Geotechnique: new word - old science

Legget, R. F.

Publisher's version / Version de l'éditeur:

Proceedings of the Geological Association of Canada, 12, pp. 13-19, 1961-03-01

NATIONAL RESEARCH COUNCIL

CANADA

DIVISION OF BUILDING RESEARCH

Geotechnique: NEW WORD–OLD SCIENCE

by

R. F. LEGGET

Reprinted from

PROCEEDINGS OF THE GEOLOGICAL ASSOCIATION OF CANADA

VOL. 12, DECEMBER 1960, P. 13-19

TECHNICAL PAPER NO. 120

OF THE

DIVISION OF BUILDING RESEARCH

OTTAWA

PRICE 25 CENTS MARCH 1961 NRC 6174

This publication is being distributed by the Division of Building Research of the National Research Council as a contribution towards better building in Canada. It should not be reproduced in whole or in part, without permission of the original publisher. The Division would be glad to be of assistance in obtaining such permission.

Publications of the Division of Building Research may be obtained by mailing the appropriate remittance, (a Bank, Express, or Post Office Money Order or a cheque made payable at par in Ottawa, to the Receiver General of Canada, credit National Research Council) to the National Research Council, Ottawa. Stamps are not acceptable.

A coupon system has been introduced to make payments for publications relatively simple. Coupons are available in denominations of 5, 25, and 50 cents, and may be obtained by making a remittance as indicated above. These coupons may be used for the purchase of all National Research Council publications including specifications of the Canadian Government Specifications Board.

GEOTECHNIQUE

NEW WORD — OLD SCIENCE[1]

By ROBERT F. LEGGET[2]

All who are concerned in any way with scientific work will agree that we live in an age of specialization, and especially so in the field of science. Never a month goes by without one seeing notice of some new journal, or hearing of some new meeting, concerned with some detailed branch of scientific inquiry that, to the outsider, scarcely seems to warrant such individual attention.

At such a time as this, when there appears to be in progress what might be called the fragmentation of science, it may be useful to take a glance at one development in the other direction, one in which mining engineers, geologists, geophysicists, and civil engineers are all involved. This is the increasing attention that is now being given, from many directions, to the scientific study of soils, from both the strictly scientific and the essentially practical standpoints, a study that involves the interrelation of many disciplines since soil, despite its familiarity, is really a most complex assemblage of materials.

A relatively new word is coming into general use to describe this significant development, this being the word *Geotechnique*[3], a word happily taken from Canada's other language. Et à mes amis Canadiens, a qui la langue maternelle est la belle langue française, permettez moi de vous remercier pour ce mot si expressif, si comprehensif, un mot qui rend un service aux études du sol ce que le mot *bâtiment* contribue à la signification des recherches en construction. As is sometimes the case with words from the French, this one word, *Geotechnique,* implies the integration of all the varied facets of modern scientific soil study; it is a word that can therefore be most fitly used since there is no direct equivalent for it in the English tongue.

There can be few countries in which the development of geotechnical studies is more appropriate or more necessary than in Canada. What other country has a town bearing such a geotechnical name as *Les Eboulements,* this being one of the several French words used to indicate mass earth movements such as landslides. This charming French Canadian village on the north shore of the St. Lawrence must have been so named by the early settlers because of a local landslide. This would not be unusual since major landslides have unfortunately long been a feature of many of the steeper slopes in the St. Lawrence and Ottawa Valleys. They have

---

1Text of an address to "Geosciences Luncheon" of Geological Association of Canada and the Geological Section, Inst. Mining and Metallurgy at the King Edward Hotel, Toronto, April 26, 1960.

2Director, Division of Building Research, National Research Council.

3First use of term "Geotechnique" see Geotechnique, Vol. 10, No. 6, 1960.

been recorded from the earliest times in the archives of Canadian history. The Jesuit *Relations* contain references to some catastrophic landslides. It is therefore not surprising to find that Canada's first great geologist should also have had his attention attracted to them. With that acute observation that is so characteristic, Sir William Logan, when still a young man and still Mr. Logan, presented a paper to the Geological Society of London (1841) in which he vividly described what we now call the Leda clay of the St. Lawrence Valley, and the landslides to which it is so subject on occasion.

