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MEMBER BUSINESS PRESS BPA ASSOCIATION

Leading article

Professional engineering 217

Papers and articles

Wind machines for large-scale electricity production *Alan F. Wylde* 218

New developments in controlled landfills at Happy Valley, Wellington .... *Philip K. Nordberg* 224

Measurement of thermal gradients under the Wellington Airport runway .... *Allan F. Ward and Jeffery L. Tallon* 227

General

Secretary's newsletter 217

N.Z.I.E. news 229

Consultants' notebook 230

Government Service Division 230

Industries Division 231

Conference discussion 232

N.Z.I.E. Council 1978-9 235

Change in roll 236

Twenty years on—a history of the N.Z. Geomechanics Society 237

Correspondence 238

Candidates for election 239

Obituary 239

Personal 239

Conferences and courses 239

An engineer's bookshelf 240

Cover picture

A large diameter, well-engineered, conventional windmill used to pump water in the industrial zone at Takapuna, Auckland. Windmills for electricity production are discussed in the paper on p. 218.

Photo by Joseph Cameron

NEW ZEALAND

Engineering

THE JOURNAL OF THE N.Z. INSTITUTION OF ENGINEERS* VOL. 33, No. 10, 15 OCTOBER 1978

Professional engineering

ONCE upon a time our journal contained straightforward, interesting papers in which members described their progress and problems in simple terms that were understandable to all within their own discipline and were interesting to most outsiders as well. We were one family united in our diversity.

Now, technology has advanced by leaps and bounds but on narrowing fronts which tend to isolate one section from another so much that some sectors have been referred to as "Exclusive Clubs" to which entry is limited by stern initiation procedures demanding time and effort few can spare, to master the special "jargon" and its related mathematics.

These developments have brought far-reaching changes in the structure of the Institution in the development of "technical groups". Similarly changes in the form of its publications started several years ago when it became evident that the practice of strictly limiting the length of papers significantly impaired their value in too many cases.

There has been much discussion recently about the form and function of *New Zealand Engineering.* It is a sign of health and vigour in the Institution that members' expression of dissatisfaction with the existing state of affairs took the form of practical suggestions for improvement which have stimulated the Council to establish the newsletter appearing for the first time with this month's issue. However, it must be remembered that, no matter how many are the divers interests which demand the attention of the Institution member, there is one responsibility always with him — professional engineering, i.e., attending to the principles behind the practice.

Engineering is making practical use of scientific principles. Professional engineering requires attention to these principles at two levels of complexity. The highest, which is the province of the "exclusive clubs", is the thorough investigation, selection and application of principles for the development of standards and codes of practice by which practical design work can be carried out soundly and quickly. The second level, still a function of the professional engineer, is a thorough but not quite so comprehensive understanding of the principles, so that the use of the standards and codes is monitored to ensure they are not inadequate or misapplied.

These activities proceed in much the same way in each of the engineering disciplines but it is vitally important that disciplines should not lose contact with the rest of the engineering world. The publications committee will be doing its utmost to ensure that papers published in *New Zealand Engineering* help to bridge the gap.

Secretary's newsletter

LAST month, I talked about the policy decision that had been made by the Council to establish a newsletter in addition to this journal. This month, the first issue of the newsletter appears with this issue of *New Zealand Engineering.* It has been produced by the combined work of the publications and public relations committees — the former having done the spade-work on policy, the latter being concerned more with the details of format and presentation.

Those old blue pages

There have been a number of major decisions to make, as anyone who has ever been associated with the birth of anything such as this can imagine. One weighty problem was the colour of the paper. Most members will recall the news section that used to be published in *New Zealand Engineering* on blue paper and thus got the title, the blue pages. That phrase, the blue pages, is still sometimes heard to describe the now white pages in this journal that carry the Institution news items; there were, therefore, good reasons for debating whether or not blue should be chosen again. But there are many points against it. For one thing black ink on blue paper is not easy to read, and the combination tends to be disastrous if you want to print photographs. There is a similar problem with blue ink on white paper; all photos look as if they were taken on the day of the 100-year flood. So blue was discarded, in favour of buff, and we hope it will give us a newsletter that is both distinctive and readable.

The title is usually a contentious matter, but on this occasion, when "Print Out" was suggested, it was adopted without serious dissent. However, there was certain amount of discussion about whether the date should be added to the words "Print Out" and as you will see the date is shown bold and clear.

Share, but not alike

The question of what goes into *Print Out* and what stays in *New Zealand Engineering* has also been a matter for consideration. At the moment it looks as if the material in *New Zealand Engineering* will be very much the same as it has been before. Because of the long lead time in the journal, inevitably it has not catered for the shorter news item that perhaps might not be of interest for more than a week or two or three. The Council is looking to *Print Out* to supply this sort of news to the membership and fill a real need. *Print Out* will have a place for controversy, too, and, perhaps, for just plain cussedness. *New Zealand Engineering* will retain that material which is more matter for record than a passing fancy or the expression of an opinion that subsequent argument might well change.

One column to move permanently from the journal into *Print Out* will be this one, so from next month the leading article will again be restored to its full measure of space.

The mechanics of getting the show on the road might still be creaking a little behind the scenes but at least the designs have been finalised. All the groups involved with producing *Print Out* look now for feedback and support.

V

Wind machines for large-scale electricity production

ALAN F. WYLDE*
M.SC., M.I.NUC.E.

The variability of the wind and its low-energy density are important factors in the design and optimisation of wind energy conversion systems for electricity production. On a world scale two types are currently receiving most attention. A sophisticated experimental model of the horizontal shaft propeller type started operation in late 1975. The Darrieus vertical axis machine, unlike the propeller type, has not been investigated to any extent previously. In operation, both types experience cyclically varying structural loads. Considerable further development is required before either can be marketed commercially.

1. INTRODUCTION

IN public debate on New Zealand's energy resources and the way they should be utilised, the wind has often been cited as a resource with which the country is well endowed. This fact has long been recognised and New Zealand is mentioned in *Power from Wind,'* the account by Putnam of the classic United States attempt to harness the wind for electricity generation in the early 1940s. The wind's extent and characteristics over the country are now being assessed by a task force sponsored by the New Zealand Energy Research and Development Committee, but before it can be harnessed there must be available reliable and economic machines for its conversion to end-use energy forms.

Since the turn of the century, attempts have been made in Denmark, Germany, Russia, France, the United States and the United Kingdom to build machines to convert wind power for large-scale electricity generation in general, without notable success. Whether the wind can be widely used as a competitive means of electricity generation is still an open question.

Since 1973, a number of new attempts have been made to develop wind energy conversion systems for electricity production, and experimental machines have been built in sizes up to 200 kW. Most progress has been made on two types of machine. One typified by the American Mod O machine has a two-bladed propeller and is a horizontal axis wind turbine (HAWT). The other, known as the Darrieus, has a vertical axis of revolution (VAWT).

2. THE WIND AS AN ENERGY SOURCE

The power or energy flux in the wind is a function of the cube of the wind velocity being given by:

$$P = 1/2\, pA\, V3$$

where p is the air density
A is the swept area
V is the wind velocity

In describing the performance of wind machines it is usual to use a coefficient of performance parameter, Cp, which gives the fraction of the windpower which is captured by the machine. It is usually accepted that the maximum theoretical value of Cp is 0.59. Cp values are often presented (Fig. 1) as a function of the dimensionless ratio known as the tip speed ratio

$$\lambda = \omega R / V$$

where V is the wind velocity
X is the tip speed ratio
ω is the angular velocity
R is the radius of the swept area

A dominant characteristic of the wind compared with other energy sources currently used for electricity production is its low energy flux. This low flux necessitates wind machines being large if significant amounts of energy are to be converted. A good wind site might have a mean energy flux of about 400 W/m2, whereas, for example, at the Benmore hydro station with a 92 m head the power density in the penstock is about 4 MW/m^2, a factor of 10 000 greater.

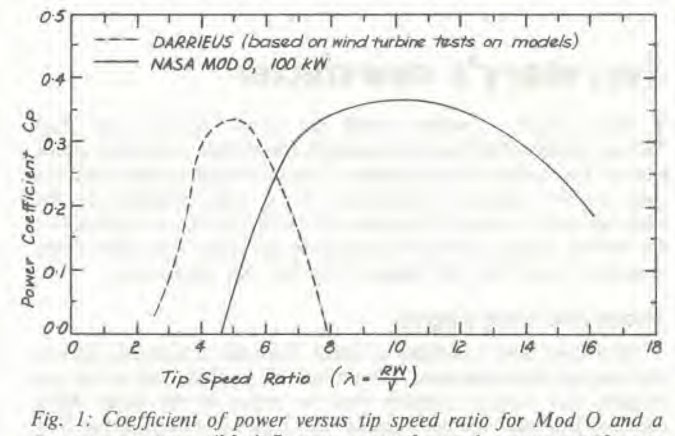

Fig. 1: Coefficient of power versus tip speed ratio for Mod O and a Darrieus machine. (Mod O curve given for pitch setting of 0° at ¾ radius.)

Another characteristic of importance to machine design is the wind's temporal and spatial variability. At any site chosen for a windfarm (a group of wind turbines), the wind flux will have short- and long-term velocity and directional variations. In addition, the flux will vary within the area swept by the machine. These variations have an impact on the structural requirement for the wind machine, as well as on the value of the wind as an energy source for electricity production.

3. ASPECTS OF WIND MACHINE DESIGN

At the present stage of wind energy conversion systems (WECS) development there are no clearly defined superior machine types.

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This paper was first received on 16 March 1978 and in its present form on 6 July 1978.

The achievement of minimum cost electrical energy will not necessarily result from the use of highly sophisticated efficient horizontal axis machines like those being built in the United States. Because the wind is free and the fuel cost thus effectively zero, the concern is to achieve the minimum capital cost per unit of electrical energy produced. This may in practice be achieved with an aerodynamically inefficient machine of cheaper construction.

WECS have been called fatigue testing devices. Parts of the structure of a wind generator will experience over 10^8 major stress cycles in a 30 yr lifetime, making fatigue a major design consideration. The nature of some of the stresses involved is discussed below in the consideration of the two major machine types.

Vibration is potentially a major problem. It will occur whenever the rotor speed is such that the excitation frequencies it produces have values near the machine's natural vibration frequencies. With a fixed speed machine, careful design can ensure that such coincidence is avoided, but it becomes more difficult if the rotor operates over a range of speeds (see Fig. 2).

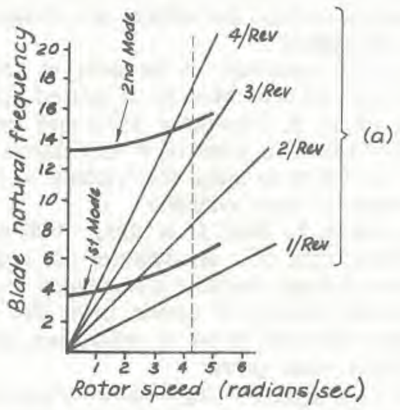

Fig. 2: Typical "fan" diagram showing wind turbine natural vibration frequency plotted against rotor speed — (a) Excitation frequencies.

A variable speed machine can potentially capture a greater portion of the available energy than one with rotation speed constant, but some form of frequency output control is required if the output is to be fed into a power system, and additionally the vibration problem must be faced. Most current designs are thus constant speed machines, though a British design is for a variable speed machine operating at constant tip speed ratio [2]. The advantage of variable speed has been expounded in a recent article which suggested overcoming the vibration problems by building very stiff blades[3].

4. WIND POWER AS A CONTRIBUTOR TO THE POWER SYSTEM

4.1 Long-term wind variability and the economics of wind power

In planning the expansion of the electrical power system the different means of generation are considered in terms of their ability to contribute both power and energy. Over the course of a year there will be a certain total energy demand and resources must be available to meet that demand with some level of confidence. The rate of energy demand (power level) varies, having daily, weekly and seasonal peaks and troughs. The total capacity of the power plant installed must be sufficient to meet the peaks with some margin to allow for the possibility of plant being unavailable. It is possible to schedule routine maintenance to occur away from the times of peak demand so that, except for breakdowns, most types of power plant can be regarded as capable of providing firm power at peak times.

This is not the case with the wind. In a simple analysis, the wind must be regarded as a random energy source liable at any time to make a zero contribution to power supply. Viewed in this way, the cost of energy from wind machines needs to be competitive with the fuel cost associated with generation at fossil-fuelled plant, before it is economically justified to include wind machines in the power system.

The cost of energy from wind power varies markedly with the wind regime at the place where the machines are sited, so that specific site details are necessary in making evaluations. Also, since commercial machines are not yet available, it is not possible at this stage to obtain credible figures for the capital cost of wind turbines. Costings done in the United States [4] have suggested competitive energy production is possible when a site has an average wind speed of 7 m/s, and a big production run is possible for wind machine manufacture. It is highly probable that suitable sites with average wind speeds above this value can be found in New Zealand. Considerable development of WECS is, however, necessary before a world market can be established sufficient to justify a large production run by any manufacturer.

The simple analysis mentioned above, which gives credit only to the energy value of the wind, probably undervalues the benefits of wind power machines to the generating system. It seems likely that wind plant, especially if it is dispersed about the country, will also have some power value. In other words, if wind power is installed, it may be possible to reduce the capacity which would otherwise be installed as a means of meeting system peak demands.

The established methods of generation capacity planning, which model system expansion possibilities, calculate loss of load probabilities at times of peak demand for different options. The techniques used usually regard individual generation units as being available or unavailable at a certain probability level with perhaps a split of the unit's capabilities into base and peak, each having different availabilities. It should be possible to treat wind power with these techniques provided allowance is made for the range of output levels which could occur arising from variation in wind velocity at the windfarm sites; e.g., while there may be only a 1% chance of full output from the windfarm, there may be a 95% chance of a 50% output.

Extensive time-related measurements are thus required of the variation of wind velocity at the windfarm sites to establish the probabilities of different levels of output, particularly at times of system peak. The wind output could then be modelled by splitting the capacity into a number of "units" with different availabilities determined from the site measurements. The wind "units" would be high in the merit order because of their zero fuel cost.

A power system expansion plan, including wind power and giving an acceptable loss of load probability, could then be compared with an alternative expansion without the wind power having the same loss of load probability value, to give an indication of the power value of the wind. The full economic benefit of a wind-power installation, arising from a combination of the fuel saved and the reduction in peaking power required, could then be evaluated.

As far as the operation of the system is concerned, as long as the amount of wind power is small in relation to the system load, the wind power can be regarded as a negative load, fluctuating as do other loads on the system. In general, because of the nature of New Zealand's electricity system, with a high proportion of hydro plant with associated storage, the inclusion of a limited wind generation capacity should be possible without difficulty. The value of the wind operationally would increase if it were possible to forecast it with some certainty since this would allow the scheduling of minor maintenance work on other plant at times when wind was expected. The New Zealand Meteorological Service are participating in an International Energy Agency project to determine the accuracy with which the wind can be predicted on time-scales up to 72 h ahead.

4.2 Short-term fluctuations

An area of wind turbogenerator performance undoubtedly not fully understood and requiring close attention is the dynamic behaviour resulting from short-term fluctuations in the input to the turbine. These short-term fluctuations are caused by turbulence in the wind and by factors inherent in the wind machines which depend on the type of machine in question. The way that these input variations are reflected through into the electric power system depends on the response of the wind turbine blades, the coupling of the turbine to the generator, and the nature of the generator.

The necessity to smooth the torque seen by the generator was recognised in the case of the Smith-Putnam machine the designers of which included a hydraulic coupling device between the wind turbine and the synchronous generator. Synchronous generators are regarded as desirable for power utility applications because of the control they afford over reactive power.

A relatively successful 200 kW wind machine was built at Gedser by the Danes. This used an induction generator having 1% slip at full load. The wind turbine was aerodynamically limited. In other words, the power produced fell off as the wind velocity increased above the operating level. The combination of induction generator and aerodynamically limited blades appears to have been a satisfactory method of dealing with short-term wind variations, though Juul, the machine designer, reported that regular pulsations occurred in the power output and recommended, "that there should be either a mechanically resilient coupling to the generator or else the latter should have a slip fixed empirically at 3 - 4 percent"'.

Johnson and Smith' have made computer simulations of various wind turbine-generator configurations subject to severe wind gusting, and have noted the need for a compliant coupling between a wind turbine and a synchronous generator. They also noted the generally favourable behaviour of an aerodynamically limited turbine driving an induction generator, though a power loss is experienced with a sharp increase in wind velocity.

The Johnson-Smith analysis derived the wind machine input torques directly from the Cp curves. It seems possible that if aeroelastic effects (blades bending) are taken into account the system response with a synchronous generator would be improved. The Canadians have noted the value of rotor elasticity in attenuating the ripple expected from a Darrieus machine'. In order to resolve this question it is clear that further results are necessary, preferably from both more sophisticated modelling and actual experience.

The question of turbulence is of importance in site selection. Undoubtedly some sites will be more gusty than others. The final site selection for any commercial wind generators can only be made when both site and machine characteristics are well defined in this respect.

The effect of wind gusts on the overall output of a windfarm also requires investigation. Wind generators in a windfarm are likely to be spread over a considerable area. To avoid shadowing, an average spacing of 13 diameters has been used in Swedish siting studies'. This means that gusts are unlikely to affect all the machines together, as the extent of the gusts will probably be small in relation to the area of the windfarm. If this is so the short-term variability in output from a farm should be less than that from a single machine. Again, the matter requires study.

5. HORIZONTAL AXIS WIND TURBINES

In most attempts to build wind-driven electricity generators, propeller-type blades rotating about a horizontal axis mounted on a tower have been used. The famous Smith-Putnam machine was of this type'. Currently the main wind research and development activity in the United States is directed to horizontal axis machines. Similar machines are currently being built in Sweden', and have been the subject of a design study in the United Kingdom2.

