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SOIL MECHANICS IN CANADA

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At the First Internal Conference on Soil Mechanics and Foundation Engineering held in 1936, seven Canadians only were present despite the fact that the Conference was held at Harvard University, but two hundred miles from the Canadian border. At that meeting, only one Canadian paper was presented. In that year, instruction in the subject was being given in only one Canadian University. These facts reflect the general attention devoted, at that time, to the subject throughout the Dominion.

At this Second Conference, there will be an appreciable delegation from Canada despite the fact that the Conference is being held in Europe. A selection of seven papers from Canada is being submitted, the papers being representative of Canadian work in Soil Mechanics and of a suitably general character for presentation to an international meeting. Some attention is being given to the subject in all the Civil Engineering Departments of Canadian Universities. Correspondingly, foundation investigations and soil studies are now generally an integral part of all major Canadian construction operations.

This change in the position of Soil Mechanics in Canada, which has developed during the last decade, can be attributed very largely to the influence of the First International Conference. Canada presents many special soil problems and it is therefore fitting that progress in the Dominion should have kept pace with that in other countries. Despite the limited facilities for scientific research and investigation available in Canada, due to her relatively small and scattered population, some definite contributions to the scientific study of soils have already been made which are of general importance, and similar progress may be anticipated in the future.

Considering the position of the subject in the curricula of the Universities, the first Canadian course in Soil Mechanics was given at the University of Alberta by Professor I. F. Morrison, starting in 1932. Dean C.R. Young initiated a corresponding course at the University of Toronto in 1936, following his participation in the First International Conference. Thereafter, the other Civil Engineering Schools in the Canadian Universities took similar action, and today there is either a special course on Soil Mechanics or a special section in a more general course in the undergraduate curricula for Civil Engineering in each of the Canadian Universities.

It is usual for Canadian graduates to undertake their postgraduate studies at leading

American Universities, and this has been the case with studies in Soil Mechanics. There are now an appreciable number of young Canadians who hold postgraduate degrees in Soil Mechanics from well-known American institutions. At the same time, a start has been made at postgraduate work in the subject in Canada. Graduate degrees have already been awarded in the subject by the University of Alberta, the University of Toronto, and Ecole Polytechnique, (the famous French Canadian engineering school in Montreal which is on an equal footing with the Engineering Faculties of the English-speaking Universities of Canada)

The principal Soil Mechanics laboratories of the Universities are located at the University of Alberta, the University of Saskatchewan (in conjunction with the Prairie Farm Rehabilitation Administration which is mentioned below), the University of Toronto, and Ecole Polytechnique. These laboratories are reasonably well equipped, but they contain no unusual apparatus calling for special mention in such a brief review as this. Laboratory work has also been started at the Universities of British Columbia and Manitoba, Queen's and McGill Universities, the University of New Brunswick, and the Nova Scotia Technical College. When the laboratories in the last mentioned group of colleges are developed as is now planned, there will be available soil testing and research facilities in all provinces of the Dominion with the exception of Prince Edward Island.

Correspondingly, attention has been given to the provision of laboratory facilities in a number of the larger engineering organizations of the Dominion. Naturally, the Provincial Highway Departments are among the leaders in this new field, most of the Departments having available some soil testing facilities. Because of the size and importance of their provincial road systems, the provinces of Quebec and Ontario have perhaps the most outstanding Soil Mechanics Laboratories, located respectively in Quebec City and at Toronto. A great deal of valuable work in connection with highway construction has been performed by these two laboratories. As an example, it may be noted that for the construction of a new limited-access highway leading from Toronto fifty miles north to the town of Barrie, nine parties have been at work exclusively on field soil studies. Similar progress is being made in other provinces and much advance may be anticipated in view of the fact that almost ninety per cent of the highway mileage of Canada still consists of

"soil roads", improved to varying degrees.

Amongst the other provincial governmental agencies which are active in the field of Soil Mechanics, the Hydro Electric Power Commission of Ontario (the largest publicly owned utility in the world) is pre-eminent. The Commission maintains extensive testing and research laboratories in Toronto, and these now include an active Soil Mechanics Section where much valuable work has been done. In British Columbia, corresponding attention is being paid to the subject by the Office of the Controller of Water Rights.