It is interesting to think that at a meeting in London, England, as early as 1841, Mr. Logan described an extensive Canadian landslide, that on the Maskinonge River which occurred on 4 April 1840, involving a total area of 84 acres all of which was disrupted, the soil beneath flowing into the river, the whole catastrophe occupying only three hours. Although no lives were lost, two complete farms were carried away. Mr. Logan described the earth masses as "double acting plough shares" and added that the disturbance of the mud in the bed of the river "produced so intolerable a stench that no-one could approach within 100 yards". The lake formed by this barrier extended 9 miles up the river until the accumulating water overtopped the natural dam when more trouble was caused by its failure. Of special interest was the fact that Mr. Logan noted a depression of the surface around the area of the land slip, observing that this interrupted the course of "a dingle" (to use his own lovely word). Although Mr. Logan's explanation of the landslide was only partially correct, since he thought that the soil flowed over the surface of the underlying bed rock through lubrication on this surface, his observations were but the first of many to be recorded by geologists throughout the century and a half that has elapsed since such field observations were first made in this country, and soil problems were thus recognized as worthy of scientific study.

Sir William Dawson was naturally able to go much further with his description of the Leda clay (which he so named) toward the end of the last century. In his notable work on the Canadian ice age, he gives a singularly lucid description of the Leda clay, noting incidentally its laminations and the inter-bedding occasionally of sand layers (Logan 1893). He described at some length the process of deposition of the clay. It is to a large extent upon his description of the clay that modern studies of this particularly treacherous material have been based.

More than 50 years ago R. W. Ells (1908) of the Geological Survey of Canada described one of the most tragic of all landslides, that which occurred at Notre Dame de la Salette on the Lièvre River not far from Ottawa, again in the Leda clay. Unfortunately this slide, because of its location, caused not only much damage to property but the loss of at least thirty-three lives. The characteristics of this slide were similar to those described in earlier accounts, characteristics which can now be readily explained on the basis of more recent soil studies.

Canadians have therefore had plenty of natural occurrences to stimulate their thinking with regard to what soil can do when disturbed. Civil engineers, however, have made their own special contributions to these demonstrations of what soil can do. There are available eye-witnesses' accounts of the slides that plagued the early years of the Welland Canal. It was, for example, because of landslides in the "Deep Cut" (between Allanburg and Port Robinson) that caused the original plan for the first canal to be abandoned, and the Grand River tapped as a feeder. In 1870, one third of the canal prism was blocked by another slide at the same location for a distance of a quarter of a mile.[1]

At the other side of the country there occurred in 1881 the remarkable collapse of a large bank of silt on the side of the Thompson River due to the escape into it of irrigation water, the disrupted silt completely blocking the new main line of the Canadian Pacific Railway, and the full flow of the Thompson River (Stanton, 1897). Even the Prairies have contributed notably to showing what soil can do. The settlement of the Transcona elevator is an almost classic case. This massive concrete structure founded on prairie clay tipped over to an angle of about 27 degrees when it was first filled with grain in 1913 (Baracos, 1957). Fortunately the structure was not fractured with the result that, by a civil engineering operation of daring and magnitude, it was brought again to its vertical position, under-pinned to rock with proper foundations. It is still serving satisfactorily today.

Is it any wonder that, with this and countless other examples available to them, early engineers in Canada, working independently but with no organized body of knowledge to help them, courageously attacked this problem of soil and its stability? In the writings of some of the officers of the Royal Engineers, who pioneered so much of the early development of Canada, both east and west, there are most penetrating comments on soil and soil properties, suggesting that they had experimented with soil in just the same way as they had with other materials, such as ice and timber, (Legget, 1958; Dennison, 1838).

One of the real leaders in early soil studies, long before soil mechanics was recognized in its own right, was a Canadian, a graduate of McGill, who eventually went to the Western States and became one of the leading modern irrigation engineers of his time (Legget, 1949). Samuel Fortier was a true scientist as well as an engineer; his early writings on the proper use of soil, and upon its necessary compaction for adequate stability, were almost fifty years ahead of their time.