The first U.S. machine to be built in the current programme is known as Mod 0. It started operation at Plumbrook, Ohio, in December 1975 and has a rated power of 100 kW in a wind of 8 m/s. Some operating experience on which to judge the wisdom of the design decisions made is thus available.

The area swept by Mod 0 is about 1000 m^2 and its output is about that of a six-cylinder car engine. This illustrates how a large machine is necessary to produce a relatively small amount of power from the wind and indicates the difficulty faced in producing competitive electricity from wind power.

The Mod 0 machine is regarded as a test-bed, but it shares its principal features with the machines scheduled to follow it, of 2 and 2½MW size, known as Mod 1 and Mod 2. These machines have two relatively slender twisted and tapered aluminium or fibreglass blades with aerofoil section. The blades are fixed rigidly to the hub and mounted downwind of the tower, angled slightly away from the wind (coning). The blades turn at a constant speed (40 rpm) and drive a synchronous generator on the top of the tower through a step-up gearbox. The whole assembly is rotated by a yawing mechanism about the top of the tower as the wind direction changes.

A number of factors led to this optimised design. The use of only two blades keeps the cost down and the strength of the individual blades up. Their narrow cross-section (solidity) allows their weight to be kept down and means they operate most efficiently at a relatively high tip speed ratio, allowing gearbox costs to be minimised. Placing the blades downwind of the tower reduces the possibility of their hitting the tower, but means they experience a reduced wind flux in the shadow of the tower for part of a revolution. The coning also reduces the chances of a tower hit and serves to relieve stresses; the angle (7° on Mod 0) is chosen to balance aerodynamic and centrifugal forces in the operating condition. The twist in the blades adds to the cost of production but increases the energy output by ensuring the angle of attack of the relative wind is such as to provide lift right along the blade length. Mod 0 blades have 35° of twist.

The use of a constant speed compromises the amount of energy that can be obtained from the system but allows 60 cycle generation to be achieved at minimum

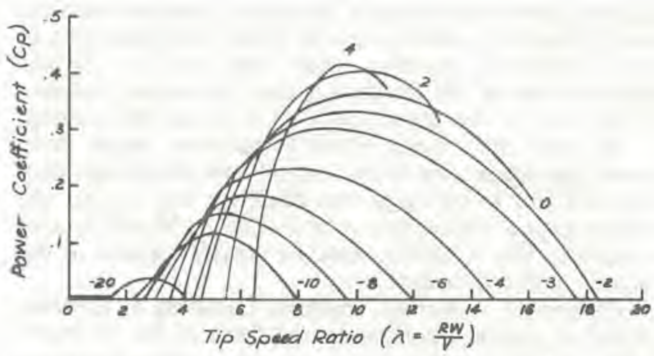

Fig.3: Mod O machine: Variation of power coefficient with tip speed ratio for different pitch angles. (Pitch angles are measured at ¾ radius.)

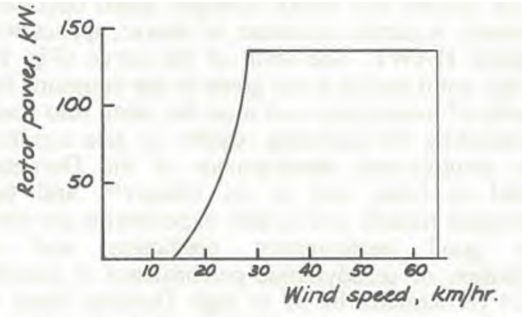

Fig. 4: Mod O: Rotor power as function of wind velocity.

cost. Having a constant speed also reduces potential vibration problems.

At wind speeds beyond the rated speed, the power output from the turbine is limited to the level of the maximum generator output by adjusting the blade pitch to reduce the turbine efficiency (see Fig. 3). This requires a fast-acting pitch control system. The form of the power versus wind-speed curve is shown in Fig. 4.

The design choices made for Mod 0 can be compared with those made for two very much simpler machines, the Gedser 200 kW machine, which has already been mentioned, and a 100 kW machine built in Britain which was specifically optimised for economic performances. Both these machines had fixed pitch, constant cross-section blades leading to control by stalling at high wind speeds as long as the electrical connection was maintained. In each case three blades were used mounted upwind of the tower, despite the fact that this position is less stable than the downwind one. The British machine had untwisted blades, but the Gedser blades were twisted (3° at the tip, 15° at the root).

Both turbines drove induction generators which, as has been noted, appear to satisfactorily smooth variable torque input when used in combination with aerodynamically limited blades. It is of interest to note with respect to this question of torque variation that, subsequent to its first period of operation, damping has been added to the power train of the Mod 0 machine".

5.1 Structural aspects of HAWT

Although the aerodynamic torque on a HAWT is a constant in an even wind regime, the torque seen by the blade roots varies as a result of gravitational effects. This is illustrated in Fig. 5. For the Mod 0 machine operating at its rated output, the maximum weight torque which occurs when the blade is horizontal is about three times the "working" torque of each blade. This is the critical reaction for stress analysis in the rated operating condition". It can be seen that minimising blade weight is an important consideration.

Apart from the gravity effects, other factors can lead to fluctuating forces on the rotor of a HAWT. With a downwind rotor the most important of these varying forces is the flapwise bending moment (out of plane bending moment) which occurs mainly as a result of tower shadow. Spera1[1] showed that at wind speeds above the rated value the flapwise bending moment became significant and concluded that a teetering rather than a hingeless rotor would probably be required in order to relieve the stresses at the blade root.

A teetering rotor provides the simplest form of blade articulation. In such a rotor the two blades are rigidly connected to each other and hinged at the hub as with a see-saw. For Mod 0 the teetering option was rejected, presumably because of the extra complexity and hence increased cost and reduced reliability it would have entailed.

In the early operation of Mod 0 it was found that the blade bending moments due to the tower wake effect were considerably in excess of those calculated. The measured moments in a 12 m/s (27 mph) wind appeared to be consistent with a wind retardation by the tower of 93%, rather than 24% as had been assumed". The central stairway in the structural steel tower has since been removed in an attempt to reduce this problem. Figure 6 shows the out-of-plane bending moment over

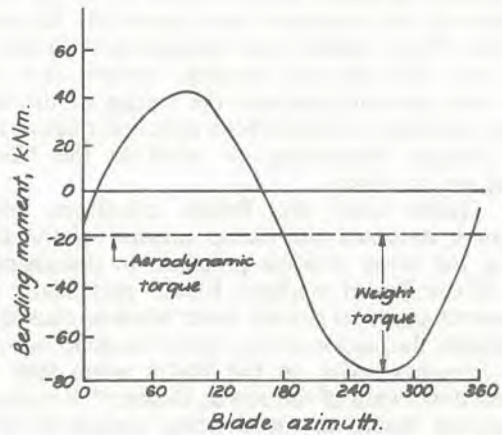

Fig. 5: Mod O: Torque moments at a blade root at rated wind speed of 8 m/s plotted against angle of rotation.

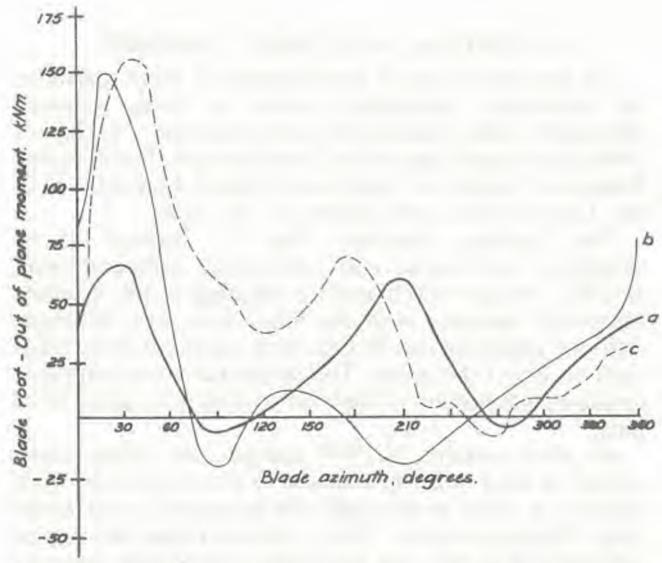

Fig. 6: Mod O: Out-of-plane bending moment in a 12 m/s wind as a function of blade rotation. Curve a, teetering (calculated); curve b, rigid shaft — no teetering (calculated); curve c. test data.

one revolution as measured, together with calculated values for a rigid shaft and a teetering shaft". These calculations were done using a computer code based on one originally developed for rotor-craft analysis. They showed that a teetering hub would roughly halve flapwise blade loads compared with a system with rigid supports. It has been found in practice that the hingeless Mod 0 rotor teeters to a significant degree as a result of flexible shaft supports. Because of this the reduction in blade root stresses to be gained by adopting a teetering rotor is only about 30%

It is of interest to note that the German Hutter-Allgaier machine, whose design strongly influenced that of Mod 0, had a teetered hub. Since Mod 0 is a test-bed it may be that a teetered hub will be tried. Another apparently simpler modification would be the use of elastic interface devices which could be "bolted on" to the existing system between the blade root flanges and the hub. More blade/tower clearance would probably be required, perhaps to the extent that a shaft tilt might be needed' 3.

The tower shadow effect has been cited as the principal cause of out-of-plane cyclic stress variations (and of torque variations on the shaft). There are two other factors which also contribute to the variations and which must be allowed for in analysis. One of these is the wind velocity gradient which results from the wind's retardation in the boundary layer caused by the earth's roughness. Wind velocity thus increases with height. The other force affecting the flapping moment is a slight gravity one occurring because the coning of the blades creates a flapping moment whose direction relative to the blade changes, depending on whether the blade is pointing up or down.

The Gedser and the British machines, already mentioned, mounted the blades upwind of the tower, avoiding the tower shadow problem. In discussing the design of the British machine, Elliott [9] particularly notes that experiments had shown tower shadow caused both considerable fluctuation in the power output curve and severe fatigue stresses on the blades when they were mounted downwind of the tower. Boshier" has reported that upwind blades are now being considered in the United States.

Clearly there remain major uncertainties with the structural design of HAWT.

6. VERTICAL AXIS WIND TURBINES

An alternative line of development of wind machines for electricity production which is being pursued vigorously both theoretically and practically is that of vertical axis machines of the Darrieus type. The National Research Council of Canada and Sandia Laboratories in the United States are leaders in the field.

The Darrieus machine (Fig. 7), because of its simplicity, has capital cost advantages compared with HAWT. No yaw mechanism is required as the machine inherently operates with the wind from any direction. Also the generator can be mounted at ground level rather than on top of the tower. The blades have a symmetrical aerofoil cross-section of high lift to drag ratio and a fixed pitch.

As with modern HAWT designs, the blade cross-section is kept small in relation to the swept area (low solidity) in order to maximise the tip speed ratio at which peak efficiency occurs. This is done so that the cost of achieving 50 or 60 cycle generation can be kept down by minimising gearbox (speed increaser) costs. The Darrieus in its present stage of development has the disadvantage that the power coefficient (Cp) values are slightly lower than those of the Mod 0 type of machine, and the peak Cp value occurs at a lower tip speed ratio so that relatively gearbox costs are up. A further disadvantage of the Darrieus is that the torque produced is zero at low tip speed ratios so it is not self-starting.

As with the simpler HAWT machines which have been mentioned, the overall capital cost advantages may be sufficient to outweigh the efficiency loss so that the energy cost is competitive with that of the Mod 0 type of machine. The reliability could be greater because of the greatly reduced complexity.

Control of a Darrieus machine operating at constant speed is greatly simplified by the form of the Cp curve (Fig. 1). This results in a power output characteristic as shown in Fig. 8, with the power output peaking and then falling with increasing wind speed, provided synchronism with the system and hence constant speed operation is maintained. A similar situation, of course, applies with a fixed-pitch HAWT. The form of the curve (Fig. 8) at very high wind speeds is not given in the literature, but is obviously of importance and must be taken into account in formulating the operating regime for gale conditions.

The aerodynamic development of the Darrieus is regarded as being still in its infancy", and better performance models and further experiments are needed before good performance prediction and thus optimisation of aerodynamic performance is possible.

A 24 m diameter by 37 m high Darrieus fitted with two aluminium blades and driving an induction generator rated at 200 kW started operating in Canada in mid-1977. The Sandia Laboratories were expected to start operation of an experimental 17 m, 60 kW machine at the same time.

The Darrieus type of wind turbine has aroused a lot of interest and is being investigated in a number of places apart from North America.

The New Zealand engineering schools at Auckland and Canterbury both have experimental 5 m machines. The simplicity of the Darrieus makes it attractive in New Zealand as a machine which could possibly be constructed here with a fair degree of local content.

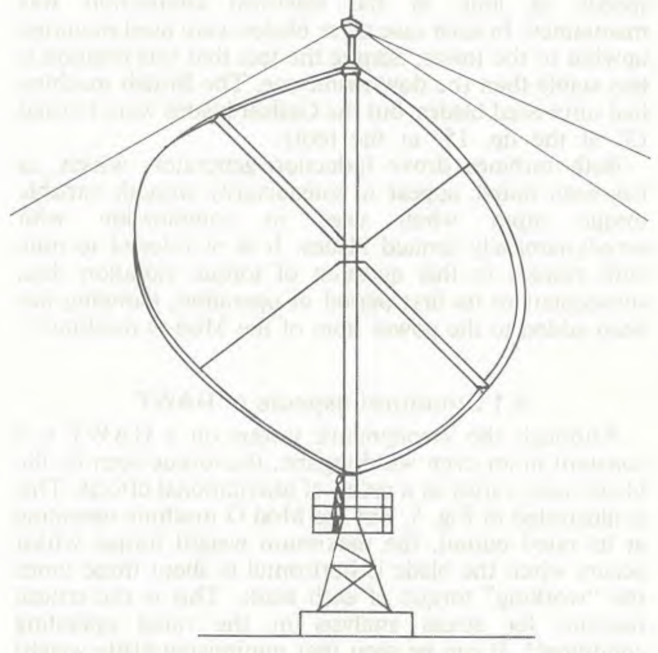

Fig. 7: Darrieus vertical axis wind turbine (60 kW).

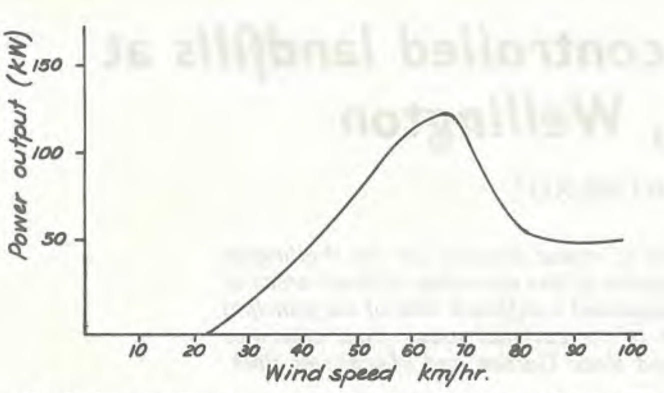

Fig. 8: Darrieus: Power output as a function of wind speed for constant speed operation.

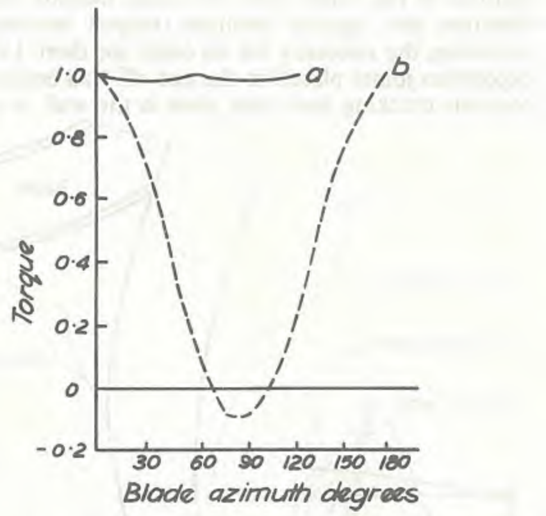

Fig. 9: Darrieus wind turbine: Torque versus angle of rotation (at normal speed). (a) 3 blades; (b) 2 blades.

However, successful operational experience with this type of machine in sizes of 100 kW or above is even more limited than with HAWT and commercial designs are unlikely to be available for some years.

6.1 Structural aspects of the Darrieus

Figure 9 shows the variation in aerodynamic torque over a revolution for a two-bladed Darrieus operating at tip speed ratio appropriate to the peak of the coefficient of performance curve. The maximum torque is experienced in a crosswind direction twice per cycle. A slightly negative value occurs when the blades travel in line with the wind. The variations can be reduced to about a 2% ripple if three blades are used although each individual blade root still experiences the cyclic bending variation. These cyclically varying aerodynamic loads on a Darrieus blade are significant because they govern the fatigue life and dynamic behaviour of the wind turbine. In Darrieus machines, in contrast to HAWT, the root reactions for each blade are distributed between two attachment points, thus easing the structural requirement to some degree.

The blade shape adopted by the Canadians and also used by other Darrieus builders has been designated the troposkein. It is the shape taken by a uniform flexible cable fastened at the two ends and spun at constant angular velocity about a vertical axis. Its use almost eliminates bending stresses in the thin direction.

It is not thought that the effects of tower or blade shadow are so significant with Darrieus machines as with propeller type turbines, but further investigation is needed to clarify this issue.

A parked turbine will experience gravitational loads and aerodynamic buckling in gale force winds. These may be critical design conditions.

