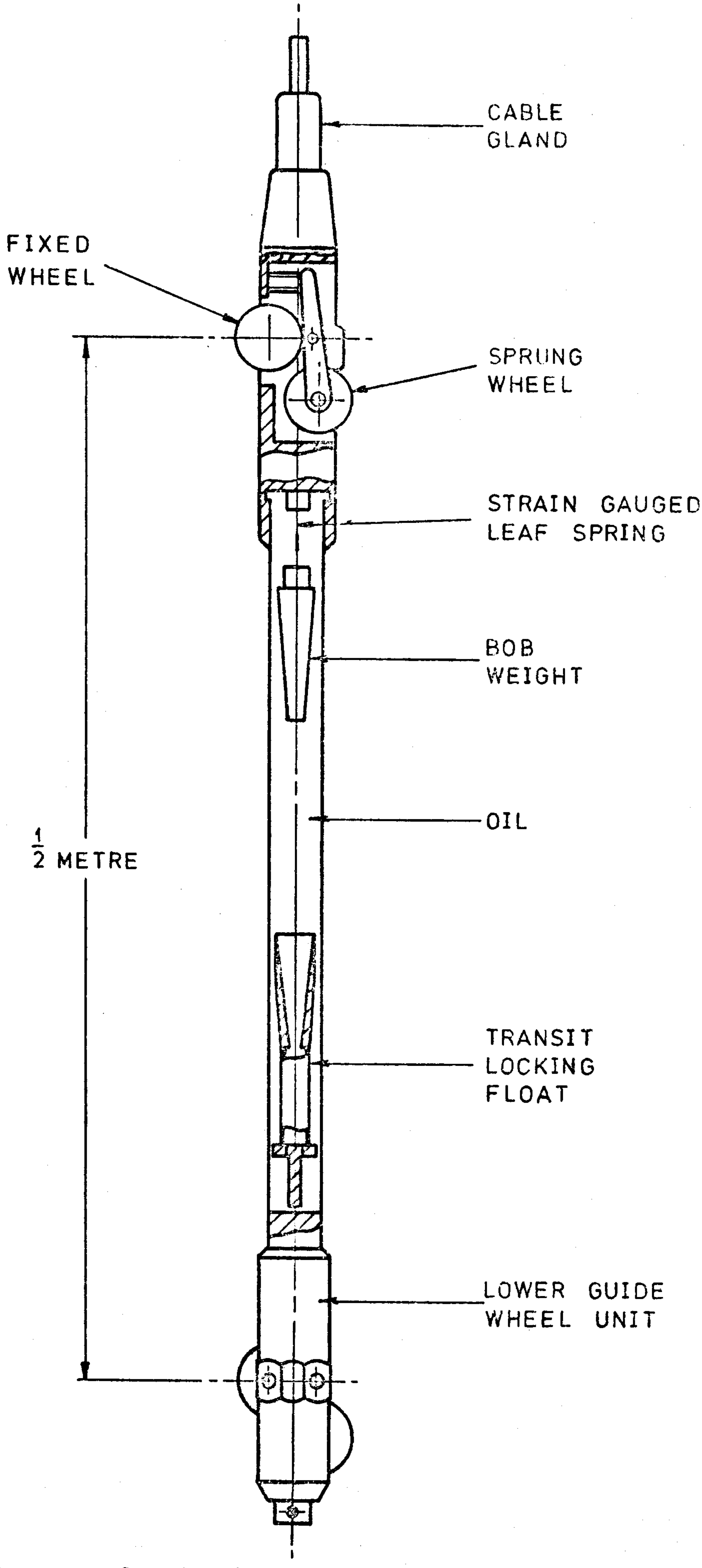
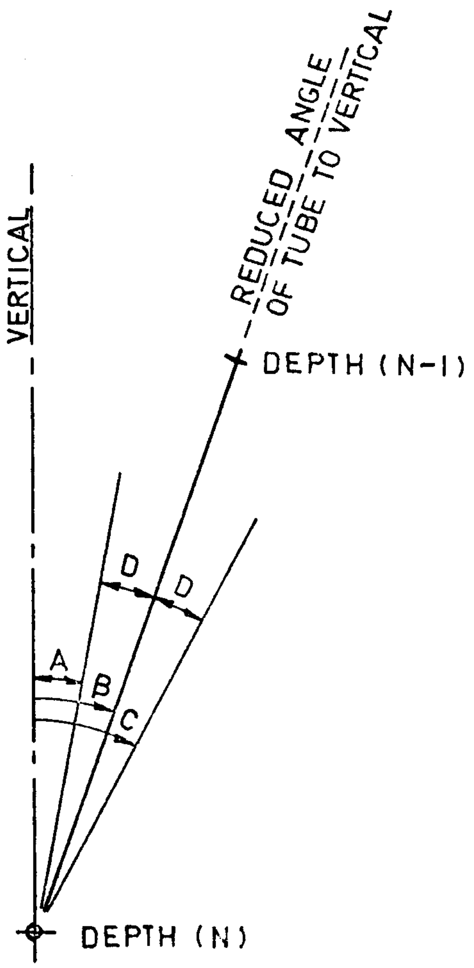


