Annual Report of the Canadian Section of the International Society of Soil Mechanics and Foundation Engineering

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

(JUNE 1954 - DECEMBER 1955)

INCLUDING PUBLICATIONS OF MEMBERS AND THE

MEMBERSHIP LIST OF THE CANADIAN SECTION

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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 1954 to December 1955. Its primary purpose is to serve as an Annual Report of the Canadian Section of the Society as required by statutes.

Its publication will serve another purpose, however, by 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 this country. In this, it will supplement the Annual Canadian Soil Mechanics Conference, which has now been held for nine years under the auspices of the Associate Committee on Soil and Snow Mechanics.

This report in principle does not include reports on routine work of the members of the Society as it is of little interest especially to the International Society. It is difficult however to distinguish in the annual reports of individual members on which this report is based, between routine and non-routine work and it is probable that some of the work reported was of a routine nature but was considered worth including because of the possible interest of other Canadians working in the same field. Brevity in reporting the work has been attempted.

It is encouraging that well over 100 individual reports were received from members of the Canadian Section. This broad coverage should make this Annual Report more useful to members of the section as a means of keeping in touch with the activities of other members. It is hoped that members will comment on the usefulness of the report and make suggestions for improvement in its content or its form.

SYNOPSIS OF ANNUAL REPORT

OF THE CANADIAN SECTION

OF THE INTERNATIONAL SOCIETY OF SOIL MECHANICS

AND FOUNDATION ENGINEERING

(JUNE 1954 - DECEMBER 1955)

Large construction and development projects contributed greatly to the expansion of Canadian activity in soil mechanics and foundation engineering during the year.

Many soil mechanics problems have been encountered in the design and construction of the St. Lawrence Seaway Power and Navigation Project. These included construction procedures, foundation investigations, the search for materials and special problems in connection with glacial tills and marine clays.

Reports on the design and use of the vane borer for in-place shear strengths came from many parts of Canada. Some interest is evident in the use of the neutron meter and various electrical methods for in-place measurement of moisture content. Work is continuing on the study of ground temperatures and frost action and activity is increasing in the study of muskeg and permafrost problems.

Many members report work in special site investigations, pile tests, pile anchorages, bearing capacity of various rock formations, and building settlements. Work on the comparison of static and dynamic penetration tests has been carried out. Model studies to determine the effect of base roughness of footings and groundwater level have been made. Reports from members showed that the swelling and shrinking of clay soils considerably affects shallow foundations.

With the rapid development of highway systems in Canada, much work in this field has been reported. This included correlations between laboratory tests and road performance, various methods of stabilization, studies of frost penetration and problems involving construction over organic soils. Efforts have been made to maintain high standards over a longer construction season. There was keen interest in the WASHO road test.

Problems involving earth pressure against sheet pile bulkheads and the effect of various back-filling practices and water conditions on earth pressures have been studied. An extensive study of earth pressures on a flexible conduit under a 200-foot embankment is being carried out. A case of advancing a tunnel by pre-freezing the soil was reported.

Several members have been studying landslides and slope stability problems. Many cases of piezometric measurements and permeability studies have been reported. Various methods of measuring earth movements in earth dams have been used. Special studies of various canal linings and relief well construction were carried out.

On December 15 and 16, 1955, the Ninth Annual Canadian Soil Mechanics Conference was held at the University of British Columbia, Vancouver, B. C. This conference, sponsored by the Associate Committee on Soil and Snow Mechanics of the National Research Council, was attended by more than 100 engineers, geologists, agricultural soil scientists and a number of forestry scientists.

Papers and discussions at the meeting emphasized the physiography, climate, and general soil types of British Columbia. Soils were discussed from the geological, agricultural, and engineering point of view. Papers were presented describing various engineering problems encountered with local soils including serious building settlements on some of the organic silts which are found on the British Columbia coast. A serious landslide which had occurred on the new Trans-Canada Highway was described.

The conference joined with the Vancouver Branch of the Engineering Institute of Canada and the British Columbia Association of Professional Engineers in a joint evening meeting at which illustrated papers on the soil mechanics' aspects of the St. Lawrence Seaway Project were presented.

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(The above division of the subject matter is based on that proposed for the Fourth International Conference on Soil Mechanics and Foundation Engineering 1957).

