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Annual Report of the Canadian Section of the International Society of Soil Mechanics and Foundation Engineering for year ending June 1963 including Membership List of the Canadian Section

Crawford, C. B.; Butler, J.

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NATIONAL RESEARCH COUNCIL OF CANADA
ASSOCIATE COMMITTEE ON SOIL AND SNOW MECHANICS

ANNUAL REPORT
OF THE
CANADIAN SECTION
OF THE
INTERNATIONAL SOCIETY OF SOIL MECHANICS
AND FOUNDATION ENGINEERING
FOR YEAR ENDING JUNE 1963
INCLUDING MEMBERSHIP LIST OF THE CANADIAN SECTION

Prepared by ANALYZED
C. B. Crawford and Miss J. Butler

Technical Memorandum No. 80

OTTAWA
October 1963

FOREWORD

This Annual Report is a summary of the activities of Canadian members of the International Society of Soil Mechanics and Foundation Engineering for the period June 1962 to June 1963.

It is published for the purpose of keeping Canadians informed of those soil mechanics investigations which are being conducted in their own country. In this way, it will assist in overcoming the natural handicap offered by the widespread geographical distribution of soil mechanics work in Canada.

The report includes a list of publications by members of the Canadian Section. In addition, it includes a list of known thesis topics presently under study and a list of suggested research projects. It is hoped that these lists will develop into useful sources of information. A special effort has been made to reduce reports on routine work. It is probable however that some of the work noted was of a routine nature but was considered worth including because of possible general interest. Brevity in reporting the work has been attempted.

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1. GENERAL SOIL PROPERTIES

H. G. Acres & Company Limited:

- (a) Continuation of laboratory research on shear strength and stress - deformation characteristics of plastic and non-plastic tills, lacustrine and marine clays.

Studies included investigation of characteristics of stiff, extra-sensitive silty clays in tension.

- (b) Laboratory studies of the engineering properties of highly plastic clays including evaluation of the effects of rate of strain in undrained triaxial tests on the measured values of pore water pressures and effective stress parameters.

- (c) Investigation of strength - deformation characteristics of compacted slate for use in an earth dam.

E. W. Brooker:

Engaged in research on both field and laboratory scale concerning the effects of geological stress history on the coefficient of earth pressure at rest and the secondary structure of cohesive soils. The influence of these factors on the mechanical behaviour and physical properties of highly overconsolidated cohesive soils both as they affect physical constants and construction activity is being considered.

Canadian National Railways:

A controlled field study of several simple types of bench mark designed to withstand frost heaving was initiated.

A comparison of the performance and economics of conventional and nuclear equipment for measuring soil density and water content was made in co-operation with the research department of the Association of American Railroads.

Department of Transport, Ottawa:

Studies of the seasonal thaw and the thermal regime in and under a rock-filled runway in a permafrost zone.

D. W. Devenny:

Library research project on effects of vibrations on sensitive soils. Project aimed at understanding properties of sensitive clays, characteristics of earthquakes, and designing test equipment for lab experiments to determine effect of vibrations on sensitive soils.

Division of Building Research, National Research Council:

Studies of the structure, that is the orientation and forces between clay particles, were carried out on marine clay, lacustrine clay and varved clay. Particle orientation was studied by optical means using thin section techniques. Orientation was also studied by measuring thermal conductivity along different axes. In the general study of sensitivity, electro-kinetic potentials in clay structures are being measured.

A continuing programme on the mechanism of ice propagation and growth in porous materials is underway. Equilibrium temperatures are being measured at the interface location between ice and a water saturated bed of particles. These studies are sufficiently fundamental to check the various theories of frost heaving in soils. Field studies of frost action are continuing.

A classification survey of a peat bog has been completed in preparation for a comprehensive field test programme. A detailed study was made of test procedures for index properties of peat including water content, organic content and specific gravity.

Further work was done on the evaluation of the neutron soil moisture meter. This included detailed studies of the influence on moisture measurement of iron in natural soil.

Studies were made of the correlations between theoretical soil moisture depletion, as calculated by Thornthwaite's technique, and change in soil moisture and vertical ground movements in grass-covered test plots in sub-humid regions of Western Canada.

A test plot was established to study the relationship between climate and soil moisture and volume under various conditions of surface cover around a large tree growing in volume changing clay soils in Western Canada. A large number of vertical ground movement gauges, access tubes for a radioactive moisture probe, tensiometers, thermocouples, piezometers and deep bench marks were installed in this test plot.

Deep bench marks were installed for precise level control surveys across Glacial Lake Agassiz.

The collection of information on the occurrence and distribution of permafrost in Canada was continued by means of literature searches, field observations and a questionnaire, with particular emphasis on the southern portion of the permafrost region. A detailed field survey of permafrost distribution along the Mackenzie Highway from Keg River, Alberta to Hay River, N. W. T. , was carried out. Field studies of ground temperatures and the distribution of permafrost at Thompson, Manitoba were continued.

An investigation of the factors affecting the measurement of ground temperature with reference to the use of thermocouples was completed. The development of a small recorder for measuring maximum and minimum ground temperatures in a borehole is underway.

GEOCON/FENCO:

- (i) Studies of tar sands on a site in Northern Alberta.
- (ii) Studies of properties and handling characteristics of bauxite tailings.
- (iii) Use of Norwegian Geotechnical Institute Corrosion Sound at several sites. Some preliminary comparisons of instrument data and actual performance of a structure.

P. F. Karrow:

Woodbridge 1/25,000 sheet has been selected for co-operative mapping by the Ontario Subcommittee of the Co-operative Mapping Project. The Subcommittee includes representatives from the Ontario Water Resources Commission, Ontario Department of Highways, Canada Department of Agriculture, and the University of Waterloo. It is hoped to collect information on the geology, hydrology, pedology, and soil engineering of the area, all to be included in a combined report.

P. LaRochelle:

Some research on frost phenomena in soils is performed in our soil mechanics laboratory. The main purpose of this research is to study the influence of transient loading upon frost phenomena in soils.

Ontario Department of Highways:

- (i) Investigation of the validity of accepted soil mechanical principles when applied to varved clays;

(ii) Use of air dispersion in mechanical analysis.

H. E. P. C. O:

Studies were continued of thermal migration of water in soils. A full-scale model of a buried cable using various types of backfill has been installed and extensively instrumented and readings have been taken for a period of approximately one year. It is hoped to obtain correlation with previously performed laboratory studies.

J. A. Pihlainen:

Completed two studies on muskeg (to be published):

(i) "A Review of Muskeg and its Associated Engineering Problems".

(ii) "Construction in Muskeg - A Summary and Compilation of Current Practice". In progress is a study on what may be called "The Hydrology of Muskeg Areas" and is based largely on Soviet experience.

Completed preliminary investigations on a quantitative method of describing peat that is analogous to the sieve test of soil mechanics. Also have completed design (with construction of a prototype underway) for an apparatus to obtain undisturbed samples of peat.

Completed studies on an approximation of probable permafrost occurrence that is based on air temperature.

R. M. Quigley:

Beginning research on the influence of soil fabric and clay mineralogy on the engineering properties of glacial clay deposits.

J. D. Scott:

Co-ordination of a combined mapping project by geologists, pedologists, groundwater hydrologists, and engineers of the soils in three areas in Canada (New Brunswick, Ontario, and Alberta). The project was originated by the Pleistocene Subcommittee of the National Advisory Committee on Research in the Geological Sciences.

The study of the geology and engineering properties of the soils in the Kitchener-Waterloo urban area is nearing completion. A statistical study of the engineering properties of the different soil deposits is being made where possible.

W. J. Staple:

Work on the movement of moisture through soils is divided under three main sections: (1) Soil moisture tension; (2) Soil moisture diffusivity and conductivity, and (3) Infiltration, evaporation and other practical applications. This includes a study of sorption and desorption of moisture in soil and of the scanning curves resulting when the soil moisture changes are not carried through complete cycles. This information is of importance in moisture redistribution in soils and is involved in almost all practical applications.

Diffusion and conductivity coefficients have been measured on small samples of fragmented soils during wetting and drying. Soil moisture tensions within the samples have been measured at the same time. In this way diffusion and conductivity coefficients can be converted from one to another taking into account the relevant moisture characteristics. Infiltration measurements have been carried out on the same soils using a small positive head. Computations of infiltration have been made from soil conductivity data.

J. Terasmae:

Engaged in a joint programme between Geological Survey of Canada and the Great Lakes Institute (Toronto) in studying bottom sediments in the Great Lakes, particularly in Lake Erie. This study includes geological identification of deposits as well as the engineering and geophysical properties of the materials. A 400 ft. core of surficial deposits was drilled at the end of Long Point (Lake Erie) in the 1963 winter season and studies of the samples obtained are in progress.

Terratech Ltd:

Extensive undisturbed sampling of permafrost soils and bedrock was carried out in summer 1962 and winter 1963. Measurements of ice content in permanently frozen soil and bedrock together with ground temperatures were carried out.

G. R. Tessier:

A programme of soil mapping is underway in the Province of Quebec by our Soils and Materials Branch (Roads Department). This mapping will give different properties of the soils encountered, mainly the stability, the bearing capacity (C.B.R. Values). The work is carried on actually in the St. Lawrence Lowlands, South of Montreal.

Underwood, McLellan & Associates Ltd:

Investigation of a submerged gravel deposit was carried out using uncommon drilling procedures. A diesel hammer was used to drive two concentric pipes to the desired elevation. Compressed air was then used to blow the material to the surface where it was recovered in a large basin. It is considered that this method resulted in better sample recovery than could have been achieved by employing conventional procedures.

R. Yong:

(a) Swelling pressure and volume change dependency of a pure clay on temperature.

(b) Soil suction and configuration effects.

(c) Energy status of water in soils.

2. MECHANICAL PROPERTIES INCLUDING PERMEABILITY

H. G. Acres & Company Limited:

Development of analogue for the study of transient three-dimensional patterns of groundwater flow in complex aquifer systems including those of large areal extent.

Division of Building Research, National Research Council:

Laboratory studies on the stress-deformation properties of undisturbed soils are continuing. The influence of strain during test has proven to be of great importance in testing sensitive clays. Laboratory studies have been made on the sensitive Leda clay and on the relatively insensitive Gumbo clay from the Prairies. Performance of the soil in the field is observed whenever possible.

Consolidation tests were carried out on various sized specimens and with various methods of loading. Pore pressures were measured during the tests to permit separation of primary and secondary compression. These observations have been made on mineral soil and on peat.

Pore pressures were measured at various distances and depths from a cellular cofferdam during and following the driving of the sheet

piling. Pressures exceeding the overburden pressure were developed near the piles but these pressures dissipated rapidly after driving.

Samples of highly plastic clay from several glacial-lacustrine deposits in Western Canada were subjected to various testing procedures in the Consolidometer to evaluate their consolidation-swell characteristics.

Ecole Polytechnique:

Variation of cohesive and frictional components of shear resistance with time and with soil deformation.

H.Q. Golder & Associates Ltd:

Laboratory research on consolidation properties of peat including possible effects of temporary surcharges on secondary consolidation.

Laboratory research on consolidation properties of fill placed underwater and comparison with results of field load tests.

B. G. Hutchinson:

Work is continuing on the correlation of shear strength development of portland cement stabilized sands and their granulometric properties.

B. Ladanyi:

Behaviour of clays at low shear strains. Initiated laboratory research.

