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N. Z. I. E. news section

A supplement to " New Zealand Engineering " sent to all members of the N.Z. Institution of Engineers

President: R. A. J. Smith, B.E., C. Eng., M.I.C.E., F.N.Z.I.E.

Secretary: R. W. K. Stevens, C.B.E.

The Secretary's Newsletter

NEW ZEALAND'S BRIDGES

A LITTLE while ago, we published in these pages an appeal for information to assist Professor Hopkins with a projected book describing the role of bridges in the development of New Zealand. We now hear of another project, which approaches the subject from a different angle. A. B. A. Hutson, of 19 Webb Road, Wanganui, has asked for information and, particularly, photographs which will help him compile a record of bridges and bridging in New Zealand from the times of the earliest settlers to the present day. Mr Hutson's work will be principally a photographic record, with text giving as much prominence to social background as to technical detail. Anyone who has information or photographs which could assist in this is asked to get in touch with Mr Hutson direct.

Incidentally, we must add that Mr Hutson and Professor Hopkins are fully aware of each other's intentions.

N.Z.I.E. INDEX OF PUBLICATIONS

In 1965 the Institution published a 50 year Index of Publications listing every paper published in the Proceedings and in *New Zealand Engineering* from 1914 to 1964 inclusive. An enquiry for pre-publication orders elicited a demand for 100 copies and eventually 120 copies were printed and sold at a price of per copy.

It has been agreed that provided there is sufficient demand the Index will be brought up to date and re-published. It is estimated that to make the proposition viable a minimum order of 100 copies must be placed and the price will be approximately $4.00 per copy.

Members interested in the revised index are requested to complete and return the pre-publication order alongside.

COMPUTERS IN CONSTRUCTION COMMUNICATIONS

In June, 1970, following two years of intensive planning initiated from within the Auckland Technical Institute, a conference was held in Auckland on the use of computers in construction communications. The conference was attended by over 200 people representing all spheres of interest in construction — architecture, engineering, quantity surveying, building, material supply and technical education. Three overseas speakers took the principal roles; Bishop and Burgess from the United Kingdom and Quarry from Australia. Seventeen papers from New Zealand authors were reported upon and discussed.

The conference, which ran over three days, demonstrated the intense interest in, and knowledge of, the problems by a wide range of people, and the resolutions which stemmed from the conference were a realistic statement of what was felt had to be done on a national scale to come to grips with the problems.

The resolutions acknowledged the need for a rationalised communication system and directed the conference organising committee to review proceedings, plan further action and report to Government and the relevant councils involving the construction industry.

The committee was concerned that the vital interest shown by all parties, the knowledge gained from the conference and the acceptance of the need to co-ordinate should result in some subsequent action. It was pleased therefore to have the task of preparing the report as directed from the conference floor.

The report has been completed and has been presented to the Minister of Works, the Hon. P. Allen, by the chairman of the conference, R. G. Norman, deputy commissioner of works.

Copies have also been presented to the Standards Association, the Building Industry Advisory Council and the Building Research Association.

When general distribution is authorised copies of the report will be forwarded to all members who attended the conference and to the headquarters of the institutions and associations connected with construction industry.

N.Z.I.E. INDEX OF PUBLICATIONS

The Secretary,
N.Z. Institution of Engineers,
P.O. Box 12241,
WELLINGTON.

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(Name in block letters)

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THE BENEVOLENT ASSOCIATION OF NEW ZEALAND

From discussion which took place at the Annual General Meeting of the Institution in February it was obvious that many members were not fully aware of the existence of the Benevolent Association or the purposes for which the Association was established.

The Association itself is comprised of those members of the Institution who donate each year a sum of money, no matter how small, to the funds of the Association. The affairs of the Association are managed by a committee, partly ex-officio and partly elected, whose main function is to invest funds surplus to immediate requirements and to consider and, where appropriate, approve applications for assistance from the fund.

The objects of the Association are set out in the Rules and state that the funds shall be devoted to the relief and assistance of members or former members of the Institution or their dependants who may be in distress. In recent years there have been few requests for assistance. This may be partly due to the fact that cases of real hardship or distress are comparatively rare among professional people but there is also evidence that the membership, and particularly Branch Committees, are not always aware of the availability of funds to assist those in distress.

It is not possible to precisely define the degree of distress or hardship which justify a grant or loan from the Benevolent Fund, but it can be said that most cases where the dependents of a deceased member are in financial difficulty, either temporary or long term, would receive sympathetic consideration. For example, a widow may be unable to draw on funds held in her late husband's name pending grant of probate and may have some urgent commitment to meet. In such circumstances the Committee of Management could make an immediate grant to cover the existing situation and then examine the family's financial position with a view to continuing aid. Again, a widow with dependent children might be unable to supplement her income by working and if the full circumstances could be put to the Committee, it is possible that assistance from the Fund could be provided.

The Benevolent Fund is not intended to help members to finance purchases or other expenditure which would normally be met from income or savings, nor would it defray, by grant or loan, the cost of overseas travel for any purpose. If, however, a member who was temporarily resident overseas had an urgent reason for wishing to return to New Zealand but was unable to raise the money for the fares, a request to the Benevolent Association for a loan might be approved.

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

M. R. H. Adams, M.I.Struct.E., 5 Hall Street, Cobden.
M. W. T. Ball, M.I.Struct.E., c/o J. R. G. Hanlon, 219 High Street, Dunedin.
M. D. J. Hewings, M.I.Mech.E., 2 Cornwall Street, New Plymouth.
M. D. J. Higgins, A.M.I.Chem.E., 21a St. Clio Street, Ilam, Christchurch.
M. R. J. Nankivell, M.I.Mech.E., M.N.Z.I.W., 63 Normandale Road, Lower Hutt.
M. R. J. Pearce, M.I.Mar.E, 1 Pandora Avenue, Rotorua.
M. K. C. F. Spring, M.I.Struct.E., 401 Te Moana Road, Waikanae.

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Assoc. P. D. Wolff, 79 Terry Street, Auckland 7.

Graduates

Grad. D. R. Aylward, B.E.(Hons)(Elect), 237 Wellington Road, Wainuiomata.
Grad. P. Barker, B.E.(Hons)(Mech), 40 Ranger Street, St. Albans, Christchurch.
Grad. G. J. Barton, B.E.(Elect), 37 Athens Road, Auckland 6.
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Grad. T. N. Cavanagh, B.E.(Hons)(Civil), P.O. Box 9041, Hamilton.
Grad. K. C. Chen, B.Sc., B.E.(Civil), 12 Jesmond Terrace, Mt. Albert, Auckland 2.
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Grad. B. B. C. Evans, B.E.(Civil), Governors Bay, No. 1 R.D., Lyttelton.
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Grad. R. W. Fleming, B.E.(Civil), Ministry of Works, Staff Hostel, Turangi.
Grad. I. A. Fraser, B.E.(Mech), 36 Scoular Street, Mornington, Dunedin.
Grad. N. W. Galvin, B.E.(Elect), 153 Helensburgh Road, Dunedin.
Grad. D. J. Gatland, B.E.(Elect), 19 Forrest Hill Road, Takapuna, Auckland 9.
Grad. R. W. Gibbard, B.E.(Hons)(Elect), 1 Devon Road, Springvale, Wanganui.
Grad. R. D. Gold, B.E.(Civil), Flat 2, 22 Marama Street, Hamilton.
Grad. J. E. Grigg, B.E.(Elect), 10 Easter Parade, Glen Eden, Auckland 7.
Grad. N. O. Higgs, B.E.(Civil), 28 Highsted Road, Christchurch 5.
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Grad. A. R. Kennaird, B.E.(Civil), 9 Mary Huse Grove, Manor Park, via Trentham Camp P.O.
Grad. A. H. Kennedy, B.E.(Elect), 4 Woodford Road, Mt. Eden, Auckland 3.
Grad. A. B. King, B.E.(Hons)(Civil), 38 Ohuanga Road, Turangi.
Grad. J. A. Kivell, B.E.(Hons)(Mech), Flat 1, 77 Sherbourne Street, Christchurch.
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Grad. W. N. Larsen, B.E.(Civil), 9 Herekiekie Street, Turangi.
Grad. W. G. McQuarrie, B.E.(Civil), 49 Mays Road, Te Papapa, Auckland 6.
Grad. J. B. McShane, B.E.(Hons)(Civil), 7 Hawker Street, Wellington.
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Grad. D. Marriott, B.E.(Mech), 22 Pencarrow Avenue, Mt. Eden, Auckland.
Grad. T. A. Moore, B.Sc.(Maths), B.E.(Hons)(Civil), 99 Moorfield Road, Johnsonville.

Grad. D. McL. Munro, 65 Pulham Road, Warkworth.
Grad. C. M. Nairn, B.E.(Hons)(Mech), Omakere Station, R.D.1, Waipawa.
Grad. A. J. Olsen, B.E.(Civil), c/o M.O.W., P.O. Box 33, Te Kuiti.
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Grad. T. L. Scott, B.E.(Elect), 319 Port Hills Road, Christchurch 2.
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Grad. A. J. Stanbury, B.E.(Hons)(Elect), 37 Kirkwood Avenue, Christchurch 4.
Grad. P. N. Skilton, B.E.(Mech), 80 Birdwood Avenue, Beckenham, Christchurch 2.
Grad. P. R. Swain, B.E.(Civil), 25 Bourke Street, Kilbirnie, Wellington.
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Grad. D. A. Thomson, B.E.(Civil), c/o City Engineer's Dept., City Council, Palmerston North.
Grad. P. R. Thorpe, B.E.(Civil), 15B Saratoga Avenue, Herne Bay, Auckland.
Grad. K. A. Tweeddale, B.E.(Civil), Flat 2, 1 Mana Street, Wellington 2.
Grad. A. A. Winwood, B.E.(Civil), 174 Ngatai Road, Tauranga.
Grad. K. C. Yong, B.E.(Mech), 8 Burnley Terrace, Mt. Eden, Auckland.
Grad. S. Young, B.E.(Civil), c/o Y. F. Young Esq., Kawiu Road, Levin.
Grad. B. C. Brooking, B.E.(Civil), 44 Cormiston Avenue, Concord, N.S.W. 2137, Australia.

PROMOTIONS

Member to Fellow

F. A. W. Tassell, County Engineer, P.O. Box 244, Whakatane.

Graduate to Member

M. D. M. Blackwell, M.I.Mech.E., 6 Kenny Road, Remuera, Auckland 5.
M. R. M. Frengley, B.E.(Civil), 98 Weston Road, Christchurch 5.
M. S. B. Gooder, B.E.(Elect), 44 Pirie Street, Wellington.
M. C. D. Moore, B.E.(Elect), c/o District Engineer, Post Office, Dunedin.
M. A. R. Parsons, B.E.(Civil), 62 Wainuiomata Road, Wainuiomata.
M. D. H. Smith, M.I.Mech.E., P.O. Box 615, Luanshya, Zambia.
M. T. B. Steven, B.E.(Civil), 12 Rickards Place, Kelston, Auckland 7.

Students to Graduates

Grad. B. Bellard, 155 Princes Street, Otahuhu, Auckland 6.
Grad. P. M. Dickens, B.E.(Hons)(Elect), 65 Waimairi Road, Christchurch 4.
Grad. J. W. Jones, 16 Woburn Road, Northland, Wellington 5.
Grad. W. L. Mandeno, B.E.(Civil), Box 5715, Wellesley Street, P.O., Auckland.
Grad. J. S. Oldfield, c/o Waitemata County Council, P.O. Box 5440, Auckland.
Grad. C. M. Snook, Engineering Dept., Hamilton City Council, P.O. Box 937, Hamilton.

THE STATISTICS SURVEY AND WELFARE RESEARCH

The statistics survey for the year ended 31 March, 1971, has now been completed and the figures have been made available to the consultant retained to carry out the investigation into the salaries of employee engineers. Much work still remains to be done before the statistical tables and graphs are in a form suitable for publication and it may not be practicable to publish the results of the survey before October.

SOCIETY OF AUTOMOTIVE ENGINEERS — AUSTRALASIA 1971 National Convention 18-22 October 1971

The Society's 1971 Convention will be held in Melbourne from 18-22 October, 1971, and the theme will be "Transportation 1981". The Convention will provide an expert forum to evaluate the role of all forms of transport systems and the effect on the community.

Programmes and registration forms may be obtained from the General Manager/Secretary, Society of Automotive Engineers Australasia, National Science Centre, 191 Royal Parade, Parkville, Vic. 3052.

Candidates for Election

For Election as Members:

Allott, J.; Apperley, G. C.; Carter, G. F. C.; Chalmers, R. J.; Clissold, C. M.; Davis, M. G.; Duxfield, F. R.; Firth, R. D.; Grey, R. A.; House, J. M.; Jones, A. L.; Lindley, Dr D.; Robinson, L. M.; Robson, F. L.; Shaw, A.; Turner, T. E.; Watson, Lt./Cdr. W. S.

For Election as Associates:

Abbott, F.; Chalmers, D. R.; Fisher, R. W.; Pearson, J.; Prigg, A. C.; Sands, L.

For Admission as Graduates:

Brown, G. F.; Cromie, H. J. S.; Davis, 'I. A.; Davison, B. L.; Entwisle, M. I.; Grant, S. C.; Harris, D. C.; Jones, R. D.; Jowett, I. G.; McClymont, I. T.; McKay, D. J.; Mackie, I. B.; Missen, H. J.; Moore, B. C.; Pemberton, D. G.; Rountree, J. L.; Warren, R. G.; Wells-Green, P. S.; Williams, H. J.