1. SOIL PROPERTIES AND THEIR MEASUREMENT

J. I. Adams:

Extensive laboratory tests to locate and determine the suitability of materials for use in construction of dikes, railroads, roads, etc. Special investigations to improve field and laboratory testing procedures and equipment. An in-place density apparatus, based on the oil immersion principle, was designed and developed for use.

A. G. L. Andersson:

Design of apparatus for extrusion of soil samples from sample tubes.

L. J. Chapman:

Completed a study of the mineralogical composition of the clay (less than one micron fraction) in the tills and the lacustrine and marine sediments of southern Ontario.

Measurements of evaporation from sod on continuously moist soil were continued at Kapuskasing and Norman Wells.

Jacques E. Hurtubise:

Investigation of the shear strength of recompacted, well-graded till.

Study of the influence of sulphite liquor on the properties of various soils.

N. D. Lea:

Studies of the new townsite of Aklavik have included the measurements of density and volume change in the granular till and geological features of the arrangements of the strata and the occurrence of large pieces of fossil ice.

J. D. MacKenzie:

Investigation of methods of improving the quality of aggregate deposits so that they can be used as concrete materials.

R. W. Pryer:

Investigation of the vertical extent of stratified sands and clays in the Moisie Valley and the slope of the underlying rock surface.

G. Rankin:

In connection with development of suitable foundations for a school and teacherage at Hay River, N.W.T., test holes were made in 1947 and again in 1955. During these eight years the permafrost receded about 20 feet at a site which was not protected by peat moss.

W. A. Richards:

Examination of stratigraphy by photographing of sliced samples of glacial lake silts and clays, sensitive marine clays and deltaic silts and sands.

Charles F. Ripley:

Comparison of densities of granular fills placed by hydraulic and mechanical methods and correlation with standard Proctor laboratory tests.

B. B. Torchinsky:

Development of a boron trifluoride counter for use with the neutron moisture meter. Laboratory calibration satisfactory. Field testing to be carried out.

W. A. Trow:

Development of a device for the measurement of pore pressures in quick undrained triaxial tests.

Investigation of the effect of unit weight of trimming samples in a soil lathe.

D. Tubbesing:

Studies on the relations between consistency limits, clay content, cohesion determined by means of field vane tests and unconfined compression tests, effective overburden pressure, etc.

Department of Public Works, Ottawa:

Equipment acquired to investigate the correlation of "sticky point" to certain other physical characteristics of soils.

Investigation of the most accurate methods of determining bulk density of soils with emphasis on methods of preparing soil specimens.

Division of Building Research,
National Research Council:

Construction of a small laboratory at Norman Wells, N.W.T., for the study of permafrost.

Observations on permafrost conditions as they are affected by terrain, buildings, utilities and roads.

Work on the occurrence of permafrost in Canada, and in particular, delineating the southern boundary of permafrost in Canada.

Work was begun on the study of muskeg. Much literature was reviewed. During the summer months field work was carried out in an attempt to test the newly-developed muskeg classification system. Laboratory tests were begun.

Ground temperature measurements were continued at 12 locations in Canada and theoretical work is being developed and co-ordinated with field work. Various ground temperature measuring instruments were studied.

A laboratory study of the frost action phenomena was begun. Equipment was developed with very accurate temperature control and measurement facilities. The first phase of work has been to evaluate the effect of grain size, unsaturated permeability and ground water conditions on frost heaving. Field studies of spring breakup were made.

Testing of the properties of varved clays is continuing. Carbonate content of these soils is being studied.

A laboratory study of resistance block-type moisture meters was completed in the low suction range and extended into the high suction range. A neutron meter for the measurement of soil moisture content in situ based on the principle of gamma ray scattering was constructed and calibrated in the laboratory.

The St. Lawrence Seaway Authority:

Laboratory and field study of engineering properties of soils of the St. Lawrence River Valley from Montreal to Prescott.

Adaptation of an oil immersion method for finding the unit weight of chunk samples of soil. Comparison of this method with the sand cone and water balloon methods is favourable.

Study of glacial tills of the St. Lawrence Valley comparing information obtained from drive samples in test borings with observations and tests of actual material excavated.

Detailed investigation of large pocket of layered silt and clay in highly distorted condition.

2. TECHNIQUES OF FIELD MEASUREMENT AND SAMPLING

J. I. Adams:

Vane testing was used extensively in investigations for the power development on the St. Lawrence Seaway. Correlation tests with quick undrained triaxial compression tests and with actual field failure tests have been made. Report to be presented to ASTM.

