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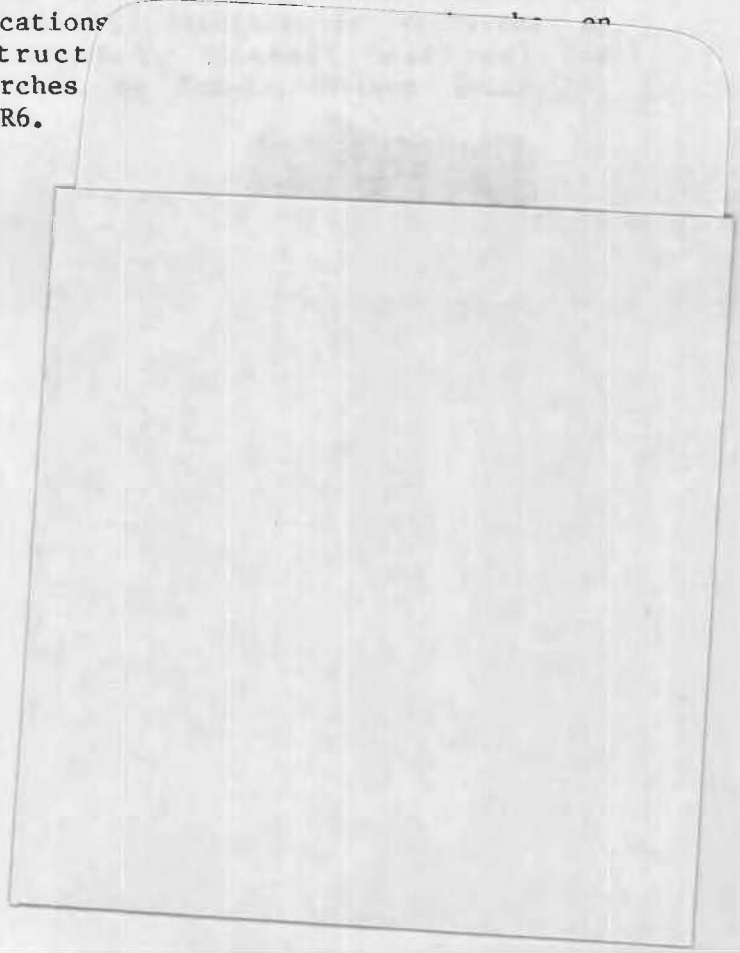

Archival material and site investigations

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The prediction of subsurface conditions at building sites is a prime responsibility of the geotechnical engineer, and the improved accuracy with which he can make such predictions is a continual challenge. Information is derived primarily by studying the local geological and groundwater conditions, and from sampling and testing of soil and rock. In most instances, this procedure provides adequate assessment of the conditions likely to be encountered during construction. Increasingly, however, particularly in towns and cities, building sites are located where the natural terrain may have been altered significantly by earlier human activity, such as the erection and demolition of buildings and other structures, excavation and subsequent filling of pits and quarries, and the reclamation of land at waterfronts. The remains of these activities are now buried and hidden from view but they may present unusual and sometimes unexpected conditions, which can complicate the construction of new foundations and lead to increased costs for unanticipated work. Records of these earlier activities are sometimes available in drawings, maps, and paintings housed in local archives, and it is the thesis of this paper that these often constitute a useful tool in subsurface investigations—one that is too often overlooked. To support this contention, several case histories illustrating valuable information derived from archival material are cited, including examples from Canada, the United States, and Europe.

Key words: archival material, site investigation, anthropogenic material.