For Admission as Student:

Dixon, W.

For Transfer to Fellow:

De Terte, D. A.; Burns, D. McN.

Graduates for Election to Members:

Allan, J. D.; Anderson, G. I.; Barber, N. E. A.; Beever, D. J.; Bickers, A. N.; Brown, K. M.; Bunting, D. J.; Camberis, D. A.; Carver, D. M.; Cato, R. E.; Cavanagh, T. N.; Christian, J. B.; Clark, R. B.; Cook, C. W. R.; Day, E. B.; Flint, J. B.; Hegley, N. I.; Hodder, D. W.; Jenks, J. R.; Loughnan, A. A. M.; Mansell, D. S.; Matthewson, Dr C. D.; Muir, D. G.; Owen, M. C. R.; Raper, A. F.; Ranchhod, M.; Read, P. W. A.; Reynolds, P.; Richards, J. V.; Rix-Trott, T.; Selby, D. V.; Shepherd, B. O.; Sligo, C. A. S.; Vivian, R. J.; Watkins, A. T.; Watts, J. R.

Student for Election to Member:

Cutler, D. R.

Students for Promotion to Graduates:

Henry, R. W.; Kovacevich, P. G.; Lobb, N. R.

ENVIRONMENTAL AWARD

The attention of members is drawn to the announcement, in the main body of the Journal, inviting applications for the 1972 Environmental Award. This announcement is being given wide publicity, both in professional and other journals, and in the daily press.

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NEW ZEALAND
Engineering

The journal of
THE N.Z. INSTITUTION OF ENGINEERS, Fourth Floor, Molesworth House, 101 Molesworth Street, P.O. Box 12241, Wellington N.1.
President, R. A. J. SMITH, B.E., C.ENG., M.I.C.E., F.N.Z.I.E.
Secretary, R. W. K. STEVENS, C.B.E.

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MEMBER BUSINESS PRESS BPA ASSOCIATION

Leading article

Articles

General

Cover picture

The aluminium smelter at Bluff—see p. 223.

NEW ZEALAND
Engineering

THE JOURNAL OF THE N.Z. INSTITUTION OF ENGINEERS Vol. 26, No. 8, August 1971

Exclusive club

THE N.Z. Society for Earthquake Engineering, it has been suggested, appears like an exclusive club, even with its own publication for circulation amongst its members!

Any element of exclusiveness would be paradoxical for a society whose objective is to advance the knowledge of methods of anti-seismic design, but it must be said that there are some valid reasons for such an impression.

Much earthquake engineering involves the mathematics of the response of complex structures to random excitation. Many engineers are excluded from this area because they cannot spend the time and energy necessary to restore or extend their mathematics capabilities. Again, the essential part played in earthquake resistance by post yield ductility, and other energy absorbing effects, presents an intellectual barrier to many engineers, civil, mechanical and electrical, whose design philosophy is based on ensuring that their products are "protected" by "a factor of safety" from even approaching yield stress. For them to grasp the concept that some structures must work beyond yield stress during earthquakes, not once, but many times, and that behaviour in this region must be dealt with quantitatively, may require an intellectual upheaval comparable only with tigious conversion. Even structural engineers, used to plastic design methods, and military, naval and automobile engineers, familiar with blast and impact effects, would have to re-orientate their thinking to include low cycle fatigue effects in earthquakes—though this should be less difficult in their case.

It is not surprising, therefore, that the Society is seen by some as exclusive. Nevertheless, the work of the members of the Society and the field of earthquake engineering affects the profession as a whole. Society members do sterling work on the Standards Association Loading Committee, attempting to distill the essence of the complex studies of earthquake response into the rules of the Building Bylaws Loading Code. But the process of reducing the complexities of dynamic behaviour to a set of static loads can only be approximate, and when the rules are applied by others, who are not familiar with the underlying principles, it should occasion no surprise if the results are not always as desired.

The lengthening list of code designed structures which have failed seriously in earthquakes has been further lengthened in the San Fernando 1971 earthquake. It is becoming increasingly evident that a clear understanding of the implications of dynamic response in the post yield region is not an esoteric "alternative approach" to antiseismic design, but should be regarded as a design check without which survival of a structure in a major earthquake remains conjectural.

With this in view, some papers of a more general and fundamental nature which have been published recently in the Society's Bulletin, have been made available for publication in *New Zealand Engineering* It is also intended to publish a summary of the activities at the recent National Conference on Earthquake Engineering. It is hoped that this will help to keep a wider readership aware of the work being done by the Society's members and perhaps encourage more of those who ought to be concerned to "join the club".

The aluminium smelter at Bluff

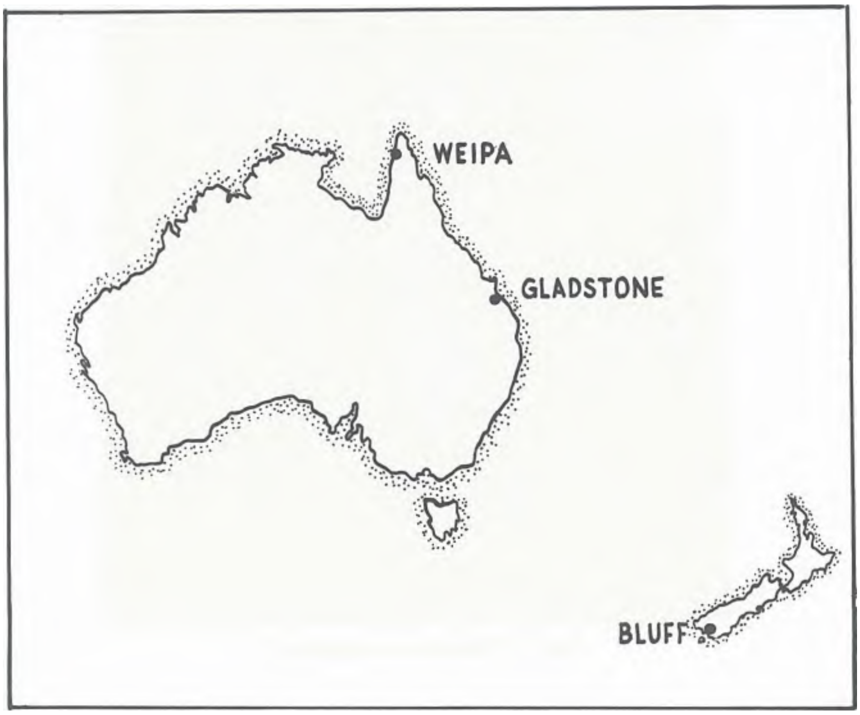

Fig. 1. Location of project.

In April 1971, the aluminium smelter at Bluff began production of aluminium for world markets. By October 1971 its capacity will be 73,000 tons per annum, rising to 110,000 tons per annum by the second quarter of 1972, and ultimately to twice this figure, making the Bluff smelter one of the largest in the world. About half of the $95 million cost to reach 110,000 ton/year capacity will be spent on New Zealand goods and services. Electricity requirements will exceed those of Wellingkon initially, and at full capacity the smelter will require more power than is used in the whole of the South Island.

1. INTRODUCTION

THE planning and building of the smelter by New Zealand Aluminium Smelters (NZAS) is the biggest industrial undertaking linking New Zealand, Australia and Japan. NZAS is a consortium of three companies, Comalco Ltd. (Australia) with a 50% interest, Japan's Showa Denko K.K. (25%) and Sumitomo Chemical Company Ltd. (25%). Each partner has contracted to supply finance and raw materials and share output in proportion to its equity interest. Comalco will manage the Bluff smelter for NZAS.

Kaiser Engineers & Constructors Incorporated (KECI) are responsible for design and engineering management for NZAS during the construction period, and are acting as engineer managers for New Zealand Construction Company. This company holds the overall construction contract. The arrangement ensures that a high New Zealand labour and material content is achieved and also provides a respondent for the composite agreement for unions. There are several hundred tender packages and more than 150 New Zealand companies are involved in the construction of the smelter.

Fig. 2: Unloader on wharfhead.

So far more than 50 New Zealand companies have been awarded prime contracts worth, in total, over $35 million. Orders include one million square feet of roofing and siding sheet, rolled in Auckland and formed in Wellington and Christchurch, more than 100 miles of electrical cable manufactured in Christchurch and New Plymouth and nearly 100,000 cubic yards of concrete mixed in Southland.

2. PRODUCTION OF ALUMINIUM

The main raw material, alumina, is refined at Gladstone from bauxite mined at Weipa (Fig. 1).

About four tons of Weipa bauxite are needed to produce two tons of alumina which in turn yield one ton of aluminium for an electrical energy input of nearly 17 kWh. (Table 1).

TABLE 1

Requirements for 100 kilotons of aluminium per year

200 kilotons of alumina	3 kilotons aluminium fluoride
45 kilotons of calcined coke	0.2 kilotons soda ash
10 kilotons of hard pitch	0.3 kilotons fluorspar
2.0 kilotons of cryolite	15 kilotons fuel oil

In the smelting process alumina is fed into electrical furnaces called "pots" or "cells". In these 15 X 30 ft furnaces, shaped like a shallow bath, the alumina is dissolved in molten cryolite (sodium aluminium fluoride) at 1,000° C. Power for each pot is supplied by a steady potential of about 4.5 volts across each cell.

In a cell the current flows from 18 anode assemblies, each with two carbon blocks forming the anodes, through the molten cryolite to a carbon lining at the cell bottom (the cathode). The alumina dissolved in the cryolite dissociates into aluminium and oxygen, the latter is liberated at the surface and reacts with the carbon anodes to form waste carbon dioxide gas. The aluminium is deposited on the furnace bottom where it is tapped each day by means of an air-pressure operated venturi syphon.

The smelter process is continuous, as aluminium is recovered from the furnaces, more alumina is added from hoppers forming part of the cell superstructure and charged daily by crane. Periodically, a crust of frozen cryolite which covers the molten cryolite in the reduction cell is broken automatically to allow alumina to fall into the molten bath.

Each cell operates individually and produces more than one ton per day, consuming about half a ton of anode.

3. THE SITE AND APPROACHES

The smelter site covers 215 acres on a spit of land bounded by Bluff harbour to the west, Awarua Bay to the north and the sea to the south. Work on the site started in July 1969.

The Southland County Council was responsible for building the site access road, including a bridge and causeway with a total length of 4,200 ft.

The wharf is part of Bluff harbour and was constructed for the Southland Harbour Board by Wilkins and Davies Taylor Woodrow to a design by E. R. Garden & Partners and Harbour Board Engineers. The wharf head is 650 ft long and 54 ft wide, the approach to land, over shallow water, is 4,170 ft long with single carriage way and passing bays. Eventually, ships are expected on average every 10 to 14 days, limited to 20,000 ton carriers at present due to a restriction at the harbour entrance. It is proposed to blast this clear and open access to 35,000 ton ships.

The wharf is an application of pre-cast, -pre-stressed and post-stressed design. Fenders consist of chain-hung 20 ton pre-cast blocks: a ship finds little resistance on contact but then must lift the blocks as they swing on the chains. The wharf stands on reinforced concrete piles which were jetted into position, the piles were prestressed and had hollow cores.

A single-screw ship, blown across the harbour out of control caused some damage to the wharf during the construction period and a protective bolstering device will be fitted between the end of the wharf and the mooring dolphin to take such impacts. The device is a spring steel--cored nylon rope terminated in Andre bellows-type impact res;stors made of corrugated welded steel. The bellows are replaceable and will break before the rope.

Alumina and pitch from Australia and petroleum coke from the United States will be vacuum unloaded at the wharf head. The unloader is a German design fitted with telescopic action suction pipes and two independent vacuum systems. It can operate in winds up to 35 mile/hour and, if tied down, will survive 60 to 100 mile/hour winds. (Fig. 2.)

The wharf is designed for day or night operation and suitably illuminated throughout its length.

With the smelter operating at 220,000 ton/year a million tons of freight will pass across the smelter wharf each year, including finished products which will be trucked to the wharf.

4. BULK STORAGE

A-frame storage buildings are provided for alumina, coke and pitch. (See Fig. 3 for layout.) In each case the angle of the roof conforms to the natural angle of rest of the contents. Material is taken to a transfer tower by the wharf conveyor thence it is deposited under the apex of the roof.

Fuel oil will be pumped through a 12 in. pipe from the wharf head to a 7,000 tons storage tank for use in the carbon baking and metal casting furnaces.

