Urban geology

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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/40000830
Canadian Building Digest, 1969-05

Canadian Building Digest

Division of Building Research, National Research Council Canada

CBD 113

Title

Originally published May 1969

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Please note

Napoleon is not usually associated with building. The lovely modern city of Paris owes much, however, to the great Emperor, who by imperial decree put a stop to the mining that had been carried out beneath the streets of Paris since the time of the Romans. Much of the limestone used for the buildings of pre-nineteenth century Paris and the gypsum necessary for interior plaster finish was obtained from quarrying the horizontal rock strata beneath the city's surface. The stone and gypsum were simply hoisted to street level through vertical shafts. Land transportation outside the city was then so difficult as to make hauling from any great distance almost impossible.

Cave-ins at the surface had already caused trouble when underground quarrying was stopped, and 10 per cent of the land area of Paris was underlain by open tunnels. When close to the surface these were clearly a hazard to further building construction, so that a special organization had to be established to make accurate surveys of the tunnels. The results were plotted on some of the very earliest maps of *Urban Geology*, showing the geology of the land beneath city streets. These quite beautiful maps are carefully maintained today. All excavation or foundation work in Paris must still be reported to l'Inspection Générale des Carrières de la Seine, which also supervises the maintenance of the old underground workings, some of which are the macabre catacombs of Paris.

There is probably no other city in the world that has to control its building because of such an unusual subsurface hazard, but other great cities have other geological problems that complicate local construction. How many visitors to Mexico City realize that parts of its central area have settled more than 25 feet since 1900? The Palace of Fine Arts built in 1904 has settled more than 10 feet. Its architect, warned of potential settlement, is reported to have said "If the structure is pleasant to my eye it is structurally sound," and refused to stop the building when settlement revealed itself during early stages of construction.

The ancient and beautiful city of Prague in Czechoslovakia has the reverse problem. Much of its ground surface is above the original ground level owing to the accumulation of rubble and other debris from buildings long since demolished. One of its most famous churches is so far below the present ground level that one has to go down a flight of steps to enter it. Today, however, there is available accurate information regarding the subsurface conditions for the whole of Prague so that modern building can proceed with certainty.

The need for maps of urban geology was recognized publicly in Canada at the turn of the century, and probably well before that by individual practitioners. In a paper presented to the Royal Society of Canada in 1900, Dr. H. M. Ami said "The larger cities of our Dominion, as well as those of other countries, are the centres of work and research in the pathways of science and commerce. . . . What the drill has to penetrate in any one of our larger centres of activity in Canada is a question not only of interest but also of economic value." He proceeded to give summary accounts of the urban geology of Saint John, Montreal, Ottawa, Quebec, and Toronto, and this, almost seventy years ago.

Every city and every town should have readily available accurate information about the ground upon which it is built. Despite widespread private ownership of land, this information is essential for the safety of the public and cannot properly be regarded as private property in this regard. No city or town planning worthy of the name can be carried out without a full appreciation of local geology. Not only does geology determine the natural physiographic features that may have to be modified in the framing of a master plan, but it will also influence the pattern of natural drainage, the types of materials to be excavated, and the suitability of building sites for different kinds of construction.

It is the purpose of this Digest to assist architects and planners as well as engineers and building officials to gain a general appreciation of the importance of urban geology in their professional work. It is true that the design of major building foundations will usually be the work of the specialist engineer, but an architect must have at least a general idea of local ground conditions (whether soil or solid rock, as a start) for the preliminary project planning and for later discussions with the engineers. Correspondingly, the planning of new urban developments must comprehend more than a two-dimensional plan of the area and must be based, from the outset, on at least a general appreciation of the three-dimensional character of the land under study.

The geology of any area - such as that covered by a number of city blocks or a new municipal subdivision, the planning of which is in prospect - is essentially a three-dimensional concept, extending to a depth well below that at which any surface loadings can be significant. This picture of the structural makeup of a block of land (and the word "block" is singularly appropriate) is not to be thought of in isolation, for it is an integral part of the geology of the region around. The detailed study of specific building sites or planning areas will be more effectively and economically carried out against the background provided by such general knowledge of the local geology.

It may be thought necessary to put down an adequate number of test borings only at building sites that warrant such expenditure. This, however, can be a somewhat limited and possibly wasteful way of determining local ground conditions. There should be publicly available in every city a collection of all logs of test borings, correlated with the local geology. It can truly be said of such compilations of subsurface information that the whole will be of much greater value than the sum of the individual parts, important and useful as the logs of single test borings may prove to be.

Urban geology has thus a two-way importance for all those concerned with building. It provides a useful and often invaluable source of information for specific design cases. At the same time, the record can be extended if all those who gain access to further information will add it to the common store. There will be an opportunity for wider service in promoting the development of such records where they do not already exist.

City Records

There is an interesting parallel to this desirable procedure in the commendable and general practice of having centrally coordinated records of all subsurface utilities such as water-mains, gas-mains, telephone and electric power cables beneath city streets. Many cities now have excellent and often quite extensive systems for recording this type of specialized subsurface information which is usually available in the office of the city engineer for consultation by those interested.

The necessity for such records has come about because of the essential coordination of the different services now buried beneath the streets of modern cities. A committee of representatives of the several local utility organizations is usually responsible for supervising steady and accurate maintenance of these vital records. Exactly the same type of subsurface records of the urban geology of all Canadian cities should be similarly maintained and publicly available. In some, a start has been made, but it will require strong support from those concerned with building - architects, engineers and contractors - to ensure that city engineers and their staffs are provided with the necessary facilities for the preparation and regular maintenance of these vital records.