La prédiction des conditions du sous-sol sur les sites de construction est la responsabilité première de l'ingénieur géotechnicien, et l'amélioration de la justesse avec laquelle il peut réaliser de telles prédictions offre un défi sans fin. Les informations proviennent principalement de l'étude des conditions locales de géologie et de nappe d'eau, de l'échantillonnage et des essais de sol et de roche. Dans la plupart des cas, cette procédure fournit une évaluation adéquate des conditions qui seront vraisemblablement rencontrées lors de la construction. De plus en plus, cependant, et particulièrement dans les municipalités et les villes, les sites de construction sont situés dans des endroits où le terrain naturel peut avoir été altéré de façon significative par une activité humaine antérieure, telle que l'érection et la démolition de bâtiments et autres structures, l'excavation et le remplissage subséquent de bancs d'emprunts et de carrières, et la mise en valeur de terrains le long des rives. Les vestiges de ces activités sont maintenant enfouis et cachés à la vue, mais ils peuvent présenter des conditions inhabituelles et parfois inattendues qui peuvent compliquer la construction de nouvelles fondations et conduire à des coûts accrus pour travaux imprévus. Les données sur ces activités antérieures sont parfois disponibles dans des dessins, des cartes et des peintures entreposés dans des archives locales, et la thèse du présent article est que ces documents constituent souvent un outil utile dans les investigations du sous-sol—outil qui est trop souvent ignoré. À l'appui de cette prétention, plusieurs cas illustrant les informations précieuses provenant de matériel d'archives sont cités, incluant des exemples du Canada, des États-Unis et de l'Europe.

Mots clés: archives, investigation d'un site, matériel d'anthropogenèse.

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Site investigation is a crucial operation in the practice of civil engineering. It provides the most stimulating of challenges to the geotechnical engineer. Accuracy of prediction regarding subsurface conditions is the prime aim of all the studies and tests, which, today, in combination, constitute this advance investigation of building sites.

Available records of the local, or regional, geology provide the invariable starting point. In urban areas such records may be limited in scope, especially in older places. Seldom will they give any indication of what may be called the local "man-made geology," alterations to the natural terrain caused by the works of man, such as the deposition of fill material, rubble resulting from fires, and the earlier erection of small structures now covered up by city streets and hidden from view. Anthropogenic material is the name now applied to such deposits.

It is the thesis of this paper that the records of such earlier human activity constitute a neglected tool in site investigation, but one always worthy of attention, sometimes proving to be of unusual value.

Local libraries have generally been, up to the present, the repositories of these early municipal records. Today, an increasing number of larger cities throughout North America are developing their own archives, as official custodians of the more valuable and older local records. Provincial archives have long been maintained by the provincial governments of Canada, while the Public Archives of Canada have a reputation for service well and favourably known far beyond the borders of this country. Research workers in other countries look with envy at the remarkable service given by the Public Archives of Canada in Ottawa, which, for registered users, are open 24 h every day of the year, a unique operation.

These official repositories of old local records are not the only sources of archival information that can assist with site investigations. In earlier days, before the diversions provided by radio and television, groups of citizens interested in a particular hobby—such as natural history—often banded together in small local societies, some of which issued their own publications; many remain active today. Transactions of these bodies, and especially of local naturalists' clubs, may sometimes be found to contain information of real value in current subsurface investigations.

Local publications are mentioned as typical of other possible

sources of early records of long-forgotten human activity—now out of sight and so out of mind—that may have a bearing on site studies. It is impossible to suggest all the other varied possibilities that exist as potential aids to determining in advance what are the actual underground conditions that will be found when excavation for a new urban construction project proceeds. What can be, and what is suggested with all due emphasis, is that, as preliminaries to actual work on a site, not only should all written records of the local geology be searched out but, also, diligent inquiry should be made as to the availability of any local archival material that might similarly prove to be of use.

The following examples give warrant for this suggestion. They have been selected to illustrate the variety of sources of archival material, generally in North America, as well as the different ways in which such material may prove to be of value in civil engineering work.

Case histories

Chateau Laurier garage, Ottawa

The Chateau Laurier, one of Canada's leading hotels, is located in the centre of downtown Ottawa, capital city of Canada. Built, and extended, several decades ago, it did not include a parking garage for private automobiles, now an almost essential facility for modern hotels. The owners, Canadian National Railways, decided in 1968 to construct a five-storey reinforced concrete parking garage as an addition to the hotel, using land that was available to the north of the hotel building. When the first test borings were put down at the site, to the direction of Canadian National engineers, some showed rock at a depth of 0.6 m, others at a depth of 6 m. The site is directly adjacent to the Rideau Canal and one of those responsible recalled reading a book about the canal in which a quarry in this vicinity had been mentioned (Legget 1955).