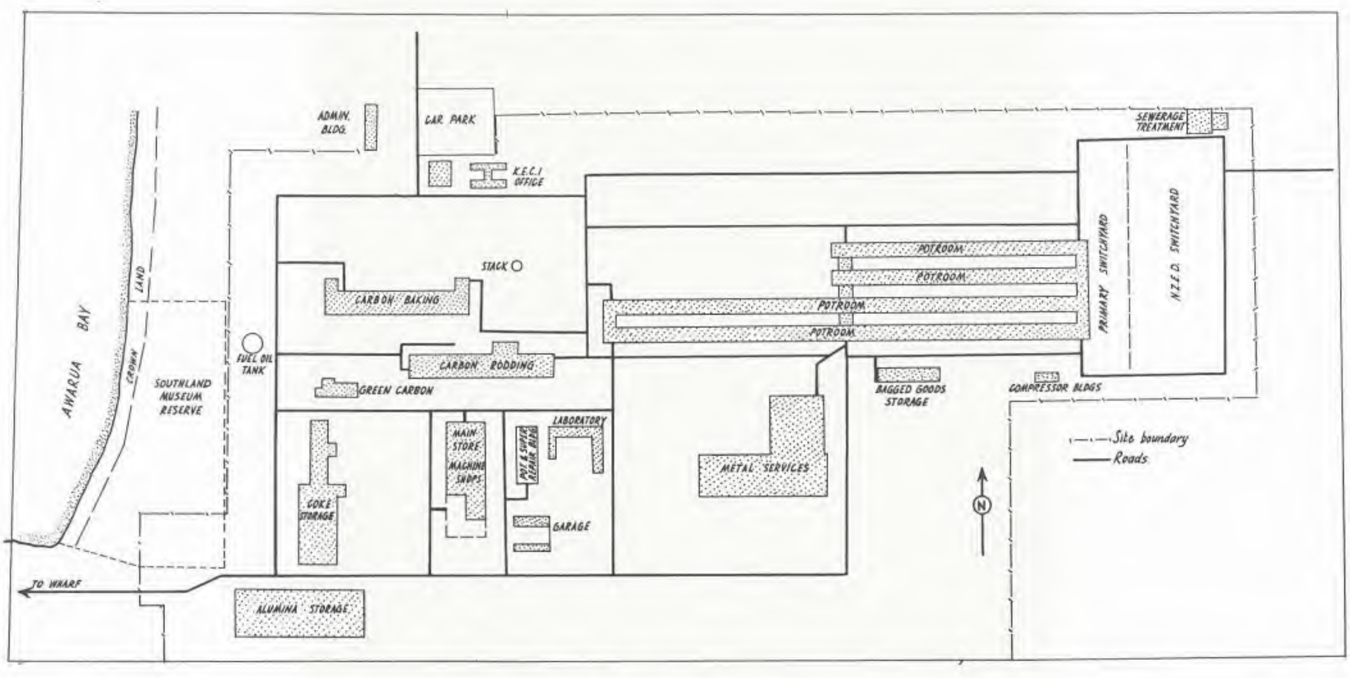

Fig. 3. Smelter layout.

TABLE 2—BULK STORAGE

Throughout the plant the basic technique is not to refine materials but to use refined materials from the start and keep them uncontaminated.

5. ELECTRODES FOR THE REDUCTION CELLS

Paste to form anodes and parts of the reduction cell linings is made in the "green carbon" plant. (Fig. 5.) Pitch is used to bind the petroleum coke and the paste. Materials pass fine-grind systems and magnetic separators, the latter being necessary because used anodes (butts) are re-used as paste ingredients and iron contamination is possible.

The paste is pressed into block form in either of two hydraulic presses each with a capacity of 2,500 tons and taken to the "carbon baking" building. Conveyor systems in the press and baking rooms have cost over $2 million.

Both the "green carbon" and "anode press" plants are automated as far as possible and have a complex control system. Control rooms in both plants are air-conditioned.

The carbon baking plant is a portal frame structure with a rigid frame standing on concrete pillars, it is 50 ft high, 100 ft wide and 580 ft long. The 360 furnace pits, each holding 24 anodes, operate at about 1,100° C. The plant has a capacity of 500 anode blocks per day and the furnace pit firing is a continuous operation.

The firing carbonises the pitch and gives a hard consistency to the block. The blocks are left in the pits for two weeks to cool then cleaned by blasting.

To reduce heat loss problems such furnaces are usually below ground level but this has not been possible at Bluff as the water level is a few feet below the surface and these furnaces are at ground level.

More than 100 kilotons of anodes will be used each year, with a smelter capacity of 220,000 ton/year aluminium.

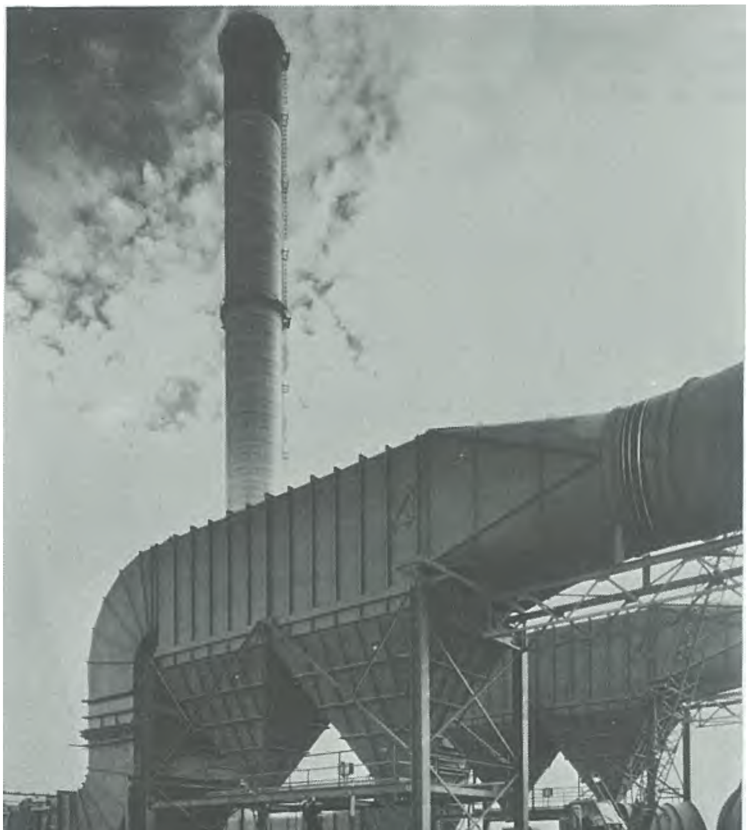

Fig. 4: Multitube cyclonic dust collectors.

An automatic system controls the operation of the line of reduction cells, the voltage across each cell is scanned in turn and alumina is fed into the cell as required from the bin incorporated into each cell superstructure.

9. METAL PRODUCTS

The metal products area of 140,600 ft^2 receives the primary molten aluminium from the potrooms, and converts the molten metal into saleable products by furnace processing, casting, homogenising, and bundling. Facilities are installed for inspection, cutting, binding, coiling and weighing.

The water requirements for the casting shop for a production of 110,000 ton/year is 550,000 gal/day with a 200,000 gal/day requirement for the rest of the plant, all obtained from a shallow aquifier on Tiwai Peninsula. For storage purposes a two million gallon water reservoir was constructed by the Invercargill City Council.

The smelter output consists of 99.5% purity ingot, alloyed ingot, direct chill cast extrusion billet and rolling block and electrical grade redraw rod in coil form (for cable manufacture).

The Japanese partners will export their share of the metal produced whilst Comalco will export its share of output not used or sold in New Zealand.

10. ATMOSPHERIC CONTROL

For air control the furnaces are fully hooded and made as airtight as possible (Fig. 6). Carbon dioxide is generated in large quantities and is collected by scavenging air exhausted from each furnace at a rate of 4,200 cubic feet/minute. To maintain gas velocity ducts running the length of the potline buildings increase in diameter as the gases approach multicyclone dust separators (Fig. 4). Small amounts of fluorine are also evolved during the smelting process. Not less than 90% of the particulate matter is removed from the gases by the dust separators before leaving the plant through the 450 ft stack, the tallest in New Zealand except for the power station at New Plymouth. The first 100 ft of the stack is steel refractory lined. Hot furnace gases from the carbon bake plant create a thermal lift in the stack for the gases from the reduction cells.

$2.5 million has been spent on air control equipment. Monitor points for gas quantity, dust loading and gaseous fluoride are located throughout the system. Several stations have been established in the vicinity of the smelter to monitor fluoride levels in animals and atmosphere. Although monitoring will be carried out over a fifteen mile radius from the plant it is considered that the gases will be extremely dispersed beyond the three mile radius. The air control equipment and the monitoring programme have been installed to meet strict standards set by the New Zealand Department of Health.

11. STAFFING AND ANCILLARY SERVICES

Whilst the construction labour force reached a peak of 1.200 a nucleus of the smelter's permanent operating staff of about 700 was receiving training in the Comalco smelter at Bell Bay, Tasmania. There will be a staff of almost 100 in the 17,000 ft^2 administrative building. Laboratories for chemical, metallurgical and radiological tests on incoming materials and outgoing products are provided. About 33 professional engineers will be employed (14 mechanical, 1 civil, 7 electrical and 11 chemical) plus about 16 N.Z.C.E. trained staff.

Fig. 6. Reduction cells and bus bars.

Due to the continuous nature of the process an intensive preventive maintenance programme is required.

More than 150 houses have been built for the smelter staff in Invercargill through the Ministry of Works and State Advances Corporation.

12. CONCLUSION

Through the smelter, New Zealand will become a significant participant in the world aluminium industries. On present trends, the size of the world market for aluminium win double in less than ten years to a total consumption of more than 20 million tons per annum.

Advantages of the smelter to New Zealand are a savings in, or earnings of, overseas funds, gains in expertise, a boost to local industry (which is used to the extent of its ability) and opportunities for people to gain experience in heavy industry. There has been a high New Zealand content in labour and materials during the construction period and there will be a high New Zealand labour content during the plant operation.

ACKNOWLEDGMENT

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Settlement analysis of building foundations

C. J. A. NICHOLAS
B.F., M.E. (GRADUATE)

Current design office procedure in the determination of the magnitudes of shallow foundation settlements is described with special reference to the major assumptions and limitations of the one-dimensional theory. This is followed by a description of recent developments in three-dimensional settlement analyses. A review of available computer programs for the analysis of foundation settlement indicates a need for further programs to be developed. The features of a computer program developed by the author for foundation settlement analysis is described. The program takes into consideration more of the practical aspects of settlement problems associated with building foundations making available a more versatile and flexible analysis to the design engineer.

COLIN NICHOLAS has been employed as an assistant design engineer by Babbage, Shores, Andrei!, Eagles and Partners, Auckland, since 1968. He was born in Auckland and attended Mount Roskill Grammar School. Studying at Ardmore Engineering School, University of Auckland, from 1964 to 1968, he gained a Bachelor's Degree (Civil) and a Master's Degree (Soil Mechanics).

He will be travelling to the United Kingdom later this year to gain further experience in the field of civil engineering.

This paper was first received on 10 October 1970 and in this revised form on 28 April 1971.

1. INTRODUCTION

THE one-dimensional theory of settlement analysis provides a simple method by which designers of building foundations may obtain reasonable estimates of foundation settlement. However, many site situations arise which do not conform to the conditions required by the one-dimensional theory. Moreover, complex site profiles and foundation layouts generally necessitate gross over-simplification because of time limitations present in the design office.

There are, currently available, a selection of design methods for foundation settlement which will overcome these problems. Awareness of the advantages and limitations of the methods will enable the design engineer to make a reasonable choice of method with resulting improvements in standard and economy of design.

2. METHODS OF SETTLEMENT ANALYSIS

2.1. The one-dimensional analysis

The one-dimensional theory proposed by Terzaghi[6] heralded the first recognised concepts of the settlement analysis of building foundations resting on compressible clay. The one-dimensional theory has since then been the basis for conventional methods of interpreting consolidation test data.

The major assumption of the one-dimensional theory is that strains due to applied loads occur in the vertical direction only. This condition may be assumed if the layer of compressible soil is an appreciable distance below the foundation or if the width of the foundation is large with respect to the thickness of the soil layer. In general, considerable variation from this assumed condition may occur in practice. If this condition can be assumed, the pore pressures induced by the ioad may be considered identical to the increase in vertical stress and the vertical deformation will be directly proportional to the volumetric strain. Also, changes in voids ratio of an in-situ element of soil corresponding to changes in stress at the midpoint of the element are known to follow a relationship similar to that shown in Fig. 1. The one-dimensional settlement at a particular point is then given by the summation of the change in thickness of each horizontal element, over the total thickness of the compressible layer, or

= |

where m is the coefficient of volume decrease or slope of the *e-p* curve and

|

of thickness dz

The application of equation (l), however, is not straight forward since the value of m_v changes while settlement proceeds. This is overcome by plotting the e-logP diagram shown in Fig. 2 and obtaining a straight-line relationship of slope C,..

The increment of one-dimensional settlement ds, of a horizontal element, thickness dz, is then given by the expression

$$(dz/1 + e_0)C_e(\log P_1 - \log P_O) \quad . . . (2)$$

where e_o is the initial voids ratio of the soil

P_o and P_1 are the initial and final states of stress acting at the midpoint of the element and

C, is the compression index.

The application of equation (1) includes summing the settlement increments or horizontal elements of given thickness knowing the consolidation properties of each layer. Thick layers can be divided into several thin layers enabling problems involving non-uniform pressure distribution throughout the layer to be solved reasonably accurately.