FIGURE 2. INCLINOMETER TORPEDO.



A : READING ON FACE 1 AT DEPTH (N)

C : READING ON FACE 1-REV AT DEPTH (N)

B : REDUCED ANGLE OF TUBE TO VERTICAL AT DEPTH (N) IN THE FACE 1 DIRECTION

$= \frac{1}{2}(A-C)$

D : FACE ERROR

$= \frac{1}{2}(A+C)$

FIGURE 3. DATA REDUCTION

GROUND VIBRATIONS

P.C. Whiteford

INTRODUCTION

When explosives are used in blasting operations it is necessary to limit the magnitude of the ground vibrations to prevent damage to nearby structures. It is also desirable to limit the ground vibration so that people in the vicinity are not alarmed by the explosion. The previous article on ground vibrations (Taylor and Parton (1976)) described how people become alarmed about vibrations at levels which do not cause damage to structures.

The explosion caused by blasting generates seismic waves which produce vibrations at the ground surface whose magnitude depends on the charge weight, the distance from the explosion, and the type of ground. Some of the characteristics of seismic waves and a criterion for assessing safe blasting practices will be described. Details will be given of two methods used for estimating the magnitude of ground vibrations from explosions.

CHARACTERISTICS OF SEISMIC WAVES

When explosives are detonated, extremely high gas pressures are generated in the medium (rock, soil, etc.) surrounding the explosion and a shock wave is formed. The stresses associated with this shock wave initially exceed the compressive strength of the medium, and it crushes the material through which it passes. However, the wave rapidly attenuates as it travels and the stresses soon fall to values below the compressive strength of the medium. At a definite distance from the source, elastic (or seismic) waves are formed from the shock wave. These carry the wave energy and continue to travel away from the source.

The wavefront travelling out from the explosion can be visualised as an expanding spherical shell centred on the explosion. As this shell becomes larger, then the energy density of the wave falls. The energy density is inversely proportional to the area of the shell and so to the square of its radius. Energy is also dissipated in the medium because it is not perfectly elastic. Both these factors cause the decrease in energy density of the wave as it travels through the medium.

As the seismic wave passes from one medium to another with different physical properties, the wave is reflected and refracted and the characteristics of the wave, such as particle displacement or dominant frequencies, change.

Various types of seismic waves form, depending on the structure of the medium. These are divided into two main types: body waves, which travel through the bulk of the medium, and surface waves, which form at the surface of the medium and travel along it. The various waves types travel at different speeds and so arrive at a point some distance from the source at different times. They also attenuate at different rates. Close to the source these various wave types have not separated and cannot be easily distinguished.

The dominant frequencies of the seismic wave depends on the properties of the medium through which it passes. For rock, frequencies are generally between 30 Hz and 100 Hz while on alluvium or swampy ground the frequencies may be less than 10 Hz.

The largest amplitude of particle velocity, particle displacement, or particle acceleration, is used as a criterion for evaluation the effects of ground vibration. The duration of the ground vibration is not taken into account. If different types of explosives are used, then it is necessary to take into account any diferences in the explosive energy per kilogram.

When a number of charges are being fired at time intervals of more than 9 ms, then the charge weight fired at one instant is the parameter used in these evaluations and not the total charge weight fired. Electric delay detonators are used to achieve these time intervals. It is found that by using delays when blasting, more material can be removed from a rock face than when all the charges are fired simultaneously. The U.S. Bureau of Mines (1971) established that the maximum ground particle velocity from two charges separated by a delay in excess of 9 ms is no greater than that from one of the charges alone. Hence not only does the use of delays increase the efficiency of the blasting operation, it also reduces the ground vibration.