The Rideau Canal was constructed between 1826 and 1832 under the direction and to the designs of officers of the (British) Corps of Royal Engineers, under the command of Lieutenant Colonel John By. The start of the canal, as it leaves the Ottawa River, is a splendid flight of eight masonry locks. In the book noted, it is recorded that these locks "were surrounded by the yards and workshops erected by the Royal Engineers," and also that Thomas McKay, the responsible contractor, "got permission to use the limestone found in the cliffs adjacent to the locks."

These cliffs constitute a noble escarpment on the top of which sits the Chateau Laurier. There was, therefore, a distinct possibility that the old quarry, although not now to be seen, might be so located as to interfere with the foundations for the garage. (A view of the new garage is shown in Fig. 1). The Royal Engineers kept excellent drawings of all their works; fortunately, many have survived through the century and a half since the canal was built owing to the care given to them and the excellent paper on which they were executed. Inquiry was therefore made at the Map Division of the Public Archives of Canada, and an 1828 Royal Engineers drawing was found showing the layout of the workshops and yard as well as the location of the quarry.

An early photograph was also found in the Public Archives, taken from the opposite side of the ravine in which the locks are located, looking towards the site of the Chateau Laurier, and it showed the quarry clearly. It was possible to correlate the position of the existing hotel building with features shown on the old drawing and in the photograph. This showed that the location of the proposed garage was on top of the now backfilled quarry. The necessary additional test borings were therefore located accordingly and they determined the elevation of the bedrock of the old quarry floor. Foundations were designed appropriately and constructed without difficulty. This might not have been the case had the old records not been available and put to such good use (W. E. Jubien and F. L. Peckover, personal communication, 1979, 1983).

New library, St. Mary's University, Halifax

A new million dollar library building was planned in 1964 for St. Mary's University in Halifax, Nova Scotia. The location of the new building was selected at a convenient site on the pleasing campus of the University which is adjacent to the ocean shoreline in the southern part of the city. A report was prepared on site conditions and this showed bedrock generally at about 1 m below the surface, in no place deeper than 1.2 m.

When excavation started, no bedrock was encountered at a depth of 2 m. Further investigation showed soil extending to a depth of 6 m, below which was a swamp deposit of at least 3 m depth. An old labourer said that he had worked on filling in the site 25 years before; he recalled a line of old elm trees, which were cut down. Their stumps were found as he had predicted.

This experience led the Clerk of Works, George Young, to consult all available records in the Provincial Archives of Nova Scotia. Just as the search was proving fruitless, he recalled having once seen, on the upper floor of the Archives building, an old ordinance plan of Chebucto Peninsula (now Halifax). This was found and proved to be a plan, painted in oils on linen, based on a survey carried out in 1784 by Captain Charles Blaskowitz under the direction of Colonel Robert Morse, then the Chief Engineer for the British Army in British North America.

The town of Halifax at that time was only 35 years old, the population thinly spread along the waterfront. The plan showed such buildings as there were, the fortifications that dominated the little town, and the main topographic features with a few spot elevations, colour shading being used to indicate contours. Using a small creek shown on the plan, the location of which he knew, Mr. Young was able by an ingenious triangulation system to locate the building site on the plan. This showed it indeed to be a swamp but it showed also a rock knoll 15 m to the west. This knoll was soon found, close to the present surface of the filled ground. The location of the building was moved in the direction of the knoll a distance equal to its own width and there founded on bedrock, with considerable saving in cost. The original site was then landscaped (Young 1972*a*). The library is shown in Fig. 2.

When supervising the construction of a new sewage treatment plant at Bridgewater, N.S., at a later date, Mr. Young's sense of history again proved useful. He noticed in the office of the town clerk an old painting of the Bridgewater waterfront as it was in 1895. Old cribwork had just been uncovered at the site of the new plant. The old painting (done by the father of the Town Clerk) enabled old "obstructions," now covered up and not revealed by test borings, to be located within 30 cm, greatly to the advantage of construction progress (Young 1972*b*).