Even some of the greatest scientists have made their contributions to Canadian soil studies, although not always with success. How many Canadians, for example, know that in the early years of this century Thomas A. Edison applied his inventive genius to the use of a simple

---

[1]From an old untitled Letter Book in the Dept. of Building Research, National Research Council, Ottawa, Canada.

magnetometer for the location of ore in the Sudbury Basin (Langford, 1954). He located what was clearly a large ore body and, with others, organized the necessary group to exploit it. Unfortunately, the area was covered by 100 ft. of "overburden" (so called) and this proved too much for this early mining venture, despite the fact that Edison was one of the persons involved. The shaft that was attempted had to be abandoned 30 feet above the ore body. Not until many years later did the main shaft of the Falconbridge Mine penetrate this overburden, at almost exactly the same point as Edison's, as the first stage in the development of one of Canada's most notable mines. To think of Thomas Edison being thwarted by soil is a sobering thought.

Most Canadians know that the great Lord Rutherford obtained some of his earlier scientific experience while a member of the faculty of McGill University. Very few Canadians, however, know that one of the first jobs undertaken by Rutherford after arriving in Montreal was a study of soil vibrations. This project was carried out at the request of the Montreal Tramway Company which had been sued by irate householders who claimed that vibrations from a new-fangled electric dynamo were shaking their homes to pieces. Rutherford built a special seismograph and by its careful use was able to prove that the vibrations, although felt, could not have caused any serious damage.[1]

Geophysical studies of soil in Canada are therefore in a good tradition. They have included some singularly interesting early examples, one of the most unusual being the location about thirty years ago of a steam shovel that was buried in a slide of another type of sensitive clay in northern Ontario on the Frederic House River. This large piece of construction equipment was completely buried by the slide and could not be found even after a most extensive program of probing by the engineers on the job when the slide was stable. Eventually someone thought of geophysical studies and Dr. Lachlan Gilchrist of the University of Toronto was appealed to. He took up to the job a very sensitive magnetometer and quickly located two anomalies, one of which proved to be the steam shovel buried 9 feet deep beneath the surface of the clay and the other a large collection of reinforcing steel.[2]

What of the north and its special soil problems? It would be almost universally believed that these are entirely recent, permafrost having first revealed itself in all its serious engineering implications during the construction of the Alaska Highway as a major wartime construction project. Since then much careful study of northern soils has taken place, but these too follow in a good tradition. In this year 1960 when the Royal Society celebrates its tercentenary of eminent service in the field of international science, it is of signal importance to be reminded that six of the eighteen original "Gentlemen Adventurers", named in the

---

[1]This information privately received, but the same is briefly noted in Maclean's Magazine, January 3, 1959.

[2]Private Communication.

Charter of the Hudson's Bay Company, were Fellows of the Royal Society. Not only this, but a number of the early explorers of the North were elected to Fellowship in the Royal Society because of their scientific studies in northern Canada (Stearns, 1945). In 1768, for example, William Wales was sent by the Society to Fort Prince of Wales, now known through the neighbouring post of Fort Churchill, in order to observe the transit of Venus. Being a true scientist he observed many natural phenomena and recorded these carefully, reporting them to the Society in 1770. One of his small party made a special study of the soil in the vicinity of the Fort and duly reported upon its frozen state (Dymond and Wales, 1770).

There is available in the National Research Council Library the report of a Committee appointed to study "The Depth of Permanently Frozen Soil in the Polar Regions, its Geographical Limits, and Relations to the Present Poles of Greatest Cold". This report summarizes a large number of observations of permafrost made in the Arctic, in the Yukon, down the Mackenzie River, and in a number of locations on the Canadian borders from Edmonton to Winnipeg. Some general observations from the Head of the Meteorological Service of Canada are also included with regard to the relation between the annual mean air temperature and the occurrence of permanently frozen soil. All this has a familiar ring and might be thought to refer to the Permafrost Sub-Committee of the Associate Committee on Soil and Snow Mechanics of the National Research Council. This is not the case, however, since the report was made to the Royal Geographical Society in 1886, the Chairman of the Committee being General Sir Henry Lefroy (1885). The report makes clear that many careful observations on permafrost had been made by early settlers in the west and in the Mackenzie Valley one hundred years ago.