A FORMULA TO DESCRIBE THE SEISMIC WAVES

A number of formulae have been developed to describe the amplitude of the ground vibration as a function of charge weight and distance from the explosion. Crandell (1948), Medvedev (1968), Theonen and Windes (1942). Probably the best empirical formula is one developed by the U.S. Bureau of Mines in Bulletin 656 (1971) from statistical analysis of the results of 171 blasts at 26 sites, viz:

$$v = H \left(\frac{\sqrt{w}}{d}\right)^{b} \qquad (1)$$

v - maximum amplitude of particle velocity at point of interest.

d - distance from the explosive to the point of interest.

w - charge weight per delay (i.e. charge weight fired instantaneously)

H and b are constants which apply to one component or particle velocity at one site.

The inverse of the term in paranthesis $(d/\sqrt{w})$ is known as the scaled distance.

In this formula the constant b is often close to one. For such cases the approximate relationships between particle velocity and charge weight and distance are $v \propto \sqrt{w}$, and $v \propto 1/d$.

The particle velocity given by equation (1) applies to a seismic wave travelling in a uniform medium. However, the local geological structure can change the amplitude of the particle velocity, either increasing it or decreasing it from the value predicted by equation (1). These changes occur due to the wave travelling from one medium to another with a different acoustic impedance or from interference, multiple reflection resonance, or focussing of the seismic waves due to the ground structures (Stevenson 1971). Medvedev (1968) claims that the amplitude of the particle velocity can vary by a factor of over 3 between measurements made on compact rocks and made on swampy ground. The U.S. Bureau of Mines in Bulletin 656 (1971) acknowledge that such effects can occur but their tests did not show any appreciable differences in the maximum particle velocity amplitudes on different types of ground. They did however note changes in dominant wave frequencies and in maximum displacement and acceleration amplitudes.

While changes in particle velocities due to varying ground types and structures may not occur often, it is necessary to be aware that they can occur.

CRITERION FOR DAMAGE

When firing explosives it is necessary to limit the ground vibration to magnitudes that nearby structures will withstand without damage. Any of the parameters which characterise ground vibration could be used in a criterion for likelihood of damage providing that it was applicable to all types of ground conditions. Duvall and Fogelson (1961) established, using statistical methods, that particle velocity was more reliable than particle displacement or acceleration, and that ground vibration with particle velocities less than 50 mm/s had a low probability of causing any damage. The U.S. Bureau of Mines Bulletin 656 (1971) also recommends a safe blasting limit of 50 mm/s in any of three mutually perpendicular directions to ensure that the probability of damage is small (probably less than 5%). This criterion has been adopted by N.Z.S. 4403 "The Storage, Handling and Use of Explosives" (1976).

The criterion for damage applies to structures of average strength. In the previous article on ground vibrations it was stated that structures weakened in some way, such as by subsidence of ground, will be susceptible to damage from ground vibrations with particle velocities below the safe limit. (Taylor and Parton (1976)).

ESTIMATION OF SIZE OF CHARGE

There are two common methods for estimating safe charge sizes.

In the first method, the charge size is chosen so that the scaled distance is greater than 25 $m/\sqrt{kg}$. The U.S. Bureau of Mines (1971) found in their numerous tests that the particle velocity did not exceed 50 mm/s when the scaled distance was greater than 25 $m/\sqrt{kg}$. They concluded that, at a scale distance of 25 $m/\sqrt{kg}$, the probability was small of finding a site that produces a vibration level in excess of 50 mm/s. This criterion has been adopted by NZS 4403 (1976).

The scaled distance method of estimating safe charge sizes can be applied to all types of ground conditions. For most types it ensures a large factor of safety, and therefore a smaller charge than necessary to keep within the limit.

When it is desired to increase the charge size to the limit of safe blasting, a second method of assessing maximum charge size can be used. This method determines experimentally the relationship between particle velocity, charge size, and distance.