Quantitative understanding of blade dynamics is relatively incomplete for Darrieus turbines. The natural vibration frequencies of the blade bending modes depend on turbine speed as a result of centrifugal stiffening. It is obviously desirable for blade natural frequencies to be made sufficiently high to avoid the turbine operating frequency. Auxiliary struts can increase resonant frequencies. Struts can also improve turbine response to gravitational loads. Further discussion on these aspects may be found in reference 14.

7. CONCLUSION

This paper has discussed some aspects of the status of wind energy conversion systems for large-scale electricity production. Although the production of electricity from the wind has been under investigation for a number of years, recent efforts have led to an increased understanding of the problems involved. Uncertainties remain as to the way wind energy conversion systems should be designed so they are both economic and capable of withstanding operational stresses. It appears as if further development and some successful operation of prototype machines are necessary before designs for commercial machines can be established.

8. ACKNOWLEDGMENT

I am grateful for helpful discussions with various members, past and present, of Development Division, New Zealand Electricity Department. Thanks are due to the General Manager, New Zealand Electricity Department, for approval to publish this paper.

9. REFERENCES

'PUTNAM, P. C. (1948): *Power from the Wind.* Van Nostrand.
'ENERGY TECHNOLOGY SUPPORT UNIT, HARWELL (1977): The prospects for the generation of electricity from wind energy in the United Kingdom, *Energy Paper No. 21.* HMSO.
[3]KLING, A. (1977): Variable speed wind turbines for high wind energy conversions. *Wind Engineering, 1 (2).*
[4]COTY, U., and VAUGHN, L. (1977): *The Effects of Initial Production Quantity and Incentives on the Cost of Wind Energy.* Am. Assoc. Adv. Sci.
[5]JUUL, J. (1961): Economy and operation of wind power plants. *Proc. Conf. New Sources of Energy. U.N.,* Rome.
'JOHNSON, C. C., SMITH, R. T. (1976): *IEE Transactions on Aerospace and Electronic Systems.* Vol. AES-12, No. 4.
'TEMPLIN, R. and SOUTH, P. (1976): The Canadian wind energy programs., *Vertical Axis Wind Turbine Technology Workshop, SAND 76-5586.*
' *Wind Energy in Sweden — Report of Results, June 1977.* National Swedish Board for Energy Source Development, Stockholm.
°ELLIOT, D. E. (1975): Economic wind power. *Applied Energy, 1.*
10BOSHIER, J. F. (1977): *Report on Third Biennial Conference on Wind Energy Conversion Systems.* (unpubl. rep.)
"SPERA, DAVID A. (1975): *Structural Analysis of Wind Turbine Rotors for NSF-NASA Mod 0 Wind Power System.* Lewis Research Center (NASA TM X-3198).
"THOMAS, R. L. (1976): Large experimental wind turbines . . . Where are we now? *Vertical Axis Wind Turbine Technology Workshop, SAND 76-5586*
"HOFFMAN, J. A. (1977): *Coupled Dynamics Analysis of Wind Energy Systems.* Final Report Paragon Pacific Inc., El Segundo, Calif.
14BLACKWELL, B. F., *et al.* (1977): *Engineering Development Status of the Darrieus Wind Turbine.* Sandia Laboratories (SAND 76-0650)

New developments in controlled landfills at Happy Valley, Wellington

PHILIP K. NORDBERG*

Controlled landfill is the most suitable method of refuse disposal for the Wellington district because of the availability within the region of less desirable, difficult areas of land, such as steep gullies, where housing development is difficult. One of the principal advantages of this method is the formation of recreational areas from otherwise useless land. Examples are the Lady Norwood Rose Garden and Macalister Park.

1. INTRODUCTION

THE controlled landfill method has a geater ability to accept a wide range of waste material at maximum delivery rates than other more costly disposal methods. It involves the collection vehicles depositing the solid waste in the vincinity of the working face. Bulldozers or other suitable machines are then used to crush and compact the refuse by blading it up the working face and thereby achieving maximum compaction. The refuse is placed in 3 m lifts which are then covered with 150 mm layers of earth. At the end of each day, all refuse is completely covered to prevent flies, rodents and other vermin using the landfill as a breeding ground. In this way steep gullies can be filled in by layer upon layer of 3 m refuse lifts.

The total life of all the landfill stages at Happy Valley is expected to be over 70 years. Some new concepts have been incorporated in Stage I in connection with the stormwater and leachate disposal systems.

The first stage of a new landfill scheme has been completed at Carey's Gully, a large area west of Happy Valley Road, Wellington. The Stage I scheme had a life of only 1 year and involved the filling of a minor valley locally known as Demolition Gully; this has provided access to subsequent stages of the landfill.

2. LEACHATE DISPOSAL SYSTEMS

2.1 A landfill toe dam

Landfills designed with the aim of controlling leachate outflow normally feature some form of earth toe dam. The function of the earth toe dam, apart from providing support for the refuse layers resting against it, is to divert the leachate infiltrating through the layers of refuse by an impervious layer. From here the leachate finds its way into a rock filter and hence into an effluent collection system. No leachate drainage provision is normally made for the refuse layers above the toe dam as it is assumed that the leachate will permeate downwards through the layers into the rock filter. This has been found inadequate on some landfills.

The earth toe dam has previously been considered as an integral feature for drainage of a landfill. However, provided that an alternative leachate drainage system can be designed which prevents the build up of hydrostatic head of the leachate, the earth toe dam can be eliminated.

2.2 The disposal system at Happy Valley

An alternative leachate collection system was designed for Stage I without an earth toe dam. (Fig. 1).

2.2.1 *Cut-off wall (Fig. 2a)*

In the Stage I scheme a cut-off wall was keyed into the bedrock of the valley floor and sides, thereby creating an effective seal against leachate trapped behind it, and removing the necessity for an earth toe dam. Leak-proof expansion joints placed in the cut-off wall ensure that, if concrete cracking does take place in the wall, it will do so

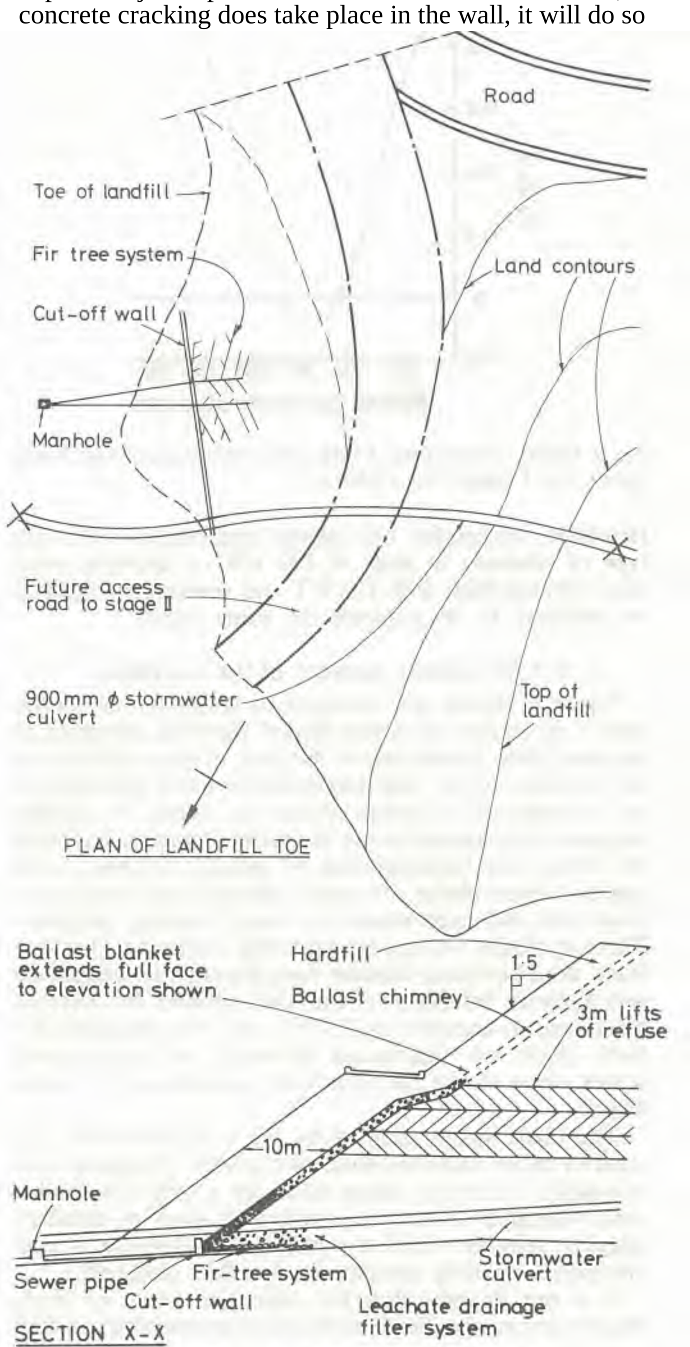

Fig. 1: Plan of landfill toe and section X-X.

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*Assistant engineer, structural branch, with the Wellington City Corporation.

This paper was first received on 15 July 1977 and in its present form on 5 December 1977.

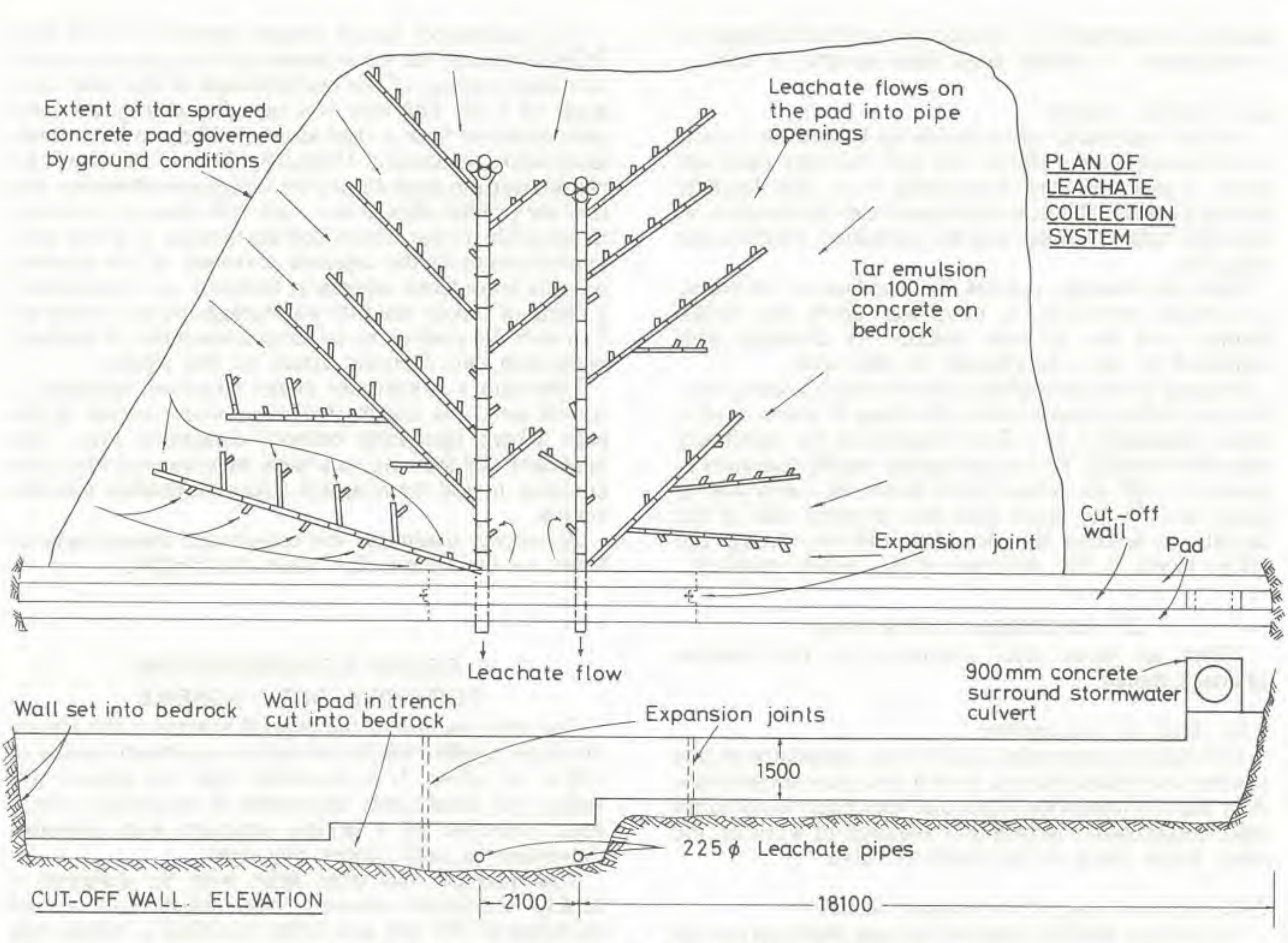

Fig. 2: Elevation of cut-off wall and plan of leachate collection system.

in the locality of the expansion joints and prevent loss of leachate.

2.2.2 *Fir tree system*

A system of pipelines and branches collects the leachate from directly behind the cut-off wall (Fig. 2b). The two main stems of the fir tree are 150 mm or 225 mm Y-junctions laid 10 m up from the cut-off wall. Branches consisting of 150 mm on 150 mm Y-junctions extend from the two main stems and openings are screened by river-worn boulders 300 mm in diameter. The pipes were laid on existing solid bedrock and a concrete pad placed up to the invert of the pipes so that leachate flow is diverted into the ends and branch openings; thus efficient drainage collection patterns are established. For protection against the imposed loadings of the rock filter and refuse layers, all ceramic pipes were concrete surrounded except at openings. The concrete surfaces of the fir tree system were sprayed with a tar emulsion to prevent leachate chemical attack, this tar emulsion also serving as an additional seal against leachate.

After the spraying, large river-worn boulders were placed over the whole fir tree system to 600 mm above the pad floor (Fig. 3). These were covered by 100 mm to 150 mm diameter rocks over the entire concrete pad to an overall depth of 1 200 mm from the pad floor. Household refuse was then placed over the boulder-covered area and tipping operations commenced. Earlier experience has shown the vulnerability of the leachate

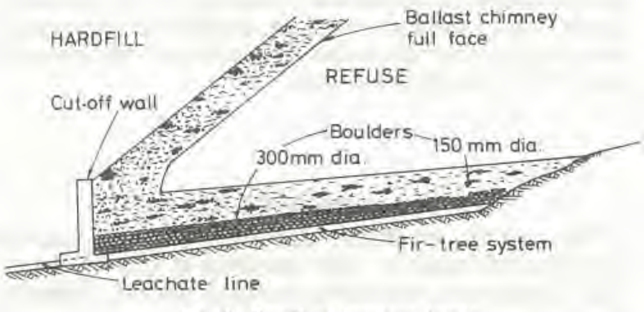

Fig. 3: Detail of leachate intake.

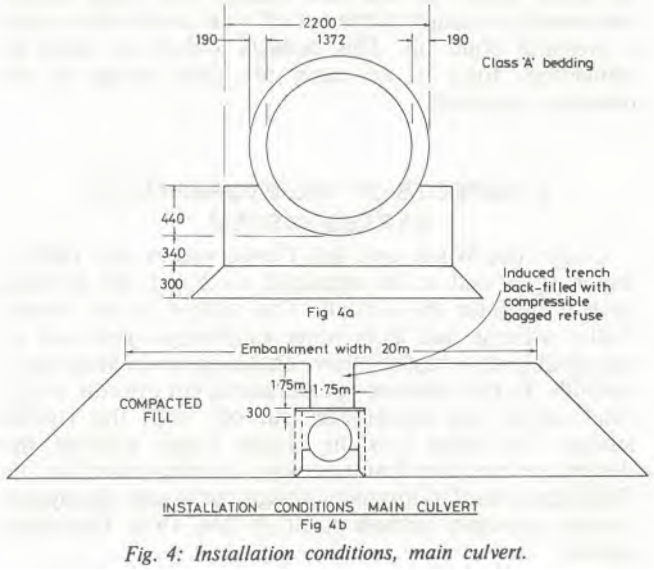

Fig. 4: Installation conditions, main culvert.

drainage system to block, especially in the initial stages of development, if smaller sized filter material is used.

2.2.3 *Ballast blanket*

As the household refuse builds up behind the cut-off wall forming a face, 100 to 150 mm diameter rocks are tipped down the face connecting it to the leachate drainage system. Thus, as the refuse rises in elevation, so does this ballast blanket and the associated landfill cover (Fig. lb).

Once the leachate reaches the interface of the refuse and ballast mediums, it permeates down the ballast blanket into the fir tree system, its drainage path contained by the impermeable hardfill layer.

Because it was considered uneconomical to continue a full face ballast blanket above the Stage II access road, a ballast chimney (1 m x 2 m) extends up the north-east side of the landfill. By instructing the landfill operators to grade at 1:100 the refuse layers down the valley and to grade at 1:70 the layers into the northern side of the landfill, the leachate is expected to infiltrate through the refuse layers in the direction of the ballast chimney.

2.4 Advantages in this design

There are three main advantages in this leachate drainage design.

2.4.1 *Ease of construction*

It is easier to construct a cut-off wall, associated fir tree system and ballast blanket, than it is to place an earth toe dam with an impervious layer and rock filter. In the latter case, compaction machinery is required to work on the steep batter slope of the earth toe dam.

2.4.2 *Effectiveness of the ballast blanket*

In previous landfills, leachate seepage problems existed where there was inadequate drainage provision. The ballast blanket seems to have dealt with the problem satisfactorily.

2.4.3 *Risk factor reduced*

In the past, with an earth dam, if the rock filter should ever block, a build up of leachate-contaminated groundwater could cause failure of the earth toe dam. The risk is still present in the new design but the horizontal distance from the outside face of the landfill to the cut-off wall is considerably less than the corresponding distance in a landfill using an earth toe dam. Detection of a filter blockage and build up of water would be made earlier in the new design and holes drilled horizontally through to the cut-off wall could relieve such a pressure build up. This remedy would be easier to implement than in an earth toe dam owing to the distance involved.