A. G. L. Andersson:

Field supervision of sampling of very soft soils (river delta and glacial lake silts) in test holes to depths up to 450 feet and through 160 feet of water using thin-walled Shelby tubes and drilling mud.

A. H. Graves:

In addition to routine site explorations, a special problem of sample identification was encountered. This involved distinguishing between a very hard clay and bedrock. From a core sample it was identified as bedrock but since the material had been penetrated by a procedure known as "piping" it was actually a hard clay deposit.

G. T. Hughes:

Analysis of soil conditions to determine most economical method of construction of a trunk storm sewer system. The soil conditions were exceptionally poor due to silty, sandy, silty clay and loose fill materials accompanied by high water table. In one location an upward flow of water occurred.

G. G. Meyerhof:

Field investigation on various sites underlain by cohesionless soils in which dynamic (standard) and static (deep-sounding) penetration tests were made have enabled correlations to be obtained between the relative density and angle of internal friction of cohesionless soils and the static and dynamic penetration resistances in such soils. From these correlations simple relationships have been derived to estimate both ultimate bearing capacity and allowable load on footings and piles in cohesionless soils from the results of penetration tests. The proposed relationships have

been checked by plate loading tests and pile loading tests on a number of sites.

R. C. Thurber:

Use of an electrically-driven power auger has been very effective in other than rocky material.

W. A. Trow:

Planning of a piezometer installation to measure the construction drawdown and steady seepage pore pressures in a water storage reservoir dike basically following the system used by the Bureau of Reclamation with some modifications.

Investigation of the accuracy of field density measurements in clay soils using thin-walled Shelby tubing. A device was developed to facilitate the driving and recovery of Shelby tube samples which increased the efficiency and accuracy of field density measurements.

Division of Building Research,
National Research Council:

Investigations of new exploratory drilling methods in permafrost.

Investigation of the terrain at the new townsite of Aklavik. Installation of thermocouples to measure ground temperatures from the surface to a depth of 50 feet under roads, a garage and on piles.

Laboratory studies to determine the effect of sampler size on soil test results on marine clay.

Geocon Limited:

A program of vane testing was carried out in connection with the St. Lawrence Seaway. The effect of rate of strain on shear strength was studied.

3. FOUNDATIONS OF STRUCTURES

3A. General subjects and foundations other than piled foundations.

C. V. Antenbring:

Engaged in developing methods of overcoming foundation trouble caused by the swelling of clay particularly in lighter structures such as houses.

D. F. Coates:

Research on failure of sand under oblique impact loads.

Paul M. Cook:

Compilation of test data showing that a relation exists between the coefficient of compressibility and moisture content over a wide range of soils, from pure peat to organic clay-silts and the relationship between moisture contents and specific gravity, void ratio and submerged weight. These simple relationships are sufficient to permit calculation of settlement without the trouble of lengthy consolidation tests.

Earle J. Klohn:

Investigation and analysis of large industrial site on Vancouver Island including foundation conditions, slope stability, methods of dredging, pile penetration and reclamation work.

C. E. Leonoff:

Study of elastic properties of sandstone and shale sedimentary rock foundation under a 20-storey building. Future correlation with settlement observations planned.

D. H. MacDonald:

Study of the settlement of buildings, sub-divided into

a) the determination of the magnitude of settlement that can be sustained by buildings before damage appears and

b) the accuracy with which settlements can be predicted when these settlements are caused by the consolidation of clay.

This work was presented in a thesis to the University of London entitled "The Settlement of Buildings". Results are also published elsewhere. (See Appendix I)

G. C. McRostie:

Investigation of a group of buildings being damaged by consolidation settlements. Good agreement observed with criterion of building damage related to amounts of differential movement as suggested by Meyerhof in the Engineering Journal, February 1954.

Investigation commenced on the bearing capacity of soft shales. Structure of rock mass including thickness and continuity of bedding in shales now suggested as additional criterion for capacities. Load tests on soft shales being arranged.

Investigation of underpinning existing heavy building. Six-foot layer of sandy till with large boulders lies beneath the watertable and between footings and rock. Use of building basement could not be interrupted. Supporting tubes drilled through existing spread footings recommended.

Routine foundation design and site investigations in Ottawa area continue to provide many examples of building damage due to soil shrinkage and swelling rather than bearing capacity failure.