Foundations in Pittsburgh, Pennsylvania

Canals were a prominent feature of early Pittsburgh and here early record drawings have proved of value in connection with the construction of modern foundations. In the great days of the "canal era" one could travel from Philadelphia to Pittsburgh by

FIG. 1. New garage for the Chateau Laurier (Hotel), Ottawa, as seen from across the Rideau Canal, the gates of one of the entrance locks of which is seen in the foreground.

canal, barges being hauled up and down inclined planes between Hollidaysburg and Johnstown to get over Cresson Mountain (Charles Dickens once made this journey). In Pittsburgh a canal was constructed across the famous triangle that now lies at the heart of the city, linking the Alleghany and Monongahela Rivers. Part of this Pittsburgh canal was constructed in tunnel, in order to penetrate Grant's Hill (see Fig. 3). This was solidly lined with excellent stone masonry. With the coming of the railways, the canal fell into disuse about 1860 and was soon filled in (apart from the tunnel) and covered up as the modern city rapidly developed.

When, in 1959, the Pennsylvania Department of Highways came to design the new crosstown boulevard, it was known that the route selected was, in places, not far from the route of the old canal but the only plan available was one dated 1883 prepared after the abandonment of the canal. A story about this problem was published in the *Pittsburgh Sun-Telegraph* and this was seen by the Reverend William O'Donnell, a retired member of the staff of Duquesne University. He had been given a copy of an 1830 map of Pittsburgh, which showed clearly the route of the old canal and the exact location of its tunnel. The map was a gift to Father O'Donnell from Mother de Chantal of the Ursuline Academy in Pittsburgh, who had received it from an unidentified woman attorney.

Not only did this map of 1830 assist with the design of the Crosstown Boulevard but when, almost a decade later, the great building in Pittsburgh of the U.S. Steel Corporation was erected on Grant Street, preparation of its site (see Fig. 3) involved removal of some of the old canal tunnel and so the old map again proved its value (R. E. Gray, personal communication, 1978). This example is a useful reminder of the archival material that may still be in private hands but available for use when needed, such as the valuable private map of the old streams and ravines that underlie the paved streets of Toronto. A recent exhibition in that city disclosed that there are at least 700 maps of Toronto that were made before 1867 (Braide 1984).

World Trade Centre, New York

One of the great buildings of the present era is the World Trade Centre in New York, incorporating two of the tallest buildings in the world (see Fig. 4). The basement of this great complex has an area of 4.5 ha and is 21 m deep. Its construction was therefore a major enterprise. Before designs were completed, old maps of the city of New York were searched out and

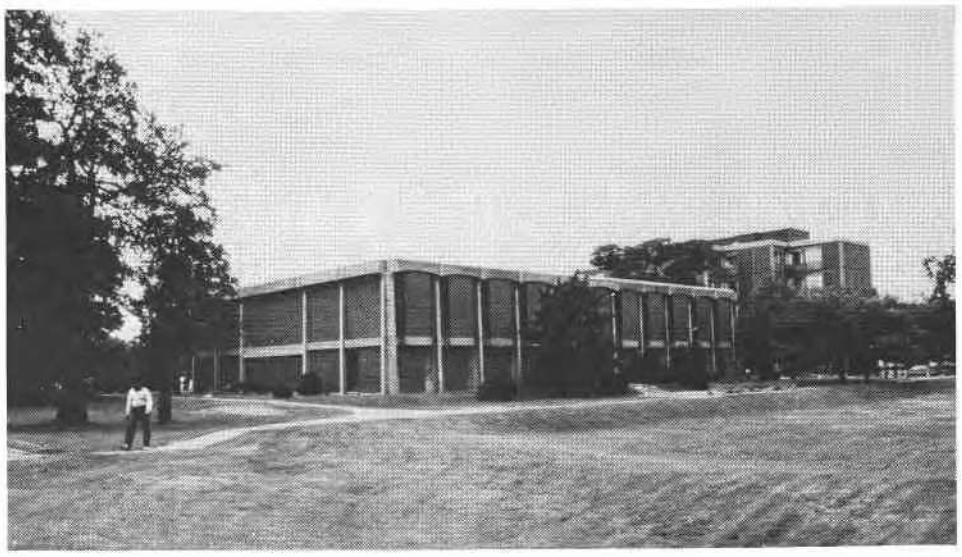

FIG. 2. The library at St. Mary's University, Halifax, with the original site landscaped in the right foreground.