3. ASPECTS OF THE STORMWATER BYPASS SYSTEM

Under the Water and Soil Conservation Act 1967, a water right had to be obtained to divert the existing stream through the landfill. The valleys in the Happy Valley scheme had large water catchment areas and an appreciable dry weather flow, unlike previous steep gully landfills. In the latter an open channel cut into the valley side carried the stormwater run-off from the landfill surface. For Stage I of the Happy Valley scheme, the design wet weather flow rate was 4 cumecs based on the Wellington rainfall intensity design curve and the bypass system certainly proved itself in the 1976 December storm!

The stormwater bypass system consists of a 900 mm RCRRJ pipeline on a continuous concrete pad poured on to a bench cut out of the northern side of the valley at a grade of 1:10. The pipe was boxed and fully concrete surrounded to form a rigid structure likely to have small longitudinal settlement. Ultimately 30 m of refuse will be placed over the pipeline and the design consideration was that the pipeline should not crack and allow the leachate to contaminate the stream flowing through it. Extra steel reinforcement in the concrete surround of the pipeline was not considered necessary; however, as a precaution, a filling of clayey material was compacted to a depth of 1 m over the pipeline to reduce the possibility of leachate infiltration and chemical attack on the pipeline.

Upstream a stormwater intake structure, including a cut-off wall, was constructed in a narrow section of the gully where reasonable bedrock conditions exist. The upstream wall face and rock sides were sprayed with a tar emulsion to seal them against stream infiltration into the landfill.

An energy dissipator was constructed downstream to break up the stream flow from the pipeline.

4. DESIGN CONSIDERATIONS FOR THE STAGE II SCHEME

The main feature of the Stage II scheme is the stream diversion pipeline which will have a maximum loading of 120 m of refuse. It is inevitable that the ground will settle, with consequent movement of the pipeline which must therefore be a flexible structure with allowable movement at each rubber ring joint.

This problem has been dealt with by designing a doubly reinforced concrete pipe which has a wall thickness of 190 mm and is free to deflect at rubber ring joints as are normal pipes laid without concrete surround (Fig. 4a). An extra sealing process has been applied around the rubber ring joint junctions to protect them from leachate attack and the pipes are covered with a protective coating to prevent leachate chemical attack.

The pipeline has been laid on a concrete bedding and compacted fill material placed around it (Fig. 4b). A trench of the same width as the outside horizontal dimension of the pipe will be excavated down to the structure and refilled with bagged domestic refuse. This will ensure that the interior prism of material will settle more than the exterior prisms, thereby generating friction forces which will be directed upward on the sides of the interior prisms and reduce the loading on the pipeline, the principle of an induced trench condition.

This particular condition of an induced trench in a longitudinal mould in the bottom of the valley is not well documented and sensing devices have been placed around the pipe to indicate its deformation under loading, the pressure build up on top of the pipe and in the induced trench shoulders, and how loading is distributed around a pipe bedded in this condition. At least two further stages of stormwater extension will be necessary in the future development of the landfill and information from these tests may enable a reduction in pipe strength and in the construction cost.

5. ACKNOWLEDGMENTS

The author gratefully acknowledges the valuable contributions made by staff members of the Wellington City Corporation and wishes to thank the City Engineer for permission to present this paper. V

Measurement of thermal gradients under the Wellington Airport runway

ALLAN F. WARD* and JEFFERY L. TALLONt
N.Z.C.S. (App. Phys.) B.S.(Hons.), Ph.D., M.lnst.P.

This paper reports measurements, analysis and modelling of the temperature profiles in and under the surfacing of the runway of the Wellington Airport at Rongotai as part of an effort to understand the causes of the serious cracking which has been occurring in the surfacing.

1. INTRODUCTION

IN recent years substantial cracking of the surfacing of the runway of the Wellington Airport at Rongotai has been occurring. Water has been accumulating beneath the surfacing and this may be an influence in its cracking. Reported here are measurements, representative of a full year, of the temperature profile in and under the surfacing as part of an investigation as to whether water vapour may be driven up through the underlying fill by thermal gradients and condense under the surfacing. In addition, the paper shows that the heat flow in the diverse layers of the surfacing, pavement and subgrade can be accurately mathematically modelled as for a semi-infinite slab of uniform material. A fuller account of this work is given elsewhere'.

2. TEMPERATURE MEASUREMENTS

A probe consisting of copper-constantan thermocouple junctions at depths of 0, 50, 100, 180, 320, 480, 640 and 960 mm was installed along with a mercury-in-steel thermograph, in the centre of the main runway on 7 April 1976 and measurements began on 20 May 1976 and continued in an intermittent fashion until 31 May 1977. Data were recorded at 10 min intervals by a paper tape data logging system housed at the edge of the runway and over the period of investigation data were collected for a total of 134 days.

3. RESULTS

Figure la shows typical temperature/time curves for a day with uninterrupted, or nearly so, sunshine. The surface temperature passes through a minimum at about 0700 hours, climbs to a maximum at about 1500 hours, then falls again. Below the surface the same variation is followed but with (a) a smaller amplitude, and (b) a shift in phase. Because of the phase shift, at times the thermal gradients are normal ($dT/dx < 0$, where x is the distance from surface into the fill) while at other times they are inverted ($dT/dx > 0$). The decrease in amplitude with increasing depth has the effect that the thermal gradient beneath the surfacing ($x > 180$ mm) does not vary much within a day but is more dependent on longer term changes in average surface temperature.

If the average daily surface temperature decreases over a number of days then rises after passing through a minimum, then at about 0900 hours on the day at, or immediately following the minimum a maximum temperature inversion occurs within the fill. Under these conditions the displacement of water vapour up through the fill is maximised. In Fig. 2 the average surface temperatures for the 5 days, 12 to 16 November 1976, are plotted and these show a minimum on 14 November and a maximum on 17 November. Associated with this minimum is a maximum temperature inversion which at 0850 hours on 14 November shows a temperature increase of 6°C through the pavement and subgrade to a depth of $x = 1$ m. To anticipate, the theoretical analysis described below suggests that this temperature inversion persisted to a depth of 2 m.

This particular temperature inversion was the largest recorded. However, inversions of 3 to 5°C were common

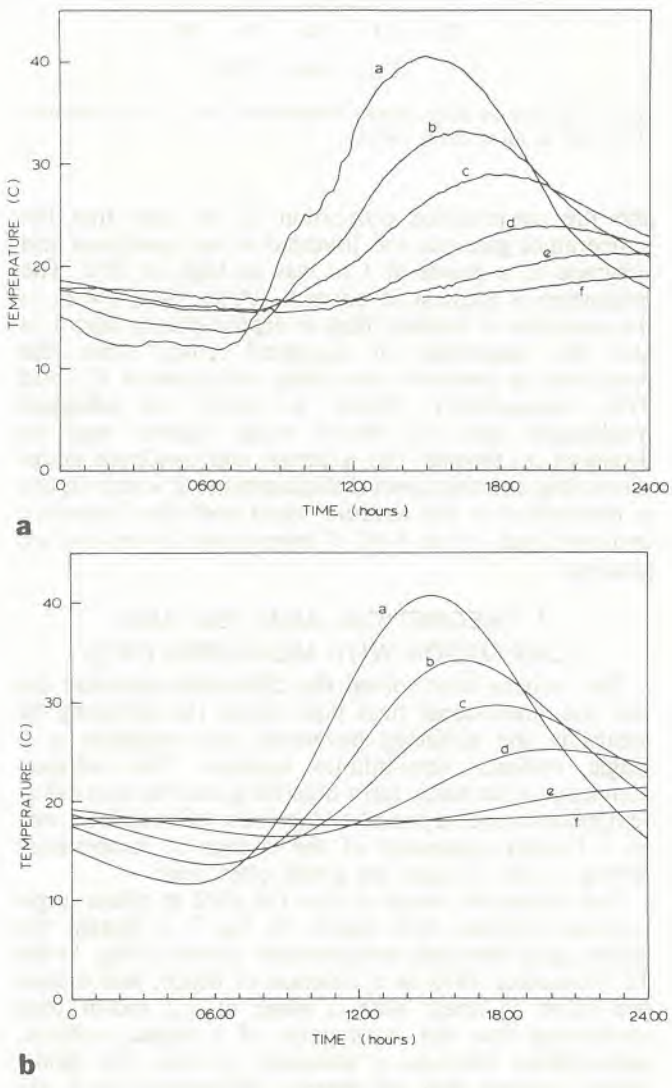

Fig. 1
(a) The recorded time dependence of the temperatures at various depths in and under the runway seal on 16 November 1976.
(a) x = 0; (b) x = 50 mm; (c) x = 100 mm; (d) x = 180 mm; (e) x = 320 mm; (f) x = 480 mm.
(b) The calculated time dependence of temperatures at various depths for 16 November 1976.

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This paper was received for publication on 25 November 1977 and is a summary of the complete paper which will be published in the *N.Z.I.E. Transactions.*

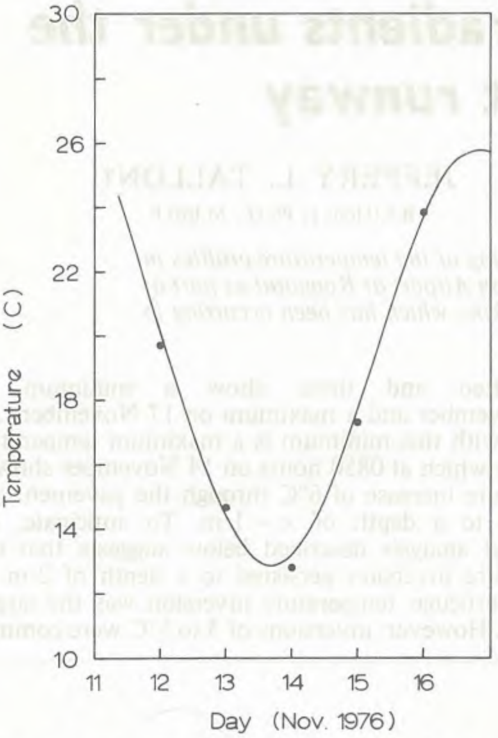


Fig. 2: The average daily surface temperatures for 12 to 16 November 1976, with a fitted cosine curve.

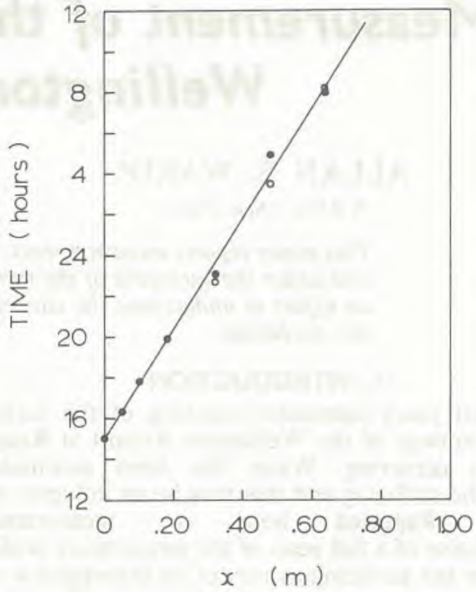


Fig. 3: Solid points: the phase lag of the peak temperatures shown in Fig. 1 for 16 November 1976 as a function of depth. The gradient is 7.15 rad/m. The open circles are for 4 February 1977.

and the accumulated proportion of the year that the temperature gradient was inverted in the pavement and subgrade to a depth of 1 m was as high as 70%. The proportion is greatest in autumn (90 to 94%) owing to the retention of summer heat at depths greater than 1 m and the occurrence of autumnal frosts, while the proportion is lowest in the spring and summer (53 and 37%, respectively). There is clearly an adequate mechanism here by which water vapour may be. displaced up through the subgrade and condense under the sealing and this upward displacement of water vapour is maximised in the autumn when both the frequency and the depth (up to 3 m) of temperature inversions are greatest.

4. THEORETICAL ANALYSIS AND COMPARISON WITH MEASURED DATA

The writers have solved the differential equation for the one-dimensional heat flow under the surfacing by idealising the surfacing pavement and subgrade as a single uniform semi-infinite medium. The solution comprises a harmonic term describing the rise and fall in temperature over a period of the order of a week as well as a Fourier expansion of the change in temperature during a day. Details are given elsewhere'.

One important result is that the shift in phase angle increases linearly with depth. In Fig. 3 is plotted the phase lag of the peak temperatures shown in Fig. la for 16 November 1976 as a function of depth, and indeed the curve is linear with a slope of 7.2 rad/m thus confirming that the assumption of a single, uniform, semi-infinite medium is adequate. In fact, the model simply requires that the thermal diffusivities κ/ρ C are the same for the two seals, the pavement and subgrade. Here κ is the thermal conductivity, ρ the density and C the heat capacity, and though there may be some variation in ρ, C and κ individually in the different layers, there appears to be little variation when combined together in the thermal diffusivity.

The temperature profile is now calculated from a knowledge of surface temperatures only in the following manner. The daily mean surface temperatures for 12 to 16 November 1976 are plotted in Fig. 2 and a cosine curve is fitted to these. Then, for each 10 min interval, this curve is subtracted from the surface temperatures throughout 16 November, and the result is Fourier analysed to obtain the Fourier coefficients in the solution to the heat flow equation. The complete profile calculated in this manner, using the first three cosine and sine Fourier terms only, is shown in Fig. 1b. Agreement with the measured profile, shown above it, is very good and only minor discrepancies exist.

The present method for predicting subsurface temperatures is potentially successful irrespective of surface conditions whether there be unrestricted sunshine or intermittent cloud cover and rain. The tendency for the thermal diffusivity to remain reasonably constant for a range of differing materials makes the method applicable to any general pavement type and structure. It is noted that medium density concrete, shingle bound in a matrix of bitumen, compacted fill, damp soil and certain rocks all have about the same thermal diffusivity', namely, 5 to 6 x 10^{-7} m^2/s. One could therefore, to a reasonable approximation, assume the deduced value for the phase lag of 7.2 rad/m for any pavement and subgrade and, using the writers' equations, calculate the temperature profile and the time development for any given variation in surface temperature. It follows also that the figures quoted above for the frequency, magnitude and depth of temperature inversions should apply to any general pavement.

6. REFERENCES

'WARD, A. F. and TALLON, J. L., 1977. *Physics and Engineering Laboratory, DSIR, Report No. 586.*

'INGERSOLL, L. R., ZOBEL, D. J. and INGERSOLL, A. C., 1948. *Heat Conduction.* McGraw-Hill, New York. p. 12.

'Ibid., pp. 243; 244.

V

N.Z.I.E. NEWS

CHANGES TO DOCUMENTS A & B (1976)

The Council of the Institution approved on 7 December 1977 the following Amendment No. 3 to Document B to clarify the intent of the two-stage method of charging for secondary adviser work as stated in Clause 23.01.

The following new clause, 23.11, is to be inserted on page 15 to read:

23.11 When assessing a project for compliance with Clause 23.01 the "cost of the works" in the first paragraph of Clauses 23.01.1 and 23.01.2 shall mean the total cost of the works in the Principal Adviser's commission.

A stick-on label to cover the above amendment may be ordered from the Secretary of the Institution.

The Council also approved on 1 August 1978 an increase to the car travel rates shown in Document A Clause 28.04 and Document B Clause 24.02 to:

"23 cents per kilometre".

ADDRESSES WANTED

The following have been deleted from the mailing list — mail returned:

P. V. Nilson, Grad.N.Z.I.E., 227 Tay St., Invercargill.

Lt.Cdr. R. J. Tucker, M.N.Z.I.E., 94 Lorong Golok (JKR 841) Ministry of Defence Kuala Lumpur 15-03, Malaysia.

P. M. C. M. van Amsterdam, Stud. N.Z.I.E., Flat 4, 12 Berry St., Christchurch 1.

News of these members' current addresses would be welcomed by the Secretary.

CONTINUING EDUCATION

Mechanical Common Technical Core Course, Thursday 16 - Saturday 18 November (Incl.)

The brochure and application form for this non-residential course are now available upon request from the Centre for Continuing Education, University of Auckland, Private Bag, Auckland. The course provides a series of introductory lectures on recent material, physical and human factor developments affecting those involved in mechanical engineering. A day is devoted to each of "Material Resources", "Appraisal and Evaluation Techniques" and "Human Factors".

Topics include ferrous metals, non-ferrous metals, non-metals and composites, thermal imaging, holography, engineering dynamics, metrology, manufacturing philosophies, ergonomics and design, industrial safety, pollution, social attitudes to work, value engineering and legal aspects. There are also demonstrations, panel discussions and workshops. A course dinner will be held at the Auckland Professional Club on the Friday and is included in the fee of $80.

Common Core Management Course

The first management course to be sponsored by N.Z.I.E. as part of the new structured credit system of continuing education for professional engineers, held at Logan Park motor-hotel in Auckland in the last week of August, attracted 43 registrants from many parts of New Zealand. This was about the optimum number for a course of this nature where group work and interaction were emphasised.

Topics were well chosen to provide for the broad spectrum of interests of the profession and the accent of the course was very much on its relevance. Engineers unable to be present may take heart in the fact that a similar course is planned for presentation in Wellington in 1979, possibly fairly early in the year.

Common Core General Studies Course and Civil Common Technical Core Course

Mid-October will have seen the presentation of both the three-day general studies course at Victoria University from 12-14 October inclusive and the civil common technical core course from 11-13 October inclusive in Christchurch. The former was planned to cover such matters as regional and local government, population changes, resource planning and management for New Zealand. It is hoped to produce a similar course at Auckland in 1979.