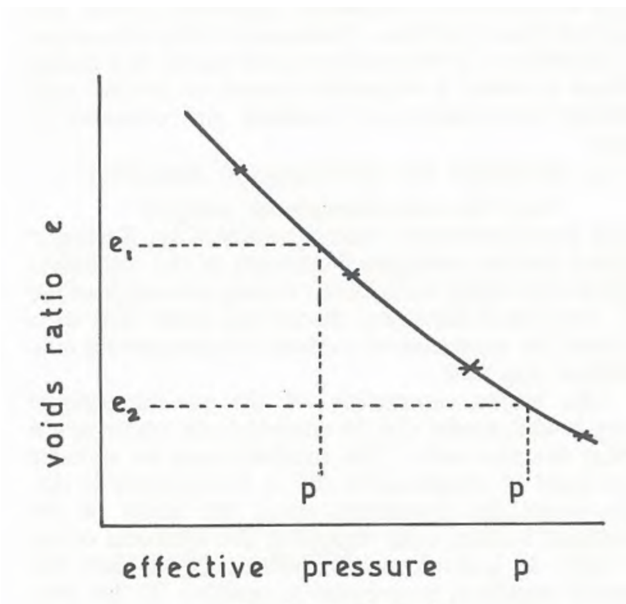

Fig. 1: e-p relationship.

A general site survey, borehole data and standard oedometer test results are sufficient to provide the necessary information to obtain values of settlement in a manual calculation.

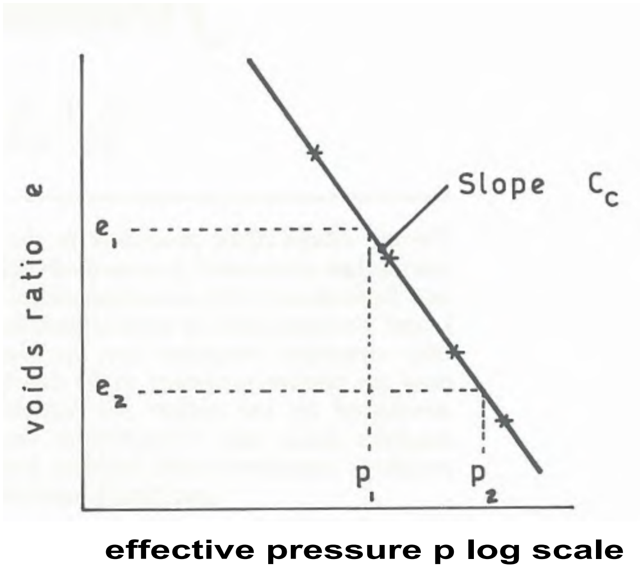

Fig. 2: e-logP relationship.

The general limitations of the one-dimensional analysis as applied in a design office arise in one or more of the following ways:

(i) The changes of stress at depth owing to applied loads are generally determined from stress charts based on elastic stress distribution theory for semi-infinite media. However, most site profiles approach the condition where a compressible clay layer is overlain by a sand blanket or preconsolidated hard layer. Wu[5] has drawn attention to the modification of stresses in the lower layer of a two-layer system compared with stresses determined assuming semi-infinite media. He shows that stresses determined by the latter could be 100 to 150% higher than those found from layer theory. It is essential that stress charts incorporating layer theory be made more readily available before accurate stress determination may be predicted and economical foundations designed.

(ii) The consolidation properties are determined from a standard oedometer test. The disturbance induced by sampling, and errors inherently induced by the testing procedure necessitates empirical modifications of the measured laboratory curve to obtain the true in-situ properties. In some cases, the modifications have been found to be unsatisfactory.

(iii) Generally, time limitations promote a simplification of the problem including choosing large horizontal elements and neglecting the complexities of existing loads or irregular surface profiles. This induces errors by virtue of the fact that the problem being analysed differs considerably from the actual problem in-situ.

Despite the inherent limitations, the one-dimensional theory provides a simple tool, enabling reasonable estimations of foundation settlement to be made.

2.2. Three-dimensional analyses

In general, many site conditions deviate significantly from those assumed in a one-dimensional settlement analysis. It is evident, therefore, that modifications to the present theory or development of new methods must be made to enable reasonable accuracy to be obtained within a settlement analysis. These developments are generally termed three-dimensional theories.

In many cases, owing to the limited extent of loading, a compressible soil will experience some form of lateral strain under an applied load. The pore pressures induced by the load will no longer be equal to the increase in vertical stress, and the vertical deformation will no longer be directly proportional to the volumetric strain. It follows that if lateral strain occurs within a loaded clay layer, a settlement analysis based on one-dimensional theory would not give a true account of the amounts of vertical displacement which take place.

In this light several authors have attempted to take three-dimensional effects into account by modifying the present one-dimensional theory or by developing experimental procedures in which the volumetric and vertical deformations of the soil are measured.

2.3. Use of pore pressure parameters

As a consequence of the lateral strain of a clay, porewater pressures induced by the applied load will no longer be identical to the vertical stress at any point and will be changing as settlement proceeds.

Skempton[5] expressed the changes in pore pressure which occur under applied load in terms of the changes in vertical and lateral stress and pore pressure parameters, namely

$$\Delta u \qquad + A \qquad \Delta\sigma 3)$$

rather than the conventional assumption that

$$\Delta u = \Delta\sigma^1$$

where B is a function of the porosity and relative compressibilities of the pore fluid and soil skeleton and

A may vary in magnitude, depending on the in situ stress conditions, the magnitude of induced strain and the geological stress history of the clay.

This procedure led to improved evaluations of consolidation settlement which for most clays, A being less than unity, were substantially less than those indicated by the conventional approach.

It should be noted that A may not be determined from elastic theory, as soils change in volume during shear, but must be determined experimentally during an undrained triaxial test.

A further modification involves relating the "three-dimensional" settlement to the conventional oedometer value by

pe =

where μ is a function of A and the geometry of the site profile and can be obtained from a diagram relating these parameters.

2.4. The stress path approach

Recent research has developed a three-dimensional method of settlement analysis based on triaxial tests in which the lateral and vertical deformations of the soil sample are measured during loading. In effect, this method endeavours to simulate the three-dimensional in-situ, changes in stress occurring in the field within the triaxial cell. Measured axial and volumetric strains are then related to the overall settlement of the soil layer directly or through expressions obtained from elastic displacement theory.

Stress path methods of settlement analysis have been compared with actual observed settlements with good results. The values of settlement are closer to the observed values than results obtained from one-dimensional methods of analysis. The examples cited, however, generally include thick layers of clay close to the surface constituting ideal three-dimensional conditions. If site profiles such as these are present, and strict design tolerances are required, solution by three-dimensional analysis should be considered. If this is the case the following limitations of the stress path should be recognised.

(i) **In** general, the amount of deformation measured in the triaxial cell is dependent on the initial and final states of stress applied to the soil. However, as conditions approach failure, more consideration must be given to the way in which the stresses are applied and to the corresponding shape of the path of stress between the initial and final states. Present knowledge of the behaviour of soil and soil/water inter-action under load is not advanced enough to predict correctly the variation of stresses experienced by particular elements in going from one state of stress to another.

(ii) At present, conventional triaxial equipment is capable only of applying vertical and equilateral stresses to an element of soil. This limitation restricts the determination of settlements to elements situated on the centreline of axisymmetric foundations only. Present laboratory apparatus must be improved before stress path methods provide wide application to most civil engineering problems.

(iii) Foundation conditions often generate small localised areas of material at or near failure, under the applied loads, which do not affect the overall settlement because of the constraining effect of the surrounding soil. This may induce unwanted creep deformations in the triaxial cell which may not be large enough to be detected but are enough to cause errors in the result.

2.5. The computer approach

The accuracy and speed of calculation resulting from the use of a computer program leaves the engineer with more time to des'gn in the true sense of the word. If necessary, the engineer may consider alternative designs or conditions so that optimum results and a better design can be achieved.

It must be emphasised that a computer program should not take the place of design but should be an efficient and effective aid in problem analysis.

The one-dimensional settlement analysis lends itself ideally to computerisation in that the repetitive application of equation (2) provides a systematic and simple procedure which the computer can follow.

The author is aware of two computer programs currently available for the analysis of foundation settlement.

(i) The program developed by Wong and Graves7 is based on the one-dimensional consolidation theory and the elastic theory of stress distribution. The computer programe is developed for point loads only and takes into account the variation of soil properties within the subsoil.

The program has many limitations. The effects of preconsolidation properties of the soil and sloping layers are not featured. The point loading feature restricts the program considerably as complex combinations of rectangular foundations occur more frequently in routine design.

(ii) A computer programe has been developed by Schiffman and Jordan (1967) within the Integrated Civil Engineering System project for computing the settlement under a series of loads. The program package is called SEPOL. No computer or programming experience is necessary and orders to the computer are transmitted by engineer-language commands.

This SEPOL program has a wide range of applications. The engineer may select several types of output including stresses at any point and magnitudes and/or rates of settlement.

The methods of solution may be based on the one-dimensional approach or on the modification considered by Skempton and Bjerrum, the particular method being selected by the engineer. If a sophisticated method of solution is chosen more detailed input information is required. In some cases if a Young's Modulus or a Poisson's ratio is required further laboratory tests other than the conventional oedometer test must be carried out to provide adequate input information.

The surface loadings may be plane strain, rectangular or axisymmetric and the effects of a water table are automatically taken into account.

Notable omissions within program SEPOL are the consideration of existing loads increasing the existing stresses at any point and allowances for sloping soil strata and an irregular surface profile.

Despite certain limitations, SEPOL provides the engineer with a powerful tool for determining the results of many soil problems.

Too often time limitations in routine design necessitate broad assumptions in the manual analysis of settlement problems. The computer programs described above do not overcome th;s problem and give speedy and accurate solutions to a variety of simple problems only. The computer program developed by the author takes into consideration more of the practical aspects of settlement problems associated with building foundations making available a more versatile and flexible analysis to the design engineer.

3. THE PROGRAM FOR FOUNDATION SETTLEMENT

3.1. General description

A program has been developed utilising one-dimensional theory for the calculation of the ultimate consolidation settlement of foundations resting on compressible media. The program is written in Fortran IV language, being developed with the use of an IBM 1130 8K word computer. Minor modifications would enable the program to be used on the IBM system 360 model or similar computers.

Because of the wide use of the one-dimensional approach in settlement analyses, Terzaghi's one-dimensional settlement theory and an elastic stress distribution theory have been chosen to give an analysis comparable to that used in most design offices at present. The total consolidation settlement at a point is computed by summing increments of the settlement of horizontal dz elements below the point.

The major features incorporated in the program are:

(i) Calculation of settlement magnitudes at any point using the one-dimensional theory of consolidation.

(ii) Determination of stresses using elastic stress distribution theory.

(iii) The capability of considering the following practical aspects of a site profile.

- New loads, excavations and existing loads applied on rectangular flexible foundations;
- Preconsolidation of the soil layers;
- Sloping soil layer interfaces;
- Irregular surface profiles.

(iv) The capability of being able to modify certain variables during execution to obtain rapid information on the effects of changing input parameters.

The program is capable of handling a settlement problem which involves up to

- 30 different new loads (including excavations);
- 20 initial loads existing at the site and
- 10 separate soil layers.

A typical site condition well within the scope of the program is shown in Fig. 3.

All the information required for a one-dimensional manual analysis is sufficient to provide the necessary input information to obtain a settlement analysis using the program. The basic information required includes:

(i) Locations and magnitudes of all existing and applied loads.

(ii) Thicknesses and depths of all soil layers.

(iii) Properties of each soil layer as determined from conventional oedometer test results.

(iv) Position of the water table and locations of required calculation points at which the settlement values are required.

Irregular surface profiles may be taken into account by considering the profile as comprising equivalent rectangular existing loads computed with referenc to a selected horizontal datum.

For each soil layer, a choice is made of the number of horizontal elements which the layer can be broken into for stress and settlement determination. A criterion has also been developed which provides a guide to the number of elements given layer thickness and load width. In this way, an optimum choice can be made which gives a reasonable accuracy of result with minimum computer time.

3.2. Outline of the working procedure

The computer program consists of a mainline program which controls a series of subroutines, each called in turn to carry out specific sections of the computation.

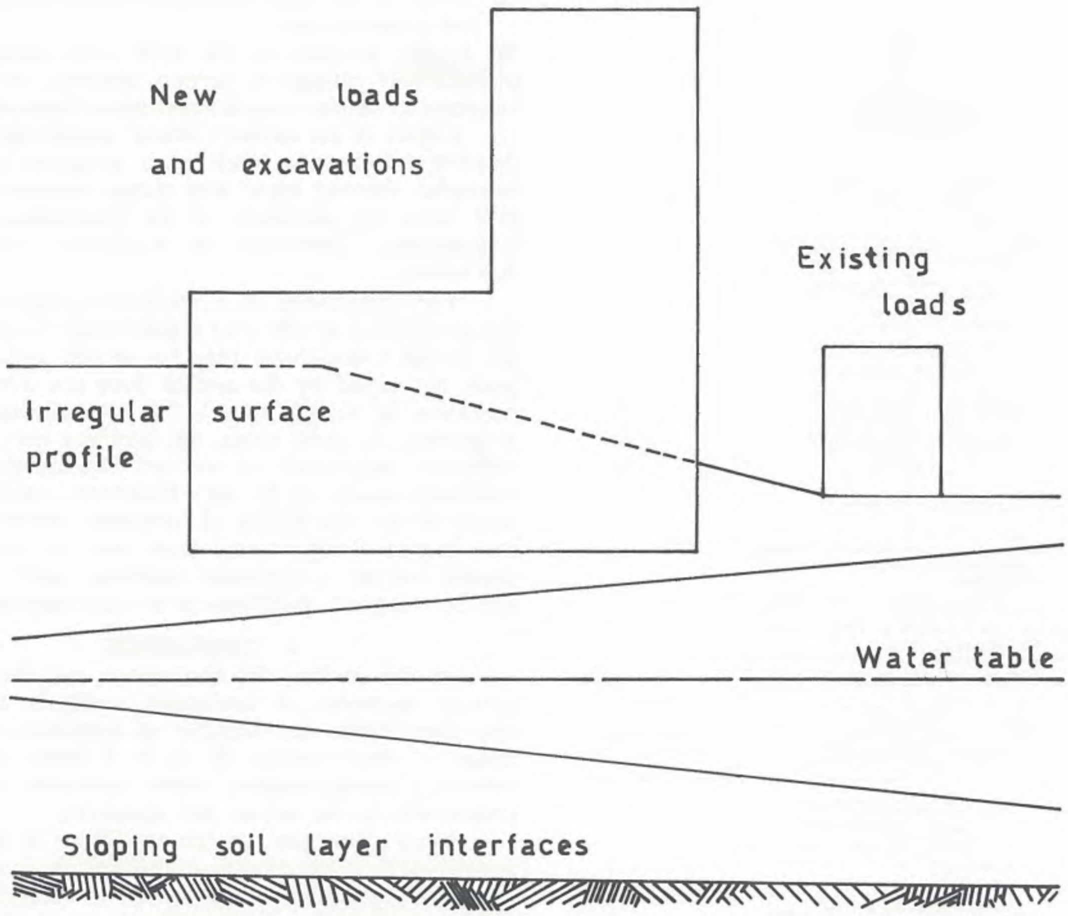

Fig. 3: Typical problem which settlement program may undertake.