G. G. Meyerhof:

Previous theories of the ultimate bearing capacity of perfectly rough and perfectly smooth strip footings have been reviewed and combined to suggest a method for estimating the bearing capacity of a foundation with any degree of roughness of the base. An analysis has also been made of the bearing capacity of partly submerged cohesionless materials. The results of some loading tests on model footings with different base frictions and under various ground-water conditions were found to be consistent with the proposed methods of analysis.

F. W. Patterson:

Investigation of excessive settlement of school due to water demand of chestnut trees adjacent to two sides of the structure.

W. F. Riddell:

Preparation of a report for the foundation of a large oil storage tank on a deep fill of soil washed from sugar beets.

Charles F. Ripley:

Settlement observations at plant site areas where heavy fill and building loads have been applied. The settlement observations have been correlated with the theoretical settlement analyses based on laboratory tests on the foundation soils.

B. B. Torchinsky:

Investigation of foundations on highly plastic clay soils. In two cases where settlements occurred water was added to the clay causing an uplift.

Division of Building Research,
National Research Council:

Continuing observations of settlement of several large buildings. Two new buildings on slab foundations were brought under study during the year.

Detailed study of seasonal movements in clay at various depths and the effect of these movements on shallow foundations. Soil water content observations are compared with the ground movements. Most damage is attributed to the action of vegetation.

Geocon Limited:

Site investigation resulting in the recommendation that preloading of a clay deposit be carried out before building construction. After two months, surcharge caused 5 inches of settlement and construction proceeded. Preloading was required because of the variable depth of the clay deposit at the site.

R. M. Hardy and Associates Limited:

Settlement problems at the Kitimat Plant Site of the Aluminum Company of Canada in co-operation with C. F. Ripley and Associates.

Measurement of ground temperatures incidental to construction of concrete foundations in freezing weather.

Study of the heaving of structures on over-consolidated montmorillonite type clays due to "rebound" accompanied by seepage pressures.

The St. Lawrence Seaway Authority:

Design of foundations for large gravity concrete walls (navigation locks and approach walls) on glacial till, non-plastic shales, limestone and dolomite.

3B. Piling and piled foundations.

J. I. Adams:

A pile loading test was carried out to correlate data from driving resistance and from adjacent boring data. A 12-inch H-type pile was driven through marine clay to glacial till and loaded to failure by settlement.

L. A. Fraikin:

In order to check the standard bearing capacity formula for footings, developed by Terzaghi, footings were forced into sand under 150,000 ft/lb blows of a 13-inch diameter ram, stopping this operation when it became necessary to spend 5 blows of 150,000 ft/lb each to force into an already partially formed footing the last cubic foot of concrete. Assuming a spherical shape for the footing, it is concluded that these footings will carry the loads given by the Terzaghi formula. Further tests are planned.

Earle J. Klohn:

Pile foundation investigation for large industrial development on west coast. Correlation of drill hole and steel rail penetration test hole data to pile loading tests. Correlation of final penetration resistances to damage caused by overdriving of timber piles. Magnitude of soil and pile "heave" was observed and effects of heaving on the bearing capacity of end bearing piles were checked by loading tests.

N. D. Lea:

Investigations at the new townsite of Aklavik show that in this climate piles need not freeze in over the winter.

C. E. Leonoff:

Review of uplift and pull out forces on transmission line towers and analysis of various types of anchorage.

Correlation of penetration of steel casings for heaving loaded cast-in-place piles with sounding tests in glacial till and heavily preconsolidated bedded silts.

G. C. McRostie:

Investigation continued into methods of developing resistance to large tension forces required for tower anchorages in both soil and rock. A type of rock anchor previously developed was simplified and now provides mechanical self-tightening connection at bottom of 30-foot drilled hole. Approximately 50 anchors now installed, each pretested to 60,000 lb.

B. B. Torchinsky:

Evaluation of bearing capacity of cast-in-iron concrete piles in highly plastic clay. Field performance compared with design based on unconfined compression tests.

Geocon Limited:

Dutch Cone Penetrometer used for site investigation at the Burlington High-Level Bridge. Results used to calculate the ultimate bearing capacity of timber friction piles. Computed value checked by full scale pile loading test.