A series of test shots are fired and the particle velocities for various values of distance and charge weight are measured. These values are used to determine the constants b and H of equation (1) which is then used to predict the charge size that will give the required particle velocity. The measurements should be made near the structure of interest and at first charge sizes could be chosen to give a scaled distance of 25 $m/\sqrt{kg}$ or larger. If possible each of three mutually perpendicular components should be measured and used separately to determine the constants b and H.

If the instrument will measure only one component, three separate measurements should first be made with the same charge weight and distance to establish which component has the largest maximum particle velocity. Further measurements of particle velocity with various values of distance and charge weight should be made for this component.

The best method of obtaining b and H is by regression analysis of v, w, and d in equation (1). A small calculator can be used for this. An alternative method is to evaluate the scaled distance for each measurement and plot this against particle velocity v on log-log graph paper. If the scatter is not too large a line of best fit can then be drawn by eye through the plotted points and the values of b and H obtained from this line. If the scatter is large it will not be possible to obtain satisfactory estimates of the constants b and H of equation (1). However it will be possible to obtain an approximate estimate of the ground vibration levels likely to occur by considering the area covered by the scatter of points. When the scatter is large, a large factor of safety should be used. This procedure should be followed for each of the three components.

MEASUREMENT OF GROUND VIBRATIONS

Ground vibration is measured with equipment consisting of a sensor, an amplifier, and a recorder.

As particle velocity is the parameter required it is preferable to have a sensor with an output proportional to the particle velocity. Many geophones and seismometers satisfy this requirement. If however accelerometers or displacement transducers are used, then the recorded waveform can be converted to particle velocity by integration or differentiation respectively. The sensor needs to be firmly coupled to the ground otherwise the sensor and the elastic earth will form a damped oscillatory system in the frequency range of interest (Wolf 1944).

The amplifier is usually electronic, although it may be mechanical. It should have a gain control.

The recorder should have a frequency response from about 1 Hz to 100 Hz if the aspects of the waveform which are of interest are to be accurately recorded. Photographic galvanometer recorders or fast-response pen recorders give an immediate display of the seismic waveform, although other types of recorders can be used.

A number of companies in New Zealand will undertake the measurement of ground vibration from explosives.

EXAMPLE OF DETERMINING THE CONSTANTS b AND H IN EQUATION (1)

Date measured for seven shots fired in Wellington Harbour and recorded on land (Whiteford 1970) are used in the following illustration. Equation (1) is transformed into the linear equation

$$\log v = \log H + b.\log (\frac{\sqrt{w}}{d})$$

and values for log H and b are obtained by regression analysis from the measured values of v, w, and d. Estimates of log v and the standard errors or 95% confidence limits of the estimates can then be obtained for the desired values of w and d. The value of v can be obtained from log v. The further the values of w and d lie from the range of values that were measured, the larger the 95% confidence limits and hence the less reliable the estimate of v.

The measured values for the longitudinal component (see table 1) are plotted in Fig. 1. Particle velocity is plotted against scaled distance. The regression line $v = 0.07 (\frac{\sqrt{w}}{d})$ is also plotted in Fig. 1.

In Fig. 1 the values of the transverse component of particle velocity (see table 1) are also plotted against scaled distance. They are smaller than the corresponding values for the longitudinal component. The regression line $v - 0.0004 (\frac{\sqrt{w}}{d})^{0.32}$ is also plotted. The scatter of points in Fig.2

is typical of the results obtained from measurements of ground vibration. It is thought that the greater scatter in the transverse component was due to the changes in attenuation in the mud layer on the sea floor through which the transverse waves propagated. The dominant longitudinal waves probably travelled through the sea water through which the transverse waves cannot be transmitted.

In table 2 estimates of v and 95% confidence limits for such an estimate are shown for two values of w and d for the longitudinal component. Table 3 shows values for the transverse component.

CONCLUDING REMARKS

Two methods have been described to ensure that the velocity of ground vibration is kept to less than 50 mm/s, the safe limit of ground vibration.

When it is necessary to blast close to the safe limit or when it is desired to establish the magnitude of ground vibrations accurately (for example when complaints are made) then measurements with instruments should be made and analysed as outlined.