Some subroutines carry out the input-output functions and others carry out certain sections of the calculation. A generalised flow chart is shown in Fig. 4.

Each problem is handled in the following sequence:

(i) Initial input data which is read in from punched cards, is stored in the computer memory and recorded on the results output sheet.

(ii) For each calculation point, determination of the total ultimate settlement of the column of soil directly beneath the calculation point owing to the application of all new loads is carried out.

(iii) At the conclusion of the problem, the computer operator may adjust and modify certain initial input variables and the problem run again or

(iv) Depending on the information on the next card to be read, a new problem deck can be run or a normal exit from the program can be made.

3.3. Description of the results output

The program produces a results output sheet which completely summarises the initial input of the particular problem and the results of computation.

The geometry and magnitudes of the loads and the properties of the soil layers are listed under appropriate headings.

Intermediate results of computation are also recorded on the results sheet.

For a particular calculation point the state of stress at the base of each layer and settlement of each layer is recorded, that is for each soil layer a listing for each calculation point gives

(i) The ultimate settlement in inches.

(ii) The depth to the base of the soil layer in feet.

(iii) The initial overburden pressure existing at this depth and

(iv) The change in stress at this depth due to the application of all the new loads.

The total ultimate settlement of the calculation point is collated and recorded before the next calculation point is considered.

If any modifications are made by the computer operator via the console keyboard, a record is made of the particular variations and the problem is run again.

The output sheet has been developed in this way to give the design engineer an overall picture of the site profile. Specific information such as the stresses at the base of each soil layer or an indication of where the seat of settlement occurs at any point may be an aid in formulating an economical design.

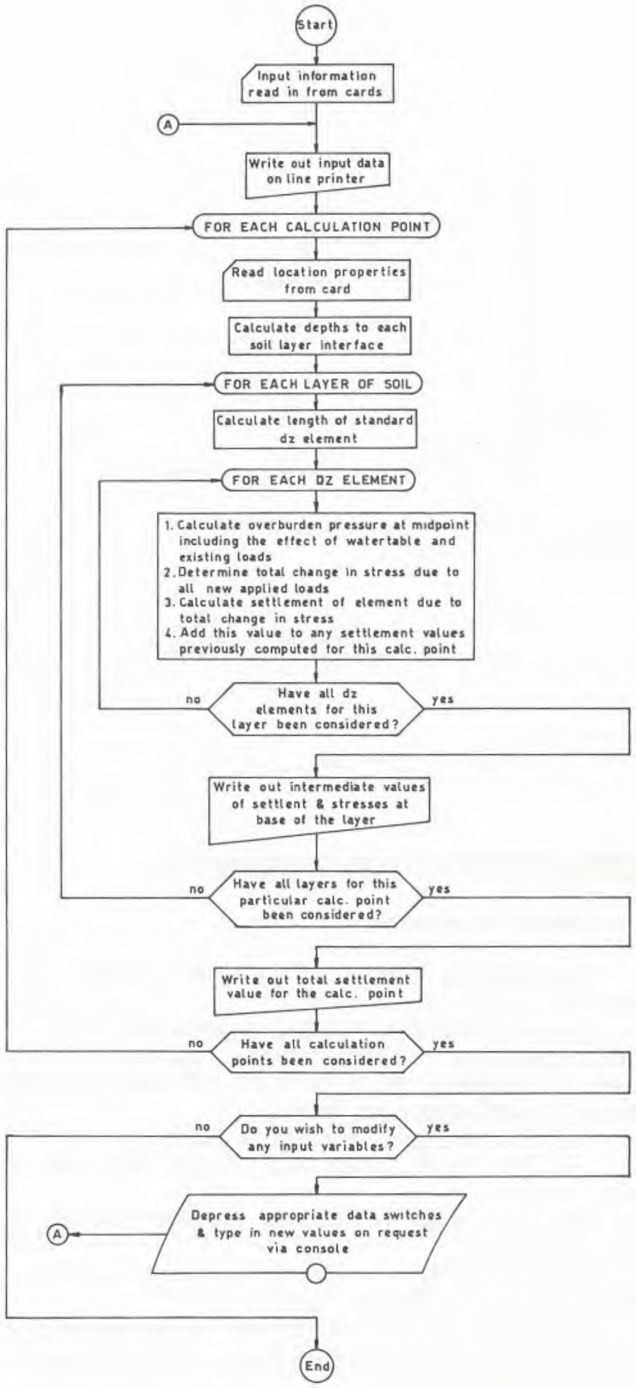

Fig. 4: Generalised flow chart of program for foundation settlement, Auckland.

The main advantages of the program developed over those programs currently available are:

- There is no need for gross simplification of the site problem and
- A user/operator of the IBM 1130 computer may conveniently change a certain number of the input variables to obtain a rapid indication of their effects.

Copies of the author's thesis[3] which includes more detailed information such as a program listing and examples showing input and output formats are available from the secretary of the Department of Civil Engineering, University of Auckland, Private Bag, Auckland.

The application of a computer program such as this provides a speedy and reliable way in which accur ate design calculations may be carried out. The program developed by the author does not overcome the problems of sampling and the determination of soil properties. In some cases, the problem may not be of sufficient importance to warrant consideration of the practical aspects of the site. However, recent developments in the availability of computer services indicate that routine design calculations may be more readily carried out by a computer, enabling fairly simple, as well as complex, problems to be run economically.

4. CONCLUSION

In this review, the limitations and conditions of several methods of settlement analysis have been described. Once the designer of foundations becomes aware of these factors he is in a better position to choose a design method which conforms as close as practicable to the actual site situation.

More often than not, the conditions of the problem approximate those of the one-dimensional theory, but require simplification to carry out the manual calculations economically. The computer program described herein provides the engineer with a more versatile and flexible analysis enabling speedy and accurate solutions to be obtained to a problem resembling closely the situation on site.

5. ACKNOWLEDGMENTS

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The place of the Technicians Certification Authority in the training of technicians

G. V. WILD
B.A.(N.Z.), B.SC.AGR.(EDIN.)

Since 1955 G. V. Wild has been chairman of the Controlling Authority for N.Z. Certificates in Engineering and of its successor, the Technicians' Certification Authority of New Zealand.

Mr Wild has been interested in technical education since 1923 and although an educationist, not an engineer, he has made an outstanding contribution to this important aspect of engineering.

1. HISTORICAL BACKGROUND

1.1. Consultative committee

THE beginnings of the Authority are to be found in the "Report of the Committee on the Education, Training, and Supply of Professional Engineers in New Zealand", published in 1949. That committee had as chairman, E. Caradus, who had lately retired from the Department of Education; and 12 other members of whom six were educationalists. Nine of the 12 members were professional engineers by training. One of the important questions placed before the Consultative Committee was this: "To what extent, if any, should instruction in professional engineering be provided in the technical schools?"

1.2. Committee's views

The committee expressed its views in these words: "While there is a weight of evidence that ultimately all civil and electrical engineers, at least, should be graduates, the Committee realises that, for some years, it will still be necessary to train a proportion of professional engineers by means of courses leading towards diplomas in professional engineering. It will therefore be necessary to provide facilities for instruction in the subjects of these examinations in certain of the technical schools. . . ."

The recommendations of the committee were numerous, selected here are those which relate to this proposed diploma. They were:

"That in future all civil and electrical engineers should qualify by way of a university degree."

"That the policy for development in mechanical engineering be based on the assumption that there will be a demand for some years for engineers who obtain their professional qualifications while employed in industry."

"That for some years a proportion of professional engineers should be trained by means of courses leading towards diplomas in professional engineering."

A later section of the report suggests in some detail how a system of diplomas in professional engineering should be developed. To quote:

"That the Education Department institute a system of diplomas in professional engineering of a standard at least equal to that of the present Institution membership examinations."

"That these diplomas be awarded in respect of courses which, though mainly part-time, shall include at least one year of full-time study."

"That these diplomas be awarded as a result not only of examination success, but also of satisfactory completion of a course of study approved by the Education Department."

"That a candidate must pass at the one time in all subjects of any year before proceeding to the next year of the course."

"That entry upon a diploma course be permitted only to a student employed as a cadet, articled pupil, or apprentice under conditions approved by the Engineers' Registration Board for this purpose."

This paper was first presented to the Canterbury Branch, N.Z.I.E., on 24 June 1970. It has been abridged for publication.

"That the Education Department and the Engineers' Registration Board co-operate in drawing up prescriptions and conditions for qualifying examinations for diplomas in professional engineering, as circumstances warrant, and in conducting or arranging for these examinations.

"That diplomas in professional engineering be issued under the authority of the Education Department."

The report had this to say in support of its recommendations:

"One reason for the establishment of diploma courses is that they are considered more suitable than degree courses for certain types of students. They also provide an avenue to the engineering profession for those students who, for one reason or another, find it impossible to attend a university school of engineering. It will generally happen that a decision as to whether a particular student will enter upon a degree course or a diploma course will be made at the time of leaving post-primary school. This is a very important decision; but it would be folly to imagine that it will always be wisely made," *but*

"The Committee is definitely of the opinion that the successful establishment of the diploma system is contingent upon the recognition of diplomas by the Engineers' Registration Board.

1.3. N.Z.I.E. opinion expressed

These extracts concerning a diploma are not quoted to support a case for a diploma, but to indicate the lines along which professional engineers, or some of them, were thinking 21 years ago. When the report was published, the N.Z. Institution of Engineers was unable to accept the recommendation. Its attitude was then, though it may not be altogether so now, that the only route to professional status was via a university degree.

1.4. Status of engineers' assistants

The order of reference of the Consultative Committee did not include any consideration of the educational requirements of the sub-professional engineer. Nevertheless it included this paragraph, under the heading:

Recognition of *status* of *engineers' assistants:*

"It was clear from the evidence submitted to the Committee that there is a demand for some recognition of status for engineers' assistants. Evidence to this effect was given by the Engineers' and Assistants' Association Inc. The Committee regards the establishment and continued activities of this and similar associations as desirable and recognises the importance of their members to industry and to the engineering profession. The qualifications of the membership, however, are varied, and will in many cases depend more on length of experience than on examination certificates. This Committee does not regard the establishment of any form of certificate for this group as coming within its functions, but it desires to commend the matter to the Hon. the Minister for his sympathetic consideration."

2. ESTABLISHMENT OF CONTROLLING AUTHORITY

2.1. First meeting 1954

The report was published in 1949. The forerunner of the T.C.A.—the Controlling Authority for New Zealand Certificates in Engineering—had its first meeting late in 1954. For two years after 1949 there was virtually a stalemate on this question of non-university educalon for engineers or engineers' assistants. Finally the N.Z.I.E. agreed to co-operate in the search for a suitable sub-professional qualification with the Department of Education and others. It did so on the condition that there should be no ladder from this qualification to the profession; there should be no diploma; and there should be no additional equipment given to technical colleges that might encourage them to continue teaching at the A.M.I.X.E. level.

2.2. Constitution of the Controlling Authority

The Authority as set up in 1954 consisted of a representative of the N.Z.I.E., W. L. Newnham, a retired Commissioner of Works; J. Goldie, representing the Engineers' and Assistants' Association; E. W. Mills representing the Technical Education Association; B. C. Lee representing the Department of Education; and Professor N. M. MacElwee, a co-opted member from a university school of engineering. This was a ministerial committee, and the assistant director of education was given the job of chairman.

Two or three years later the N.Z. Institute of Draughtsmen was added to the list of members; and the late Mr Jennings was its first representative.

2.3. Functions and attitudes of the controlling Authority

It was dealing essentially with work based part-time students. Looking back on it there was no question about that: the students were assumed to be in employment, the classes available were only part-time classes and held, originally anyway, only or mainly in the evening. The hope was expressed that day release would be made available and industry accepted that challenge very quickly as did the Public Service. The first two years of the designed five-year course was essentially basic science and mathematics. In fact, the science was called Engineering Science and was a mixture of physics, chemistry and mechanics. Later, the relationship of these first-two-year subjects to the secondary school curriculum was recognised by a shift to straight-out physics, chemistry and mechanics from which exemption could be obtained by a suitable pass in School Certificate or University Entrance.