P. LaRochelle:

Some research has been initiated on the consolidation and shear strength properties of sensitive marine clays. These measurements are related to the actual behaviour of the clay on the field.

M. LeBel:

A detailed subsoil investigation is underway in connection with the construction of a steel bridge, the four main piers of which are to be seated on caissons resting on glacial till material.

Geocel Tests are taken by operating a pressure probe into boreholes at pre-established levels with a view to establishing the existing mechanical properties of the till and its behaviour under the anticipated loads.

W. H. Mathews:

Investigations of properties of freshly deposited and of normally consolidated silts and clays in the Vancouver area.

Ontario Department of Highways:

Investigation of the regain of shear strength of the soils in failure zones. Relationship of pore pressures to strains in clay soils. Measurement of local pore pressures in triaxial test specimens.

Investigation of pore pressures in the vicinity of freshly driven piles. Investigation of skin friction on piles in over-consolidated deposits.

H. E. P. C. O:

Studies on the behaviour of compacted clays were continued. Consolidative, permeability, and triaxial compression tests have been carried out on material placed at various initial conditions of water content and density.

P. F. R. A:

Studies are continuing on the shear strength, swelling and consolidation characteristics of highly plastic clays, clay shales, and compacted clays. The following items have been investigated:-

- (a) Laboratory determination of time to failure vs. effective stresses obtained from Triaxial \bar{R} (consolidated undrained) test and Triaxial S (consolidated drained) test for highly plastic clays and compacted clays.
- (b) Effect of back pressure saturation in a Triaxial \bar{R} (consolidated undrained) test on compacted clay.
- (c) Effect of use of high air entry stones in a Triaxial \bar{R} (consolidated undrained) test on compacted clays.
- (d) Comparison of several saturation procedures in a triaxial test on compacted clays.

- (e) Comparison of effective stress data obtained from a Triaxial R (consolidated undrained) test vs. that obtained from a Triaxial S (consolidated drained) test.
- (f) Laboratory determination of the effect of the addition of glacial clay to the permeability, compaction and consolidation properties of a sand.

Queen's University:

In co-operation with the Ontario Department of Highways, an embankment situated upon a 150 ft. deep deposit of varved clay has been instrumented. Settlement readings will be taken on the surface as well as at depth. Piezometers have been installed under the embankment as well as outside the toe to measure the dissipation of pore pressure with time. Oedometer and hydrostatic triaxial consolidation tests have been performed upon the varved samples with the layers vertical and horizontal to the applied loads.

In connection with the above project, triaxial samples were tested at rates of strain varying from 0.4% per minute to 0.007% per minute. While there was a noticeable reduction in strength in terms of the total stress at the slow rate of strain, the effective stress parameters were reasonably constant for similar percentages of silt and clay. An approximate relationship was developed to account for the loss in soil strength due to varved structure of a soil sample.

Fundamental investigations were also conducted on two and three-dimensional consolidation of soil samples, and equipment was designed and constructed to measure the pore pressures during consolidation of samples in these tests, as well as in standard oedometer tests.

Ripley, Klohn & Leonoff Ltd:

Design of high pressure, large diameter triaxial equipment. Maximum confining pressures up to 640 psi, maximum specimen size 12 in. diameter.

R. C. Thurber & Assocs. Ltd:

A series of compression tests were carried out on tube samples recovered from borings in a recently completed fill and on laboratory compacted samples of increasing age which indicated a significant thixotropic regain of strength over a period of a month for a non-sensitive

low plastic clay.

A series of permeability tests were carried out on laboratory sedimented samples of an increasing number of distinct layers and various layer thicknesses all with the same average soil gradation and indicated that at a particular void ratio a layered soil was more impermeable in a vertical direction than a homogeneous soil.

High pressure triaxial compression testing equipment has been put into operation which will accept soil specimens of 6 in. diameter by 12 in. high at lateral confining pressures equivalent to an embankment 500 ft. high.

Underwood McLellan & Associates Ltd:

Studies were continued on the effect of saline immersing fluids on the swelling pressures recorded in free swell and constant volume consolidation tests on clay and clay till samples.

The effect of soil swelling around a piezometer tip on the piezometric levels was studied and found to be very significant. The reliability of the results from such installations are being studied.

University of Alberta and/or Alberta Research Council:

(a) Shear strength of overconsolidated clay shale soils.

(b) Ion exchange phenomena as affecting strength, consolidation and physical limit characteristics.

(c) Swelling properties of clay soils.

University of Saskatchewan:

Studies of volume change in highly plastic clays, consolidation and stabilization of soils.

V. E. Vaughan:

Working is continuing on soil subjected to repeated loading. Soil stabilized with lime is being tested under triaxial conditions in the repetitive loading machine. These samples have various percentages of lime and curing times. The effect of wetting the stabilized soil is also being observed. Repeated plate loading tests on clay is in progress.

Shear strength of crushed stone, as determined by the direct shear box method, up to 1 1/2 in. size has been underway. The angle of internal friction has been determined on several sizes (from No. 4 to 1 1/2 in). A series combining two or more sizes has also been completed. Future series include the addition of sand to the crushed stone, in various combinations. The final series will combine the clay size material with the crushed stone and the crushed stone/sand combination.

N. E. Wilson:

Research was conducted on the applicability of the vane test to dilatant soils. The research, using the laboratory vane in sand, silt and clay, showed that the size and rigidity of the container, the magnitude of pore water stresses and the rate of deformation influence the values of the torque applied to the vane shaft. It was found that the vane test in dilatant soils assumes the characteristics of a "drained" test.

Research was conducted on the consolidation and flow characteristics of peat. Laboratory work on the analysis and load-bearing characteristics of peat was reported.

It was shown that, when peat is subjected to loading, the compression is a combination of two properties; firstly, the permeability and, secondly, the viscous flow properties of the peat. Some large-scale consolidation tests, which were conducted to measure the pore-water pressures during consolidation, showed that the pore-water pressures, immediately after loading, were considerably less than the theoretical value and the pore-water pressures increased to a value slightly less than the theoretical value during the early part of the process.

R. Yong:

(a) Shear strength parameters and influence of time rate of strain on parameters.

(b) Inertia effects in shear testing.

(c) Partial soil freezing and unfrozen water content effects.

(d) Influence of molecular forces on permeability and moisture transport.

3. SHALLOW FOUNDATIONS INCLUDING PAVEMENTS

Department of Transport, Ottawa:

Current studies include profilometer measurements of pavement roughness, skid resistance of pavements, dynamic response of aircraft to pavement roughness, deflection under aircraft, triaxial strength tests of soils and bituminous mixes, correlation between Benkelman Beam deflection and plate loading capacity, curling of concrete slabs due to temperature, effect of coloured concrete on slab curling and ice removal cement stabilization of base course material, and settlement measurements under earthfills.

Division of Building Research, National Research Council:

The failure of a farm silo founded on very soft normally consolidated varved clay was examined. Good agreement was found between

the bearing capacity calculated from field vane strengths and the actual failure conditions.

Observations of settlement and pore pressures beneath two earthfills are continuing. Preparations are made for additional field instrumentation of this type.

After ten years of observations, a settlement analysis of the Mt. Sinai Hospital, Toronto, was published. Additional laboratory stress-deformation tests of the subsoil were carried out.

Bottom heave of a 30 ft. deep excavation and a 12 ft. deep excavation was measured and correlated with effective stress changes.

Some long-term observations of ground movements and shallow foundation performance were published. In connection with these and similar studies, the experience gained with deep bench marks has been described.

Measurements of the movement of basement walls and floor slabs, and slabs-on-grade over heavy clay subsoils were continued. The Prairie Regional Station participated in a study of the effects of various loading rates and relative humidities on the stress-strain characteristics of cardboard void forms. These forms are becoming more popular in the construction of structural floor slabs over void spaces in cases where heaved floors can not be tolerated.

Studies of the performance of engineering facilities erected on permafrost were continued by means of ground temperature and foundation movement observations at selected structures at Inuvik, N. W. T. , and Thompson, Manitoba, located in the continuous and discontinuous permafrost zones respectively.

Ecole Polytechnique:

Strain and stress distribution in soils (continued).

GEOCON/FENCO:

Measurement of settlement, lateral movement and pore pressure in peat below a low highway embankment. Effect of Spring thaw observed and also variations in pore pressure under loads from construction traffic.

P. T. Hodgins:

Field research during the past year has been limited and almost entirely to an inspection trip of various test roads, construction sites, and stretches of pavement affected by "frost cracks" throughout northern

Sweden during February 1963.

A laboratory project has been the development of a new ground temperature indicator from the frost depth indicator developed in 1956 by R. Gandahl of Statens Vaginstitut. In the new instrument, several solutions are used and hence several isotherms can be located at one time. A curve of temperature vs. depth may be drawn and thus the thermal gradients above and below the frost line may be deduced.

B. G. Hutchinson:

Fundamental studies of road roughness characterization are being pursued with the ultimate objective of establishing a rational formulation of highway pavement serviceability. An examination of the rational underlying the AASHO Road Test subjective rating technique indicates several deficiencies in it.

B. Ladanyi:

Definition of the total safety factor for various loading conditions. A theoretical study.

N. W. McLeod:

A study has been made of the application of the elastic theory layered system approach to the structural design of pavements.

G. G. Meyerhof:

A theory has been developed to estimate the ultimate load-carrying capacity of concrete footings and pavements. Field observations on concrete pavements have been analyzed and the results support the theory, as shown in paper.

A simple theory has been developed to estimate the deflection of flexible pavements and the estimates are compared with field measurements in a paper.

Ontario Department of Highways:

Preparation of equipment for measuring soil suction as part of an investigation of the cracking of flexible pavements.

Observation and analysis of settlements and failures in embankments founded on soft clays.

Investigation of mechanism of cracking in flexible pavements at selected points throughout Ontario.

Participation in the Canadian Pavement Evaluation Programme under the auspices of the C. G. R. A.

Investigation of skidding characteristics of Ontario roads.

H. E. P. C. O:

Studies of footings in uplift were made using model footings. Footing size, the depth of burial and soil type were varied over a wide range. A number of tests were carried out making pore pressure measurements in the clay surrounding the footings.

P. F. R. A:

A frost research programme was continued, primarily to determine the effects of frost action on spillway structures. Apparatus has been installed to measure the depth of frost penetration, the amount of heave due to frost action, and the fluctuation in groundwater levels. Seventeen sites are under observation.

Observations were continued on the heave associated with spillway structures founded on clay-shale and other clay soils. Rebound gauges have been installed prior to excavation in an attempt to measure the heave as excavation occurs.

J. D. Scott:

Field and laboratory studies of the settlement of various structures in Kitchener-Waterloo are being made.

Terratech Ltd:

Settlement and pore pressure observations of road fills built over peat bogs.

G. R. Tessier:

Pavement investigations are carried on under the auspices of

the Special Committee on Pavement Design and Evaluation of the C. G. R. A.

Intensive work is done every year to cover the three stages of the study. Forty-five hundred miles of roads are inventoried annually. For more details on the nature of this work one can contact C. G. R. A. in Ottawa.

Underwood McLellan & Associates Ltd:

Studies were also continued on the evaluation of the properties of lime stabilized clay soils as related to road construction.

Stabilization methods of natural soils for use in the pavement structure are still being studied. Several experimental strips have been constructed and performance will be evaluated.

University of Alberta and/or Alberta Research Council:

(a) Continuing studies on frost action phenomena in both open and closed systems.

(b) Evaluation of load-deflection phenomena in layered pavement systems.