The civil CTC course was intended to be a review of professional topics for practising civil engineers. In particular the general nature and significance of some technical innovations and design methods were outlined to provide an awareness of current trends in this discipline.

SYMPOSIUM ON "TUNNELLING IN NEW ZEALAND", HAMILTON, 1977 — N.Z. INSTITUTION OF ENGINEERS, PROC. TECH. GROUPS VOL. 3, ISSUE 3(G)

The proceedings of the above symposium have now been published. Titles of papers are as follows:

Section 1 — Introduction: Downer, A. F., Historical aspects of tunnelling in New Zealand.

Section 2 — Investigations: Prebble, W. M., Engineering geological investigations for tunnel location and design; Pender, M. J., Rock properties, *in situ* stresses, and underground openings.

Section 3 — Design: Rutledge, J. C., Engineering classifications of rock for the determination of tunnel support; Rutledge, J. C., Tunnel portal practice; Fama, M. E., Parton, I. M., Finite element study of mine roadways.

Section 4 — Construction: Flynn, E. A., Geomechanics and tunnelling machines; Newsome, B., Contracting for underground excavations.

Section 5 — Data Recording and Instrumentation: Oborn, L. E., Documentation of tunnel data; Olsen, A. J. *et al.,* Instrumentation for Tunnelling; Osborne, H. R., Ashcroft, R. F., Terrace Tunnel instrumentation.

Section 6 — Case Studies: Bennion, J. D., Hegan, B. D., Kaimai — some tunnelling problems; Paterson, B. R., Engineering geology and construction, Western Diversion tunnels, Tongariro Power Development; Hegan, B. D., Engineering geological aspects of Rangipo underground powerhouse; Bryant, J. M., Deane, P. A., Rock deformation investigation at Rangipo; Millar, P. J., Design of Rangipo underground powerhouse.

The wide scope and detail of these papers should make the volume of interest to anyone involved in the geomechanical aspects of tunnelling. Copies, priced at $NZ20 each, may be ordered from: The Secretary, NZ Institution of Engineers, P.O. Box 12-241, Wellington.

DESIGN FLOOD ESTIMATION SEMINARS

Christchurch 23 November 1978

Wellington 9 February 1979

A nation-wide flood frequency study has been carried out in the Water and Soil Division, Ministry of Works and Development, over the past two years. The study has used the flow records for more than 200 recording stations, and it represents the first major advance in design flood estimation in New Zealand since the introduction of *Technical Memorandum No. 61* some 25 years ago.

In view of the importance of the results to those involved in design flood estimation, two special seminars have been arranged for the presentation of these results. One seminar will be held in Christchurch and cover the South Island results; the other seminar will be held in Wellington and cover the North Island results.

For further details please contact:

South Island Seminar

Scientist-in-Charge, Water and Soil Division, Ministry of Works and Development, P.O. Box 1479, Christchurch.

North Island Seminar

Manager, Technical Services Section, Water and Soil Division, Ministry of Works and Development, P.O. Box 12-041, Wellington.

GEOLOGICAL HAZARDS: ANZAAS Conference, 22-26 January 1979, Auckland

The Geology and Mining Section of the 49th Congress of the Australian and New Zealand Association for the Advancement of Science includes a symposium on geological hazards.

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

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

Those interested in presenting a paper to the symposium should contact one of the undersigned:

W. M. Prebble (convener), Geology Department, University of Auckland, Private Bag, Auckland.

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

'Consultants' Notebook

FROM RUBBISH DUMP TO PLEASURE PARK

UNSIGHTLY piles of rubbish rotting in the sun should soon disappear from Whangarei's dump as part of a sanitary landfill plan to convert it progressively into attractive parkland. In time, the rubbish, rodents and scavenging seagulls will be replaced by green hills, trees and walkways, sportsfields and other recreational amenities. Indeed, the 54 ha tip site has the potential for imaginative development into a fine recreational park.

The tip has been in use since 1962, accepting refuse at a current rate of 20 000 tonnes per annum to a depth of about 3 m. By 1985, the dump would have been filled, forcing the Council to find an extensive new site elsewhere and that could triple refuse disposal costs, to the tune of $12.4 million to the year 2005. However, it has now been agreed that, by placing further layers of rubbish over areas already filled, the life of the tip can be extended by about 20 years. In the process, rubbish will be piled in man-made hills and hollows to create a varied topography easily developed as parkland.

The site is to be developed as a sanitary landfill, with rubbish compacted and covered each day. Tip operations will be controlled to minimise problems of leachate, gas, odour, noise, air pollution, litter, rats, flies and birds, and to improve the aesthetics of the area. Refuse disposal costs will almost double in such an operation, but long-term costs will still be $3 million cheaper than developing a new dump. And that saving will more than cover the cost of landscaping and development of park facilities, to provide the city and district with a unique asset.

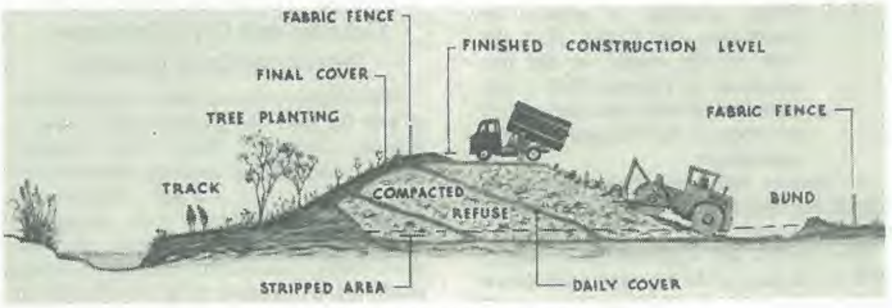
The city's consulting engineers for the project, Brickell, Moss, Rankine & Hill, are carrying out studies into site drainage, soil stability and foundation requirements, traffic access, recreational needs, and many other detailed matters. Those data will help in planning day-to-day landfill work to fit in with their overall park development plans. For instance, suitable debris will be used to construct future park roads. Ultimately the dump — now rechristened William Fraser Memorial Park — may accommodate:

- equestrian facilities with pony rides and stables
- frontages for rowing, small yachts, motor boats
- areas for kite flying, model planes and other outdoor hobbies
- an archery range
- barbecue and picnic facilities throughout the park
- adventure and other playgrounds
- trails for walking, jogging and cycling
- outdoor festival meadows for open-air concerts, possibly including a sound shell
- a scenic drive in and around the park, where roads would have low design speeds
- and a park headquarters with a tea kiosk, information centre, clubrooms and toilets.

The City Council had already identified a need for "the type of reserve in which people can simply stroll, sit, relax, picnic and enjoy the scenery". But the first priority is playing fields, of which 6.2 ha are needed just to serve the growing suburbs of Onerahi and Parahaki during the next 20 years, quite apart from other city needs. This first stage will not be completed until 1985, but the first three playing fields should be ready for use within four years. The playing fields will also have room for softball diamonds, plus related facilities such as changing rooms, toilets and parking for more than 400 cars.

In explaining the philosophy to the Council, the consulting engineers stated "we would like the site to be something the city can be proud of — both the site operators and people taking their rubbish there can feel they are helping to construct a park."

Their proposals, developed in consultation with the city's engineering officers and with representatives of community groups, have been well received by the public.



Sanitary landfill principles

GOVERNMENT SERVICE DIVISION

AIDS FOR THE DISABLED

USING the telephone is something most of us do every day without thinking, but to a lot of people the ability to give someone a call is a minor miracle. Disabled people often cannot just lift up the handset and dial a number. They can have difficulty even in getting to the telephone, and sometimes their speech is too weak for the person at the other end to hear them.

The New Zealand Post Office has several services for disabled telephone users, and the telephone equipment section of the Engineer-in-Chiefs office works together in this field with the New Zealand Aids and Appliance Unit, administered by the Palmerston North Hospital, which deals with aids and appliances of every sort for the disabled.

For the deaf, for instance, an illuminated handset is available in which a neon lamp glows as the bell rings. Deaf aid amplifiers are also available to increase the loudness of the incoming call, and for the mildly deaf subscriber who suffers from loss of high frequency hearing a gliding tone is available, using a tone at various frequencies which is more easily perceived than the normal telephone bell.

For those with weak speech, a speech amplifier can be provided, with its own volume control for adjustment by the disabled subscriber, and for blind subscribers, both tactile and audible indicators can be provided to allow them to use an ordinary dial telephone.

Sufferers from arthritis often appreciate a "third hand" attachment, a flexible arm on which the handset is clipped so that it is always in a comfortable position for use, and the loud speaking telephone is useful for the disabled as well as the able-bodied subscriber. For subscribers who have no hand movement, a plastic mouth stick in conjunction with a decadic push button telephone can be provided. To get a dial tone and to take an incoming call, a push on-push off switch hook is mounted on the telephone and the switch hook and the desired buttons are depressed using the mouth stick.

The work of developing suitable telephone equipment for each disabled subscriber is now being taken over from Post Office engineers all round the country by the Aids and Appliance Unit, which has its own workshop. The Post Office is continuing to supply stock list items and aids from its districts to the A.A.U. which

Injured in a car crash, this man can only move his head. A mouth stick for depressing a push-hook and for pushing the buttons on a decadic push-button phone, as well as a handset mounted on a flexible stand, enable him to operate the telephone independently.

will co-ordinate developmental work. There is still work required from the district engineers, however. Frequently a particular aid required by a disabled person requires specific design and adjustment to take advantage of whatever movement he or she has. The instrument often needs altering, either as the disabled subscriber's capabilities change or when an improvement is made.

The satisfaction and sense of independence the disabled gain from free access to the telephone is a measure of the value of this co-operation between the Post Office and the Aids and Appliance Unit.

ANNUAL GENERAL MEETING 1979 and Election of Management Committee for 1979-80

The election of the management committee for 1979-80 will be held at the 1979 annual general meeting of the Division which is to be held in February at Victoria University during the N.Z.I.E. 1979 conference in Wellington. Details will be available with the conference information.

Nominations for the management committee for 1979-80 should be forwarded to the Secretary of the Institution, arriving not later than 15 January 1979. Candidates must be members of the Institution, employed in the Government Service, and preferably located in or adjacent to Wellington where the meetings are held.

Each nomination should be in writing and should state name and address of candidate; department or other government body which the candidate is nominated to represent; offices held in the Institution; present occupation; the written consent of the candidate to nomination; name of proposer who must be a financial corporate member of the Institution and Government Service Division.

Representatives for all government agencies are entitled to seek election apart from the Broadcasting Council of New Zealand and the New Zealand Post Office, for which agencies representatives are separately appointed by their own employee organisations.

was satisfied that at long last worth-while progress had been achieved and that the discussions to be held with ERB and EARB at the end of September would lead to fruitful discussions at division and branch levels.

GENERAL

What would Division members consider to be a worth-while format for the annual general meeting? Do they consider it should follow the same lines as ACENZ which chooses a different location each year and involve the wives of participants?

Your comments would be appreciated, preferably before Christmas 1978.

NEW PUBLICATIONS

The *New Zealand Reinforced Concrete Design Handbook* has been written to meet new needs in local reinforced concrete design created by the advent of metrication. It has been produced specifically for engineers working to New Zealand standards and using New Zealand materials.

The contents have been compiled by the N.Z. Portland Cement Association and publication has been made possible by co-operation with N.Z. Steel Ltd and Pacific Steel Ltd.

The handbook is published in separate self-contained sections enclosed in an attractive hardback ring binder designed to accommodate subsequent sections as they become available.

Section 1, members in pure bending, comprises:

- Coefficients for rectangular sections without compression steel for concrete strengths 20, 25, 30 MPa and steel grades 275 and 380.
- Coefficients for rectangular sections with compression steel for concrete strengths 20, 25, 30 MPa and steel grades 275 and 380.
- Coefficients for T-sections for concrete strengths 20, 25, 30 MPa and steel grades 275 and 380.
- Resisting moments coefficient for rectangular or T-sections.
- Resisting moments for sections 1000 mm wide, 75 to 350 mm deep, for 20, 25, 30 MPa concrete and steel grades 275 and 380.
- Reinforcement, basic data of areas and spacing.
- Design examples on the use of all the tables.

Section 1, complete with hardback ring binder, is available from Concrete Publications Ltd, P.O. Box 3644, Wellington, at $15 per copy.

It is intended that additional sections will be published dealing with:

;a) Combined binding and compression of columns;
;b) Shear and torsional deflections;
;c) Stress development in reinforcment;

complete with design examples on the use of ill tables.

NEW COMPANY —OLD NAME

Ceramco Ltd has amalgamated its two Christchurch-based heavy engineering companies, Mason Anderson Ltd and Norman J. Hurll Ltd, on the one Woolston site and they will both now trade under the 128-year-old Anderson name.

The enlarged company has been divided into an engineering company, Anderson Engineering Ltd, and a foundry company, Anderson Foundry Ltd.

INDUSTRIES DIVISION

MANUFACTURING GROUP

DURING the Management Committee meeting of August 8th, some time was spent discussing aspects of a paper "The Institution as an Umbrella" which the chairman, B. J. Main, presented to members of the executive committee for professional qualification during the August Council meeting.

Basically the paper covered the need for the Institution to make a decision as to whether it should attempt to provide an umbrella for the multitude of organisations, professional, technical and trade, which are associated with the engineering aspects of the manufacturing sector.

Ten such organisations were named and there are undoubtedly more. All are endeavouring to do their own "thing" and at the moment it seems most are of little interest to the Institution. Tragically, it would seem that the Institution knows too little about even the smaller professional bodies which play an active part in the manufacturing side of industry.

The question was asked concerning whether New Zealand had a large enough engineering population to support this multitude of activities as separate entities.

Should the Institution persist in keeping open the route to corporate membership by thesis or C.E.I. examination? The paper strongly supports the need to make it possible for late starters to attain corporate membership by being able to satisfy the required academic standards by study outside the university.

The management committee agreed that provided standards were not lowered it should be possible for engineers at technician level, or lower, to undertake a course of study in their own time, if necessary, which would enable them to pass the required examinations. In this context, it is becoming apparent that some thought must be given to the aspect of how engineering graduates entering such professions as industrial engineering can satisfy the Registration Board and corporate membership requirements.

The paper was well received and the Council agreed to the Industries Division carrying out the necessary steps to set up a manufacturing group. The management committee hopes to discuss the proposed objects of this group during their late September meeting with the view of formally obtaining Council approval. Once this latter step is achieved, all organisations outside the Institution will be approached and asked to attend an inaugural meeting.

LEGAL RESPONSIBILITIES

There appears to be a feeling among engineers in industry that their professional performance is becoming accountable under law. Some have actually signed papers accepting liability when leaving an employer.

The management committee has received an inconclusive reply from the Institution's solicitors and has decided the question must be pursued with the utmost vigour. It could be necessary for engineers in industry to be insured against professional negligence or accident.

The committee would welcome facts which may be available from members of the Division.

ENGINEERS REGISTRATION ACT

Concern was expressed over the possibility of raising the current limit of $80 000 expenditure in the Act. It was felt that, in industry, extremely dangerous situations can be achieved with an expenditure of less than $1 000 and this situation must extend into areas currently covered by the Act.

Mr Main gave an up-to-date report on the Berry committee activities which indicated that the discussion stage was very close at hand. He

Conference discussion

Brief notes only of 1978 Conference discussion of technical papers.

STATISTICAL ESTIMATES OF THE LIKELIHOOD OF EARTHQUAKE SHAKING THROUGHOUT NEW ZEALAND

W. D. Smith

CONCERN about the usefulness of the historical record of earthquakes drew several questions. R. Park (Christchurch) commented that earthquake records in countries with long histories commonly showed periods of activity and quiescence, often hundreds of years in duration, and that this should be borne in mind when calculating long return periods in New Zealand, based on 140 years' data. The author pointed out that he had tried to extract as much information as possible from the data to hand, but agreed with the suggestion that long return periods were much less reliable than return periods about the length of the historical record, or less. P. Waring asked if the author's technique could be validated by applying it to different subsets of a long historical record. As far as is known this had not been attempted. R. I. Skinner (Lower Hutt) asked if the geological record suggested that the last 140 years had been typical. The author believed his results were of the same order as obtained from geological considerations, except in the area of the Alpine Fault, which appeared to be relatively inactive at present.

A. F. Raper (Wellington) asked about the sensitivity of the results to possible omissions in the historical record and the implications for places such as Dunedin where damaging earthquakes were extremely rare. The author replied that the results for any particular locality were not based on the actual number of occasions any particular intensity had been observed there, but rather on a statistical model fitted to all the occurrences of shaking that have occurred. So the odd earthquake added to or removed from the list did not have a large effect. The question of completeness of the record was also raised by A. D. Dawson (Kawerau), who was concerned about early offshore earthquakes whose magnitude might not have been fully appreciated. The author acknowledged this weakness in the analysis, and suggested that the true return periods for high intensities in the East Cape area might accordingly be less than the calculations showed.

C. M. Strachan (Lower Hutt) pointed out the difficulty of using the concept of risk in an engineering context. The author agreed that most people found it difficult to appreciate the concept but claimed that it is the most convenient way of presenting the results. Mr. Strachan was also concerned about the modified Mercalli intensity scale. While emphasising its importance as a measure of damage, he cautioned that improvements in building materials and building practice should be kept in mind. The author agreed that intensity scales perhaps needed revision periodically. He also pointed out that different scales were in use in different countries, each one tailored to local construction practices and materials.

R. Park (Christchurch) asked if there was any clear reason why the major axis of isoseismal ellipses tends to lie along the strike of the country. The author replied that this was not understood, except that most of the tectonic features of the country had the same strike, so it could be a propagation effect. Ellipticity appears to be dependent on geographical position and not on magnitude. In certain areas the major axis tended to be perpendicular to the strike of the country.