Observations of the sensitivity of marine clay were made during the driving of sheet piles in connection with a 40-foot excavation. These observations showed an excellent example of the thixotropy of sensitive marine clay.

Raymond Concrete Pile Company, Limited:

Driving of 8-inch open-end pipe piles into permanently frozen glacial till in Northern Canada. Work was carried out late in the year which created special construction

problems such as operation of equipment and the obtaining of sufficient water for jetting purposes. Because of the heavy till, steam jetting was abandoned in favour of chopping the permafrost with a rail spud.

4. ROADS, RUNWAYS AND RAIL-TRACKS

K. O. Anderson:

Laboratory study of correlation between Atterberg Limits and Standard Proctor densities for fine-grained soils used for highway construction. Charts were prepared to allow prediction of density and optimum moisture content from Atterberg Limits.

P. M. Bilodeau:

Stabilization of sand-clay soil for highway construction.

Construction of roads over organic soil. Generally recommend removal of organic material. This is usually done by blasting.

Observations of frost penetration under roads.

W. G. E. Brown:

Site classification for forest productivity and regeneration and for logging haul and access road location, with considerable emphasis on the use of air photographs in classifying and mapping.

F. C. Brownridge:

Study of past performances of rigid-type pavements in relation to soil conditions and construction procedures. In widening these pavements by means of base course and flexible pavement design, it was found that more emphasis must be paid to compaction of all materials and a greater depth is required.

In order to extend the construction season, a study is being made of;

1) Average densities in fall months with moisture contents,

2) Average densities in spring months with moisture contents,

3) Depth of frost penetration as determined from reading taken weekly by installations already in place, and

4) A study of the correlation between spring densities and frost penetration.

J. A. Chalmers:

Study of the failure of certain city streets resulting in new design procedures. These studies emphasized the need for an adequate base of granular material.

J. G. Clark:

Correlation of the Proctor Compaction tests with the miniature Harvard Compaction apparatus for a cohesive soil (highly plastic clay).

J. A. Knight:

Sponsoring of a fellowship at Laval University to study the action of calcium chloride as a frost inhibitor in highway bases.

C. E. Leonoff:

Correlation of deflections with service performance of asphaltic concrete pavement and base under 46,000 lb. axle loads. Deflection measurements taken with Benkelman Beam indicator. Determination of minimum thickness of pavement and base over muskeg subgrade for these wheel loads.

Determination of test properties of asphaltic concrete and sheet asphalt pavements using several penetration grades of asphalt cement. Determination of differences in properties of the mix using the same penetration grades of asphalt cement as supplied by different refineries. Work was carried out by Marshall Stability Test method.

A. A. McLean:

Study of the effectiveness of the Hyster Grid Roller in compacting Fraser River pump sand used as sub-base fill under concrete pavement at Vancouver Airport.

Design and control of concrete and asphaltic concrete pavements.

N. W. McLeod:

Study of the test results from the WASHO test road in Southern Idaho. One of the most striking results is that for any given flexible pavement of uniform thickness,

the outer wheel path is fundamentally weaker than the inner wheel path. This appears to occur because the bituminous pavement on the outer wheel path serves as a paved shoulder for the inner wheel path. The practical implications of this thoroughly substantiated test result are discussed in a paper (see Appendix I).

Further work consisted of publishing comments on papers dealing with the use of C.B.R. tests for subgrade evaluations, intensity of load transmitted to the subgrade through a given thickness of granular base course, laboratory compaction of bituminous paving mixtures and sonic testing of bituminous paving mixtures (see Appendix I).

Charles L. Perkins:

Calculation of ultimate strength of multiple-layered pavement systems.

Theoretical correlation of numbers of coverages with pavement thickness requirements.

Preparation of charts showing relationships between voids properties, density, and asphalt content of asphaltic concrete mixtures.

R. W. Pryer:

Development of specifications for crushed rock and prepared gravel ballast. Work on drainage improvements in muskeg areas, construction of clay stabilized roads, investigation of frost heaving of railway track and structures and ground temperature observations in granular soil.

N. W. Radforth:

Assessment of organic terrain organization with reference to problems of access by foot and by heavy vehicles. As a result access routes can be suggested for summer conditions over organic terrain. The empirical nature of the mineral soils beneath organic overburden can in most cases be assessed. These studies have advanced to the point where field engineers can apply the principles involved, and plan for quantitative determination on a more detailed scale.