(c) Stabilization of various types of soil with portland cement, asphalt or lime.

R. Yong:

(a) Measurement of stresses under moving loads.

(b) Bearing capacity prediction from model tests on simulated plastic soil with high layering effects.

4. DEEP FOUNDATIONS

H. G. Acres & Company Limited:

Field and office engineering studies on behaviour of "H" piles driven to end bearing on a hard steeply-inclined rock surface.

J. C. Brodeur:

During the past year, we completed a rather unusual job for

conventional piling. Herkules Precast Concrete Piles were driven 210 feet to rock through an existing timber crib. Two 200-ton load tests were successfully carried out.

Division of Building Research, National Research Council:

Measurements of the performance of "friction" pile foundations for light structures in heavy clay soils were continued.

Ecole Polytechnique:

Evaluation of bearing capacity of piles; with depth, type of pile and time effects on cohesion and friction.

B. Ladanyi:

Relationship between the deep penetration and the expansion of cavities in sand. Initiated laboratory study by model tests.

G. G. Meyerhof:

Model tests on pile groups under eccentric load in sand have been initiated to determine the settlement and ultimate load. The uplift resistance of single model piles with bulbous toe is being studied in clay and sand to determine the deformation and ultimate load for comparison with theories.

Ontario Department of Highways:

Correlation of calculated and measured bearing capacities of piles.

E. I. Robinsky:

Studies are continuing on the effect of pile displacement and shape on pile capacity in cohesionless soils. The studies are being conducted with the use of model piles.

5. EARTH AND ROCK PRESSURES

H. G. Acres & Company Limited:

Planning of field instrumentation programme for observation of rock movement in a tunnel driven in shale.

Division of Building Research, National Research Council:

Measurement of earth pressures on a 10-foot diameter tunnel is continuing. The deflection of bridge abutments on steep clay banks are being observed.

R. Dussault:

Review of earth pressure theories and their applications to earth retaining structures with special references to bulkheads.

GEOCON/FENCO:

Measurements of loads in struts and side supports of an open cut in stiff fissured clay during construction of one section of the Toronto subway. Measurements taken at various stages over one construction cycle. Measurements taken with a view to determining lateral earth pressures.

Measurements with Slope Indicator equipment on several steel sheet pile bulkheads. Use of the same apparatus for detection of possible movements of abutments to a bridge, and in a high slope. Some experience gained in the use of the apparatus under very low temperature conditions.

B. Ladanyi:

Pore pressure distribution around a circular tunnel in clay.
A theoretical study.

G. G. Meyerhof:

Model tests have been made on steel culverts in compact sand to determine the earth pressure, deformation and collapse load. The experiments and full-scale observations are compared with previous theories and a new method of analysis in a paper in preparation.

K. Peaker:

An investigation, using a medium-size model to measure earth pressures, continues. Measurements include the distribution of force on the wall and the mobilization of the angle of wall friction with strain. This work is now carried out in the new 60-ton capacity sand flume of the Manchester University.

N. E. Wilson:

Preparations are being made to install vibrating-wire earth pressure cells on a deep sheeted excavation in dense sand and gravel. The excavation, 40 ft x 60 ft in plan, is 50 ft deep and adjacent to a

river. It is intended to determine the earth pressure distribution behind the sheeting and to measure the strains in the bracing. (This project, in association with Prof. J. D. Scott, will use the vibrating-wire pressure cells).

R. C. Wyld:

Present programme includes reactions of soils media to varying blasts and shocks, effect of shock on sand columns, and effect of different types of soil cover over "scaled" concrete slabs and effect of blast waves at different intensity levels.

6. EARTH AND ROCK DAMS, SLOPES AND OPEN EXCAVATIONS

H. G. Acres & Company Limited:

(a) Study of the geotechnical properties of impervious fill materials in Canadian earthfill and rockfill dams.

(b) Continuing observations of the performance of earthfill dykes built on permafrost foundations.

(c) Field studies of groundwater flow patterns in very extensive aquifer systems including effects of dam construction operations on flow regimes.

(d) Field and office engineering studies of a large landslide in extra-sensitive estuarine clayey silt.

Canadian National Railways:

Treatment of a one and one-half mile railway cut in water bearing fine sand was designed, using sub-drains and filter blankets. Drawdown and discharge were measured on trial sections and on the finished work for comparison with design estimates. Effect of varying wellpoint spacing was also studied.

Division of Building Research, National Research Council:

Slope failures in varved clays at the Beattie Mine in northern Quebec were studied in the field and in the laboratory. Stability of slopes was correlated with the criteria for critical heights of banks and found to correlate with previous experience in this type of material.

Assistance was given DHO in study of a landslide near Cumberland, Ontario. Field investigations were made at an earthflow which occurred near Breckenridge, Quebec, in April 1963.

Piezometers and an access tube for a radioactive moisture probe were installed in a bank of the Red River to investigate seasonal changes in water content and pore water pressures as related to river bank stability.

Observations on the performance of sand-fill dykes constructed on permafrost in Northern Manitoba were continued.

GEOCON/FENCO:

Investigation of slides in stiff fissured clays and clay tills, forming slopes of relatively deep highway and railroad cuts.

G. A. Gorman:

Construction of zoned earthfill dyke on Mattagami River. Second year of construction of 5-mile dyke. Foundation conditions ranging from Precambrian bedrock, glacial till to sands and silts. Foundation piezometers were installed and observed during the initial in-service period in April-May 1963. Variations in barometric pressure were found to affect the piezometer readings.

Per Hall & Associates:

Design of an earthfill dyke to permit the dewatering of a 28-acre dry dock required during construction of a tunnel-bridge. The bottom of the dry dock will be dredged below the river bed, and the concrete tunnel elements constructed in the dry dock, floated out and sunk into their final positions.

The cross-section of the dyke is a uniform section of well-graded, compacted till, with armour stone protection on the outside.

Seepage beneath the dyke will be controlled by a well-point system consisting of two stages in the deeper portion of the dry dock and one stage elsewhere.

Manitoba Hydro:

A programme of field research was established involving the determination of construction pore pressures in plastic and till foundations. These pressures are being correlated with rates of construction to determine stability at various stages.

P. F. R. A:

Continuing studies are being carried on in an effort to improve the apparatus for observation of movements and pore pressures in earth dams and natural slopes. This has involved:-

- (a) Development of an improved seal for Casagrande piezometers.
- (b) Development of the plumb line indicator to measure lateral movement in vertical test holes.
- (c) Use of high air entry stones in embankment piezometers.

Ripley, Klohn & Leonoff Ltd:

Large-scale field tests to determine suitability of wet silty clay soils for use in the impervious zone of a proposed high earthfill dam.

APPENDIX "A"

MEMBERS OF THE CANADIAN SECTION OF THE INTERNATIONAL SOCIETY OF SOIL MECHANICS AND FOUNDATION ENGINEERING

<u>Name</u>	<u>Title or Occupation</u>	<u>Address</u>
Adams, J. I.	Engineer	Research Division, Hydro-Electric Power Commission of Ontario, 200 Kipling Avenue South, Toronto 18, Ontario.
Agensky, N.	Post-Graduate Student	5625 Cote St. Luc Road, Apt. 402, Montreal 29, P. Q.
Almeda, F. A.	Design Engineer	Construction Branch, Department of Transport, Ottawa, Ontario.
Anderson, C. E.	Engineering Geologist	Underwood, McLellan & Assocs., 1495 Pembina Highway, Winnipeg 19, Manitoba.
Anderson, K. O.	Associate Professor	Department of Civil Engineering University of Alberta, Edmonton, Alberta.
Andersson, A. G. L.	Drilling Supervisor	Ripley, Klohn & Leonoff Ltd., 1930 West Broadway, Vancouver 9, B. C.
Argue, G.	Design Engineer	Construction Branch, Department of Transport, Ottawa, Ontario.
Armstrong, M. D.	Principal Research Engineer	Department of Highways, Downsview, Ontario.

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Audy, R.	Soils Engineer	1134 Chemin St-Louis, Quebec 6, P.Q.
Baikie, L. D.	Project Engineer	Testing Laboratories, Department of Public Works, Riverside Drive, Ottawa, Ontario.
Basarke, N. S.	Assistant to Consulting Engineer	Department of Highways, Bridge Division, Parliament Buildings, Toronto, Ontario.
Bazett, D. J.	Supervising Engineer	Research Division, Hydro-Electric Power Commission of Ontario, 200 Kipling Avenue South, Toronto 18, Ontario.
Bell, E. S.	Planning Engineer	Hydro-Electric Power Commission of Ontario, 620 University Avenue, Toronto, Ontario.
Bordeleau, J. B.	Technical Officer	Division of Building Research, National Research Council, Ottawa, Ontario.
Bourget, S. J.	Associate Professor	Faculté d'Agriculture, Université Laval, Ste-Foy, Quebec 10.
Boyer, L.	Geologist	H. G. Acres & Company Ltd., Niagara Falls, Ontario.
Bozozuk, M.	Graduate Student	226-1 Arnold Drive, West Lafayette, Indiana.
Bradshaw, T. J.	Soils Engineer	H. G. Acres & Co. Ltd., Niagara Falls, Ontario.
Bray, J.	Geologist	1825 Blvd. St. Germain, Ville St. Laurent, Montreal 9, P.Q.

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Bremner, P. C.	Manager, Contract Drilling Division	Canadian Longyear Ltd. , Drawer 330, North Bay, Ontario.
Brodeur, J. C.	Vice-President	A. Johnson & Co. (Can.) Ltd. , 1255 Laird Blvd. , Montreal 16, P.Q.
Brodie, A. F.	Project Engineer	James F. MacLaren Ltd. , 321 Bloor Street East, Toronto, Ontario.
Brooker, E. W.	Asst. Prof. of Civil Engineering, Univ. of Alta.	1835 Orchard Place, Urbana, Illinois.
Brown, A. A.	Soils Engineer	NWHME, Whitehorse, Y. T.
Brown, J.	Civil Design Engineer	1208 Duthie Avenue, Burnaby 2, B. C.
Brown, J. D.	Senior Soils Engineer	Geocon Ltd. , 420 Michel Jasmin Avenue, Dorval, P.Q.
Brown, R. J. E.	Research Officer	Division of Building Research, National Research Council, Ottawa, Ontario.
Brownridge, F. C.	Special Assign- ments Engineer	Department of Highways, Downsview, Ontario.
Brusey, W. G.	Soil Mechanics Engineer	Hydro-Electric Power Commission of Ontario, 620 University Avenue, Toronto, Ontario.
Burn, K. N.	Research Officer	Division of Building Research, National Research Council, Ottawa, Ontario.

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Brzezinski, L. S.	Senior Soils Engineer	Geocon Ltd. , 420 Michel Jasmin Street, Dorval, P. Q.
Campbell, D. B.	Senior Engineer	Ripley, Klohn & Leonoff Ltd. , 1930 West Broadway, Vancouver 9, B. C.
Chan, H. T.	Research Assistant	Ellis Hall, Queen's University, Kingston, Ontario.
Chan, L. G.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Chapman, L. J.	Director, Dept. of Physiography	Ontario Research Foundation, 43 Queen's Park Crescent East, Toronto 5, Ontario.
Cherrington, G. G.	Project Foundation Engineer	Department of Highways, Downsview, Ontario.
Chmielenski, A.	President	Foundation of Canada Engineering Corp. Ltd. , 1980 Sherbrooke Street West, Montreal, P. Q.
Chong, G. J.	Project Soils Engineer	Department of Highways, Downsview, Ontario.
Christensen, C. J.	Research Asst. & Graduate Student	Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.
Chrumka, S. J.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.