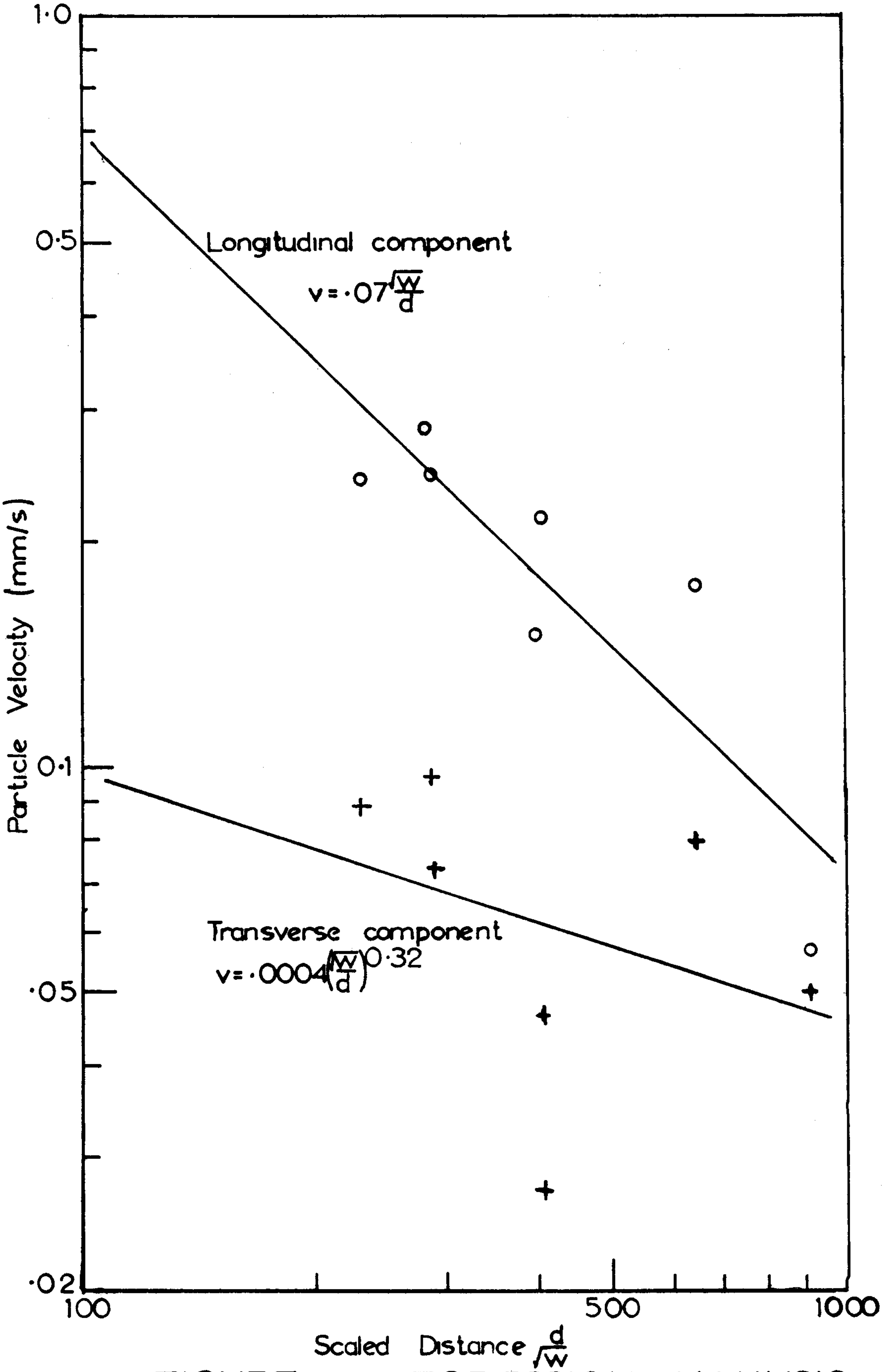


FIGURE 1. REGRESSION ANALYSIS.

Table 1

Values of w, v, and d for the longitudinal and transverse components							
d metres	610	610	610	610	610	610	610
w kg	0.45	0.9	2.27	2.27	4.53	4.53	6.8
v mm/s longitudinal component	0.057	0.176	0.152	0.218	0.25	0.289	0.245
v mm/s transverse component	0.051	0.081	0.028	0.047	0.098	0.074	0.090

Table 2 Estimates of v for the Longitudinal Component

w kg	d m	v mm/s	95% confidence limits of v mm/s lower	upper
.7	610	.1	.069	.15
30	610	.641	.313	1.31

Table 3 Estimates of v for the Transverse Component

w kg	d m	v mm/s	95% confidence limits of v mm/s lower	upper
.7	610	.0513	.0285	.0924
30	610	.0946	.0316	.283

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REFERENCES

Crandell, F.J. (1949) Ground vibrations due to blasting and its effect upon structures: J. Boston Soc. Civ. Eng. 36, p. 222.