3. TOWARDS T.C.A.

Scientists, employers of scientists, the building industry and those associated with it such as architects, quantity surveyors, clerks of works, became interested in this form of training as the scheme was clearly attracting students. The registration of new students for N.Z.C.E. increased most pleasingly from something under 50 in 1955 to more than 200 in 1956, to about 450 each year to 1961, then forward towards the 1,000 mark. In 1969 there were 1,299 new students for N.Z.C.E., 231 for N.Z.C.D., 18 for E.T.C., and a grand total of 3,507 new students for all courses.

The original Controlling Authority was only a ministerial committee without defined powers or finance. So legislation was designed and passed in 1958 as the Technicians Certification Act, more or less setting out the lines along which the education of technicians should develop. It was not brought into force until early in 1960.

4. THE TECHNICIANS CERTIFICATION AUTHORITY

4.1. Constitution and function

To make this clear it is necessary to begin with the executive committees which deal with particular segments of industry. There are now four of these:

(i) For engineering and draughting which is the old controlling authority in a new dress;

(ii) For building, including architectural draughting and quantity surveying;

(iii) For science in several options;

(iv) For commerce, the newest of all but already with the most extensive range of options.

Each executive committee is constituted as follows: The director of technical education and a representative of the Technical Institutes Association of New Zealand; and up to six representatives of the occupational group; and a chairman. The chairman of the Authority is chairman of each executive committee which is one of the means by which a certain degree of uniformity is maintained among the various executive committees.

The Authority itself consists of two representatives from each executive committee, two representatives of the Department of Education, two representatives of the T.I.A. and one representative of the Vice-Chancellors' Committee of the Universities—a total of 13 members plus the chairman. Both on an executive committee and on the Authority there is a majority of individuals coming from the occupational group. Membership of the executive committee for engineering and draughting at present is: the director of technical education is represented by H. Marshall (an engineer); the T.I.A. by A. S. Prime, principal of the Teennical Correspondence Institute and also a professional engineer; the occupational group consists of a representative of N.Z.I.E., F. D. Tonkin, a representative of the Institute of Engineering Technicians, B. R. Gibson, a representative of the N.Z. Institute of Draughtsmen, H. C. Kinvig, and a representative of the State Services Commission, C. J. Tustin.

There are only four representatives of the occupational group—not the maximum of six—although we have had requests from several quarters to be represented. We have found this a very good and hard-working committee and are reluctant to make a decision among those clamouring albeit gently, for representation.

The inclusion of a representative of the State Services Commission may be queried. There was some difficulty in assimilating the Engineers and Surveyors' Assistants examination of the Public Service and it was decided that the best way to improve our understanding was to have a representative of the Commission on the executive committee. It will be agreed that the State Services provide a very large proportion of all our students and to that extent are no doubt deserving of representation in their own right.

4.2. How does it work

First of all we do not go out looking for business as we have no staff for such a purpose; but it may be of interest to give a little information about how we have dealt with certain courses or problems arising from them. The original courses, and most of the options, were prepared by the committee established by the Department of Education and the N.Z. Institution of Engineers in co-operation prior to 1954. We began, in fact, with complete courses in civil, mechanical, electrical and telecommunications; and with syllabuses devised for all subjects of those courses.

We were almost immediately pressed for a course in refrigeration, one of the main arguments being that some 40 to 50% of the wealth of New Zealand depended upon refrigeration. This was probably true enough when one considers what otherwise would happen to our butter and our lamb, not to mention the household refrigerators in every day use. So we developed a course in refrigeration; but after a few years it was evident that there were very few takers, and it looked as if it was not worth continuing. We had meetings with representatives of the Institution of Refrigeration Engineers who said the syllabuses were unsatisfactory, outmoded and not up to date. So we said: "Fine, you give us some up-to-date syllabuses". While we were waiting for these new draft syllabuses to arrive the closure had to be applied to the refrigeration option, which no longer appears in the Handbook.

On the other hand, when the electrical option came under fire from the Auckland branch of N.Z.I.E. in 1968, and their criticisms were supported by the N.Z.I.E. Council, the executive committee for engineering quickly set up a syllabus revision committee under the chairmanship of H. Marshall. The full committee broke up into working parties and came up eventually not only with revised syllabuses but with a very considerable revision of the course structure eliminating, for example, drawing and mechanics and strength of materials from the existing course, and giving much greater emphasis to the electronic developments in the field of electrical engineering.

The executive committee for engineering sent these suggestions out widely for comment to schools, employers, institutes and institutions likely to be interested. The suggestions attracted a very considerable measure of criticism, especially those concerning the dropping of mechanics and strength of materials. It was considered necessary to refer the whole problem back to the syllabus revision committee with the suggestion that the criticisms were so extensive that some modification of the proposals was necessary.

This was done; mechanics was restored as a fourth year subject and the new proposals were received with a greater measure of support. They were approved by the executive committee and adopted by the Authority, though some final year syllabuses have still to be settled in detail. The new Year 3 is now in force.

That is a summary of the usual method of working. Syllabuses are provided by those interested, they are sent out widely for critical comment and as far as possible any criticisms are met before the final draft is submitted to the Authority for adoption.

4.3. What has been achieved

The first N.Z. Certificates in Engineering were awarded on the results of the 1958 examination—the end point of three or four years' study beginning in 1955 or 1956.

There were six of them—one electrical and five mechanical. The 1959 examination produced 19 more—one civil, five electrical, eleven mechanical and two telecommunications. The number increased to 29 in 1960--two civil, nine electrical, twelve mechanical and six telecommunications.

The full sequence is shown in Table I. These are "first certificates"—the figures exclude certificates gained by students who already hold a N.Z. Certificate.

5. STATISTICS

At this stage it may be useful to have a look at some other statistics. Theses should not be regarded—perhaps unfortunately—as the last word in completeness; but they at least give some sort of picture of the range of student we are dealing with. All are "hand-made" statistics—not "machine-produced".

TABLE I

N.Z.C.E.'s obtained (certificates other than first not included)

Year of Exam.	*Civil*	*Electrical*		*Mech.*	*Telecoms.*	*Prod.*	*Re frig.*	*Aeronautics*	*Plastics*	*Total*
1958		1		5						6
1959	1	5		11	2					19
1960	2	9		12	6					29
1961	13	8		14	5					40
1962	27	11		20	8					66
1963	33	21		20	13	6				93
		Heavy	*Light*							
1964	54	9	—	31	25	2	1			122
1965	38	15	1	34	28	7	1	5		129
1966	54	21	4	39	32	19	1	2		172
1967	45	24	3	67	48	26		2	2	217
1968	68	31	5	72	41	24	5	8	3	257
1969	95	22	6	42	57	27		5	4	258
Totals	430	196		367	265	111	8	22	9	1,408

TABLE II

Precourse qualification: 1965 Registration

(Percentages in brackets)

Course selected	*Univ. unit**	*U.E.*	*S.C.*	*Trade*	*None*	*Total*
N.Z.C.E.	27	234	394	51	180	886
	(3)	(27)	(44½)	(5)	(200	(100)
N.Z.C.D.	3	66	172	1	49	291
(not Arch.)	(1)	(23)	(59)		(17)	(100)
N.Z.C.S.	24	139	105	0	29	297
	(8)	(47)	(35)		(10)	(100)
N.Z.C.D.	4	42	72	1	22	141
(Arch.)	(3)	(30)	(50)	(1)	(16)	(100)
N.Z.C.B.	0	9	31	29	14	83
		(11)	(37)	(36)	(16)	(100)
N.Z.C.Q.S.	0	34	26	2	11	73
		(46½)	(35½)	(3)	(15)	(100)
Totals	58	524	800	84	305	1771
	(3)	(30)	(45½)	(4½)	(17)	(100)

*Includes O.N.C.

Table II shows for 1965—and the figures for 1964 are remarkably similar—the highest academic-type qualification of students who registered in an N.Z.C.X. course; i.e., in one or other of the 5-year courses.

There are many things of interest in this Table. About one in three have U.E. or better—much higher than this for N.Z.C. Science, much lower for N.Z.C. Building; that better than three in four have S.C. or higher; that we still attract one in five or six who have not gained that minimum academic qualification—S.C. —and lack a trade qualification as well.

TABLE III

Precourse qualification: 1967 N.Z.C.E.Registrations

(Percentages in brackets)

Option selected	*Univ.*	*U.E.*	*S.C.*	*Trade*	*None*	*Total*
Civil	13	63	95	0	12	183
Mechanical	18	58	130	18	75	299
Electrical	8	19	95	31	28	181
Telecommunications	11	39	65	10	20	145
Production	3	7	11	2	2	25
Plastics		3	1			4
Aeronautical	1	1	6	1	4	13
Refrigeration			3	3	2	8
Not Stated	1	2	13	1	11	28
Totals	55	192	419	66	154	886
	(6½)	(22)	(47)	(7½)	(17)	(100)

* Includes O.N.C.

TABLE IV

Precourse qualifications: 1969 N.Z.C.E. winners

(Percentages in brackets)

Option selected	*Univ. unit**	*U.E.*	*S.C.*	*N.O.C.*	*Trade*	*None*	*Total*
Aeronautical		5					5
Civil	6	65	20	1	1	5	98
Elec. (Heavy)		7	10	2	3	1	23
Elec. (Light)		2	5				7
Mechanical	6	18	15		2	4	45
Plastics		4	1				5
Production	3	17	10		2		32
Telecommunication	2	31	15	1	4	2	55
Totals	17	149	76	4	12	12	270
	(6½)	(55)	(28)	(1½)	(4½)	(4½)	(100)

Table IV is a similar analysis, this time of those who completed the examination course in 1969. The 270 include perhaps a dozen who already had one Certificate and tried for another—usually production following mechanical, or N.Z.C.E. after N.Z.C.D. It will be noticed that the spread of attainment is different: almost two of three had U.E. or better, nine of 10 had S.C. or better.

TABLE V

1969 N.Z.C.E. Winners: Distribution according to year of registration

Year of reg.	*Aero*	*Civil*	*Electrical Heavy*	*Electrical Light*	*Mech.*	*Plastics*	*Production*	*Telecom.*	*Total*
1955			1						1
1956		1							i
1957		1						1	2
1958		4			1				5
1959		1			1			1	3
1960		3	1		2		1	1	8
1961		5	2		1		4	3	15
1962		7	3	2	3	1	2	3	21
1963		4	1	2	4		5	2	18
1964	1	12	3		7	1	3	8	35
1965	2	24	4	1	4	1	5	13	54
1966	2	25	7	2	13	2	9	12	72
1967		9	1		6		3	6	25
1968		2			3			5	10
Totals	5	98	23	7	45	5	32	55	270

Table V shows the extraordinary fact that the 270 N.Z.C.E. winners came from every year from "T.C.A. 1" to "T.C.A. 14"-1955 to 1968. One is invited to admire, on the one hand, the patience and perseverance of the "late 1950's" vintage, and to stare uncomprehendingly at the 10 who completed a nominal five-year course in two years. One will see that the modal time to complete is 4 years, the median time is about

Table VI gives some of the same information in a different way. It adds details about the median age on completion (to the nearest year) and the age range. The age is dropping slowly; but there are still a number of 40-year olds, though perhaps no more 60-year olds. The employment figures show the Government in a very good light: 147 out of 270 is very good—higher than in the past.

The age of the certificate winners is of interest—not merely the greatest age, which sometimes suggests that the man is verging on retirement; but the lowest age at which anyone may contrive to finish. It will be noted that a 19-year old completed N.Z.C.E. in Telecommunications. This is not unusual in this option, which appeals to the bright young student from secondary school; but some may be surprised, even slightly shocked, to note that at 18—that is, somewhere between 17½ and 181—a youth has completed N.Z.C.E. (Civil), that course which is geared to the needs of "tough guys" on the main highways and hydro-electric dams, ploughing through cuttings, and tramping over new bridges whose bending moments have filled their waking hours; or perhaps to the needs of others subdividing the hilly suburbs, and fixing culverts, stormwater drains, footpaths, street formations, sewerage outfalls and all that goes with water reticulation and disposal.

You may feel like taking your hat off to this 18-year old "whiz-kid". You will, too, if you're the perfect gentleman—for this one is a girl!

TABLE VI

1969 N.Z.C.E. Winners

Option	*Years to qualify* Median	Range	*Age of completion* Median	Range	*Employment* Government	Local body	Private	*Not stated*
Aero.	5	4-6	22	21-23	5			
Civil	5	2-14	23	18-41	66	14	17	1
Elec. (Heavy)	5	3-15	27	22-42	11	5	7	
Elec. (Light)	6	4-8	30	24-36	4	2	1	
Mech.	4	2-12	24	21-49	16	6	21	2
Prod.	5	3-10	24	22-39	2		29	1
Plastics	51½	4-8	24	22-27			5	
Telecom.		2-13		19-40	43	1	9	2

6. EMPLOYMENT

Table VI gives a broad picture of the employment of the 270 certificate winners of 1969.