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Clark, J. G.	Civil Engineer	Montreal Engineering Co. Ltd. , P. O. Box 250, Place d'Armes, Montreal, P. Q.
Coates, D. F.	Head, Mining Research Lab.	Geological Survey of Canada, Department of Mines & Tech. Surveys, 562 Booth Street, Ottawa, Ontario.
Collin, C. J. P.	Soils Engineer	Geocon Ltd. , 420 Michel Jasmin, Dorval, P. Q.
Conlon, R. J.	Soil Mechanics & Foundation Engineer	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
Cook, R. D.	Graduate Student	Department of Civil Engineering, University of Alberta, Edmonton, Alberta.
Crawford, C. B.	Head, Soil Mechanics Section	Division of Building Research, National Research Council, Ottawa, Ontario.
Dalton, C. J.	Supervisor of Soil Investi- gations	Canadian National Railways, Engineering Department, P. O. Box 8100, Montreal 3, P. Q.
Danys, J. V.	Superintendent of Construction	Department of Transport, Aids to Navigation, Hunter Building, Ottawa, Ontario.
Darch, B.	Soils Engineer	Geocon Ltd. , 420 Michel Jasmin Street, Dorval, P. Q.

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Davis, M. M.	Associate Professor	Department of Civil Engineering, University of Toronto, Toronto, Ontario.
Davison, D. M.	Senior Engineer	Ripley, Klohn & Leonoff Ltd. , 1930 West Broadway, Vancouver 9, B. C.
Demellweek, J.	Design Engineer	Construction Branch, Department of Transport, Ottawa, Ontario.
DeLory, F. A.	Associate Professor	Department of Civil Engineering, University of Toronto, Toronto, Ontario.
Desjardins, G.	Managing Director	Laboratoires Ville-Marie Inc. , 3042 Ave. Lacombe, Montreal 26, P.Q.
Devata, M.	Senior Foundation Engineer	Materials & Research Division, Department of Highways, Parliament Buildings, Toronto 5, Ontario.
Devenny, D. W.	Engineering Geologist	Testing Laboratories, Department of Public Works, Riverside Drive, Ottawa, Ontario.
Dickson, W. J.		Department of National Defence, Army Headquarters, Ottawa 4, Ontario.
Dobrowolski, J. Z.	Chief Structural Engineer	Department of National Defence, Q. M. G. Design Division, Cartier Square, Ottawa, Ontario.
Dodds, R.	Engineer	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.

"A"-7

Doherty, J. F.	Soils Engineer	Geocon Ltd. , 14 Haas Road, Rexdale, Ontario.
Domaschuk, L.	Lecturer	Department of Civil Engineering, University of Saskatchewan, Saskatoon, Sask.
Dowse, B. E. W.		H. Q. Golder & Assocs. Ltd. , 2444 Bloor Street West, Toronto 9, Ontario.
Dufour, M.	Chief Engineer	National Boring & Sounding Inc. , 615 Belmont Street, Montreal 3, P.Q.
Dussault, R.	Post-Graduate Student	Imperial College of Science & Technology, University of London, London, England.
Dutz, H. G.	Design Engineer	Construction Branch, Department of Transport, Ottawa, Ontario.
Dyregrov, A. O.	Soils Engineer	Underwood, McLellan & Assocs. , 1495 Pembina Highway, Winnipeg, Man.
Eden, W. J.	Research Officer	Division of Building Research, National Research Council, Ottawa, Ontario.
Elson, J. A.	Asst. Professor	Department of Geological Sciences, McGill University, Montreal 2, P.Q.
Fazili, K. A.		224 St. George Street, Apt. 203, Toronto 5, Ontario.

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Fennerty, H.		James F. MacLaren Limited, 321 Bloor Street East, Toronto 5, Ontario.
Fennessy, F. J. W.	Design Engineer	Construction Branch, Department of Transport, Ottawa, Ontario.
Flynn, C. T.	Engineer	H. G. Acres & Co. Ltd., Niagara Falls, Ontario.
Foures, G. H.	Acting Chief	Structures Division, Department of Public Works, Riverside Drive, Ottawa, Ontario.
Fowler, E. L.	Assoc. Professor	Department of Civil Engineering, University of Alberta, Edmonton, Alberta.
Fraikin, L. A.	President	Franki of Canada Ltd., 187 Graham Blvd., Town of Mount Royal, P.Q.
Fredlund, D.	Graduate Teaching Asst.	Civil Engineering Department, University of Alberta, Edmonton, Alberta.
Garneau, R.	Resident Engineer	Terratech Ltd., 1440 St. Catherine Street West, Montreal, P.Q.
Gass, A. A.	Soils Engineer	H. Q. Golder & Assocs. Ltd., 2444 Bloor Street West, Toronto 9, Ontario.
Ghadiali, B.	Project Fdn. Engineer	Ontario Department of Highways, Downsview, Ontario.
Godawa, J. J.	Soils Engineer	6 Monarchwood Crescent, Don Mills, Ontario.

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Golder, H. Q.	Principal	H. Q. Golder & Assocs. Ltd. , 2444 Bloor Street West, Toronto 9, Ontario.
Goodman, K. S.	Manager	Materials Testing Labs. Ltd. , 27 - 6A Street N. E. , Calgary, Alberta.
Goodwin, T.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Gorman, G. A.	Senior Soils Engineer	Hydro-Electric Power Commission of Ontario, 620 University Avenue, Toronto, Ontario.
Granger, J.	Asst. Professor	Ecole Polytechnique, 2500 Guyard Avenue, Montreal, P. Q.
Graves, A. C.	Field Geologist	Shawinigan Engineering Co. Ltd. , 620 Dorchester Street West, Montreal, P. Q.
Graves, A. H.	Head, Test Borings Group	Testing Laboratories, Department of Public Works, Ottawa, Ontario.
Green, H. W.	Engineering Geologist	Geocon Ltd. , 14 Haas Road, Rexdale, Ontario.
Grice, R. H.	Graduate Student	Department of Geology, University of Illinois, Urbana, Illinois.
Groves, B. A.	Design Engineer	Construction Branch, Department of Transport, Ottawa, Ontario.

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Guibord, A. O.	Technical Officer	Division of Building Research, National Research Council, Ottawa, Ontario.
Haas, R. C. G.	Graduate Teaching Assistant	Department of Civil Engineering, University of Alberta, Edmonton, Alberta.
Hall, P.	President	Foundation of Canada Engineering Corp. Ltd. , 1980 Sherbrooke Street West, Montreal, P.Q.
Hamilton, A. B.	Asst. Res. Officer	16418 - 88th Avenue, Edmonton, Alberta.
Hamilton, J. J.	Research Officer	Prairie Regional Station, Division of Building Research, National Research Council, Saskatoon, Sask.
Hamilton, R. D.		1824 Kiva Road, Santa Fe, New Mexico.
Handa, V. K.	Lecturer	Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.
Hardy, R. M.	Consulting Engineer	R. M. Hardy & Assocs. Ltd. , 10214 - 112 Street, Edmonton, Alberta.
Harris, M. C.	Graduate Student	11139 - 87th Avenue, Edmonton, Alberta.
Hausmann, M.	Graduate Student	Civil Engineering Department, University of Alberta, Edmonton, Alberta.
Haydock, J. L.	Head, Applied Mechs. Dept.	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.

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Heffernan, F. J.	District Soils Engineer	Geocon Ltd. , 14 Haas Road, Rexdale, Ontario.
Hickey, W. E.	Executive Vice-Pres.	The Foundation Company of Canada Limited, 2200 Yonge Street, Toronto, Ontario.
Hilts, D. E.	Graduate Research Assistant	Department of Civil Engineering, Queen's University, Kingston, Ontario.
Ho, K. H.	Soils Engineer	Terratech Ltd. , 1440 St. Catherine Street West, Montreal, P.Q.
Hodgins, P. T.	Civil Engineer	248 Roger Road, Ottawa 8, Ontario.
Holubec, I.	Graduate Student	Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.
Hood, R.	Chief Engineer	Underwood, McLellan & Assocs. Ltd. , 1495 Pembina Highway, Winnipeg, Manitoba.
Hoskin, E. D. E.	President	Hoskin Scientific Ltd. , 1878 De La Salle Avenue, Montreal 4, P.Q.
Hoy, M.	Soils Engineer	Foundation of Canada Engineering Corp. Ltd. , 1425 West Pender Street, Vancouver, B. C.
Hughes, G. T.	Assoc. Professor	Department of Civil Engineering, Royal Military College, Kingston, Ontario.

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Hurtubise, J. E.	Professor	Ecole Polytechnique, 2500 Guyard Avenue, Montreal, P. Q.
Hurwitz, L. E.	President	Independent Test-Lab. Ltd. , 526 St. James Street South, Winnipeg 10, Manitoba.
Hutchinson, B. G.	Lecturer	Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.
Insley, A. E.	Soils Engineer	R. C. Thurber & Assocs. Ltd. , 628 Dupplin Road, Victoria, B. C.
Ismaily, S. A.	Soils Project Engineer	Testing Laboratories, Department of Public Works, Confederation Heights, Ottawa, Ontario.
Iverson, N. L.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Jaspar, J. L.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Johnston, G. H.	Research Officer	Division of Building Research, National Research Council, Ottawa, Ontario.
Jolly, J. P.	Lecturer	Department of Civil Engineering, Queen's University, Kingston, Ontario.
Journeaux, N. L.	Soils Engineer	Terratech Ltd. , 1440 St. Catherine Street West, Montreal, P. Q.

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Jubien, W. E.	Engineer	Canadian National Railways, Engineering Department, P. O. Box 8100, Montreal 3, P. Q.
Karasek, C. J.	Engineer	Planning & Design Engineer, Department of Highways, Confederation Bldg. , St. Johns, Nfld.
Karrow, P. F.	Geologist	Ontario Department of Mines, Parliament Bldgs. , Toronto, Ontario.
Kenney, T. C.	Civil Engineer	Norwegian Geotechnical Institute, Oslo-Blindern, Norway.
Kilgour, D. A.	Dyke Materials Engineer	Manitoba Hydro, Hybord, Manitoba.
Kilpatrick, B. L.	Civil Engineer	P. F. R. A. , South Saskatchewan River Dam, Box 85, Cutbank, Sask.
King, K. H.	Divisional Engineer	Racey, MacCallum & Assocs. Ltd. , 59 Curlew Drive, Don Mills, Ontario.
Kingham, R. I.	Project Soils Engineer	Department of Highways, Downsview, Ontario.
Klohn, E. J.	Director	Ripley, Klohn & Leonoff Ltd. , 1930 West Broadway, Vancouver 9, B. C.
Kohuska, A.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.