From this all too brief survey there can probably be seen running through the history of scientific observations on the one hand, and the practice of engineering on the other, threads linking together individual workers in Canada who have studied soils with scientific detachment, treated them with respect and not merely regarded them as "mud". In more recent years, these continuing threads have been woven together and are gradually forming the fabric of Canadian geotechnical studies which are now contributing to basic understanding of soil as a material, and to its use in the service of man. These studies involve application in the laboratory of the most refined techniques of chemistry, physics, and even biology (for the study of soil bacteria). In the field, they call for the acute observations of the geologist, the scientific methods of the geophysicist, the observations of the mining engineer as he tackles soil problems in his search for ore, and the practical experience with soil problems of the civil engineer. The pedologist is a relative newcomer to the scene, but he also has made notable contributions to general understanding of the nature of soil and its close relation to climate.

That this is no idle dream of an enthusiast is shown perhaps by the fact that the Royal Society of Canada devoted this year an appreciable part of its annual meeting in respect to geological sciences to an unique series of papers dealing with the soils of Canada from the geological, pedological, and engineering points of view. Moreover, in this year too the National Research Council of Canada for the first time has recognized the Earth Sciences as a separate scientific discipline for comparable treatment to Physics and Chemistry in the making of grants for research in this field at the universities of this country.

"Earth Sciences" may be a clumsy term but may be semantically necessary. In keeping with Canada's happy tradition of having two notable languages in its own heritage, the hope may be expressed that *Geotechnique* will come more and more into use in this country as describing an integrated scientific approach to one aspect of the earth sciences, the scientific study of soil. With this practice established it will have the further happy effect of bringing even closer together mining engineers, with an appreciation of what civil engineering can contribute to their work; geophysicists, with an awareness that their incidental studies of the physical characteristics of the "overburden" may be significant in the study of soil; pedologists, their studies of surficial soil formation often providing a clue to soil behaviour; geologists, who will perhaps recognize that civil engineers can make some contribution to geological knowledge and are not, as one notable Canadian geologist once said "intruders at any geological meeting"; and civil engineers, appreciating anew the fact that in the practice of their art they can and should involve the fullest possible use of all that the scientific disciplines can provide. This truly joint effort should lead to a fuller appreciation of the real nature and character of the soil that makes up so much land that is Canada.

REFERENCES CITED

Baracos, A. (1957)—The Foundation Failure of the Transcona Grain Elevator; Eng. Jour., vol. 40, July.

Dymond, Joseph and Wales, W. (1770)—Observations On the State of the Air, Winds and Weather made at Prince of Wales Fort on the Northwest Coast of Hudson Bay in the years 1768-1769; Roy. Soc. Phil. Transactions, vol. 60, p. 137.

Dennison, W. (1838)—A Series of Experiments on Different Kinds of Timber; Trans. Inst. C. E., vol. 2, pp. 15-32.

Ells, R. W. (1908)—Report on the Landslide at Notre Dame de la Salette, Lièvre River, Quebec; Geol. Surv. Canada (Separate Report, No. 1030), pp. 1-10.

Langford, G. B. (1954)—Out of the Earth, p. 37; University of Toronto Press.

Lefroy, Gen. Sir J. H. (1885)—On the Depth of the Permanently Frozen Soil in British North America; Scott Geogr. Mag., vol. 1, No. 11, pp. 577-578.

Legget, R. F. (1958)—Early Canadian Experiments on Ice; Jour. Glaciology 3, pp. 320-321, October.

.... (1949)—Samuel Fortier, Pioneer in Soil Mechanics; Eng. Jour., vol. 32, February.

Logan, W. E. (1841)—Proc. Geol. Soc. London, vol. 3, pp. 767-769.

.... (1893)—The Canadian Ice Age; "Witness" Printing House, Montreal.

Stanton, R. B. (1897)—The Great Landslides on the Canadian Pacific Railway in British Columbia; Min. Proc. Inst. C. E., vol. 1, p. 132.

Stearns, R. P. (1945)—The Royal Society and the Company; The Beaver, Outfit 276, June, pp. 8-13.