6.1. Civil option

M.O.W. claimed 59, Railways five and Lands & Survevy two. Local body employers included:

Nelson City Council	Lyttelton Harbour Board
Timaru City Council	Otago Catchment Board
Waiapu County Council	Christchurch Drainage Board
Waikato River Valley Authority	Tauranga County Council

Private employers represented included:

Shell Oil	Certified Concrete
Dominion Sawmillers' Federation	William Cable
British Pavements (three times)	N.Z. Forest Products

6.2. Electrical (Heavy) option

The 23 were spread pretty well, the N.Z. Electricity Department taking six; power boards four; the Navy three. The private firms were a mixed lot—Gear Meat Co.: Holeproof (N.Z.) Ltd.; Unilever; and some straight electrical firms.

6.3. Electrical (Light) option

Six of the seven were taken up by power boards (two) and four different departments. N.Z. Forest Products was the only private employer. It looks as if the revision of the electrical course was necessary.

The man who registered in 1955 and completed the Heavy option in 1969 is a draughtsman with an electric power board. He began with School Certificate.

Engineering - accounting relationships in management

R. W. **STEELE**

B.COM., F.C.A.

An edited version of an address presented to the Wellington Branch, N.Z.I.E., and members of the Accountants' Society on 17 September 1970 as an activity of the Industries Division of the N.Z.I.E.

R. W. STEELE is the president of the N.Z. Society of Accountants. He was in public practice as a partner in the Wellington firm of W. H. and R. I. Nankervis, chartered accountants, from 1950 to 1967, when he became a full-time director of Cable-Price-Downer. He is chairman of directors of Allied Freightways, I. B. Westray and Co. (N.Z.) Ltd. and James Cook Hotel Ltd. and a director of the Mt. Cook and Southern Lakes Tourist Co. Ltd.

THE first thing that needs to be said about engineer-ing-accounting relationships in management is that there is a great deal of misunderstanding about the role which each plays. To the average accountant, an engineer is either an oil-stained wretch pottering with a machine that never seems to work properly, or perhaps a Mr te-collar character at a drawing board dreaming up better (and usually more expensive) ways of spending the firm's hard earned dollars. To the average engineer, an accountant is an ink-stained wretch who, when he is not fiddling about with his ledgers, is busy explaining to the general manager how there is no money to finarce any of the bold, imaginative projects which the engineer wishes to promote.

Both images are over-simplified, simple-minded and *wrong.* The first principle of business—the prime objective of management—is to make a profit. Profit is earned by maximising the use of resources and minimising the cost of the use of these resources. The criteria by which these two objectives are judged are the profit and loss account of the enterprise allied to the accounting measurements that can be provided for management in res-Ject of specific activities within the enterprise. The only people capable of providing these measurements are accountants, by reason of their knowledge of the processes necessary to provide the figures.

Now, it may come as something of a surprise to engineers that accounting is regarded by its practitioners as an *art* and not a *science.* Any intelligent schoolboy can learn the elements of the double-entry equation which is the basis of all accounting, but it requires a lot more than that for an accountant to become skilled in the interpretation of financial data and in being able to guide management in the task of making meaningful decisions about the future activities of the enterprise.

All managements must face the fact that

- If profit is the prime objective, and
- If profit can only be measured by accountants, and
- If only accountants have the expertise to interpret financial information wtih a clear understanding of the reservations which apply to that information

then accountants will continue to dominate all business decisions.

In this situation an accountant has a very grave responsibility to ensure that, quite apart from his technical qualification for his job, he has the sort of mind that does not regard figures or accounting reports as an end in themselves. The accountant must bring to his interpretation an understanding of the physical problems that beset other members of the management team, a realisation that accounts, like all statistics, are capable of varying interpretations, and above all, a lively, constructive and imaginative approach to the problems that his figures disclose—not the "dead hand" of conservation, but the liberal: "What help can I be?" attitude.

In a management team, the good accountant should be a contributing influence. But even if *his* attitude is superlatively good, what about the attitudes of those with whom he works; to what extent are those others conscious of the "artistic" approach to accounting which influences that good accountant?

An engineer faces the same sort of dichotomy in management that the accountant does. The engineer is accustomed to the most minute measurement of things (as an accountant is) and at the same time he is expected (again as an accountant is) to exercise his imagination in terms of his particular intellectual discipline. The capacity of both professions to measure some things very accurately, is counter-balanced by their very lack of capacity (except in the very best) to change their thinking and adopt the broad views necessary for the efficient administration of a business. Each profession faces the same problem (which is not limited to their special spheres): as soon as someone becomes very good at his chosen profession, there is an almost overwhelming desire on the part of a board of directors, to make that someone an administrator—a manager. The appointee then stops being solely a "pro" in his chosen field and moves into a field in which, apart from what he has been able to pick up by observation, he has no expertise whatever. Think of other professions. What happens to a good teacher? If he is at a secondary school, he becomes a headmaster, if at university, a professor; and all of a sudden, he is an administrator—not a teacher at all!

It is necessary to differentiate between the relationships of accountants and engineers at varying levels of management.

The first, and perhaps not so important one, is at the second tier of management where contact between the professions is limited to day-to-day discussion or queries about operational matters. Because each professional will be working in an atmosphere of detail as it applies to himself, each will be involved in the minutiae of his job and all that needs to be said is: "Be tolerant!" It is just as easy for an accountant to make a mistake while checking an estimate, charging a customer, or even filling in an I.R.12, as it is for the engineer to buy the wrong tool steel, set a machine incorrectly, or misinterpret a drawing. Each must be aware that in any discipline that requires the application of theoretical expertise to a practical job, there is the probability of human error.

At top level management the greatest possibility for misunderstanding arises. It is here that an accountant may be described by his confreres as "the abominable no-man" and conversely the engineer described by his, as the "starry-eyed theorist". Neither description is apt, yet each has the germ of truth. What is needed is a clearer understanding by each profession of the skills and limitations of the other so that neither expects too much but each knows what to expect.

Starting with the premise that each member of the management team has the same end in view; the maximum possible profit; we can start with the thought that each can assume that all the others in the team will make decisions, or query decisions only from that point of view. This may sound rather Utopian, but it is true more often than false.

Let us look then in broad detail at the sort of job each profession is expected to do as part of a top management team. Given the overall target of profitability, how does the accountant seek to do his job? He has a certain amount of money to play with and, in conjunction with the advice tendered to him by members of the management team, he must, in terms of the feasibility of various projects, determine an allocation of funds in a way which best suits the priorities that his board of directors have laid down. Just like the Government, he will never have enough money to meet all the calls for it, so something has to be scaled down, or deferred. Would you believe those rotten, unimaginative accountants will normally recommend that lowest priorities should be accorded to those projects that have the lowest profitability or the longest pay-back period, despite the fact they may be the product of the most inventive, forward-looking thinking that the engineers have ever indulged in.

Too often, an engineer has done all his engineering homework on his own and at no stage has he taken any other section of management into his confidence to check the arithmetic of his feasibility studies. How many engineers understand break-even point, marginal costing, contribution accounting, and other esoteric arts of the accountant? Yet these can be vital things in determining whether a project is "on" or "not on". Many ideas have been blown out because an accountant has been able to demonstrate some fundamental financial fallacy in what an engineer thought was a "lay-down mazaire".

All a bit depressing, but there is worse to come! This time, it is the accountant's turn. How many of them are really qualified to comment on the proposals which the engineers put forward; how many of them could walk into the plant and differentiate between a press brake, a lathe, a guillotine and a set of rolls; how many know what tolerances a particular machine will work to; what the difference between 16 and 24 gauge sheet steel is; why a particular process needs or does not need deep drawing steel; how many can check why a process needs three man-minutes or four or five?

Some accountants could, but not very many.

But accountants should at least have some understanding, instead of blank incomprehension, when the engineer talks of things which to him are second nature.

Perhaps it is all part of the process of "impressment" or "one-up-manship" whereby the use of a few bits of technical jargon, either accounting or engineering, can be used to convince a listener that the things being talked about are outside his province and far too technical to be considered by one not skilled in the particular "black art" under discussion.

In conclusion, the main point seems to be this: most people come into management, particularly top management, because they are good at their particular job. They got that job because of professional qualification in a specialised sphere. That qualification stands them in good stead in the management of the particular activity to which it is appropriate, but it does not qualify them for "management" in the sense that management inherently is management of the whole of an enterprise, and not a series of isolated and mutually exclusive activities.

What is needed is a realisation by business that all members of the management team, should truly *understand* the functions of all sections of a business —they need not be expert—far from it—all that is needed is enough knowledge to ensure that real and fruitful communication can take place between the professionals. By this means, the strengths, the weaknesses, the problems and the possibilities of each are mutually brought together to achieve the right result for the owners of the business.

PAPERS AND ARTICLES RECEIVED

THE following have been received by the New Zealand Institution of Engineers:

W. Strong—Low temperatures and their effect on transmission line components.
D. Alexander—Some thoughts on the Doubtful Sound gabbroic differentiate.
R. M. Hastie and P. A. Toynbee—Pneumatic handling of coal.
G. A. Hutchinson—Municipal composting can pay.
N. A. Davidson—The Association of Professional Engineers, Australia.
E. J. Forrest—Can we neglect concrete tension in earthquake design?
R. A. Callendar and John Stephenson—Teaching Engineering Design.
A. C. Callendar—Engineers and patent rights
C. R. Francis—Developments in wood technology.
B. V. Rangan—Strength of reinforced concrete beams with web reinforcement in combined torsion and shear.
R. Shepherd—Some aspects of the San Fernando earthquake.
W. J. Lewthwaite—Empirical methods for estimating flood peaks on rural catchments in New Zealand.
P. Johnstone—Strain gauge measurements at West Arm, Lake Manapouri, N.Z.
P. D. Milne—Problems at Stratford substation.
L. M. Meggett and R. Park—Reinforced concrete exterior beam-column joints under seismic loading.
H. J. Hopkins—Sands for concrete—study of shapes and sizes.
R. F. Coddington—Wellington's West Coast.
I. A. Williamson—Variable speed waterworks booster station at Haywards.
M. R. H. Henare—Te Rapa railway marshalling yards.
B. Kaiser—So you want to be a management consultant.

Environmental Award

The New Zealand Institution of Engineers invites applications for the 1972 Environmental Award. The Conditions of the Award are set out below and applications must be submitted to the Secretary, The N.Z. Institution of Engineers, P.O. Box 12241, Wellington not later than 30 September, 1971.

CONDITIONS OF AWARD

1. The Award shall be made for the predominantly engineering work which, in the opinion of the judges, best exemplifies care for, and consideration of environmental values as evidenced by identification of environmental elements to be considered in the design, the manner in which these problems have been resolved and the overall contribution of the end result to environmental values and public enjoyment.
2. Projects qualifying for the Award shall have a predominantly engineering content, and be of significance either nationally or relatively to the context in which they are set.
3. The recipient of the Award may be an individual or public or private body, and in the case of an individual, the person need not necessarily be an engineer or a member of the Institution.
4. Entries, which must be in triplicate, shall be supported by written design statements, plans, pictures, photographs and any other relevant information particularly identifying the factors by which the project fulfils the requirements of the Award.

NATURE OF THE AWARD

The Award consists of a plaque giving details of the project, the recipient and date of award and will be presented to the indivdival or organisation responsible for the work. In addition, a certificate will be presented to the person or persons prodominantly responsible for the design and execution of the project.

JUDGING OF ENTRIES

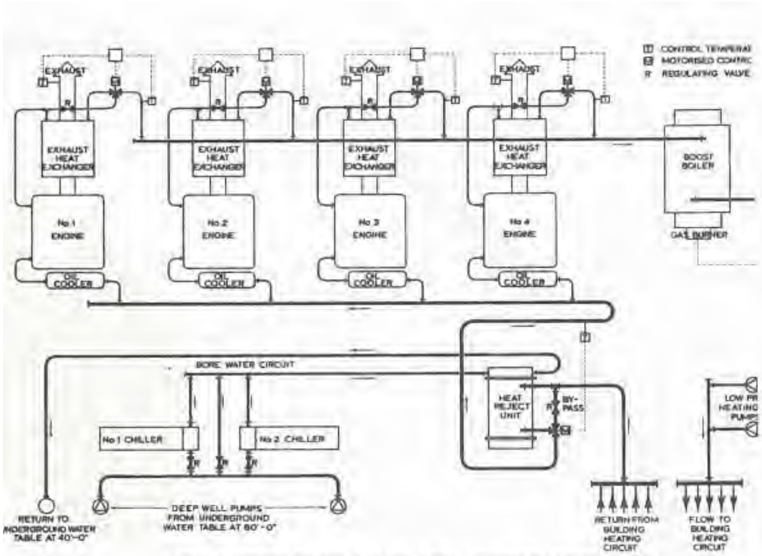
The judges are the President of The New Zealand Institution of Engineers and the Chairman of the Environmental Council assisted by such other judges as they may co-opt. The judges' decision shall be final.

ANNOUNCEMENT OF AWARD

The announcement of the winner will be made in Christchurch at the Annual Conference of the N.Z.I.E. in February 1972.

Public Service Division news

Total energy system for N. Z .B.0 . television studio complex at Avalon



HEAT RECOVERY SYSTEM FOR THE NZBC TELEVISION CENTRE-AVALON.
SIMPLIFIED PIPING SCHEMATIC

The new television studio complex at present being built at Avalon for the N.Z.B.C., will use natural gas engine generating plant to provide electricity, central heating and air-conditioning reheat, and hot water, using the total energy concept. This term is used to describe a system which provides the total energy requirements for a building or group of buildings from one source of energy, in this case Kapuni natural gas.