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Koropatnick, A.	Area Engineer, Dykes & Materials	Manitoba Hydro, Hybord, Manitoba.
Lachance, L.	Geologist	H. G. Acres & Co. Ltd., Niagara Falls, Ontario.
Ladanyi, B.	Assoc. Prof. of Civil Engg.	Civil Engineering Department, Laval University, Quebec 4, P.Q.
Lake, J. O.	Consulting Engineer	100 University Avenue, Toronto 1, Ontario.
Laliberte, M.	Resident Engineer	Terratech Ltd., 1440 St. Catherine Street West, Montreal, P.Q.
Lalonde, J. Y.	Asst. Soil Engineer	St. Lawrence Seaway Authority, 685 Cathcart Street, Montreal, P.Q.
Lamb, K. N.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A., P. O. Box 908, Saskatoon, Sask.
L'Ami, C.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A., P. O. Box 908, Saskatoon, Sask.
LaRochelle, P.	Assoc. Prof. of Civil Engg.	Civil Engineering Department, Laval University, Quebec, P.Q.
Laycraft, N. E.	Chief	Testing Laboratories, Development Engineering Branch, Department of Public Works, Riverside Drive, Ottawa, Ontario.

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Lea, N. D.	Principal	N. D. Lea & Assocs. Ltd. , 1112 West Pender Street, Vancouver, B. C.
Leach, T. A. J.	Chief, Hydraulic Investigations Division	Water Resources Department, Department of Lands & Forests, Victoria, B. C.
LeBel, J. P. M.	Senior Engineer	George Demers, Consulting Engineer, 1425 Mountain Street, Montreal, P.Q.
Lee, K. L.	Assistant Specialist & Graduate Student	1115 H6th Street, Albany 10, California.
Lefebvre, L. M.	Engineer	Laboratoires Ville-Marie Inc. , 400 Blvd. Labelle, Chomedey, P.Q.
Legget, R. F.	Director	Division of Building Research, National Research Council, Ottawa, Ontario.
Le Lievre, B.	Graduate Student	University of Waterloo, Waterloo, Ontario.
Lenz, K.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Leonoff, C. E.	Director	Ripley, Klohn & Leonoff Ltd. , 1930 West Broadway, Vancouver 9, B. C.
Lissel, K. M.	Embankment Engineer	P. F. R. A. , South Saskatchewan River Dam, Box 101, Cutbank, Sask.

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Lo, K. Y.	Supervising Fdn. Engineer	Department of Highways, Downsview, Ontario.
Locker, J. G.	Lecturer	Department of Civil Engineering, Royal Military College, Kingston, Ontario.
Loiselle, A. A.		Ecole Polytechnique, 2500 Marie Guyard Avenue, Montreal 26, P.Q.
Long, W. C.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Maduke, B. I.	Graduate Student	1013 - 9th Street, University Village, Albany, California.
Makowichuk, P. B.	Graduate Teaching Asst.	Civil Engineering Department, University of Alberta, Edmonton, Alberta.
Marttila, R. E.	Post-Graduate Student	Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.
Mason, C. A.	Branch Mgr.	Canadian Longyear Ltd. , 7 Taber Road, Rexdale, Ontario.
Mathews, W. H.	Professor	Department of Geology, University of British Columbia, Vancouver 8, B. C.
Matich, M. A. J.	Vice-Pres. & Chief. Eng.	Geocon Ltd. , 420 Michel Jasmin Street, Dorval, P.Q.

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Matthews, D. N. P.	Engineer	P. F. R. A. , South Saskatchewan River Dam, Cutbank, Saskatchewan.
Matyas, E. L.		School of Engineering, Carleton University, Ottawa, Ontario.
Meyerhof, G. G.	Director, School of Grad. Studies & Head, Dept. of Civil Engg.	Nova Scotia Technical College, Halifax, N. S.
Millard, A. W.	Divisional Soils Engineer	Franki of Canada Ltd. , 214 Merton Street, Toronto, Ontario.
Milligan, V.	Partner	H. Q. Golder & Assocs. Ltd. , 2444 Bloor Street West, Toronto 9, Ontario.
Mindess, M.	Asst. Prof.	Department of Civil Engineering, University of Manitoba, Winnipeg, Manitoba.
Mitchell, P. C.	Engineer	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
Morgan, G. C.	Senior Engineer	IPEC Ltd. , 570 Dunsmuir Street, Vancouver, B. C.
Morgan, J.	District Manager	The Foundation Company of Canada Ltd. , 1 Place Ville Marie, Montreal, P. Q.
Morris, P. G.	Geologist	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.

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Morrison, K. I.	Senior Engineer	Ripley, Klohn & Leonoff Ltd. , 1930 West Broadway, Vancouver 9, B. C.
Mowchenko, M.	Engineer	P. F. R. A. , South Saskatchewan River Dam, Cutbank, Sask.
Murphy, D. F.	Chief Civil Engineer	Foundation of Canada Engineering Corp. Ltd. , 1980 Sherbrooke Street West, Montreal, P.Q.
Murphy, D. K.	Geologist	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
MacDonald, D. H.	Director	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
MacFarlane, I. C.	Research Officer	Muskeg Laboratory, Hamilton Hall, McMaster University, Hamilton, Ontario.
MacKenzie, I. D.	Geologist	The Shawinigan Engineering Company Limited, P. O. Box 6072, Montreal, P.Q.
MacLean, D. A.	Civil Engineer	R. C. Thurber & Assocs. Ltd. , 628 Dupplin Road, Victoria, B. C.
MacMillan, D. C.	Technical Officer	Division of Building Research, National Research Council, Ottawa, Ontario.
MacPherson, J. G.	Engineer	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
MacRury, A.	Graduate Student	Civil Engineering Department, University of Alberta, Edmonton, Alberta.

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McCammon, N. R.	Senior Soils Engineer	H. Q. Golder & Assocs. Ltd. , 2444 Bloor Street West, Toronto, Ontario.
McFarlane, H. W.	Assoc. Prof. of Civil Engg.	University of New Brunswick, Fredericton, N. B.
McKittrick, D. P.	Graduate Student	21-9 Ross Ade Drive, West Lafayette, Indiana.
McLean, A. A.	Regional Materials Engineer	Regional Materials Laboratory, 33 Wellington Crescent, Sea Island, Richmond, B. C.
McLeod, N. W.	Asphalt Consultant	Imperial Oil Ltd. , 111 St. Clair Avenue West, Toronto 7, Ontario.
McLure, G. E.		Manitoba Hydro, P. O. Box 815,
McRostie, G. C.	Consulting Engineer	393 Bell Street, Ottawa, Ontario.
Nasmith, H. W.	Geologist	R. C. Thurber & Assocs. Ltd. , 628 Dupplin Road, Victoria, B. C.
Nicholls, B.	Geophysicist	Hunting Survey Corp. Ltd. , 1450 O'Connor Drive, Toronto, Ontario.
Noble, C. A.	Asst. Prof.	Department of Civil Engineering, University of Saskatchewan, Saskatoon, Sask.
Normand, J.	Research Student	Civil Engineering Department, Imperial College, London S. W. 7, England.

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Oates, D. B.	Soils Engineer	Geocon Ltd. , 14 Haas Road, Rexdale, Ontario.
Olsen, M. T.	Senior Engineer	Ripley, Klohn & Leonoff Ltd. , 1930 West Broadway, Vancouver 9, B. C.
Osler, J. C.	Asst. Prof.	Department of Civil Engineering & Applied Mechanics, McGill University, Montreal 2, P. Q.
Ottley, H. E. R.	Sessional Lecturer	Department of Civil Engineering, University of Alberta, Edmonton, Alberta.
Owen, E. B.	Engg. Geologist	Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario.
Paget, A. F.	Comptroller of Water Rights	Department of Lands, Forests & Water Resources, Parliament Bldgs. , Victoria, B. C.
Panter, R. A.	Asst. Construction Engineer	Department of Highways, Downsview, Ontario.
Paré, J. J.	Asst. Prof.	Faculty of Science, Sherbrooke University, Sherbrooke, P. Q.
Patterson, F. W.	Director	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
Peaker, K.	Lecturer	Department of Civil Engineering, University of Manchester, Manchester, England.

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Peckover, F. L.	Engineer of Soils & Fdns.	Canadian National Railways, Engineering Department, P. O. Box 8100, Montreal 3, P. Q.
Penner, E.	Research Officer	Division of Building Research, National Research Council, Ottawa, Ontario.
Penner, F.	Design Engineer	Construction Branch, Department of Transport, Ottawa, Ontario.
Perkins, C. L.	Staff Engineer	Imperial Oil Ltd. , 111 St. Clair Avenue West, Toronto, Ontario.
Peters, N.		Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Peterson, R.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Pihlainen, J. A.	Arctic Engg. Consultant	255 Montreal Road, Ottawa, Ontario.
Price, G. C.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Prior, A.	Manager of Engineering	Franki of Canada Ltd. , 214 Merton Street, Toronto, Ontario.
Pryer, R. W.	Soils Engineer	Quebec North Shore & Labrador Railway, Sept Iles, P. Q.

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Quigley, R. M.	Asst. Prof.	Faculty of Engineering Science, University of Western Ontario, London, Ontario.
Racey, H. J.	Executive Vice-Pres.	Racey, MacCallum & Assocs. Ltd., 5890 Monkland Avenue, Montreal 28, P.Q.
Radforth, N. W.	Chairman, Dept. of Biology	McMaster University, Hamilton, Ontario.
Raudsepp, V.	Chief Engineer	Water Investigations Branch, B. C. Water Resources Service, Parliament Buildings, Victoria, B. C.
Raymond, G. P.	Asst. Prof.	Ellis Hall, Queen's University, Kingston, Ontario.
Reid, N. L.	Vice-Pres.	Haddin, Davis & Brown Co. Ltd., 1134 - 8th Avenue West, Calgary, Alberta.
Richards, W. A.	Engineering Asst.	Department of Highways, Victoria, B. C.
Ringheim, A. S.	Materials Engineer	P. F. R. A. , South Saskatchewan River Dam, Cutbank, Sask.
Ripley, C. F.	President	Ripley, Klohn & Leonoff Ltd. , 1930 West Broadway, Vancouver 9, B. C.
Rivard, P. J.	Soil Mechs. Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.

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Rix, H. H.	Asst. Res. Officer	Highway Research Division, Alberta Research Council, Engineering Building, University of Alberta, Edmonton, Alberta.
Robinsky, E. I.	Soil Mechs. & Fdn. Consultant	301 Jedburgh Road, Toronto 12, Ontario.
Rochette, P. A.	Asst. Prof.	Ecole Polytechnique, 2500 Marie Guyard Avenue, Montreal 26, P.Q.
Rolko, L. S.	Chief Soils Engineer	Dominion Soil Investigation Ltd. , 77 Crockford Blvd. , Scarborough, Ontario.
Ruebenbauer, J. M.	Soils Project Engineer	Testing Laboratories, Department of Public Works, Riverside Drive, Ottawa, Ontario.
Rutherford, J.	Asst. to the Chief Civil Engineer	Integrated Consultants Ltd. , Montreal, P.Q.
Rutka, A.	Materials & Res. Engineer	Department of Highways, Downsview, Ontario.
Ryder, H. W.	Engineer	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
Sainani, U. R. (Mrs.)		1233 Mount Royal Blvd. , Outremont, Montreal 8, P.Q.
Salvas, R. J.	Instructor	Ryerson Polytechnical Institute, Department of Civil Technology, 50 Gould Street, Toronto 2, Ontario.