R. C. Thurber:

Scope of work and study of road construction over

swamps has been increased. For secondary roads, floating construction over deep swamps or peat bogs has been satisfactory. Sand piles have not yet been effective.

A new laboratory, under construction, will contain a specially designed freezing room for study of frost heaving.

W. E. Winnitoy:

Study of existing pavements in Saskatchewan and correlation of their behaviour with soil characteristics in order to improve design of bituminous pavements under local conditions. Deflection of bituminous surface under a 9,000-pound wheel load at creep speed is determined by Benkelman Beam. This is correlated with subgrade soil characteristics.

R. M. Hardy and Associates Limited:

Electro-osmosis stabilization of embankments behind bridge abutments on the North West Highway System in co-operation with the Canadian Army.

Possibilities of stabilization of soft unstable soils by treatment with dispersants in co-operation with the R.C.A.F.

The St. Lawrence Seaway Authority:

Design of roadways on disposal fills and embankments consisting of broken, non-plastic shale.

University of Alberta:

Study of field procedures for the injection of chemicals to prevent frost heaving and fundamental work on the possibilities of injecting chemical solutions into soils by the process of electro-osmosis.

5. EARTH PRESSURE ON STRUCTURES AND TUNNELS

J. F. Brett:

Study of soil conditions and preparation of preliminary design for piled wharves of different types, suitable for certain locations along the St. Lawrence River where deep silt beds occur.

Investigation of various methods and materials for backfilling. Determination of comparative values of saturated backfill pressure under various assumptions of physical properties, varying water levels, etc.

Evaluation of required depth of piling and sheet piling to provide for safe vertical load transfer, acceptable conditions of lateral stability and adequate provisions against ship's impact, wave action, ice, etc.

Design of load relieving platform-type of wharves supported by A-frames, battered piles and sheet piling.

D. F. Coates:

Research on the applicability of soil mechanics to rock failure.

H. W. McFarlane:

Studied cause of concrete sewer pipe collapse at a large drainage project.

C. H. Templeton:

In the construction of a 24-inch water line in loose, wet silt, a tunnel was extended 38 feet by freezing the ground and excavating through frozen material. Freezing pipes were inserted in 2-inch holes ahead of the excavation. Measurements of the deflection of the walls of the frozen tunnel were taken as the excavation progressed.

Prairie Farm Rehabilitation Administration:

Detailed studies are being made in an attempt to develop suitable methods of analysis for the design of large diameter flexible steel conduits under a 200-foot embankment.

The St. Lawrence Seaway Authority:

Choice of earth pressure values and specifications for back-filling procedure for navigation lock and approach walls and other gravity concrete walls.

6. EARTH DAMS, SLOPES, AND OPEN EXCAVATIONS

D. J. Bazett:

Studies with respect to the stability of slopes, particularly earth dams and the stability of retaining walls.

Studies and planning in connection with a piezometer installation of the twin line system developed by the USBR for inclusion in the dike system at the Sir Adam Beck-Niagara Pumped Storage Reservoir. This piezometer system is partially installed and is expected to be in operation next summer.

P. M. Bilodeau:

Study of landslides particularly the one that occurred at Nicolet in order to restore traffic that was cut off by the slide.

D. F. Coates:

Design, investigation and inspection of foundation and earth dams.

J. V. Daniliauskas:

Design of earth dams and dikes in Newfoundland. Foundation and fill of sandy, glacial till.

Inspection of dike construction for Seaway and Power Development on St. Lawrence River on foundation of glacial till and marine clay.

G. A. Gorman:

Quality control on the construction of a Pumped Storage Reservoir involving a zoned dike, 5 miles in circumference, composed of rock fill and clay embankment ranging in height from 15 to 68 feet and subject to a 25-foot drawdown in a period of six hours. Piezometers are being installed to determine the pore pressures in the clay zone under conditions of construction, steady seepage and rapid drawdown.

G. T. Hughes:

Investigation of stability of high road fill over a

creek with high banks in northern Alberta. The foundation soil was highly compressible.

Jacques E. Hurtubise:

Investigation of the failure of a cellular land cofferdam filled with natural clay.

Study of landslides in Eastern Canada.

Desmond F. Kidd:

Appraisal of the stability of a dam abutment composed of lightly consolidated stratified sands and silts through which seepage was occurring. Test holes were drilled and piezometers installed.