The Existing Situation

Application to the office of the local city engineer should always be the first step in determining the general pattern of local geology. Supplementary information may often be obtained in large cities from the department of geology of the local university. Availability of geological maps of the area under study and geological reports that may be useful can be checked with the appropriate provincial department of mines, or with the Geological Survey of Canada.

Already available for some Canadian cities is additional information usually developed by the cooperative efforts of interested persons. A partial list follows; it should be taken as suggestive only. In other cities, inquiry of the city engineer may reveal the existence of similarly useful information.

Montreal
Working cooperatively with the Geological Survey of Canada, the City of Montreal has published a comprehensive report on the local geology (by V. K. Prest and J. Hode Keyser). The accompanying geological maps are being kept up to date as herein suggested. The City Planning Department has published in addition a guide for urban and regional planning that is a model of its kind.

Toronto
Construction of Canada's first subway, starting in 1944, led to the first assembly of local test boring records. Full geological profiles along the subway excavations, and suites of soil samples are now available at the Royal Ontario Museum. The office of the Commission of Works of Toronto is now collecting local test boring records.

Vancouver
The local staff of the Geological Survey has been studying the geology of the city area for many years; results have been recorded in a notable series of papers by Dr. J. E. Armstrong.

Winnipeg
A pioneer effort was the work of the Winnipeg Branch of the Engineering Institute of Canada which prepared a report on the local geology in 1927. More recently studies have been continued in the Department of Geology at the University of Manitoba.

Ottawa
Stimulated by a first attempt by a local consulting engineer, the Geological Survey of Canada in association with the NRC Associate Committee on Geotechnical Research has issued maps showing depths of overburden in the city.

Edmonton
The Research Council of Alberta has published a report in which the records of test borings and tests on soil samples are presented, with geological profiles through the central city area.

Use of Subsurface Information

Once an architect or town planner has availed himself of the information about local geology that is publicly available, he will readily appreciate the value of every contribution to this store of public knowledge. It is clearly a professional responsibility to assist in building up this accumulation of records. Accordingly, and without the legal compulsion to do so that now exists in quite a number of cities in other parts of the world, copies of all borehole logs and excavation profiles should be passed by responsible engineers and architects to the custody of the local city engineering authorities. If the office of the city engineer is not geared to accept, store, and compile such subsurface records, then professional men can help by developing civic support and the necessary financing for such an essential civic purpose.

Although the primary purpose of assembling information on local urban geology for public use is strictly utilitarian, and although the work and expense involved can be fully justified on economic grounds, the science of geology can often be an incidental beneficiary. New excavations and test borings in central city areas will often reveal geological information not previously recorded and sometimes of great value. The excavation for the first part of Toronto's subway, for example, revealed unique scientific information on the world-famous "Toronto interglacial beds" of soil deposited under tropical conditions between glacial periods; scientific records were enriched by papers based on the information then obtained. Excavation for a new City Hall for the city of Hamilton revealed geological conditions that permitted a new estimate of the age of Lake Ontario to be prepared and published. The department of geology at every university in Canada may therefore be expected to have a lively interest in the local urban geology and should be approached when any new project is started so that members of the staff may have the privilege of studying the new geological sections that excavation reveals.

The Ideal Arrangement

A start has been made in many Canadian cities on the development of these vital civic geological records. Much more yet remains to be done, and the need increases every day as the urbanization of Canada continues its rapid advance. City engineers will need all possible encouragement from architects, planners, engineers and contractors especially in obtaining the funds necessary for small additional staff that may be necessary in larger cities. It may therefore be helpful to outline the ideal arrangement that can readily be shown to be economically advantageous to every town and city in Canada.

In the office of every city engineer there must be a set of topographic maps of the city, now frequently supplemented by sets of aerial photographs. Small-scale maps will show the general topography; large-scale maps the legal controls on subdivision. In all cities, the office of the city engineer (or an office closely associated with it), should have a set of large-scale maps and associated written records, showing as accurately as possible the location of every buried utility in the city area.

Correspondingly, a set of small-scale maps should be available in the same office delineating the general pattern of the local geology in its dual aspect; the bedrock and the surficial soil deposits. Large-scale maps should contain detailed records of all test borings put down in the city area, the corresponding records from all excavations, and details of the local groundwater levels as observed in wells, test borings, and excavations. Associated with the maps should be copies of test reports on soil samples obtained in site exploration and written records of such other aspects of subsurface conditions as are available. Some cities have even arranged to have on display typical cores of the local rocks, obtained by test drilling, to permit visual inspection by those interested.

Arrangements should be made for copies of the logs of all new test borings to be deposited with the city engineer, after they have served their immediate purpose, as well as records of the geological conditions revealed by all new excavations. The procurement of such records for public use must be arranged at present by persuasion and mutual understanding. There is not yet, in Canada, any legal requirement that this must be done, as is the case in certain provinces, for example with the logs of holes but down in exploring for oil and natural gas. As each new record is plotted on the master record maps, knowledge of the local geology will become more accurate and more meaningful. The maps will become the more valuable with their increasing accuracy.

The savings that can be effected in reducing the number of new boreholes necessary to give accurate information about even one major site can easily offset a large part of the annual cost of maintaining the city's records of urban geology. In addition, such information will give a reasonable degree of certainty to the subsurface conditions suggested by new boreholes, to the immediate benefit of the owners, architects, engineers and contractors, and to the benefit of the city itself. Savings that can be effected by the use of this information in carrying out excavation for watermain and sewer trenches, road and bridge construction can very quickly repay the relatively small cost of such records of the local urban geology.