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Samson, L.	Vice-Pres. & Sr. Engineer	Terratech Ltd. , 1440 St. Catherine Street West, Montreal, P.Q.
Schriever, W.R.	Head. Bldg. Structures Section	Division of Building Research, National Research Council, Ottawa, Ontario.
Scott, J. D.	Asst. Prof.	Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.
Scoular, J.R.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Sebastyan, G. Y.	Head, Engg. Design Section	Construction Branch, Department of Transport, Ottawa, Ontario.
Senneville, C.	Pres. & Chief Engineer	Terratech Ltd. , 1440 St. Catherine Street West, Montreal, P.Q.
Seychuk, J. L.	Senior Engineer	H. Q. Golder & Assocs. Ltd. , 2444 Bloor Street West Toronto 9, Ontario.
Shields, B. P.	Head	Highway Research Division, Alberta Research Division, Engineering Building, University of Alberta, Edmonton, Alberta.
Shields, D. H.	Research Student	4 Brayton Avenue, Manchester, England.
Shinners, M.	Div. Soils Engineer	Donald Inspection Ltd. , 1189 Guy Street, Montreal, P.Q.

Shtenko, W.	Soil Mech. Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Sinclair, S. R.	Professor	Department of Civil Engineering, University of Alberta, Edmonton, Alberta.
Smith, R. W.	Vice-Pres.	Dames and Smith Limited, 209 Davenport Road, Toronto 5, Ontario.
Smotrych, S. W.	Research Student	City & Guilds College, Imperial College of Science & Technology, Exhibition Road, Sth. Kensington, London S. W. 7, England.
Soderman, L. G.	Professor	University of Western Ontario, London, Ontario.
Speer, E. W.	Soil Mechanics Engineer	Department of Agriculture, P. F. R. A. , P. O. Box 908, Saskatoon, Sask.
Stairs, M. A.	Design Engineer	Construction Branch, Department of Transport, Ottawa, Ontario.
Staple, W. J.	Soil Physicist	Soil Research Institute, Research Branch, K. W. Neatby Bldg. , Ottawa, Ontario.
Stermac, A. G.	Principal Fdns. Engineer	Department of Highways, Downsview, Ontario.

Stewart, W. D.		Department of Civil Engineering, Royal Military College, Kingston, Ontario.
Sullivan, R. A.	District Soils Engineer	Geocon Ltd. , 420 Michel Jasmin, Dorval, P. Q.
Tanner, R. G.	Engineer	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
Tawil, A. H.	Graduate Asst.	Ellis Hall, Queen's University, Kingston, Ontario.
Taylor, L. O.		Canadian National Railways, Engineering Department, P. O. Box 8100, Montreal 3, P. Q.
Templeton, C. H.	President	Templeton Engineering Company, 528 St. James Street South, Winnipeg 10, Manitoba.
Terasmae, J.	Geologist	Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario.
Tessier, G. R.	Soils & Materials Engineer	Department of Roads, Parliament Buildings, Quebec, P. Q.
Thompson, C. D.		100 Ridout Street South, Apt. 717, London, Ontario.
Thomson, S.	Assoc. Prof.	Department of Civil Engineering, University of Alberta, Edmonton, Alberta.

Thorley, A.	Manager	Warnock Hersey Soil Investigations Ltd. , 128 Elmslie Street, Montreal, P.Q.
Thurber, R. C.	President	R. C. Thurber & Assocs. Ltd. , 628 Dupplin Road, Victoria, B. C.
Tomlin, G. R.	Field Engineer	Ripley, Klohn & Leonoff Ltd. , 1930 West Broadway, Vancouver 9, B. C.
Torchinsky, B. B.	Consulting Engineer	121 - 105th Street East, Saskatoon, Sask.
Tordon, F.	Soils Engineer	Terratech Ltd. , 1440 St. Catherine Street West, Montreal, P.Q.
Townsend, D. L.	Assoc. Prof.	Department of Civil Engineering, Queen's University, Kingston, Ontario.
Trow, W. A.	President	W. A. Trow & Assocs. Ltd. , 1850 Jane Street, Weston, Ontario.
Tustin, T. G.	Soils & Fdn. Engineer	The St. Lawrence Seaway Authority, 685 Cathcart Street, Montreal 2, P.Q.
Vanderburgh, M. R.	Engineer	H. G. Acres & Co. Ltd. , Niagara Falls, Ontario.
Varden, D. P.	District Manager	Donald Inspection Ltd. , 1189 Guy Street, Montreal, P.Q.

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Vaughan, V. E.	Assoc. Prof.	Department of Civil Engineering, Nova Scotia Technical College, Halifax, N. S.
Visser, M. J.	Engineer	Poole Construction Co. Ltd., Box 1210, Saskatoon, Sask.
Vonas, V. H.	Soils Engineer	Hydro-Electric Power Commission of Ontario, 620 University Avenue, Toronto, Ontario.
Walker, H. K.	Graduate Student	Department of Civil Engineering, University of Alberta, Edmonton, Alberta.
Watson, G. H.	Soil Mechs. Engineer	Imperial Chemical Industries Ltd., 29 Almond Grove, Stockton-on-Tees, Co. Durham, England.
Watt, D. G.	Engineer-in- Charge	Structural Research Department, Hydro-Electric Power Commission of Ontario, 200 Kipling Avenue South, Toronto 18, Ontario.
Watt, J. S.	Civil Engineer	National Harbours Board, Hunter Building, Ottawa, Ontario.
Watt, W. G.	Asst. Prof.	Department of Civil Engineering, University of Saskatchewan, Saskatoon, Sask.
Welsh, B. F.	Project Engineer	John Shore Construction Ltd., 458 MacLaren Street, Ottawa 4, Ontario.

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White, O. L.	Lecturer	Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.
White, R. C.	Construction Engineer	Roads & Runways Branch, AFHQ, Ottawa, Ontario.
Wilson, G.	Engineer	H. G. Acres & Co. Ltd., Niagara Falls, Ontario.
Wilson, N. E.	Asst. Prof.	Faculty of Engineering, McMaster University, Hamilton, Ontario.
Wilson, R. M.	District Soils Engineer	Foundation of Canada Engg. Corp. Ltd., 1425 West Pender Street, Vancouver 5, B. C.
Windisch, S. J.	Graduate Research Student	1166 Laird Blvd., Apt. 22, Montreal 16, P.Q.
Winnitoy, W. E.	Materials Research Engineer	Saskatchewan Department of Highways, Cor. Smith Street & 7th Avenue, Regina, Sask.
Wolofsky, L.	Senior Geologist	H. G. Acres & Co. Ltd., Niagara Falls, Ontario.
Wong, W. W.		Canadian National Railways, Engineering Department, P. O. Box 8100, Montreal 3, P.Q.
Wright, D. T.	Professor of Civil Engg. & Dean of Engg.	University of Waterloo, Waterloo, Ontario.
Wrong, G. A.	Principal Soils Engineer	Department of Highways, Downsview, Ontario.

Ripley, Klohn & Leonoff Ltd:

Andersson, A. G. L.
Campbell, D. B.
Davison, D. M.
Klohn, E. J.
Leonoff, C. E.

Morrison, K. I.
Olsen, M. T.
Ripley, C. F.
Tomlin, G. R.

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Garneau, R.
Ho, K. H.
Journeaux, N. L.
Laliberté, M.

Samson, L.
Senneville, C.
Tordon, F.

R. C. Thurber & Assocs. Ltd:

Insley, A. E.
MacLean, D. A.

Nasmith, H. W.
Thurber, R. C.

Underwood McLellan & Assocs. Ltd:

Anderson, C. E.
Dyregrov, A. O.
Hood, R.

University of Alberta/Alberta Research Council:

Anderson, K. O.
Bradshaw, T. J.
Cook, R. D.
Fowler, E. L.
Fredlund, D.
Haas, R. C. G.
Hamilton, A. B.
Hardy, R. M.
Harris, M. C.
Hausmann, M.

Locker, J. G.
MacRury, A.
Makowichuk, P. B.
Ottley, H. E. R.
Rix, H. H.
Shields, B. P.
Sinclair, S. R.
Thomson, S.
Walker, H. K.

APPENDIX "C"

Members' Publications Since June 1962

J. I. Adams - "A Comparison of Field and Laboratory Consolidation Measurements in Peat"; Ninth Muskeg Research Conference, 21-22 June 1963, Laval University, Quebec.

_____ and D. J. Bazett - "Till Cofferdams Dumped in Water"; EIC Annual Meeting, 22-24 May 1963, Quebec City.

M. D. Armstrong and T. I. Csathy - "Frost Design Practice in Canada"; Ontario Department of Highways Report No. 29, 1962.

D. R. Bird - "Asphalt Stabilization of a Plastic Fine-Grained Soil"; M.Sc. Thesis, May 1963.

L. Bjerrum and K. Y. Lo - "Effects of Ageing on the Shear Strength Properties of a Normally-Consolidated Clay"; Geotechnique, Vol. 13, No. 2, 1963.

P. A. Brochu - "Lime-Asphalt Stabilization of a Highly Plastic Clay"; M.Sc. Thesis, October 1962.

_____ and J. J. Paré - "Construction de Routes sur Tourbières dans la Province de Québec"; Ninth Muskeg Research Conference, 21-22 June 1963, Laval University, Quebec.

R. J. E. Brown - "A Review of Permafrost Investigations in Canada"; Canadian Geographer, Vol. VI, Nos. 3-4, Winter 1962, pp. 162-165.

K. N. Burn - "Assessment of Possible Materials for Use in the Calibration of a Neutron Moisture Meter"; RILEM Bulletin No. 15, pp. 93-97, June 1962.

_____ "A Neutron Meter for Measuring Moisture in Soils"; RILEM Bulletin No. 15, pp. 91-93, June 1962.

R. Chabot, Laval University - "Sollicitation des pieux de fondation par la pression horizontale du sol"; B.Sc. Thesis 1962.

J. L. Charles, V. R. Cox and F. L. Peckover - "Construction of the Great Slave Lake Railway"; Sixteenth Canadian Soil Mechanics Conference, Edmonton, 1962.

C. B. Crawford - "Engineering Site Investigations"; NRC, CBD 29, May 1962, 4p.

_____ - "Cohesion in an Undisturbed Sensitive Clay"; Geotechnique, Vol. 13, No. 2, June 1963, pp. 132-146.

_____ and K. N. Burn - "Settlement Studies on the Mt. Sinai Hospital, Toronto"; The Engineering Journal, Vol. 45, No. 12, December 1962, pp. 31-37.

T. I. Csathy - "Nuclear Methods for Determining Density and Moisture Content: A Review of the Literature"; Ontario Highways Department Report No. 30, 1962.

_____ - "Skid Resistance of Pavement Surfaces"; Ontario Department of Highways Report No. 32, 1963.

W. J. Dickson and R. Yong - "Principles of Vehicle Similitude Applied to Scale Model Testing"; McGill Univ. Soil Mechanics Series No. 6.

R. G. Doyle (UBC) - "The Consolidation Characteristics of Peat"; M. A. Sc. Thesis 1963.

W. J. Eden - "Soil Testing"; NRC, CBD 43, July 1963, 4 p.

_____ and M. Bozozuk - "Foundation Failure of A Silo on Varved Clay"; Engineering Journal 1962, Vol. 45, No. 9, pp. 54-57 (NRC 7049).

J. A. Elson - "History of Glacial Lake Agassiz"; McGill University Museums Pub. No. 2, pp. 1-16, 1962.

_____ - "Pleistocene Geology of the St. Lawrence Lowland, Field Trips 2 and 7 in Clark. T. H., ed. Guide Book, New England Intercollegiate Geological Conference, 54th Annual Meeting, Oct. 5-7, 1962, Montreal, pp. 15-24, 31-33, 61-66.

_____ - "Surficial Geology, Virden Area, Manitoba and Saskatchewan", Sheet 62F, Geological Survey of Canada, Map 39-1961, 1962.