Evaluation of a major earth fill dam site involving bedrock, stratified sands and gravels and two glacial till deposits by a combined geological and soil mechanics study.

Earle J. Klohn:

Investigation and analysis of slide problem in soft clay shale deposits resulting in recommendations for stabilizing slope.

I. D. MacKenzie:

Investigation of material deposits and the design of earth dams constructed from these locally-available materials.

Study of critical areas and the design of remedial measures to prevent slides or the recurrence of slides.

H. W. McFarlane:

Investigation of several potential dam sites.

Stability studies on the Beechwood Power Project. Seepage studies on a leaking dam in the Tobique River Storage System.

Studies of small slides and stability problems.

F. W. Patterson:

Design and inspection of sloping core type rock fill dams exceeding 200 feet in height. A large scale field pressure test was made to determine the permeability of impervious fill and the stability of the transition zones. Experimental program of foundation soil grouting in earth abutment carried out.

R. W. Pryer:

Investigation of an embankment failure in silty clay resulting in the institution of drainage improvements designed to relieve similar situations. Improvement of railway cut slopes in unstable areas by excavation and the provision of extensive drainage works.

Charles F. Ripley:

Analysis of seepage through pervious abutments and foundations of five dams. Installation of several types of apparatus for measuring piezometric pressures in the ground relative to seepage through pervious abutments and foundations of water reservoirs.

Use of tilt meter (S. D. Wilson design) for measurement of horizontal movement in soils relative to slope stability problem.

Analysis of underwater landslide on an alluvial fan in a coastal fjord of British Columbia.

R. C. Thurber:

Correction of the earth slide at Quesnel involving 40,000 cubic yards of soil.

Investigation, analysis and correctional work was carried out on the Park Bridge Slide near Golden, B. C. Nearly 1,000,000 tons of material were involved and stabilization work has been successful.

Department of Public Works, Ottawa:

Preliminary investigation of the Nicolet landslide including an investigation of the behaviour of soils at this location which had been collected by Federal authorities during a long period of time.

Prairie Farm Rehabilitation Administration:

Slides investigated on dams and dikes founded on saturated highly plastic clay have shown that $\phi = 0$ method and effective stress method of stability analysis result in unsafe design. To correlate field behaviour with theoretical analysis, a special investigation is being carried out involving conventional strength tests, field measurements of movements and field pore pressure determinations.

Laboratory and field observations are being made on swelling characteristics of clay shales. Slope indicator device has been utilized to study creep of slopes in this material.

Continuing study of canal and dugout lining involves experimental installations of nearly all types of materials. In general where suitable soil is available, compacted earth appears to be the most practical method. However, more recently, studies have been carried on with bentonite and the plastics with a view to developing a cheaper lining suitable for dugouts.

Studies are being made to devise the best design and installation method for relief wells along the toes of earth dams and also in connection with sand and gravel-packed wells for water supply and irrigation. Special consideration is being given to a suitable type of riser such as plastic or wood which will not corrode and is relatively cheap.

Apparatus to measure movements and pore pressures in earth structures is being continually developed and revised. Recent studies have involved the use of a slope indicator and plastic pipes to detect creep and lateral movement and also the design of more satisfactory apparatus for determining the pore pressure in highly plastic clay soils.

R. M. Hardy and Associates Limited:

Settlement and piezometric pressure measurements incidental to the design of dredge slopes and the construction of an earth dam on varved clay at Steep Rock Lake, Ontario.

Effective measures for compaction of earthwork in freezing temperatures.

Stabilization of a major slide involving reduction of high piezometric pressures by drainage tunnel and unloading operations on Trans-Canada Highway in co-operation with B.C. Dept. of Public Works.

The St. Lawrence Seaway Authority:

Choice of slopes for 90-foot excavation in glacial till including survey of natural slopes in vicinity and comparison with theoretical analyses based on laboratory tests.

Choice of slopes for 40-foot excavation for navigation channel in deposit of layered silt and clay in distorted condition. Excavation arranged in two stages, choice of final slope depending on observation of slopes during first stage.

Design of various dikes with heads ranging up to 40 feet with impervious zones consisting of glacial till and pervious zones of broken, non-plastic shale.

Investigation of numerous water-bearing layers in dike and cofferdam foundations, initially by continuous sampling and permeability tests in bore holes, and subsequently by installation of piezometers and observation of flow during excavation nearby.