Duvall, W.I., and Fogelson, D.E., (1962) Review of criteria for estimating damage to residences from blasting vibrations: U.S. Bureau of Mines Report of Investigations 5968.

Medvedev, W.V., (1968) Evaluation of seismic safety during blasting operations in mines: Bull. Earthq. Res. Inst. Tokyo Univ. 46, p.687.

NZS 4403, (1976) Code of practice for the storage, handling, and use of explosives (Explosives Code): Standards Association of New Zealand.

Stevenson, W.R., (1971) Seismic microzoning in New Zealand: Bulletin of the New Zealand Society for Eqrthquake Engineering, Vol. 4, No. 1, p.43.

Taylor, P.W., Parton, I.M., (1976) Ground vibrations: N.Z. Geomechanics News, No.12.

Thoenen, J.B., and Windes, S.L., (1942) Seismic effects of quarry blasting. Bulletin 442, Govt Printing Office, Washington.

U.S. Bureau of Mines, (1971) Blasting vibrations and their effects on structures: Bulletin 656.

Whiteford, P.C., (1971) Measurements of ground vibrations from explosions: Geophysics Division, D.S.I.R. Report No. 69.

Wolf, A., (1944) The equation of motion of a geophone on the surface of an elastic earth: Geophysics 9, p.29.

NEWS FROM THE MANAGEMENT SECRETARY

1. NEW MEMBERS

New members elected to the Society since the last list was published in issue No. 11 are as follows:

K.G. Barker, G.W. Borrie, J.N. Clapperton, R.M. Dalrymple, M.F. Egan, M.E. Fama, R.F. Jeune, L.M. Kuykandall, A.J. Pickford, G.L. Scott, D.J. Shanks, J.H. Travers, D. Van Barneveld.

2. OLD AERIAL PHOTOGRAPHS

The Department of Lands & Surveys has a library of old aerial photographs which are particularly valuable for land stability problems. The Department appreciate the value of these old photographs for comparison with recent films and has assured us that they are being preserved.

3. FORTHCOMING CONFERENCES AND SYMPOSIA

Listed below are Conferences and Symposia in the 1977 period which we know about. Members may be interested in attending or obtaining Proceedings. Further details can be made available on request.

1977

3-7 January	Symposium on Soil Structure Interaction, Roorkee
10-14 "	Sixth World Conference on Earthquake Engineering, New Delhi
4-6 July	Fifth South East Asian Conference on Soil Engineering, Bangkok, Thailand
7-8 "	International Symposium on Soft Clay, Bangkok, Thailand
11-14 "	Ninth International Conference on Soil Mecahnics and Foundation Engineering
3-7 September	Rockstore 77. A Symposium on storage in excavated rock caverns, Stockholm
17-19 November	New Zealand Geomechanics Society Conference on Tunnelling in New Zealand

4. I.A.E.G. BULLETIN

At the recent Council Meeting in Sydney it was reported that there was a marked increase in the number of papers submitted for publication in the bulletin and there would have to be greater selection of the papers. Members can subscribe to this bulletin at $4.00 per year.

5. PROCEEDINGS, NELSON SYMPOSIUM ON THE STABILITY OF SLOPES IN NATURAL GROUND, NOVEMBER 1974

Copies of the Proceedings are available from the Secretary, N.Z.I.E. at a cost of $15.00 for Society members and $18.00 for non members.

6. PROCEEDINGS, 2ND A-N.Z. CONFERENCE ON GEOMECHANICS HELD IN BRISBANE IN JULY, 1975

Copies of this proceedings are now available from the Secretary, N.Z.I.E. at a cost of $25.00.

7. 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 Management Secretary.

J.M.O. HUGHES
Management Secretary

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 ($1)

International Society for Rock Mechanics (ISRM) Yes/No ($3.50)

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 $4.50

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 ____________________