Gandahl, R. - "Determination of the Ground Frost Line by Means of a Simple Type of Frost Depth Indicator". Translated to English from Swedish and revised by P. T. Hodgins, 1963, Statens Vaginstitut, Stockholm, Rapport 30A.

H. Q. Golder and A. A. Gass - "Field Tests for Determining Permeability of Soil Strata"; ASTM Conference, New York, June 1962.

R. C. G. Haas - "Triaxial Shear Strength Characteristics of Some Sand-Asphalt Mixtures"; M.Sc. Thesis, May 1963.

R. M. Hardy - "Stability of Slopes in Soft Shales"; Presented to 42nd Annual Meeting of the Highway Research Board. January 1963 (in press).

 and K. S. Goodman - "Permafrost Occurrence and Associated Problems at Thompson, Manitoba"; Proc. First Canadian Conference on Permafrost, NRC Tech. Memo. No. 76, pp. 140-148.

 and A. O. Dyregrov - "Practical Experiments with Highway Swelling Soil Types"; Presented to Zone "A" Technical Conference of the Engineering Institute of Canada, September 1963 (in press).

 , E. W. Brooker and W. E. Curtis - "Landslides in Over-Consolidated Clays"; Engineering Journal, Vol. 45, 1962, pp. 81-89.

R. P. Henderson and M. A. J. Matich - "Use of Slope Measuring Devices to Measure Movement in Earth Masses"; ASTM 1962 Conference, Los Angeles, Calif.

B. G. Hutchinson - "Granulometric Properties of Cement Stabilized Sands"; Jour. Soil Mechs. & Foundation Division, ASCE, May 1963.

J. Hvozdzanski, (U. of A.) - "Laboratory Investigations of Some Variables Influencing Strength of a Silty Clay with a Lime-Pozzolan Additive"; M.Sc. Thesis, October 1962.

G. H. Johnston - "Soil Sampling in Permafrost Areas"; presented at the Engineering Institute of Canada Annual General Meeting, Quebec City, May 1963.

 and R. J. E. Brown - "Effect of a Lake on Distribution of Permafrost in the Mackenzie River Delta"; Procs. First Canadian Conference on Permafrost, April 1962, ACSSM, NRC, T.M. 76, pp. 218-225.

P. F. Karrow - Bedrock Topography Series of Ontario Dept. of Mines
P-164 (NTS 41A/5, 41A/6) Tiverton - Port Elgin
P-165 (NTS 41/A, 41A/3) Kincardine - Walkerton
P-166 (40 P/15) Palmerston
P-167 (40 P/10) Conestogo
P-168 (40 P/7) Woodstock
P-170 (40 P/16) Orangeville

Bedrock Topography of the Brantford Area. Map 2035 with marginal notes.

B. Ladanyi - "Mobilisation de la poussée des terres"; L'Ingénieur, Montréal, Vol. 49, No. 194, pp. 53-63.

_____ - "Expansion of a Cavity in a Saturated Clay Medium"; ASCE, Vol. 89, No. SM4, Pro. Paper 3577, July 1963, pp. 127-161.

_____ - "Evaluation of Pressuremeter Tests in Granular Soils"; Proc. of the Second Panamerican Conference on Soil Mechanics and Foundation Engineering, Sao Paulo, 1963.

LaSalle, P. and Elson, J. A. - "Surficial Geology, Beloeil Area"; Quebec Department of Natural Resources, Prelim. Rept. 497, 10 p., map. 1962.

R. D. Lawrence and J. A. Pihlainen - "Permafrost and Terrain Factors in a Tundra Mine Feasibility Study"; Tech. Memo. No. 76, Proceedings of the First Canadian Conference on Permafrost, ACSSM, NRC Ottawa, January 1963, pp. 207-214.

R. F. Legget - "Asking the Right Questions"; The Municipal World, Vol. 73, No. 3, March 1963, pp. 94-97.

_____ - "Geology and Engineering"; McGraw-Hill Book Co., 884 p.

C. E. Leonoff - "Surcharge Fill Solves Iona Foundation Problems"; Daily Commercial News, Roads and Utilities Issue, September 1962.

K. Y. Lo - "Geotechnical Properties of Mexico City Clays"; Geotechnique, Vol. 12, No. 4, December 1962.

J. G. Locker (U. of A.) - "The Influence of Pore Water Salt Content on the Shear Strength of a Remoulded Homionic Clay"; M. Sc. Thesis, May 1963.

D. H. MacDonald and G. Wilson - "The Engineering Geology of the Bersimis No. 2 Site"; 77th Annual Meeting EIC, Quebec City, 22-24 May 1963.

I. C. MacFarlane and A. Rutka - "An Evaluation of Pavement Performance Over Muskeg in Northern Ontario"; HRB Bulletin No. 316, 1962, pp. 32-43.

N. W. McLeod - "Some Implications of the Elastic Approach to the Structural Design of Flexible Pavements"; Annual Meeting Canadian Technical Asphalt Association, November 1962.

N. W. McLeod - "Some Notes on Pavement Structural Design"; Annual Meeting Highway Research Board, January 1963.

P. B. Makowichuk - "Freeze-Thaw Durability and Air Void Parameters of Some Concretes"; M.Sc. Thesis, May 1963.

W. H. Mathews and F. P. Shepard - "Sedimentation of the Fraser River Delta, British Columbia"; Bull. Am. Assn. Petrol. Geol., Vol. 46, pp. 1416-1443 (including discussion by K. Terzaghi), August 1963.

M. A. J. Matich - "Inspection and Maintenance of Power Dams for the Pulp and Paper Industry"; Presented to 1962 Annual Meeting, Canadian Pulp and Paper Association.

G. G. Meyerhof - "Some Problems in the Design of Rigid Retaining Walls"; Proc. 15th Can. Soil Mech. Conf., Montreal, 1962, p. 59

_____ - "Load-Carrying Capacity of Concrete Pavements"; Jour. Soil Mech. and Found. Div., ASCE, 1962, Vol. 88, No. SM3, p. 89.

_____ - "Preliminary Analysis of Benkelman Beam Deflections and Flexible Pavement Design"; Proc. 43rd Ann. Conv., Can. Good Roads Assoc., Quebec, 1962, p. 390.

_____ and L. D. Baikie - "Strength of Steel Culvert Sheets Bearing Against Compacted Sand Backfill"; 42nd Annual Meeting, H. R. B., Jan. 1963, Wash., D. C.

H. K. Mittal, (UBC) - "The Effect of Plane Strain on Pore Pressure Parameters"; M. A. Sc. Thesis 1963.

H. W. Nasmith - "Late Glacial History and Surficial Deposits of the Okanagan Valley, British Columbia"; Bulletin 46, B. C. Department of Mines, Victoria (1962).

_____ and A. S. Brown - "The Glaciation of the Queen Charlotte Islands"; The Canadian Field Naturalist, Vol. 76, No. 4, pp. 209-219, Oct-Dec. 1962.

E. Penner - "Sensitivity in Leda Clay"; Nature, Vol. 197, No. 4865, January 1963, pp. 347-348.

_____ - "Anisotropic Thermal Conduction in Clay Sediments"; Proc. 1963 International Clay Conference, Stockholm 12-16 August 1963.

_____ - "Electrical Resistance Meters for Soil Moisture Measurements"; RILEM Bulletin 15, pp. 98-99, June 1962.

J. A. Pihlainen - "An Approximation of Probable Permafrost Occurrence";
Arctic, Journal of the Arctic Institute of North America, Vol. 15, No. 2,
June 1962, pp. 151-154.

- "A Progress Report on a Mechanical Analysis of Peat";
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- "Inuvik, N. W. T. Engineering Site Information (with a supplement by D. W. Boyd)"; August 1962, 18 p. 18 figs.

and G. H. Johnston - "Field Description of Permafrost";
Tech. Memo. No. 76, Proceedings of the First Canadian Conference on
Permafrost, ACSSM, NRC Ottawa, Jan. 1963, pp. 156-158.

R. M. Quigley - "The Engineering Properties of Illite Related to Fabric and Pore Water Composition"; presented at 16th Canadian Soil Mechanics Conference, September 1962, Edmonton, Alberta.

N. W. Radforth - "Organic Terrain and Geomorphology"; Canadian Geographer, VI, 3-4 (1962) pp. 166-171.

- "Airphoto Interpretation of Organic Terrain for Engineering Purposes"; Transactions Symposium of Photo Interpretation, International Archives of Photogrammetry, (Delft, Holland), XIV, 1962, pp. 507-513.

- "The Criterion of Success in Off-road Mobility on Muskeg"; Proc. of Muskeg Vehicle Conference, Parry Sound, Ontario, (August 15-16, 1962) pp. 26-28.

 - "Environmental Features Affecting Vehicle Performance";
Proc. of Muskeg Vehicle Conference, Parry Sound, Ontario, (Aug. 15-16,
1962), pp. 19-24.

 - "Why and How Does Muskeg Occur"; Proc. 8th Muskeg Research Conference, 17-18 May 1962, T.M. No. 74, pp. 145-151.

and K. Ashdown - "Density and Water Measurement in Peat by Radioactive Methods"; Proc. 8th Muskeg Research Conference, 17-18 May 1962, T.M. No. 74. pp 27-30.

J. R. Rettie, A. Koropatnick and W. S. Isom - "Foundation Treatment and Construction of 16 Miles of Dykes at Manitoba Hydro's Grand Rapids Project"; 16th Soil Mechanics Conference, Edmonton, Sept. 1962.

and F.W. Patterson - "Some Foundation Considerations at the Grand Rapids Hydro-Electric Project"; 77th Annual Meeting EIC, Quebec City, 22-24 May 1963.

C. F. Ripley - "Are You a Real Professional?"; The Alberta Professional Engineer, November 1962.

 and D. B. Campbell - "Performance of Earthdam on Compressible and Pervious Foundation"; 8th Congress on Large Dams, Edinburgh, May 1964.

H. H. Rix - "A Field Program for the Measurement of Subgrade Moisture and Density Conditions"; Proc. 43rd Convention, Canadian Good Roads Association, October 1962.

A. Rutka, P. F. Andersen and M. A. J. Matich - "Soils and Foundations Aspects of the Rainy Lake Causeway"; EIC Annual Meeting, Quebec City, May 1963.

(Mrs.) U. R. Sainani - "Corrosion of Concrete and Steel in Contact with Soils"; Concrete Magazine of India, 1962.

R. J. Salvas, (University of Toronto) - "An Investigation of the Discrepancies in Shearing Strength Test Results in Clay"; M. A. Sc. Thesis.

G. Y. Sebastyan - "Flexible Pavement Design Based on the Element Method of Analysis"; Ph. D. Thesis, University of Michigan, Ann Arbor, Michigan, February 1963.

W. Semchuk - "The Effect of Temperature on the Shear Strength of Two Edmonton Clay Soils"; M. Sc. Thesis October 1962.

W. J. Staple - "Hysteresis Effects in Soil Moisture Movement"; Can. Jour. Science, 42: pp. 247-253, 1962.

S. Thomson - "Shear Strength of a Remoulded Normally Consolidated Homionic Clay"; Presented to 16th Annual Soil Mechanics Conference, September 1962.

 - "Effects of Salt Content and Adsorbed Cations on the Shear Strength of a Remoulded Highly Plastic Clay Soil"; Ph. D. Thesis May 1963.