For the initial commissioning stage of the Avalon studios, it is planned to install two 375 kVA generators, driven by natural gas engines, and one diesel-driven generator of equivalent capacity. These engines will use the total energy concept to provide, in addition to the electricity, all heating and hot water requirements for the buildings. Design of the system was undertaken for the N.Z.B.C. by Worley, Downey, Muir and Associates, consulting engineers, of Wellington, whose, partner, Mr H. Topham, studied total energy p'ant using natural gas during a tour of the United States. This study tour included factories, hotels and shopping centres.

General Plant Operation

The total energy plant consists of two 375 kVA generators driven by natural gas engines and one diesel-driven generator. Heat recovery and engine cooling are arranged on the principle indicated on the line diagram.

The coolant used for engine cooling is the low pressure hot water building heating system water, which is chemically treated to prevent corrosion and scale formation, and is circulated through the oil coolers and engine cooli-g jackets by engine-driven pumps and through the jacketed exhaust silencers and the remainder of the system by the main L.P.H.W. circulating pumps.

A supplementary gas-fired boiler is provided in the low pressure hot water circuit to supply peak demands for central heating and hot water when the tatal energy supply is unable to provide sufficient heat. This situation would arise when the gas engines are lightly loaded or on a cold winter's morning.

Operation of the supplementary boiler will be by automatic thermostatic control. Should the low pressure hot water circuit not require any or all of the coolant-heat, the coolant would be diverted in the necessary proportion through the reject heat exchangers.

The use of a muffler heat exchanger on the engine exhaust will not only allow maximum utilisation of power, but will also contribute to effective silencing, a vital factor in the television complex where noise must be kept to an absolute minimum.

Control of engine cooling, heat exchange and heat rejection and boost heating will all be under temperature actuated automatic control, with safety and limit arrangements. It is intended initially to operate the total energy system during the daylight hours and the evenings until broadcasting ceases. Outside these hours, the buildings would be supplied from the national grid,

During normal operating hours, the plant will be under the surveillance of a qualified operator who will be able to control the source of electrical supply for any one of the studio areas from either mains or generators. The system has been designed so that there is no possibility of generator output being applied to the mains.

Advantages of Total Energy System
Cost Saving

A considerable saving in the annual cost of electricity can be achieved by the use of natural gas engine generators during peak demand periods, i.e. daylight and early evenings.

Reliable Power Supply

The N.Z.B.C., by generating its own electricity, will have a duplicate power supply available for essential equipment in the event of a mains failure. The diesel driven unit has been incorporated to provide essential services in the case of simultaneous failure of natural gas and mains electricity.

Effective Use of Fuel

By utilising the fuel energy of the natural gas as a reasonably efficient electric power generation energy source, while making all possible use of the normally discarded engine heat, an overall thermal utilisation efficiency in the region of 80% is achieved, and this accounts to a large extent for the predicted annual savings in operating costs compared with conventional electric power and boiler fuel.

Quality of Power Supply

Voltage and frequency requirements can be maintained to standards necessary for the television studio equipment.

Provision has also been made in the Avalon plant installation to permit future load expansion up to 1125 kVA by the addition of a further gas engine.

General Use of Total Energy Plant

The total energy concept is used in a number of major buildings and building complexes overseas where electricity and heating are required at an economical cost. Generally, the fuel or energy source can be coal, fuel oil, or any other fuel capable of being converted into heat and electricity. In the majority of cases, however, the total energy concept, when applied to installations similar to Avalon, is usually associated with the use of natural gas as a fuel.

Western hills drainage : Hutt Valley

FLOODS are always newsworthy. Control is an engineering problem, and if action is taken soon enotugh the public is hardly aware that the engineer has even been at work. The residents in one part of the Hutt Valley, near Wellington, did become aware of the problem in recent years when, after heavy rain, many acres of residential and industrial land in Petone became flooded with heavily silt-laden water. Worse followed with a repetition of the flooding only weeks later. The cause was the bursting of a culvert which runs from the foot of the western hills of the Hutt Valley to the Hutt River.

The catchment covers 460 acres of bush and scrub covered hills, and earthworks had just started for the development of most of the area as a residential subdivision.

The serious problem which had arisen was complicated by the fact that the catchment is mostly within the Lower Hutt City boundaries and the culvert runs through the developed Petone Borough area. Thus a joint effort was required to find a solution.

The 5 ft 3 in. x 4 ft 6 in. culvert, almost a mile long, was constructed in 1926 and, apart from a short steep section near the entrance, has a grade of 1 in 2,200 across the flat area. Capacity under a maximum head of 14 ft is 134 cusecs, but due to inadequate reinforcement it was decided the head should be restricted to 4 ft allowing a flow of 75 cusecs, a figure quite inadequate to cater for the catchment runoff. Runoff from the catchment for a 50-year storm increases from 200 cusecs in the natural state to more than 400 cusecs when fully developed as a residential area.

The immediate engineering problem was to limit the flow of water in the culvert to not more than 75 cusecs and to date has involved the construction of three flood retention dams on the tributary streams. These dams restrict the flood waters during periods of heavy rain so that the peak flow downstream is reduced.

The runoff estimates were based on the M.O.W. Tech. Memo 61 (1963 revision), but it is considered that the memorandum possibly over-estimates the runoff for catchments of this type and size. Consequently a detailed hydrological field study is being carried out to determine whether or not a further control dam or culvert is required.

PERCY'S DAM

The largest dam built so far is Percy's Dam, which controls a catchment of 187 acres, two-thirds of which will be developed for housing and the rest remaining in bush and scrub. The earth embankment dam rises 35 ft above the original valley floor.

Percy's flood retention dam.
A. Standpipe inlet to 42 in. d. culvert.
B. Impact stilling basin outlet.
C. High level spillway.

The stream passes through a 42 in. diameter culvert under the dam, low flows entering the culvert through holes in the sides of a stand-pipe and flood flows through a 22 in. diameter horizontal orifice plate on top. An impact stilling basin is built at the culvert outlet downNtream from the dam. The culvert is constructed over most of its length on greywacke rock on the left abutment. On the right abutment a high level spillway has been built on original ground to deal with major floods.

The design is based on a 50-year rainfall of one hour's duration giving a peak inflow of 181 cusecs. The reservoir level will rise 18 ft above the discharge orifice to the crest level of the spillway, and impound 12 acre/ft of water. At the time of the peak inflow the downstream discharge is reduced to 42 cusecs rising to a maximum of 54 cusecs an hour later, a considerable reduction over uncontrolled conditions.

Fill was obtained from a greywacke outcrop close to the site and construction took two years. Access was difficult and unsuitable material up to 13 ft deep had to be removed over all the site. Little work was possible in the winter and spring, and the working area was very restricted, particularly for the earthworks.

A field laboratory was set up at the site for compaction control of the fill material. The total cost of the project including access roading was $95,000, and construction was by V. A. Draper and Co. Ltd.

The dam was designed and supervised by Climie, Spencer and Holmes Miller, Consulting Engineers, Wellington, for the Petone Borough Council.

OPERATIONAL CALCULUS by G. Krabbe; 349 pp., illus. (Springer-Verlag, New York, 1970, $U.S.14.90).

Operational calculus, roughly a procedure for the solution of equations involving differentiation and integration (functional equations) by algebraic methods (together with suitable tables of transforms), has a long history. Two names particularly associated with its development are George Boole and Oliver Heaviside. Boole (19th century) introduced the "D" (differential operator) method of solving ordinary differential equations which is often given in elementary courses on differential equations. Heaviside carried the procedure further, to the treatment of partial differential equations. The work of both men raised many problems for the mathematicians. That the method worked was clear, but many mathematical questions remained unanswered—for instance, what conditions are required for the existence, for the uniqueness of the solution so found?

In the early years of this century numerous attempts were made to answer these questions. The best known is the Laplace theory and procedure. However, this placed considerable restrictions on the applicability of the method. More recently, with the aid of advances in pure mathematics, in particular the theory of distributions, it has proved possible to establish the operational calculus on a broader mathematical basis.

The text under review is in the latter class. The first half is concerned with basic algebra of operators and gives an extensive range of applications to differential, integral, and difference equations.

In the second half, partial differential equations are introduced and a calculus of operators is developed with applications to non-linear differential equations.

There are several appendices including a table of formulae and a bibliography.

The text would be suitable for graduate students of engineering, mathematics or science, with a background of at least three years of algebra and analysis.

—J.T C.

WII,D IRISHMAN by Peggy Hamilton; 214 pp., illus. (Reed, Wellington, 1969, $N.Z.3.50).

Despite the title, that practical engineering genius C. W. F. Hamilton gets only about half of the story as Mrs Hamilton has an equally interesting tale of her own career during World War I as a largely self-taught machine tool operator working in English munitions factories. This makes the book even more interesting particularly for those who can recall the shocking engineering shop and general social conditions of that period.

Mr Hamilton's engineering inventions have long been deservedly renowned, but the story of his boyhood days is less well known and is particularly appropriate as it points to his later successes.

Written without any literary pretensions, the book should therefore appeal to all engineers and is especially recommended to those who consider that professional qualifications are a sine qua non.

—F.N.S.

PRESENTING TECHNICAL IDEAS by W. A. Mambert; 216 pp., illus. (Wiley, New York, 1968, $U.S.6.95).

There is something for everybody in this book, but unfortunately most New Zealand engineers will be put off by the American style. Presenting technical ideas is exactly what all want to do well, but the concept of being "technical presentors" or making "a technical presentation" smacks of slick salesmanship—which is exactly what it is. Those who can overcome the repugnance of selling themselves to an audience which may be comprised of their employers, their employees or their professional peers, and who are prepared to learn the "tricks of the trade" as revealed by a skilled American practitioner writing in the modern American idiom, will find a wealth of information including such things as the proper presentation of technical papers.

This is a book to be skimmed, rather than studied, by the New Zealand engineer. In a rapid reading, something of value will certainly be acquired, even if it is only an appreciation of the techniques—e.g. how a technical salesman can close a deal by persuading a reluctant buyer to take a simple first step which subsequently commits him.

Perhaps all professional engineers should be aware of what is in this book—partly for their own protection. For their success they might well practise some of its precepts.

BUILDING SERVICES GROUP

Air Conditioning—Necessity, Luxury or Pollutant

A continuing debate on the need for air conditioning in public buildings (particularly hospitals) was opened by G. Z. de Liefde with his paper "Hospital Building Design".

The thesis of this paper, that capital and running costs of complex buildings could be reduced by designing for open plan buildings without air conditioning, was disputed in papers by W. L. Smith and D. M. Saunders presented to a joint meeting of the Group with the Wellington Branch in April.

The discussion raised the following points:

Against Air Conditioning

Services cost (actual figures are in dispute, and basic cost information is needed), shortage of trained maintenance staff, and the thesis that waste heat from air conditioning plants causes temperature inversions and makes outdoor temperatures worse.

For Air Conditioning

Reduction in building costs due to more compact planning, improvements in staff efficiency and patient recovery rate with air conditioning, control of cross-infection and the traffic noise necessitating sealed windows.

The debate continues, with two main areas requiring resolution. First, the need for more accurate cost data on building services maintenance and operating costs, and the extent to which air conditioning contributes to these. Figures quoted for service contracts in commercial buildings do not agree with statistics quoted for hospitals. Second, the town planning argument, whether hospitals, like motorways, should be allowed free run over the landscape, or should be herded into the cities closer to their users.

METRICATION

Both Auckland and Wellington Branches have held meetings on this subject. The Auckland meeting was addressed by J. D. Sutherland, an architect, whose field of modular coordination is of direct concern to the Building Services Industry. The Wellington Branch was addressed by S. Mitchinson, also an architect, representing the building field on the Construction Sector Committee.

Engineers generally do not yet seem to be aware of the tight programme set by the Metric Advisory Board, and the implications affecting every aspect of our profession. Perhaps the M.A.B. technique of pushing ahead with the programme and letting the rest of us wake up in due course is the only way of getting those agonising decisions made —and incidentally reducing the cost to all of us of the changeoveP, which threatens to be long-drawn-out enough without any allowances for procrastination.

BUILDING RESEARCH

The Wellington Branch heard an address by Dr V. R. Gray, the B.R.A. Director, who outlined the lines on which it is intended to develop the Association.

Now that it has funds available from building levies, the B.R.A. promises to be of value to both architects and engineers in tackling the problems of the building industry. Not the least of these are problems of organisation and management of building projects. Other fields are library and information facilities on problems experienced here and overseas, and the fostering of research and testing facilities in such fields as fire rating of materials.

Liaison with the building services field has been strengthened by the appointment of H. A. Trethowen, formerly of the Ministry of Works Mechanical Section, to the staff of the B.R.A.

PERSONAL

J. W. RIDLEY, who has joined Murray-North Partners, Engineering Consultants, of Auckland, Hamilton, Rotorua and Tauranga, as a partner. This new partnership, which will be Murray-North and Ridley, will extend their present activities as engineers, architects, surveyors and town planners, to include engineering of mining and industrial developments.

Mr Ridley, a former Rhodes Scholar, has for the last six years been Mining an Development Manager of New Zealand Steel Ltd., and will continue to be associated with the company as a consultant.

MISCELLANEOUS ADVERTISEMENTS

NOTICE TO N.Z.I.E. MEMBERS

Those N.Z.I.E. members who are considering applying for positions advertised by local bodies are reminded that the Institution has a standard set of conditions of appointment, and that, if conditions relating to any advertised position appear to affect engineers unjustly, such conditions should be immediately referred to the Institution for scrutiny.