studied. Maps of 1783 were found which showed that at that time the shoreline of the Hudson River was approximately 210 m to the east of its present location, approximately along Greenwich Street, two full city blocks inland. Other records showed that the old shoreline (of 1783) was fronted by timber wharves, rock-filled cribs, and other man-made structures built for shipping purposes.

This information was one of the principal reasons that led the designers to adopt the slurry-trench method of construction. A reinforced concrete wall was built all round the site in a slurry-trench, and secured by ground anchors, giving a clear working space. During excavation the artifacts encountered included several large ship's anchors, pieces of old cannon as well as old construction remains. Had more usual foundation construction methods been used, real difficulties would have been experienced. Archival records again showed their worth (Kapp 1969).

In Great Britain

Archival material as an aid in site investigation is of unusual significance in the countries of Europe and other older centres of civilization. As an extreme case of a man-made structure completely buried and almost forgotten, there may be mentioned the first masonry bridge across the River Exe in southwestern England, the remaining parts now happily restored to public view in an attractive park. This was created as a leading feature of the redevelopment of the central part of the city of Exeter. Old records were put to good use in this imaginative project but for several centuries the remaining arches of this 12th century bridge had been buried in fill beneath the streets and buildings of the modern city (Brierley 1979).

In great contrast was the sudden development of serious settlement of one corner of a new building of the University of Kent at Canterbury in southeastern England. This took place in July 1974, when arrangements were already in hand for the strengthening of a disused tunnel 20 m below the building in question. News reports of the accident suggested a possible connection between subsidence of the foundations of the building and problems within the tunnel, which was completed in 1830 (Parkinson 1974). George Stephenson was the engineer, the tunnel being the earliest of all railway tunnels. The case is an unusual one since existence of the tunnel appears to have been known by some concerned with the university buildings. A public appeal was made for any further information that could be derived from earlier records.

An interesting source of information proved to be old local newspapers housed in the municipal library of Canterbury. These indicated that there had been an overbreak of clay somewhere along the tunnel in 1826 during construction. More-recent newspaper records showed that enemy action during World War II had resulted in the blasting of large craters in the surface of the earth near the location of the tunnel. It was not possible to establish any direct relationship between these and the collapse in 1974. The tunnel was finally stabilized by a technique of squeeze grouting with careful control of ground movement and of pore pressures (Vaughan *et al.* 1983).

Another interesting and unusual case from Great Britain has been recorded by F. G. Berry of the Institute of Geological Sciences (the current name of the British Geological Survey). He made a detailed study of all the published references he could find, going back to the start of this century, in which local depressions in the surface of the famous London Clay were recorded, depressions long since hidden from view but revealed in excavations and by test boring. Twenty-six such depressions were thus located and, when studied together, led to significant geological conclusions as to their origin. Berry's paper is a salutary reminder of the value of older records even in established journals, a reminder made the more necessary by the current 10 year period covered by "retrieval" of library material by means of computers (Berry 1979).

A Belgian parallel

After the authors had prepared a first draft of this paper, there came to their attention a short paper recording the use of archival maps for modern site investigations in two Belgian cities. This paper, by W. De Breuck and P. van Burm both of the State University of Ghent, appeared in Bulletin No. 21 of the International Association of Engineering Geology. The authors are glad to call attention to this notable publication, produced in Krefeld, Federal Republic of Germany. Each semiannual issue contains up to 250 pages, made up of succinct papers of great value from around the world. The Belgian paper is one of more

FIG. 3. Grant's Hill Tunnel, lower left, and Pennsylvania Railroad Tunnel, upper right, encountered while excavating for foundation of the U.S. Steel Building (courtesy of the Historical Society of Western Pennsylvania).

than 40 contributions in the 240 page Bulletin for June 1980; it is entitled "The use of historic maps for the preparation of engineering geological maps in Flanders (Belgium)."