R. C. Thurber - "Treatment of a Landslide Problem in British Columbia by the Relief of Pore Pressure"; Transactions of the Engineering Institute of Canada, EIC-63-Geotech. -2.

D. L. Townsend - "Relative Density as Compaction Control for Granular Sub-base Materials"; Proc. 43rd Canadian Good Roads Association, Ottawa, 1962, pp. 273-285

 and T. I. Csathy - "Pore Size and Field Frost Performance of Soils"; Bulletin 331, Highway Research Board, Washington, pp. 67-80, 1962.

B. P. Warkentin and R. Yong - "Shear Strength of Montmorillonite and Kaolinite Related to Interparticle Forces"; Pergamon Press, Clays and Clay Minerals, Vol. 9, pp. 210-218, 1962.

R. C. White - "Aeration and Curing in Asphalt Sand Stabilization"; October 1962.

W. E. Winnitoy - "Outline of the Work and Findings of the C. G. R. A. Committee on Pavement Evaluation"; 1962 Proceedings, Canadian Technical Asphalt Association.

R. Yong - "Research on Fundamental Properties and Characteristics of Frozen Soils"; Proceedings, First Canadian Conference on Permafrost, pp. 84-108, 1962.

 and E. Vey - "The Use of Stress Loci for Determination of Effective Stress Parameters"; HRB Bulletin 342, pp. 38-49, 1962.

 - "Dependency of Stress Locus on Method of Loadings"; Proc. 2nd Asian Regional Conference on Soil Mechanics and Foundation Engineering, 1963.

 , S. J. Windisch and L. Limperis - "A Study of Lake Hazen Soils - Part I"; McGill Univ. Soil Mechanics Series No. 5, 1962.

 , L. O. Taylor and B. P. Warkentin - "Swelling Pressures of Sodium Montmorillonite at Depressed Temperatures"; Clays and Clay Minerals, Vol. 11, pp. 268-281, Pergamon Press.

APPENDIX "D"

Active Graduate Thesis Work Known to Members

A. T. Bergan, University of Saskatchewan - Study of effect of topsoil in highway subgrades.

T. J. Bradshaw, University of Alberta - "Studies of Swelling Clays".

A. A. Brown, University of Alberta - "Stabilization of Granular Soils with Asphalt".

H. T. Chan, Queen's University - "Consolidation of Layered Systems".

C. J. Christensen, University of Waterloo - The engineering properties of a clayey silt till.

R. W. Culley, University of Alberta - "Deflection Bowl Studies of Flexible Pavements".

M. M. Davis, University of Toronto - A laboratory project to determine whether small quantities of cement too little to make solid soil cement will frost-proof sub-granular dense soils.

D. W. Devenny, DPW - Lab testing of sensitive soils to determine effect of vibrations.

R. Doucet, Quebec Dept. of Roads - Effet des charges cycliques sur un sol soumis au gel.

D. Fredlund, University of Alberta - "Investigations of Swelling Clays".

H. G. Gilchrist, University of Saskatchewan - Expansive characteristics of remoulded Regina clay.

R. H. Grice, University of Illinois - "The Evolution of Aquifers in a Dolomitic Sequence".

M. C. Harris, University of Alberta - "Pile Load Distribution in Multi-layered Systems".

M. R. Hausmann, University of Alberta - "Ion Exchange Phenomena in Compacted B and C Horizon Soils".

K. H. Ho, Terratech Ltd. - "A Study of the Strength Parameters of Partly Saturated Bentonite".

I. Holubec, University of Waterloo - A study of stresses and strains in earth pressure problems".

G. T. Hughes, RMC - Survey on dynamic forces in soils and vibrational effects as a start of a long-term research project.

T. W. Klym, Queen's University - "The Effect of Frost on Lime Stabilized Soils".

M. Lewis, University of Toronto - Study of bottom sediments in Lake Erie

A. F. MacRury, University of Alberta - "Transverse Cracking of Flexible Pavements".

M. Mindess, University of Manitoba - "Study of Consolidation and Strength Characteristics of Lake Agassiz Clays as Influenced by Salt Treatment".

Miss Gabrielle Paul, McGill University - Effect of ions on the permeability of soils to water.

H. Phillopson, Queen's University - "On the Interrelationship between Suction, Pore Size and Frost Heaving of Soils".

N. W. Radforth, McMaster University - Graduate students working in the Muskeg Lab. at the University on structure, bearing capacity, permeability and botanical constitution of peat. This is associated with trafficability problems in part.

S. W. Smotrych, Imperial College of Science & Technology - The Relation between the Measured and the Actual Mechanical Properties of Natural Clay Deposits".

D. H. Shields, Manchester University - Research leading to Ph. D. in consolidation

- (i) influence of sand drains;
- (ii) influence of layering.

A. Tawil, Queen's University - "The Variation in the Modulus of Deformation with Relative Density of Sub-base Materials".

V. E. Vaughan, Nova Scotia Technical College - Stabilized soil subjected to repeated loadings.

H. K. Walker, University of Alberta - "Soil Compaction".

N. E. Wilson, McMaster University

- (i) Laboratory vane tests in dilatant soils.
- (ii) Rheological properties of peat.
- (iii) Measurement of earth pressures under dynamic loads.

R. Yong, McGill University - Broad spectrum of study on Physics and Chemistry of soils as they relate to soil behaviour.

APPENDIX "E"

Suggestions of Needed Research

C. E. Anderson:

Stabilization by means of quick-lime and lime slurries of montmorillonite-illite clays used as road base material.

J. C. Brodeur:

Effect, if any, of "Negative Skin Friction" on precast concrete, steel-H and pipe piles driven in clays.

E. W. Brooker:

1. Slope movements - rate and magnitude in Upper Cretaceous deposits of Western Canada.

2. Development of effective field piezometers and the study of groundwater flow in deposits of Western Canada.

3. Development of in situ means of evaluating the shear strength and swelling properties of highly over-consolidated deposits.

4. The effects of mineralogic composition on strength, consolidation, and permeability properties of over-consolidated shales.

5. Development of continuous sampler effective in very hard clays.

6. High pressure consolidation testing to determine one-dimensional properties of over-consolidated soils with special attention to the hysteresis in lateral pressure and influence of secondary time effects.

7. A long-term evaluation of existing structures and structures under construction in Western Canada with special emphasis on complete instrumentation by all available means. The study to emphasize soil structure interaction.

8. Empirical approach to field slope stability prediction in Western Canada to include emphasis on geologic aspects of the problem.

9. Development of in situ means of measuring the principle stress relationships in soil deposits, with special reference to over-consolidated soil deposits in Western Canada with a view to the application of such

knowledge to slope stability, both natural and man-made.

10. Laboratory study of the nature of swelling soils.

11. Evaluation of the history of foundation engineering practice in Canada to examine the evolution of methods and document our progress to date.

12. Rock mechanics aspects of construction in Canada.

13. Development of rock mechanics index tests.

14. Classification of rock types and rock masses according to engineering behaviour.

M. Devata:

Research on the Bearing Capacity of silts.

D. W. Devenny:

Properties of sensitive clays particularly effects of vibrations.

J. A. Elson:

Nature, origin, and properties of till.

Relation of soil densities to mode of deposition.

K. H. Ho:

1. A comprehensive study of strength characteristics of saturated bentonite. This includes the employment of consolidated-drained and consolidated-undrained tests with pore pressure measurements.

2. A comparison of the strength characteristics and the pore pressure response of saturated clays with different particle shapes and arrangements, e. g. using bentonite and attapulgite employing different methods of sample preparation to achieve different soil structures.

3. An analysis of the influence of thickness of diffuse double layer and particle spacings on the build-up of pore pressures.

4. Determination of the influence of failure criteria on the results of strength tests on bentonite and attapulgite.

5. Determination of the influence of void ratio at failure on the strength characteristics of bentonite and attapulgite in terms of effective stresses.

6. A study of the influence of electrolyte concentration, temperature and other factors influencing interparticle forces on strength characteristics of bentonite and attapulgite in terms of effective stresses.

7. A study of the duration and rate of loading on strength in terms of effective stresses.

8. An analysis of the mechanisms of triaxial test for bentonite and attapulgite using the plastic theory to determine the nature of the failure surface and also to verify the Mohr-Coulomb criterion.

B. G. Hutchinson:

Formulation of techniques for the formal incorporation of soil property variability into soil structure design processes.

K. H. King:

Relationship between shear strengths as determined by vane tests and by compression tests in clay till soils.

B. Ladanyi:

Development of a device for measuring shear properties of soils with the conditions of uniformity of stress and strain better than in actual triaxial and plane strain apparatus.

P. LaRochelle:

Fundamental research on rock mechanics.

Research on the relation between field and laboratory behaviour of soils submitted to frost conditions.

T. A. J. Leach:

Research needed in methods of erosion control particularly with

respect to mountain streams. While this may be considered a hydraulic problem basically, it also requires the study of local materials that might be used for erosion protection.

D. N. P. Matthews:

Find method for quickly dissipating excessive pore pressures in soft rock foundations having very low permeability e. g. shale.

G. G. Meyerhof:

1. Relationships between index properties and mechanical properties of soils.
2. Mechanical properties of coarse-grained tills.
3. Settlement of foundations on cohesionless soils and tills.
4. Bearing capacity of pile groups.
5. Earth pressure on underground structures.
6. Pore pressures in earth dams. Settlement of earthworks.

J. J. Paré:

Further study on the engineering properties of muskeg, determined in the laboratory as well as in situ.

F. L. Peckover:

1. Economical in situ treatment for reduction of frost heaving.
2. Causes and cures of differential frost heaving between adjacent portions of same soil deposit.
3. Economic compaction procedures for satisfactory performance of track fills of all types.

P. F. R. A:

Research is required on the development of low cost, reliable apparatus for measuring movements below the ground surface.

Research required on the use of Hvorslev shear strength parameters in actual failures.

Research required on slope protection for earth embankments and adjacent cuts.

Ripley, Klohn & Leonoff Ltd:

1. Swelling properties of the Western Clay Shales. Mechanics of swelling phenomena, method of predetermining amount of swelling that will occur.

2. Strength properties of clay shales and stiff fissured clays.

3. Elastic properties of soils.

J. D. Scott:

1. Variation of engineering properties of natural soil deposits.

2. Field measurements - especially settlement and earth pressures.

D. H. Shields:

Utilization of sand drain models to study the horizontal consolidation of layered soils i. e. varved deposits.

L. O. Taylor:

Measurements of permeability in drill holes.

J. Terasmae:

Consolidation of Pleistocene and post-glacial clays, silts and tills for the purpose of determining previous loads by glacier ice, high-level lakes and for estimating thickness of sediments removed by erosion.

Terratech Ltd:

Settlement history of structures or works built on compressible soils, such as loose sands, clays, etc., would greatly fill a need for practising engineers. Such information to be of value would have to give adequate description of the supporting soils and superimposed loads.

University of Saskatchewan:

1. Durability criteria for soil stabilization in Canada.

2. Application of effective stress principles to practical problems of earth pressures and bearing capacity.

V. E. Vaughan:

1. Classification of glacial tills.

2. Method of determining strength properties of glacial till both in the disturbed and undisturbed state.

R. C. White:

Effects of various base course and sub-base stabilizers on frost penetration.

N. E. Wilson:

1. Engineering properties of peat.
2. Measurement of earth pressures behind flexible bulkheads.

R. C. Wyld:

Development of a Soil Pressure Gauge to measure the soil pressure and attenuation of soil pressures in varying soil media.