M. J. N. Priestley (Christchurch) asked if the results presented could be used to modify NZS4203 according to the effective life of a structure. The author replied that it would be unwise to base zoning procedures entirely on the historical earthquake record, but that there did seem to be merit in taking the expected life of a structure into consideration. Falsework for bridges was a particularly good example. He cautioned, however, that the actual life of a structure was often rather greater than the original expectation.

MODEL TESTS ON A PILE BREAKWATER AND MARINA ENTRANCE

V. Mountjoy

THE scope of the presentation of this paper at conference was broadened to present an outline of the environmental impact reporting and planning approval process for the proposed extensions to Half Moon Bay Marina, Auckland, for which the model study was undertaken.

Much of the ensuing discussion centred in a very general manner on impact reporting procedures and relationships with the "public" and various "pressure groups". The question of the jurisdiction of the various authorities involved in local and regional planning, with particular reference to coastal and harbour development, was also raised.

It was felt by those participating in the discussion that the topic of environmental impact reporting could well be the subject of one or more extremely worth-while papers at a future conference.

SOME TECHNIQUES FOR THE ASSESSMENT OF GROUND-WATER RESOURCES

Robin S. Bisley

ASKED by I. E. Jones (Gisborne) whether there was any method whereby one could assess the ideal distance for test wells to be located in relation to the pump well or wells being observed, the author replied that the taking of laboratory measurements from soil and aquifer samples gave the permeability of the aquifers in question and once these were multiplied by the depth of the aquifer the transmissibility was obtained (formula II). A projected line from the anticipated drawdown in a given pumped well could then be plotted on semi-logarithmic paper from the drawdown obtained over one log cycle (formula III) and from adjacent well logs, giving other information such as the relative positions of the acquifer(s) and aquaclude(s), these spacings for observation wells might be estimated (Fig.5).

M. F. Eagan (Takapuna) enquired whether consideration had been given in New Zealand to ground surface settlements caused by drawdown of the ground-water such as in the Santa Clara Valley in California. The author did not recall an actual case of ground settlement due to pumping water alone in New Zealand although there were instances on record of subsidence where wells had been incorrectly screened and developed when water had been pumped with quantities of sand over an extended period. He added that the situation on the west coast of the U.S.A. was almost certainly different from that in New Zealand as in the former they had been mining water for some years, i.e., removal greater than annual rate of recharge, whereas in his opinion the ground-water potential in New Zealand was currently seldom if anywhere developed to capacity.

To a further question by Mr Eagan on how local bodies could get loan finance for a test and development programme for wells intended for water supply, the author stated that some local bodies had financed such programmes out of revenue. On several occasions he had received assurances from members of the Loans Board that, although they had never yet been received for a development loan, applications of this type would be welcomed.

K. Couling (Napier) asked to what extent it was necessary or helpful to know whether the aquifer was confined or unconfined before an aquifer test was carried out. In reply, the author said that one of the objects of the test was to determine the type of aquifer, i.e., confined or unconfined, the synonymous terms being "artesian" or "surface re-charge". This would be shown in the process of determining storage coefficient as a result of the tests, in the former case of the order of 1×10^{-5} to 1 x 10-3 down to 0.01 to 0.35 in the latter, as in the paper. He added that for the same yield it was common to find a much greater drawdown over a larger area of influence in a confined aquifer, e.g., as in Fig. 3 (see also formula I).

G. S. Roberts (Rotorua) raised two points. To the first, whether the lack of geological data was a drawback in the application of these techniques, it was replied that existing geological or geophysical information was always of value in both planning a test and interpreting results although it was often possible with these techniques to establish the required information with very little geological information other than that obtained, e.g., from the drilling logs themselves. The author added that, as in the paper, there was a danger in forming conclusions from a too generalised geological approach to plan an inadequate test programme from which inconclusive information might only result. Mr. Bisley agreed with the second comment that the gradient of 1/1 ft or 1 m/1 m would be better expressed as a dimensionless 1/1 when considering transmissibility or permeability units.

W. L. Mandeno (Wellington) asked if there was any value in using a water diviner in ground-water investigations, and commented that there appeared to have been some recent work done in Russia on this topic. The author said that after extremely wide testing, e.g., in the U.S.A., it had not been found possible to produce better than a 50/50 chance of a water diviner's forecast being correct. Thus no scientific evidence was available that that technique could ever be quantitatively applied to give a definite measurement. That at least a qualitative indication may be obtained was argued by its proponents. It was probably true that ground-water might be found at some depth beneath most places in New Zealand and the belief in "water-witching" or "dowsing" had in fact been widespread since Biblical times (Ref. ground-water and wells, p. 4).

I. L. Hall (Napier) and B. A. Bartley (Auckland) enquired whether there was ever any problem of getting air into a confined aquifer to displace the water removed and whether compressed air would help in some cases. In the case of those artesian wells having a high static head the author considered it was essential to have a sealed wellhead with an outlet valve which would release air but not water, thereby allowing the level to come up after pumping had stopped, and an ordinary non-return valve allowing air to suck inwards when the water level drew down. On artesian wells with lower static heads, e.g., 1 to 2 m, a stand pipe system had generally been found sufficient. The connection of an artesian wellhead to an air compressor might also supply air to allow for drawdown but seemed rather too complicated a method compared with the alternatives available.

T. N. Costello (Whangarei) asked whether, in view of the expense of stainless steel well screens and casings, unplasticised p.v.c. screens or casings or other substitutes could be satisfactory alternatives. The author replied that there was in general little problem with using a mild steel casing but with few exceptions the preferred screen material was a wound and welded stainless steel wire of wedge section such as was originally developed by the oil industry. The advantages of this cross-section, which allows fines to pass and develop coarser material on the outside of the screen, did not appear to have been built into plastic screens at present available. There was also a requirement of screen strength which was an essential component in its mechanical function of acting as a stabiliser for a developed aquifer. Given the necessary strength and correct cross-section there appears no reason why plastic screens should not become available.

A. H. Selles (Hastings) said that in Hawke's Bay there were a large number of wells in the 50 to 100 mm size on private properties a large percentage of which were over 40 years old and were not now being used. Should such wells be sealed and not just capped to avoid future problems of leakage and were there other areas where the lack of this precaution had become sufficiently significant to justify sufficient expenditure for this operation? The author said that it was universally good practice to seal off old wells and particularly in artesian country where they were free-flowing and could cause significant losses to the aquifer of wasted water as well as surface drainage problems. In the case of those wells whose static level was below ground level — whether from confined aquifers or not — there was a definite danger of pollution of the aquifer unless they were sealed. This also applied if a local artesian aquifer was being drawn down through pumping.

B. J. Jackson (Lower Hutt) commented that it was recognised good practice that all unused wells be sealed off and such a programme had in fact been operative in the Hutt Valley for some time.

To a question from D. P. Voss (Palmerston North) on the effectiveness of bridge slotting in well screens as used by the Israelis, the author replied that this type of screen was only effective in those formations which had a particularly course average grain size, e.g., 5 mm or upwards, but in finer materials or in larger capacity wells had not been found to be as effective in its capability for development or then maintaining as high a proportion of open area in service. He also mentioned that the use of this type of screen had been very fully evaluated in this country since it was first introduced in the mid-1950s.

THE OTHER SIDE OF PROFIT

F. P. S. Lu

TWO statements were made by M. Strachan (Lower Hutt) — 90% of business in New Zealand is small business, and all businesses in New Zealand were steadily going broke; did Professor Lu have any comments? The author considered the comments and ideas in the paper were equally applicable to small businesses. He agreed that more and more businesses in New Zealand were steadily going broke, and felt something needed to be done about relief for them in these rampantly inflationary times.

J. C. North (Hamilton) asked if Professor Lu considered that the specified preference share concept (tax deductible to the company) offered any long-term solution to the replenishment of capital ("yesterday's profit") eroded by inflation? The answer was no; the nature of these shares was such that it provided only temporary relief and was no more than a stop-gap solution. To a second question whether any hope could be held out that the press could be persuaded to adopt a more responsible attitude to reporting profit, especially in cases where large percentage increases do not mean high absolute profits, the author thought it was a matter of education. Engineers could assist by having a better understanding themselves and taking part in the general debate.

J. P. Goffin (Christchurch) said thanks were due to Professor Lu for his paper, and for clearly identifying dividends as an expense. He said it should be noted that, looked at from the enterprise's point of view, dividends are a very expensive way of paying for funds used by the enterprise (i.e., share capital), because they are paid in post-tax dollars. In percentage terms share capital can cost more, effectively, than the highest interest rates charged in the finance market, which are tax-deductible. The author said there was no doubt that share or equity capital was more costly than borrowed or debt capital. However, the balance between the two and financial security of the company must also be considered. He agreed with a further comment that it was important also to regard company tax as a very real expense, though not perhaps tax-deductible, because it was a major regular outward cash flow.

J. S. Berry (Wellington) said the author inferred that the cost of complying with social responsibility is a logical deduction as an operating expense before profit. If it is possible to comply with social responsibility only if a profit is made, he felt this was a hit-and-miss method of facing up to a necessary social requirement. Was New Zealand a little out of step with the rest of the world in this philosophy? Did Professor Lu's non-engineering business colleagues accept the philosophy that social responsibility of business was in fact a true and unavoidable expense? The author said no such inference was intended. New Zealand was equal with most developed countries in her private enterprise facing up to social responsibilities when possible to do so. More and more business people in New Zealand regarded social responsibility as necessary.

W. P. Vautier (Hamilton) said incentives or allowances for business to take up social responsibility had the major disadvantage of lack of direction of social benefit, and uneven performance through the community. In a small country such as New Zealand it would appear more advantageous to control this pattern through a central direction. The author commented that New Zealanders have a habit of running to central government for everything. The paper tried to make the point that, if some of the burdens of social responsibility can be shared by private enterprise, it would be so much the better for the country.

Mr Vautier raised the further point that economic problems of businesses stem largely from inflation effect (stocks, debtors, etc.). If this factor were controlled, then the business pattern would be back to its traditional level. He asked whether the author could discuss the inflation problem and comment specifically on high interest rates affecting inflation; and external inflation being controlled through a balancing system. Which came first? Professor Lu said he did not know which came first, high interest rate or high inflation. He had a feeling that high interest rate is inevitable after high inflation. As to control of external inflation so as not to affect domestic price levels, it was quite possible. In fact, it was successfully practised in China. But the price of controlling everything, including prices and wages, might be too high for New Zealanders.

D. A. Thom (Auckland) said a previous speaker had pointed to the unevenness of the exercise of "social responsibility" when left to chance the circumstances of profit and the social interests of particular business. It could be argued that the state, albeit crudely, makes an assessment of social responsibility in setting its tax limits. It seemed possible to discuss social responsibility either as directly related to employee welfare, or as manifested by an activity right outside the company. The Carnegie Trust and the Ford Foundation provided examples of the latter on a huge scale — and also examples of unevenness. The Gear Meat Company example was an interesting one, but efforts to go beyond a certain point with employee welfare have had "paternalism" levelled at them in the past. How did a business begin to come to terms with this difficult area? Were there any helpful philosophies or guidelines? How did one start?

The author felt Mr Thom had opened up a most interesting area for research and study in New Zealand, but confessed he had no short answers to his questions.

N. Major (Wellington) noted that, in his arguments on profit, Professor Lu made the point that, in order to expand, a business needs profit: he appeared to assume that expansion was needed. Many people equated expansion with progress. Would Professor Lu comment on the question of need for continued expansion in all commercial enterprises. The author replied that expansion for expansion's sake could not be justified. On the other hand, expansion to meet increased demand was what businesses are about. The point made in the paper was that expansion needs additional capital which will come only if the business is reasonably profitable.

E. L. Gilchrist (Hamilton) expressed considerable reservation in allowing greater profits to private companies so that they could be permitted to extend their form of largesse to the public at large. Minogue in his address had said let us be specific and give examples. Two might be given.

(I) At the New Zealand Library Association Conference recently a well-known Tauranga businessman, who had made a considerable contribution to local government, criticised the higher cost of public library service to New Zealand local authorities than those in Britain. The National Librarian was able to reply that the lower cost in Britain was due to "conscience money" paid by large companies who paid their employees too little!

(2) The second example related to the chairman's comments which seemed to imply a rosier attitude to social conscience by Japanese industry. While it must be accepted, as Professor Lu said, that this was the case as regards attitude towards their own employees, even this could be interpreted as an extension of the old feudal system and not as praiseworthy as it might seem on the surface (it could even be anti-social). However, there were many cases of complete lack of social conscience by large wealthy industries, most of which seemed to have close financial ties to central government. The best example was the Minamata Bay case of mercurial poisoning which took Jon Ui, a senior lecturer in civil engineering at Tokyo University, thirteen years of crusading to get the guilty Chiiso Company into the courts and to pay the first lot of compensation ever. The latest development was that the bay was to be filled in as the only means of containing the pollution and the company felt that, as they had to bear this cost, the reclaimed land should be theirs. Was this the other side of profit? The author commented that Mr Gilchrist was, of course, fully entitled to his views.

R. C. Stiles (Hamilton) noted that, in an inflation situation, the input of labour was maintained in value by increased wages. Fixed assets also held their value during inflation. How was the value of "cash capital" to be maintained in (small) businesses (especially those of consulting engineers, accountants, lawyers, etc.)? The author said that the point raised was one of the very points discussed in the paper, i.e., the difficulty of maintaining the value of current assets which include cash in an inflationary situation. As stated in the paper, this could come only from (1) profit, (2) additional equity capital, (3) additional borrowed capital, or (4) a combination of the three.

A. N. Grigg (Lower Hutt) asked if the author would agree that the suggestion that "capital is yesterday's labour" was an analogous statement rather than a positive postulation. The reason given by the speaker for the question was that, while the above suggestion might be broadly true, it seemed to be not a good tactical point to try to get the public to accept as it appeared to suggest that yesterday's labour is expecting a tax-free concession, whereas the speaker agreed that a good case was made for shareholders' dividends to be treated as an operating capital cost. The author noted that the chairman, J. H. Ingram, had said that New Zealand Steel had 11 500 shareholders of whom only a few had more than 5 000 shares. The suggestion that "capital is yesterday's labour" was a concept only and one advanced for discussion.

Colin Bell (New Plymouth) said the basic idea of the paper was that capital was yesterday's labour. This he saw as an attempt to add respectability to capital. It did not ask the question of how yesterday's labour earned its money. In fact, capital was not yesterday's labour but yesterday's profits. In some cases the profits would be a result of labour, in some cases they would be a result of speculation. The idea that capital was yesterday's labour was misleading because it was in fact yesterday's profits, no matter how those profits were accumulated. Professor Lu said Mr Bell was also fully entitled to his views.

I. B. Middleton (Wellington) asked whether Professor Lu felt the concepts he had outlined and stated as being basically very simple but nevertheless widely misunderstood might be better taught at the secondary school level. The author agreed. Secondly, despite Professor Lu's comment that present inflation and real value losses might lead to a collapse of capitalism, the system had nevertheless continued to exist. This had been possible because of the need to invest money somewhere and the activities of such institutions as insurance companies, etc., which have a largely captive supply of money and are able to invest it at a negative rate of return but make profits by skimming the cash flow. Was this and the resultant change of financial power desirable in the longer term, or could it perhaps lead to a further disenchantment with the capitalist system and perhaps hasten its collapse? The author said he found the comment difficult to answer because he did not agree with the assumptions.

Dr D. P. Haughey (Hamilton) asked the author to comment on the present double taxation situation where not only are company profits taxed but the remaining surplus paid out as dividends is taxed again in the hands of the individual shareholders. Surely, if company taxation needed reform, so did the question of taxation of dividends. Professor Lu did not think the double taxation on company profits and dividends was equitable, and agreed that any taxation reform needed to look at this problem.

R. W. S. Ritsma (Glen Eden) said the paper seemed too one-sided to sell to the public in that it deals only with business as defined today. Possibly we should increase the definition of business to the family unit or the individual, i.e., tax deduction for interest rates if the definition is extended. Surely we would then have a greater chance of selling the proposed concept. The author replied that extension of the definition of business (presumably Mr Ritsma meant company) to the family or the individual was an interesting concept. There was nothing in company law to stop any family or individual forming into a company.

THE KAIMAI TUNNEL

A. G. Stirrat

G. F. Bridges pointed out that completion of the tunnel after hole-through had taken much longer than expected and questioned the effectiveness of management of the tunnelling operation. A. G. Stirrat and J. D. Bennion agreed that progress after hole-through had not been as rapid as predicted and the continuing of the tunnel had been delayed well beyond the expected date. There had been a number of factors which made it particularly difficult to programme that section of work accurately. The decision, taken finally in 1973, to use a paved concrete track system, imposed a requirement to produce a clean, dry invert for rail-bed construction. The standard required, and the difficulty in producing this, particularly in wet conditions, were badly underestimated. In retrospect, had the full implications of the system been realised at the time when the tunnel structure was designed, a revised design of invert would have been adopted, particularly in the machine bored section. This situation had been aggravated by late design changes to rail-bed reinforcement, drainage, etc.

The use of the tunnelling machine to bore the eastern section had meant that the machine and its back-up equipment were roughly at the mid-point of the tunnel after hole-through. It had not been possible to dismantle the machine and pass it through the equipment used for concrete lining and grouting. Hence, instead of continuing these activities from both ends, it was necessary to curtail them at the western end, strip the tunnel and remove the boring machine. From a programming point of view, this virtually split the job in half and made it difficult to use resources to the best advantage.

Predictions made before hole-through, based on twelve months of accurate barometric readings at both portals, indicated that, after hole-through, the natural airflow through the tunnel would keep working temperatures at an acceptable level. This proved to be not the case, and it had been necessary to install a ventilation system. Some time had been lost while this was done and, even after the system was operational, working conditions were often unpleasant and any defect of the system or rapid change of direction of natural air flow resulted in loss of working time.