Ghent and Antwerp are the two Belgian cities that are featured. Each is underlain by anthropogenic material, in places to great depths, overlying Quaternary and Tertiary sediments. Both are ancient cities so that "cartobibliographical" studies had to precede a study of selected historical maps, so extensive is the archival material available. In the case of Ghent, 20 old maps were selected for detailed study, the first dated about 1560. Study of this invaluable collection led to the location of old, now buried, fortifications and of filled-in meanders of the River Lys that runs through the city. A portion of the resulting modern engineering geological map of the Sint-Pieters section of the lovely modern city is presented.

The maps and plans so used were found in the collections of the Royal Albert I Library in Brussels, the Municipal Archives of Ghent, the library of the University of Ghent, and archives of municipal technical services. The Royal Library and the Archives of Antwerp were used in a similar way for the study of the subsurface of the active modern port but ancient city of Antwerp, 10 maps being selected from those known to be available. Old extensive buried fortifications were again located in this way, as well as filled-in moats; a portion of the modern map of the Hoboken area of the city is reproduced. The authors of this useful paper conclude that "historic documents, especially maps and plans, may prove helpful instruments; if the planimetry is accurate, the time lapse between successive editions related to historic events not too large and scales readily adaptable, they form a very useful tool in geotechnical mapping" (De Breuck and van Burm 1980).

Centennial histories

North American cities have histories relatively so short in comparison with most of the cities of Europe that the example just quoted from Belgium, while useful in confirming the