Departments of the Federal Government are displaying similar interest in the advances possible through the application of Soil Mechanics in Civil Engineering work. The Department of Public Works maintains a Soil Testing Laboratory at Ottawa and operates a number of test boring crews which are now equipped to take undisturbed soil samples. The Department of Agriculture has long been interested in the pedological aspects of soils, and for this purpose maintains Soil Laboratories both in Ottawa and at other locations in the Dominion. Some experimental work on special aspects of the mechanics of soils has been carried out by this Department in connection with soil erosion studies at its laboratories at Swift Current, Saskatchewan. Some work has also been done in the Ottawa laboratories of the Bureau of Mines of the Department of Mines and Resources, with special reference to the investigation of materials for highway construction and road construction in the Northwest Territories. Finally, the Department of National Defence has naturally a very keen interest in the subject and several of its Engineering Directorates have engineers on their establishments with specialised training and interest in soil studies.

One outstanding development linking Dominion and Provincial activities has been the work carried out in the West of Canada through the Prairie Farm Rehabilitation programme (of the P.F.R.A.) of the Federal Department of Agriculture. A special administration was set up for this purpose in the thirties and it soon became involved in the construction of small earth dams in the Prairie Provinces. This led to an active interest in Soil Mechanics, and there is now a well-equipped P.F.R.A. Soil Laboratory on the campus of the University of Saskatchewan in Saskatoon. Several major earth dams are under consideration and valuable studies for these structures have already been carried out both by means of extensive test drilling and field investigations and in the laboratory.

Not only engineering organisations, but also construction companies and suppliers of some construction materials have shown a lively interest in recent developments in Soil Mechanics. At least one of the larger contracting organisations of the Dominion has started a small soil testing laboratory while several of these larger enterprises have their own test boring and test drilling sections. While there were the initial objections from contractors when new soil techniques were first introduced on construction jobs in Canada, this very natural reaction has fast disappeared and on many of the larger construction projects of recent years soil and foundation problems have been treated with the respect which they deserve by engineering and construction organisations alike. As but one example, there may be mentioned the great Shipshaw water power project, one of the Dominion's greatest war undertakings (over one million horse power being provided in eighteen months for aluminium manufacture). The fantastic progress schedule planned

and attained on this job was possible only because of the accurate knowledge of all foundation conditions to be encountered gained in advance of construction by a comprehensive sub-surface exploration and soil testing programme.

In any review of achievements in the field of Soil Mechanics in Canada, special mention must always be made of the long history of soil survey work of both the federal and provincial Departments of Agriculture. While much yet remains to be done, Canada is already well served with pedological soil maps and at least a start has been made at inter-relating the soil groupings shown on these maps with known engineering properties of local soil types. These maps serve only that part of Canada which may be developed agriculturally; much of the country is of a different character and one of the papers presented at this Conference points to some of the special problems to be faced by Canadian engineers in dealing with glacial silts of the northern regions. Another special feature of the Canadian topography is the existence of permanently frozen ground under almost one third of the land area of the Dominion. This presents its own particular problems, some of which are touched upon in another of the Canadian papers presented to this meeting. A start at laboratory testing of such soils has been made at the University of Alberta (Hardy and D'Appolonia, 1946). Often associated with "permafrost" is the peculiar material called in Canada "muskeg". Organic in nature, this presents its own unusual problems in relation to foundations. Long neglected as a material, it is now being studied by paleobotanists, working in close association with engineers.

One of the most comprehensive soil investigations yet made in Canada was a study of airport runways for the Department of Transport; fortunately a brief account of this work appears as one of the Canadian contributions to this meeting. Associated laboratory work was performed at the Universities of Alberta and Toronto, with some work also done at McGill University. Principal activity of the P.F.R.A. laboratory at the University of Saskatchewan has been in connection with earth dam construction in the west of Canada, one of the most notable investigations so far carried out being the preliminary studies for the St. Mary Dam (Peterson, 1945).

Some details have recently been made public of one of Canadian's war research projects which involved Soil Mechanics, this being an investigation of the inter-relation of the mechanics of soil action and the mobility of tracked and wheeled vehicles when operated over soil. No details of this work have yet been published but it is anticipated that the basic theory which has been evolved will be made public during 1948. Similar studies were carried out at the University of Toronto in connection with the first large water conservation dam to be built in the east of Canada, constructed of glacial till (McQueen and Mc Mordie, 1940). This track research work was initiated by and is being carried out under the auspices of the Associate Committee on Soil and Snow Mechanics of the National Research Council of Canada. The Council is a relatively large and active research organisation (in addition to being also an advisory national council on research activities. It operates through a number of working research divisions and also through the medium of Associate Committees which bring together the various Canadian interests concerned with any assigned research problem.