The rates of progress achieved in tunnel driving had been almost totally dependent on geological conditions. For example, in the better quality andesite driven almost entirely full face but fully supported, 1.82 km was achieved in twelve months — a rate comparable to that for other similar tunnels in New Zealand. On the other hand, in the most difficult section driven from the West Portal where extremely high loads and heavy water inflows produced some of the worst conditions experienced in any major tunnel in New Zealand, 50 m of progress was achieved in twelve months using a multiple heading system.

Driving from the East Portal, with the machine in the best conditions over son m was achieved in ten consecutive weeks with peak rates of 105 m a week and 48 m in 8 hours. Where support was required ahead of the machine in unstable conditions, the rate of progress was reduced to 8 m per week and sometimes less.

The rate of tunnelling was the best practicable consistent with safety and geological conditions: when conditions were reasonably good, progress was comparable to that on other similar tunnels.

J. S. Berry asked whether it would have been feasible to construct a drainage channel outside the lining. J. D. Bennion, in a written reply, explains that there are two possible ways to construct a drainage channel outside the lining. The first is to drive a separate drainage tunnel parallel to the main tunnel. In a short tunnel there may be considerable advantages in doing this, particularly if the drainage tunnel is driven in advance of the main tunnel to pre-drain the country through which the latter must pass. In the case of a long tunnel, such as Kaimai, the driving of a separate drainage tunnel becomes a major tunnelling enterprise in its own right, and the cost would far outweigh the possible benefits.

The second possibility is to enlarge the cross-section of the main tunnel so that a drainage channel can be formed within the thickness of the structural lining. The difficulty of driving a tunnel, particularly in bad ground, is very dependent on the cross-sectional area. At Kaimai there were some sections of tunnel which were driven only with extreme difficulty, and an increase in the cross-sectional area, sufficient to accommodate drainage within the lining, would have resulted in an unwarranted increase in these problems. This method also requires a commitment to a designed drainage flow so that the drain and tunnel cross-sections can be defined; in this respect it is no improvement on having the drain inside the tunnel, the solution that was adopted.

T. J. Palmer and J. S. Berry asked for more details of tunnel water inflows and drain sizes. R. Preston and J. D. Bennion indicated that design was guided by old records such as Otira and Rimutaka and was based on 1000 gal/min per mile, i.e., about 400 litres/s, a total which was believed to be generous.

Very high peak water inflows were experienced where the tunnel passed through major discontinuities. For example, 100 litres/s was recorded flowing from the major fault zone, 100 m from the West Portal, and 75 litres/s from the heavily loaded zone at 3900 m from the West Portal. Flows in the andesite formation generally reduced substantially in time, but flows in the jointed ignimbrites tended to be sustained, and most of the water now entering the tunnel came from this formation. The total flow at present was 225 litres/s and this flow was expected to continue indefinitely.

A firm decision on the paved concrete track system had not been made until 1973; an earlier decision would probably have led to a different invert design which would have eased the problem of completion after hole-through.

Much of the delay which occurred after hole-through resulted from difficulties in providing a clean, dry concrete invert on which to construct the rail bed. This was particularly so in the machine-bored section with a central drain and with large quantities of water entering the tunnel from the jointed ignimbrites. In order to provide drainage and a surface for construction track, it was necessary to decide the shape of the concrete invert when the machine started boring early in 1972.

C. M. Strachan requested information on the frequency of survey checks and on rates of progress on heading and bench work. He also asked whether an adequate number of experienced tunnellers were available for this type of work. J. D. Bennion replied that precise survey checks on line and level were normally carried out each 800 m of progress by a completely independent survey team. Much of the tunnel driven from the West Portal through andesite was in material which was marginal for full face work. Nevertheless, 85% was successfully driven by this method. The philosophy was to drive full face in all conditions where this could be done safely because of the drastic reduction in rate of progress when a change was made to heading and bench work. There were two occasions where control of the face was lost and it was necessary to bulkhead and grout before continuing excavation; bearing in mind the length of tunnel driven, this was not unacceptable.

Driving full face with steel sets at 1.5 m to 2.0 m centres, weekly rates of progress of 40 m to 50 m were normal. In poorer ground with sets at 1.0 m to 1.2 m centres, the rate fell to about 30 m per week. Using a heading and bench system in reasonable ground, where the heading and bench faces could be advanced together, progress was typically 10 to 15 m per week, reducing to 5 to 10 m per week in poorer conditions when the faces had to be advanced separately. Where it became necessary to drive a pilot heading, the overall rate of progress was about 5 m per week and in the worst section, driven with multiple headings, this was reduced to 1 m per week.

With regard to the experience of the workforce, New Zealand tunnellers and their supervisors had more experience in poor rock conditions than is general in most parts of the world. The New Zealand tunneller had to be adaptable to cope with extremely variable conditions. There was considerable interchange of tunnellers and supervisors between MWD and contractors on tunnel work, and Kaimai had at least its fair share of men with experience at Tokaanu, Rimutaka, Poutu and Manapouri, the majority of whom had some experience of tunnelling in poor rock conditions.

C. M. Strachan asked why the tunnel boring machine was used in the western end first. A. G. Stirrat said that the tunnel gradient being uphill from the west, would have improved ground-water control. Based on rock samples supplied to the TBM supplier, there was reasonable confidence that the machine could bore the hard andesite of 130 to 200 MPa compressive strength in addition to the softer ignimbrites. The machine failed because of the "blockiness" of the rock due to its jointing structure rather than its hardness. The machine was not boring the rock except at the periphery but rather just tumbling loose blocks ahead of the cutter.

G. M. Perkins asked if the tunnel would have been more rapidly completed by private

N.Z.I.E. Council 1978-79

CHAIRMEN OF BRANCHES

Wellington

D. S. Ritchie, B.E.(Elect.), M.I.E.E. Managing director, Cable-Price Corporation. Branch committee as treasurer 1964-66, and as a vice-chairman since 1975.

Graduated from Canterbury University in 1954, followed by two years' graduate apprenticeship training with the Brush Elect. Eng. Co. Ltd, Loughborough, U.K. Returned to New Zealand in 1957 and rejoined N.Z.E.D. with whom he had been employed since 1949. Joined Cable-Price Corporation as electrical sales engineer in 1959, became manager of the engineering sales division in 1964, general manager of the company in 1969 and managing director in 1974.

Taranaki

Alan J. Buchan, M.I.Struct.E.

Joined P.W.D. in 1942. Worked in offices and construction camps in various parts of New Zealand. 1956 to 1969 served in Wanganui as district structural engineer, M.O.W., then joined firm of architects and consultant engineers. At present partner in firm of Thomson, Buchan and Chong, New Plymouth.

MEMBER

S. R. Jenkins, B.E.(Hons.), M.Sc. (Carnegie-Mellon), consulting mechanical engineer, was admitted to the partnership of T. H. Jenkins & Associates, Invercargill, in March 1978.


D. S. Ritchie


A. J. Buchan


S. R. Jenkins

contract, and if so, why. J. D. Bennion said that the answer to this question was not simple. Work started on the Kaimai deviation in 1964 and was committed progressively by government on a year to year basis. In the first years, work was restricted to formation and bridging on the approaches to the tunnel, to detailed tunnel investigations, and to studies of the possible use of a tunnelling machine. In 1968, approval was given to call tenders for the supply of a machine and cutters and to excavate the short section of tunnel at the West Portal through alluvial materials to provide a suitable face for machine trials. It was not until November 1969 that a contract for supply of a machine was signed and a firm commitment made that the tunnel should be driven using MWD resources.

The machine supply contract allowed for an initial trial period at the West Portal; if this proved unsuccessful, the supplier had the option of transferring the machine to the East Portal to complete the trial period. This decision was taken in August 1971, and it was only at that time that the commitment was accepted to drive the tunnel from two ends. Tunnelling was resumed at the West Portal in September 1971 and commenced at the East Portal in March 1972. From this time until hole-through in June 1976, the tunnel was driven at the best practicable rate depending on ground conditions. Where conditions were reasonable, rates of progress were comparable with other recent tunnels driven by MWD and contractors in similar conditions; very slow progress was recorded in some sections where ground conditions were amongst the most difficult ever experienced in a major tunnel in New Zealand.

Allowing time for mobilisation, etc., it is probable that a contractor would have taken 5 years from start of contract to hole-through. Hence if the contract had been let prior to 1971 earlier completion could have been expected; what is still problematic is when, and if, government would have been prepared to commit a contract of this magnitude.

T. J. Palmer asked for information on the accuracy of tunnel alignment. J. D. Bennion said that the discrepancies in tunnel line and level at hole-through were 0.209 m and 0.004 m, respectively. The error in alignment was greater than would be expected for work of this type and was fully investigated.

When the tunnel was first planned a precise level survey was carried out connecting the two portals, and an alignment traverse carried out over the top of the range. The tunnel alignment was then changed to improve the portal locations, and the new portal locations were fixed by triangulation rather than by direct traverse. This was because the difficult topography would have resulted in a number of very short lines on the traverse route and this was considered unsatisfactory. The triangulation work was carried out twice by independent survey parties from Lands and Survey and Ministry of Works and Development. In weighing the two sets of results, undue reliance was placed on one set of figures and as a result the reference pillars were displaced relative to one another. The actual setting out of the tunnel line from the pillars was to a satisfactory standard.

D. Hollands asked if there was any probability of continuing ground movement — e.g., on Okauia Fault (i.e., lowering of Hauraki Depression) — if so, was it significant and affecting design? B. D. Hegan said that the Okauia fault was not active. The N.Z. Geological Survey earth formation unit had established precise levels through the tunnel and would study deformations. The tunnel could not survive any catastrophic earth movement undamaged.

D. Hollands pointed out that strain gauge readings showed build-up at axial loading with time — stable at 70 days. Was it possible to distinguish any differences between vertical and horizontal loadings? Was any information obtained on original (pre-tunnelling) horizontal pressures in rock? Will any information be available on final (post-concreting) build-up of lateral pressures, considering ground-water and expansive rock effects? R. Preston said that at the eastern end (TBM excavation) set blocking loads predominated, and the results obtained were not particularly useful. At the western end (conventional drill and blast excavation) strain gauges were placed at four positions at each station to determine axial and bending stresses.

A number of strain gauge buttons were damaged during construction. Though acceptable axial load results were obtained, the moment results were not sufficiently reliable. Even in heavy horseshoe sets the moments from the blocking loads tended to mask moments from the country. With the limited instrumentation work that was carried out a wide range of conclusive findings was not possible.

No measurements had been taken of rock pressures prior to tunnel construction and no studies of post-lining stresses had been made. Ground-water pressures were relieved by drainage holes drilled through the lining.

W. 1. Jones asked for comment on the problems of the interface of the invert and the track slab through material erosion. Dr D. Cope (British Rail) said that the PACT railbed was a new process and they were still learning. So far, in 9 years, British Rail had experienced good performance, but slight erosion problems had been experienced where there had been no structural link between the PACT slab and the invert. To avoid these problems a structural connection was now included, particularly in areas where water could be present. A light attrition movement occurred between the contact surfaces and material migration resulted from that. In Kaimai the problems of a ballasted track would have been very real, owing to the high water inflows.

W. 1. Jones asked if track maintenance tolerances were better with slab tracks. P. Vink said that the alignment using PACT should be much better, as the rail is better restrained, whereas with ballasted track the ballast could degrade and permit horizontal and vertical movements of the track. Dr Cope added that, in 9 years of experience with PACT, the alignment performance had been very good. There had been some settlement observed on embankments in the open, but in tunnels there had been no deterioration in the track geometry, and this should be so in the Kaimai tunnel. The track gauge could increase by 1 to 2 mm in the first six months as the track bedded in, but following this any further widening would only be by rail wear.

Changes in the Roll of Members

The following additions to and changes in the roll of members result from recent decisions of the Council, subject to confirmation under the provisions of Rule 7.1 where applicable.

ADDITIONS

Members

C. J. Smale, B.E.(Civil), County Engineer, Amuri County Council, Culverden.
M. D. Woodley, B.E.(Hons.)(Chem.), M.I.Chem.E., c/- U.E.B. Industries, P.O. Box 37, Auckland 1.

Graduates

A. H. Anderson, B.E.(Elect.), 25 Coyle St., Sandrigham, Auckland 3.
R. W. Beaven, B.E.(Civil), 31 Gradara Ave., Otorohanga.
M. H. Drury, B.E.(Civil), 5 Stillwell Rd., Mt. Albert, Auckland 3.
J. M. Easther, B.E.(Hons.)(Ag.), 23 Duthie St., Karori, Wellington 5.
B. R. Legge, B.Sc., B.E.(Hons.) (Elect.), 16 Milnebank St., Christchurch 4.
B. R. May, B.E.(Mech.), 75 Stillwater Crescent, R.D.3, Silverdale.
F. S. Patten, B.Sc. B.E.(Civil), M.W.D., P.O. Box 451, Dunedin.
G. E. Peters, B.E.(Civil), 99 Poaka Ave., Hamilton.
P. R. Purves, B.E.(Civil), 38 Tanera Crescent, Brooklyn, Wellington.
G. R. Smith, B.E.(Elect.), 11A Savage Crescent, Upper Hutt.
R. H. Steele, B.E.(Civil), 3 Fayette Place, Henderson, Auckland.
S. P. Taylor, B.E.(Mech.), 41 Carlyle St., Mataura.
S. F. Thomas, B.E.(Civil), 20 Boyce Ave., Mt. Roskill, Auckland 4.
E. J. van Toor, B.E.(Civil), 7 Tern Place, Palmerston North.

PROMOTIONS

Members to Fellows

K. S. Odlin, B.E.(Civil), B.Com, M.R.S.H., 2A Osborne Place, Lower Hutt.
H. E. Surtees, B.E.(Civil), M.I.T.E., M.N.Z.I.M., 35 Ilam Road, Christchurch 4.
G. A. Tait, M.I.C.E., 17A Pakuranga Highway, Pakuranga, Auckland.

Graduates to Members

1. K. C. Dick, B.Sc., B.E.(Hons.)(Civil), M.1.E.Aust., Freefox Services Ltd., Jubilee Commercial Building, 42-46 Gloucester Rd., Hong Kong.
E. W. Foot, B.E.(Civil), 217 Tautahanga Rd., Turangi.
K. R. Love, B.E.(Civil), P.O. Box 2003, Gisborne.

Student to Associate

T. Selvadurai, 5 Waltons Ave., Masterton.

Student to Graduate

T. N. Le, B.E.(Hons.)(Civil), 21 Abbotts Way, Ellerslie, Auckland 5.

Twenty years on — a history of the *N.Z. Geomechanics Society*

J. P. BLAKELEY

Taken from the Chairman's opening address at the Symposium on Tunnelling in New Zealand held at the University of Waikato — 17-19 November 1977

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

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

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

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

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

During Mr Collins' three-year term as chairman, there was considerable controversy over whether the fourth Australia-New Zealand conference should be held in Auckland in 1963. The fledgling society finally decided it did not have the financial resources to handle the undertaking and the conference was held in Adelaide. Subsequently the fifth conference was held in Auckland in 1967 and was an extremely successful occasion.

0. T. Jones became chairman in 1962 when the membership stood at 48, and held the office for five years until the end of 1966. He was ably assisted over these years by R. 0. Bullen as technical secretary, who had taken over from Dr Northey. During these years all the planning was carried out for the 1967 Auckland conference. Also the Society formally merged with the N.Z.I.E. to become its first technical group as a result of a ballot at the AGM on 10 February 1965. Also during Mr Jones' term as chairman, the first national symposium of the Society was held in Hamilton on the subject of roading earthworks in August 1965. During the four-year period, 1962-65, K. S. Birrell of DSIR Soil Bureau served as the Australasian vice-president of the International Society for Soil Mechanics and Foundation Engineering.

R. M. Tonkin then became chairman for the two years 1967 and 1968 with C. M. Strachan as technical secretary. J. H. H. Galloway became chairman in 1969 and served for five years until 1973. Dr M. J. Pender took over from Mr Strachan as technical secretary in 1970-1 and P. G. M. Imrie as management secretary in 1972-3.

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

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

From 1970 to 1974 L. E. Oborn served as vice-president for Australasia of the International Association for Engineering Geology and from 1973 to 1977 Professor P. W. Taylor served as vice-president for Soil Mechanics and Foundation Engineering.

D. K. Taylor succeeded Mr Galloway as chairman and served in this position for the three years 1974-76 with Dr G. R. Martin as management secretary in 1974-5 succeeded in 1976-7 by Dr J. M. 0. Hughes. Dr I. M. Parton took over as editor of *N.Z. Geomechanics News* for the four-year period 1974-7.

During this period a very successful symposium on the Stability of Slopes in Natural Ground was held in Nelson in November 1974 and this was followed up by the publication of the booklet *Slope Stability in Urban Development* which was prepared by the Society and published by the DSIR in January 1977. Also the first N.Z. Geomechanics Lecture by J. W. Ridley was held in Auckland, Wellington and Christchurch in March 1974 and the second N.Z. Geomechanics Lecture by Dr C. P. Wroth of Cambridge University was held in the same centres in August 1975.

J. P. Blakeley took over from Mr Taylor as chairman of the Society in 1977 and in 1978 Dr I. M. Parton has been elected management secretary and A. J. Olsen editor of *N.Z. Geomechanics News.* The symposium on Tunnelling in New Zealand in November 1977 was another milestone in the history of the Society.

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

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

WORKERS TALK TO COMPUTER

A voice processor, developed by EMI Threshold in the U.S.A. and available from the professional electronics division of EMI (N.Z.) Ltd, has the ability to accept a variety of instructions from the human voice and translate them to computer input code. This system operates smoothly in the extremely difficult environment of a killing chain at Gear Meat freezing works, Petone — the first such installation in the world. Meat graders on the killing chain simply talk to the computer which updates data accordingly.