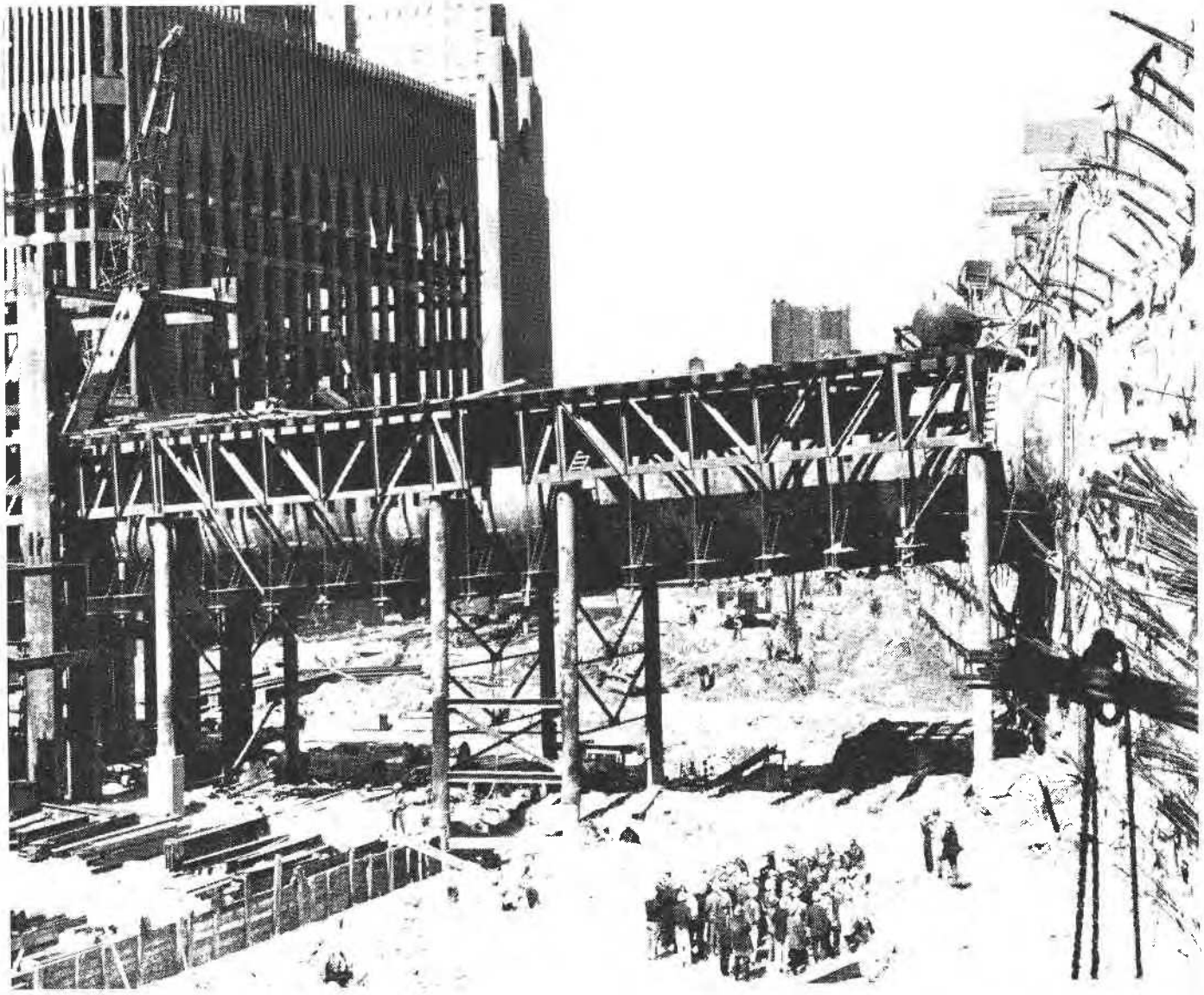

FIG. 4. Excavation for the foundations of the World Trade Center, New York City, the scale given by the figures in the group of visitors and the subway tunnel crossing the site; tieback anchors seen on the right.

general thesis of this paper, has little direct relevance to practice on this continent. There are historical documents available, however, even in North America. One series in the United States of America is so important and yet so little known that it warrants detailed description as a suitable conclusion to the examples herein given, all of which, it is hoped, illustrate some of the untapped resources available to geotechnical engineers.

When discussing the use of archival material in site investigation with a group of engineering geologists on the staff of the U.S. Corps of Engineers, generally along the lines of this paper, one of the writers (R. F. L.) was told by Mel Hill, formerly of the Buffalo District Office of the U.S. Corps of Engineers, of an experience he had when studying the site of a proposed dam in Missouri. One of the older residents of the area suggested that he should visit the local court house and examine their "old history." This he did, finding a thick, typewritten history of Benton County that proved to contain useful information about such geological features as springs, streams, and ponds, which gave clear indications of earlier groundwater conditions, as well as other geomorphological information of significant value. Upon examination, the original document was found to have been dated 1876; some more recent information had been added.

Further study has revealed that in January of that year, the year of the centennial of the United States of America, as part of the efforts made to mark that historic anniversary, Representative Hardenburgh introduced into Congress a resolution calling upon all counties to prepare histories of their areas as local centennial projects. The idea commended itself to Congress, as a result of which the President at that time—Ulysses S. Grant—issued a Proclamation on 25 May 1876. This is such a significant and relevant document in this context, and is so little known, that it may usefully be quoted in full:

> Whereas, a joint resolution of the Senate and House of Representatives of the United States was duly approved on the 13th day of March last, which resolution is as follows:
>
> Be it resolved by the Senate and House of Representatives of the United States in Congress Assembled: That it be and is

hereby recommended by the Senate and House of Representatives, to the people of the several states that they assemble in their several counties or towns on the approaching centennial anniversary of our national independence, and that they cause to have delivered on such day a historical sketch of such county or town from its foundation and that a copy of said sketch be filed in print or manuscript in the clerk's office of said county, and an additional copy in print or manuscript be filed in the office of the Librarian of Congress to the intent that a complete record may thus be obtained of the progress of our institutions during the first centennial of their existence. And whereas, it is deemed proper that such recommendation be brought to the notice and knowledge of the people of the United States; now, therefore, I, Ulysses S. Grant, President of the United States, do hereby declare and make known the same, in the hope that the object of such resolution may meet the approval of the people of the United States, and that proper steps may be taken to carry the same into effect.