The Soil and Snow Mechanics Committee has

been from the start a joint military and civilian body, coordinating work by the Canadian Army, Universities, and the National Research Council itself. From the outset of its work, the Committee has considered problems of snow in association with those of soil, in view of the fact that the Dominion is largely covered with snow for almost half the year. The association of Soil and Snow Mechanics has been found to be essential; it is reflected in the similar association of the subjects in Swiss investigations. It may be noted briefly that work on Snow Mechanics has started in Canada, so far in a very small way only, although rapid progress is anticipated and planned; the subject provides even more complications than the mechanics of the most complex soils!

With the coming of peace, the Associate Committee on Soil and Snow Mechanics has broadened the scope of its work, now functioning through five working sub-committees - on Track Studies, Permafrost, Muskeg, Snow and Ice, and Civilian Soil Mechanics. This last subcommittee was initiated at a conference held in Ottawa in April 1947 at which were present almost all the active workers in Soil Mechanics in Canada, such meetings being an invaluable part of Research Council activity in view of the size of the Dominion (N.R.C. 1947). The meeting appointed, as the continuing subcommittee, regional representatives in British Columbia, the Prairie Provinces, Toronto, Ottawa, Montreal and Quebec, and the Maritime Provinces. These representatives are keeping in touch with workers in their regions; group meetings are being held; a small national bulletin is being issued from time to time; and future general meetings will be held, probably once a year. In this way, Canadian workers are managing to keep in touch with each other for mutual benefit. Since Canadian engineers freely participate in the technical activities of American engineering organisations, all members of the Canadian group are thus enabled to maintain indirect contact with relevant developments in such bodies as the American Society of Civil Engineers, the American Society for Testing Materials, and the Highway

Research Board.

Finally, brief mention may be made of the most recent Canadian development, the setting up by the National Research Council of a new Division of Building Research. Eventually, this Division is to serve the interests of the construction industry of Canada. It will always have, therefore, a vital interest in Soil Mechanics and Foundation Engineering, if only in view of the fact that soil problems are unique no two ever being identical so that the testing of soils can never become a routine operation. Even though, due to manpower shortages, the new Division is starting its activities in a very modest way, a Soil Mechanics laboratory has already been set up in Ottawa. The engineer in charge of the laboratory is serving as Secretary of the Civilian Soil Mechanics subcommittee just mentioned. Since the Division is in close touch with similar Building Research organisations in Great Britain, the other British Dominions and in the United States, it is thus hoped to ensure a maximum of cooperation on the part of Canadian engineers in international developments in Soil Mechanics, while ensuring their own close association in view of the unusual soil problems to be faced in Canada, the vast size of the country and corresponding necessity for utilizing all available scientific facilities most efficiently.

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XII c 3 NATIONAL EXPOSITION OF THE LATEST INVENTION AND IDEAS IN THE SPHERE OF SOIL MECHANICS WITH A REPORT OF LITERATURE

NATIONAL COMMITTEE OF INDIA

1. IMPROVEMENTS IN THE PROCTORS' APPARATUS 1)

In tests with the Proctors' apparatus, two sources of error were observed:-

(i) The personal error of the worker - After about an hour's continuous work the same person could not carry out the tests with the same ease and skill.

(ii) Non-verticality of the needle - During a test the needle had to be held between the two legs and pushed downward by the weight of the body in addition to the force applied by the arms. By this arrangement the vertically downward penetration of the needle could not be ensured, as the apparatus was not fixed on a rigid frame.

The improvements described below were made to eliminate these errors.

The soil cylinder and the compaction rod

- x) Based on the work done at the following institutions:
- 1) Punjab Irrigation Research Institute Lahore
 - 2) The Military Soils Engineering Station
 - 3) Soil Stabilization Laboratory, Public Works Department, (Buildings and Roads Branch) East Punjab.
 - 4) Irrigation Research Laboratory, Colombo.
 - 5) The Central Board of Irrigation.
- Numbers in the text indicate the institution at which the work was done.