Above the high background noise peaking to 110 dB, the voice processor accepts a vocabulary of words or phrases such as "blood splash" or "cancel". It prompts each grader from a display screen to ensure complete accuracy and checks his identity in an instant against 32 vocal characteristics — said to be as uniquely distinctive as a man's fingerprint.

(Circle 52 for more details)

CORRESPONDENCE

WHITHER THE MANUKAU?

Sir,

As an erstwhile resident and long-term admirer of your beautiful country, I found much of interest in the recent article by Smith and Nicholls ("Whither the Manukau?" *N.Z. Engng, 33 (4),* 79-81) which has just come to my attention.

Since the authors use an organismic analogy with respect to the estuary, it may be appropriate to observe that the value of, and importance to the Health and Productivity of the estuary of intertidal wetlands and their associated ecosystems is supported by a voluminous literature in the biological sciences (see, e.g., Odum *et aL,* 1974). It is not always realised that these systems provide the primary production of food material upon which the higher order animals significant for man's commercial or recreation fishing ultimately depend, and, moreover, that their productivity is comparable to that of well-managed farmlands.

Unpublished data held by the writer shows that, as early *as* the end of the nineteenth century, demand for large level sites suitable for playing fields in Sydney's harbourside suburbs had initiated reclamation of intertidal wetlands for that purpose with the result that today only a few hectares of mangroves still exist in the Port Jackson-Parramatta River estuary. We are now in a position to more adequately appraise the value of wetlands against potential gains to be derived from their destruction and it is to be hoped that younger (and perhaps more enlightened) communities will not be as readily tempted to see short-term gains in level sites preferable to long-term viability of their estuarine systems.

Further work on the Broken Bay estuary of the Sydney coast, directed by the writer (Blacker, 1977), has shown that rapid postwar urban expansion in these areas was initially accompanied by an *increase* in mangrove areas, but subsequently both haphazard filling (as illustrated in Smith and Nicholls' Fig. 2) and systematic reclamation have reduced the area of this vital resource. Blacker also found that lopping, felling, and poisoning of mangroves were practised by foreshore residents whose attitudes to the plants were almost unequivocally unfavourable, and that increased stormwater flood peaks, boatwash, and slumping into dredged channels, all by-products of urban expansion, also hastened the demise of mangrove areas.

Successful re-creation of wetland areas and of artificial islands from dredged spoil (as mentioned by Smith and Nicholls) has recently been carried out by the U.S. Army Coastal Engineering Research Center.

Asymmetrical sediment transport, due to the salt-wedge effect, causing a tidal delta to build on the inside of an estuary, is common in eastern Australia, where in some cases marine sands may be found several kilometres upstream in coastal rivers. However, in broad, movable bed estuaries such as the Manukau (or the Nerang estuary in Queensland, with which Smith would no doubt be familiar) it is common for ebb and flood channels to be spatially distinct. One is tempted to speculate whether selective dredging and spoil deposition of the type alluded to by the authors could work with nature in reinforcing this tendency and facilitate both navigation and the viability of the estuary.

I believe the sewage ponding system referred to by the authors is one of the largest such systems in the world. Moderate quantities of added anthropogenic nutrients (as distinct from toxic industrial wastes) can stimulate primary production in an estuary, *especially if they are directed to the loci of such production,* which leads me to comment that (a) there must be an optimum level of sewage input into the estuary for maximum "health" and productivity thereof, and (b) perhaps the selective dredge/fill ideas of the authors could be expanded to the re-creation of intertidal wetlands over which effluent could be released for "polishing", thereby directing the nutrients to the ecosystem best adapted to use them.

D. M. CHAPMAN
Lecturer,
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University of *Sydney.*

References

BLACKER, J. (1977): Changes in mangrove distribution in Pittwater, Cowan Creek, and Middle Harbour, Sydney, since the early 1940s. B.Sc. IV thesis, Univ. of Sydney.

ODUM, H. T., COPELAND, B. J., and MCMAHAN, E. A. (1974); *Coastal Ecological Systems of the United States,* 4 vols., Conservation Foundation & National Oceanic & Atmospheric Administration, Washington, D.C.

METRIC UNITS

Sir,

It seems to me that R. A. St C. Brown has missed the whole point of SI units by getting screwed up over terms which might confuse rather than enlighten. SI units are simple, if we accept them for their simplicity; at least we are within grasp of creating a technical message possible with *one language* worldwide without conversion; what could be more simple?

The history of international metric units began last century, and over the intervening years the International System has developed for use in all fields, not just civil engineering and/or statics. There are rules especially drafted to encourage people to use coherent units. I suggest that the use of other units in Europe is a continuation of an M.K.S. system and that this reveals that resistance to change is as much part of their world as it is ours.

We have in New Zealand adopted the International System of units (SI). It is not difficult to work with; in fact for those who are willing to give it time, there are many benefits. I believe that as the world shrinks such changes as we are now making are relevant, and that it is necessary to rapidly phase out units which do not belong to SI, in very much the same way as we phased out pounds, shillings and pence.

How well can we recall those anxious days at school. "If 33 sets of tyres cost three hundred and sixty five pounds thirteen shillings and ninepence halfpenny and there are five tyres in each set how much does one tyre cost?"

JOHN CHAPPLE
Auckland

SOURCES OF ENERGY

Sir,

B. W. Leyland, in his letter (Vol. 33, No. 8) commenting on the article by D. Lindley, said the latter had used arguments in support of solar water heating which ignored reality. Mr Leyland in his comprehensive reply detailed eight major benefits all of which were indeed realistic.

I should like to refer to a few other possible benefits that were not dealt with by either writer. The first is the trend towards thermally generated electricity supplying base load, with the consequence that peak demand would ultimately be controlled by hydro-electric generation. When this position is reached, 100% of the energy saved by domestic solar water heating would then be in the thermal fuel sector.

The second possibility is the introduction of district solar heating in which groups of 100 dwellings, each equipped with solar panels, share a common thermal store facility for space and water heating on a year-round self-sufficient basis. Such a scheme makes virtually no demand on the national electricity supply and can substitute for a greater percentage of electric energy than Mr Lindley's calculations would allow.

The third benefit overlooked by Mr Leyland and only mentioned in passing by Mr Lindley, is that all industrial applications of solar energy for water heating would tend to reduce peak loads since they are not subject to ripple control. And in the industrial and commercial field, the scope for solar energy technology to provide low-grade heat is at least as extensive as in domestic water heating.

While on this subject, it is regrettable to note to date how few services engineers seem to have been able to interest their clients in the 100% tax write-off which the last two budgets provided for solar energy technology in commerce and industry.

J. D. C. LAING
Auckland

REGISTRATION AND REGULATION

Sir,

I was very annoyed to read the letter by Joseph J. Jones (August 1978) which he apparently sent to the I.E.E.E. regarding the U.S. registration debate.

In my opinion a letter of this type is a waste of ink. Mr Jones makes a series of emotional statements about New Zealand ("the railroads continually break down, and on the occasions when they do run they are rarely on time", . . . "Apathy, indolence, and worker-management confrontation are common-place."). Not a single statistic is produced showing comparisons between New Zealand and other countries to back any of these assertions, nor was any positive alternative suggested — we are merely subjected to a harangue against the present system ("do-gooder bureaucrats", "chaos", etc.).

A letter of this type would be more in place on the editorial page of a provincial newspaper than in a professional journal. If Mr Jones wants people to take notice of his ideas he should present them with supporting facts, and in a balanced and constructive manner. I hope the I.E.E.E. would share my view.

B. K. WATSON
Wellington

OBITUARY

In August ARTHUR LUSH, B.E., F.N.Z.I.E., died, aged 89. When he retired in 1954, Mr Lush was a senior lecturer at the School of Engineering at Canterbury. Born in Auckland, he was educated there until he studied engineering at Canterbury, graduating in 1915 after practical work on Lake Coleridge power scheme. Early that year he joined the N.Z. Engineers, serving in Gallipoli and France.

He was elected A.M.I.C.E. about 1920, became a Registered Engineer by virtue of "civil and electrical" experience and an Associate Member of the then N.Z. Society of Civil Engineers in the 1920s.

He had a lifelong interest in hydro-electricity beginning with his work on Lake Coleridge power station and transmission line. For the Arapuni scheme he carried out investigations on site, and design work in Wellington on the staff of the Public Works Department. As the department would not send him to Arapuni on the construction he resigned and joined the contractor's staff on site. When he later rejoined the Department, his short second period of service led to early dismissal during the Depression. He also worked for the N.Z. Refrigerating Co.

He found work for several years in Kirkcudbright, Scotland, including hydro-dam construction, roads and bridges.

In 1936 he returned to New Zealand as a lecturer at the Canterbury School of Engineering where he remained till his retirement. During some vacations he supervised practical work for engineering students on hydro-electric investigations commissioned in the Clarence River area and a suspension bridge in North Canterbury. His interest in the Clarence-Hurunui area was so great that he continued investigations on his own account and presented a paper to the N.Z.I.E. annual conference in 1952 on "North Canterbury Water Power".

Photography was one of his other interests. When young, he had lessons from Josiah Martin in Auckland and was a keen photographer thereafter. The *Weekly News* published his photographs from time to time, featuring one of the Arapuni Gorge site on a full page. The Auckland Museum library holds a large collection of his negatives.

He continued an early interest in astronomy. In the 1920s he gave an engineering paper on the possible relation between sunspots and the water levels of Lake Taupo. The layout and mechanism for the 6 ft diameter earth globe in Canterbury Museum was designed by him. He encouraged the installation of the planetarium there but became blind just before acting as one of the first panel of lecturers in it. More recently he initiated the preparation of the talking book for the blind adapted by Lionel Warner from his book *Astronomy for the Southern Hemisphere.*

Over a long period he had many articles and letters published in the Christchurch *Press.* Some articles were on general subjects such as Maori place names and the history of the Wellington-Lyttelton ferry service — others were on engineering topics, including controversial ones.

After his retirement he continued his many interests including photography, astronomy, wood-turning, music, his long concern for the preservation of the natural environment, particularly the mountains, bush and birds, writing and correspondence. From 1960 he was blind but retained his enthusiasm for life, gaining great enjoyment from the Talking Book service of the N.Z. Foundation for the Blind. He remained interested in present and future matters preferring to write on these rather than to write memoirs.

He leaves a son, Martin, who is water supply engineer in Dunedin, and a daughter, Alison, wife of Ian Williamson, also an engineer.

AGENCY APPOINTMENTS

Mason Mesco Ltd have been appointed sole New Zealand agent for the Ikegai range of precision machine tools. Mason Mesco, a member of the Ceramco engineering group, will initially concentrate on selling Ikegai computer-controlled lathes.

(Circle 56 for more details)

The Hansen Corporation of Japan have appointed W. Arthur Fisher Ltd their sole New- Zealand representatives. Hansen manufacture a comprehensive range of low-cost multimeters capable of measuring a.c. and d.c. voltage and current, resistance, decibels, capacitance, load current and internal resistance.

(Circle 57 for more details)

PERSONAL

DENIS A. FARRIER, B.E., B.Sc., D.I.C., F.N.Z.I.E., has resigned as Scientist-in-Charge, Christchurch Science Centre, Water and Soil Division, Ministry of Works and Development, after 31 years with the department, to take up the position of borough engineer, Kapiti Borough Council

R. B. KEEY, B.Sc., Ph.D. (Birm.), C.Eng., F.I.Chem.E., F. N .Z.I.C., M . N .Z.I.E., previously reader in chemical engineering, has accepted a personal chair in chemical engineering at the University of Canterbury.

J. P. BLAKELEY, M.E., M.S., M.A.S.C.E., M.I.C.E., M.N.Z.I.E., has been appointed a director of Beca Carter Hollings and Femer Ltd, consulting engineers, Auckland.

D. BLUNT, B.E., M.N.Z.I.E., has been appointed to the Mount Richmond State Forest Park advisory committee.

P. YOUNG, N.Z.C.E.(Elect.), previously engineer to Colts (N.Z.) Ltd, has been appointed industrial sales engineer, National Electrical and Engineering Co. Ltd, at Christchurch.

TERENCE ARTHURS, F.I.Mar.E., M.I.Mech.E., C.Eng., has been appointed New Zealand manager of Hawker Siddeley Engineering Pty Ltd. Mr Arthurs, a former director of marine engineering in the Royal New Zealand Navy, will be located in Auckland.

JOHN POLLARD, B.Sc., Dip.Ind.Chem., C.Eng., F.I.Chem.E., F.N.Z.I.C., F.N.Z.I.E., has been appointed to the Testing Laboratory Registration Council for a three-year term.

Candidates for Election

The following additions to and changes in the roll of members result from recent decisions of the Council, subject to confirmation under the provisions of Rule 7.1 where applicable.

For election as Members

Chandler, N. S.; Congalton, D. A.; Hodgson, R. M.; Niven, R.

For election as Associate

McCafferty, H. J.

For election as Graduates

Blakemore, R. P.; Burnett, W. R.; Chatterton, T. N.; Fong, A.; Hine, R. T.; Lane, W. P.; McEwan, N. G.; Macleod, P. K.; Moran, A. C.; Rappoport, M.; Silich, S. D.; Sutton, J. R.; Tomlinson, C. M.

For election as Students

Prajapati, D. T.; Stone, C. E.; Vickerman, A. R.

For transfer to Fellows

Earl, W. B.; Smith, R. W.

Graduates for promotion to Members

Barrow, C. G.; Cameron, A. J.; Harrison, C. J.

CONFERENCES AND COURSES

New Zealand

Seminar on Bridge Design and Research, Auckland, 16-18 November 1978.

TELARC Soil Testing Symposium (with SANZ soil testing committee), University of Auckland, 29 November 1978.

New Zealand Roading Symposium 1979, Wellington, 14-16 August 1979.

Papers: summaries by mid-January 1979.

Overseas

Symposium on Computer Aided Design of Digital Electronic Circuits and System, Brussels, 27-29 November 1978.

Australian Conference on Computer Graphics and Spatial Analysis, Adelaide, 13-15 August 1979.

Papers: synopses by 31 October 1978.

Graduate Course in Hydrology, University of N .S.W Kensington, March 12 - June 15 1979.

AN ENGINEER'S BOOKSHELF

ADVANCING TECHNOLOGIES, edited by E. G. Semler, 182 pp., illus. (Mechanical Engineering Publications Ltd, London and New York, 1977, US$16).

The editor of this excellent book will be well known to members of the Institution of Mechanical Engineers as one of their past editors: he is now free-lance and has edited this book for the Institution.

There is a foreword by Sir Owen Saunders, which in itself would serve as a review but I shall quote only the first paragraph: "This collection of surveys by eminent authorities is to be warmly commended to all engineers, and to general readers interested in technological progress. They describe what is happening in some thirteen advancing technologies chosen for their industrial signficance and for their current activity. The authors are themselves all active in their fields and speak with authority."

The chapter headings are: Fast reactor prospects; supersonic transports; the aircraft ducted fan; superconducting machines; the ultra-high-speed centrifuge; recent developments in postal mechanisation; machine tools; water as a cutting tool; engineering applications of lasers; battery systems; fibre-reinforced composites; self-lubricating materials; polymer engineering.

The material of a particular chapter has not been written for technical specialists in that particular topic: the chapters present overviews, emphasising basic principles and possible directions of future developments. However, even the technical specialist would gain from such an overview, in focusing more clearly his own objectives.

One pair of printing errors was noticed in Chapter 7; Fig. 2 should be Fig. 3 and vice versa, but readers will quickly make the inversion, without confusion.

This book is recommended reading, to all practising and student mechanical engineers, and it should be enlightening to those practising other engineering disciplines.

—H. McC.

THE COMPLETE BROADCAST ANTENNA **HANDBOOK,** by John E. Cunningham, 449 **pp., illus.** (TAB Books, 1977, $US17.95.)

At first glance this book gives the appearance of being too elementary, being devoid of the large mathematical analysis and formulae one comes to expect in a book on antennas. However, closer inspection reveals that, as the author claims, all the essential information is included to enable an engineer to cope with the basic problems of all types of aerials encountered in broadcasting.

The first four chapters of the book deal with fundamental concepts, the fourth chapter being a good introduction to the Smith chart and applications. This section occupies about one-third of the book. Chapters 5, 6, 7 and 8 deal with all aspects of vertical broadcasting aerials, including directional arrays and their impedances. Chapter 10 covers impedance transformation and phase shifting, while Chapter 11 discusses feeder systems for standard broadcast antennas.

Ground systems and measurements are taken up *in* the next three chapters; parasitic re-radiation, maintenance, and FM/TV aerials, feeders and measurements complete the book.

Overall, this very readable book can be used as a basis for a large amount of design work in this field.

One topic conspicuous by its absence is that of actual mechanical construction of feeder/antenna systems — for this the tyro would have to search elsewhere.

— J. G. S. W.

CORRECTION

In the review of *Computational Methods for the Solution of Engineering Problems* published in the July issue, the published price was wrongly given as $2; this should have read $12.00.

DESIGN FLOOD ESTIMATION SEMINARS

Christchurch 23 November 1978
Wellington 9 February 1979

A nationwide flood frequency study has been carried out in the Water and Soil Division, Ministry of Works and Development, over the past two years. The study has used the flow records for more than 200 recording stations, and it represents the first major advance in design flood estimation in New Zealand since the introduction of Technical Memorandum No. 61 some 25 years ago.

In view of the importance of the results to those involved in design flood estimation, two special seminars have been arranged for the presentation of these results. One seminar will be held in Christchurch and covers the South Island results; the other seminar will be held in Wellington and will cover the North Island results.

For further details please contact:

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