Given under my hand at the City of Washington, the 25th day of May in the year of our Lord 1876, and of the Independence of the United States the 100th.

By the President:

U. S. Grant

Hamilton Fish, Secretary of State

Diligent search has been made for any general published account of these significant local records, but so far without success. In *The story up to now; the Library of Congress 1800–1946*, there is a brief reference to these local histories (p. 111). The following statement is quoted in this volume from the Annual Report of the Librarian of Congress for 1877:

> ... There have been received to date 225 historical memorials, which are carefully laid aside and catalogued for binding and preservation. While it may be regretted that the suggestion of Congress has not been to a larger extent complied with, no such contribution to our historical literature can be wholly without benefit.

A glance through one of these county histories, such as that for Benton County, confirms beyond doubt this very modest tribute.

Little known though they are, these invaluable guides to local history are listed in *United States local histories in the Library of Congress: a bibliography*. This is a five-volume work, edited by Marion J. Kaminkow and published in 1975 by the Magna Carta Book Company of Baltimore. The fact that this remarkable compilation lists about 90 000 items is some indication of the vast amount of information on local history that is available if one knows where to look for it. A copy of this bibliography is available in the National Library of Canada in Ottawa, and doubtless in other leading libraries of this country.

Although Canada has nothing comparable with the U.S. centennial county histories, there is available to Canadians an even wider ranging guide to the local histories that do exist than the Library of Congress bibliography just noted. This is a three-volume work with the general title *Canadian local histories to 1950: a bibliography*, the compiler being W. F. E. Morley of Queen's University, the publishers, the University of Toronto Press. The first volume, on the Atlantic Provinces, was published in 1967, the second, on Quebec, in 1971. The third volume, covering Ontario and the North, appeared in 1978. Volumes have been published separately for the Prairie Provinces and British Columbia. There are now available, therefore, for the use of Canadian geotechnical engineers, most useful guides to local histories, which, on occasion, may prove to be of use in the preliminary stages of site investigations.

Referencing

Each of the cases discussed in this paper has so many features unique to its locality that detailed illustrations (such as copies of local maps mentioned) would be of limited interest and use. Photographs have been included to add some corroborative evidence to the textual descriptions. The omission of any reproductions of maps or plans, however, has the regrettable consequence that no documentary references to maps are included in the list of references at the conclusion of the paper. The authors have been kindly reminded by Mrs. B. Kidd, Director of the National Map Collection in the Public Archives of Canada, that maps and plans, used as herein suggested, can, and should, be referenced in exactly the same way as are papers and books. Map archives are now a well recognized part of all leading archival collections, with their own excellent indexing systems. When maps or old plans are used as an aid to site investigations, therefore, every effort should be made to identify them clearly, for future reference and as the usual aid in any published account of the work in question. The paper by De Breuck and van Burm illustrates this matter with excellent references to the maps therein described.

Conclusion

In all site investigations, every effort should be made in preliminary studies to locate archival material which may contain information of use as a supplement to the overall picture of the local geology, without which no site work can be planned or should be started. Some indication has been given in this paper of some of the sources of such local archival material, which, on occasion, may prove to be of unusual value and which will always be of general use in presenting the background against which actual subsurface exploration may be conducted. Special attention should be given to the possible existence of old maps and plans, some of which may be found, on enquiry, to be still in private hands, although an increasing number are happily being placed in the custody of public archival collections. To some readers, this relatively simple but generally neglected procedure may appear to be out of keeping with modern advances in subsurface investigation. But, as one of those with whom the authors have had the pleasure of discussing the thesis of this paper (W. G. Hetherington of London, England) has pointedly observed, could it be that we are so obsessed with technology that we are ignoring history?

Acknowledgements

From the foregoing it is evident that the authors are greatly indebted to a number of friends for their help in providing useful information in support of the theme of this paper and they wish here to confirm their appreciation of this to all those mentioned in the text and with whom they were in personal communication. A special note of thanks is due to D. C. Tibbetts for drawing to the authors' attention the fine work of George Young.

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