University of Alberta:

Investigation of major slides in Northern Alberta in overconsolidated clay shale materials.

APPENDIX 1

PUBLICATIONS BY MEMBERS OF THE CANADIAN SECTION

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2. Brown, W. G. E., "Roads and Land", Timber of Canada, February 1956.

3. Crawford, C. B., "Frost Penetration Studies as an Aid to Construction", Roads and Engineering Construction, V. 93, No. 2, February 1955.

4. Crawford, C. B. and Legget, R. F., "Ground Temperature Investigations in Canada", presented to Montreal Branch, Engineering Institute of Canada, December 1955.

5. Crawford, C. B. and Boyd, D. W., "Climate in Relation to Frost Action", Highway Research Board, Washington, Bull. 111, 1955, pgs. 63-75.

6. Curtis, W. E. and Dickson, W. J., "The Effects of Freezing and Thawing on the Engineering Properties of Clays and Shales", Graduate thesis, University of Alberta, October 1955.

7. Eden, W. J., "Laboratory Study of Varved Clay from Steep Rock Lake, Ontario, Canada", American Journal of Science, November 1955.

8. Granger, J., "Etude de la Résistance au Cisaillement d'un Till d'Origine Glaciaire", Master's thesis, Ecole Polytechnique, Montreal.

9. Hardy, R. M., "Soil Stabilization Experiments Aid Highway Engineers", Public Works in Canada, pgs. 8 and 12, May 1954.

10. Hardy, R. M., "Highways for Tomorrow - Soils and Materials", Proceedings Thirty-Fifth Annual Convention Canadian Good Roads Association, 1954, pgs. 102-107.

11. Hardy, R. M., "Engineering Characteristics of Western Muskeg", Proceedings of the Western Muskeg Research Meeting, National Research Council, Ottawa, Technical Memorandum No. 38, September 1955.

12. Hardy, R. M., "Diagnosis and Treatment of Slide Conditions Affecting Highways", Roads and Engineering Construction, October 1955, pgs. 151-156.

13. Hardy, R. M. and Ripley, C. F., "Foundation Investigation for the Kitimat Smelter", E.I.C. Journal, November 1954.

14. MacDonald, D. H. and Skempton, A. W., "A Survey of Comparisons between Calculated and Observed Settlements of Structures on Clay", Conference on the Correlation between Calculated and Observed Stresses and Displacements, London, September 1955.

15. MacFarlane, I. C., "A Preliminary Annotated Bibliography on Muskeg", Division of Building Research, National Research Council, Ottawa, Bib. No. 11, September 1955.

16. Mathews, W. H., "Climate and Physiography of British Columbia", Ninth Annual Canadian Soil Mechanics Conference, December 1955.

17. Mathews, W. H., "Physical Limnology and Sedimentation in a Glacial Lake", to be published by the Geological Society of America.

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19. Meyerhof, G. G., "Influence of Roughness of Base and Ground Water Conditions on the Ultimate Bearing Capacity of Foundations", Géotechnique, V. 5, September 1955.

20. Meyerhof, G. G., "Penetration Tests and Bearing Capacity of Cohesionless Soils", Proceedings ASCE, V. 82, January 1956.

21. Peckover, F. L. and Bazett, D. J., "Soil Mechanics Aspects of the St. Lawrence River Development", Proceedings of the Ninth Canadian Soil Mechanics Conference, Vancouver, B. C., December 1955.

22. Penner, E., Crawford, C. B. and Eden, W. J., "The Measurement of Moisture Content", Proceedings of the Conference on Building Research, Division of Building Research, National Research Council, Ottawa, Bull. No. 1, September 1955.

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26. Radforth, N. W., "Organic Terrain Organization from the Air", Defence Research Board, Ottawa, Handbook No. 1, D.R. No. 95, October 1955.

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28. Sharpe, R. N., "The Influence of Soils on the Design and Construction of the Trans-Canada Highway", Engineering Journal, November 1955.

29. Skempton, A. W., Peck, R. B. and MacDonald, D. H., "Settlement Analyses of Six Structures in Chicago and London", Proceedings of the Institution of Civil Engineers, Part 1, pgs. 525-544, July 1955.

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35. "Proceedings of the Western Muskeg Research Meeting", Associate Committee on Soil and Snow Mechanics, National Research Council, Ottawa, Technical Memorandum No. 38, September 1955.

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