Geotechnique in Calgary – A 60-year retrospective

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ABSTRACT
This paper describes heritage and foundation engineering aspects of the development of geotechnique in Calgary. It focuses on the post-1953 era, after Calgary's first geotechnical consulting firm was established, and on the development of the downtown core, where most of the high-rise buildings are located. Highlights include a short history of the Calgary Geotechnical Society, and a brief overview of the development in the city's downtown core including subsurface conditions, the types of foundations used, and some of the lessons learned.

RÉSUMÉ
Ce document décrit les aspects du patrimoine et du génie des fondations dans le cadre du développement géotechnique à Calgary. Il se concentre sur l'ère post-1953, après que la première firme de génie-conseil en géotechnique ait été établie, ainsi que sur le développement du centre-ville, où la plupart des grands édifices sont situés. Les faits saillants comprennent une courte histoire sur la société géotechnique de Calgary, ainsi qu'un bref aperçu du développement du centre-ville, incluant les conditions du sous-sol, les types de fondations utilisées et quelques-unes des leçons apprises.

1 INTRODUCTION

The authors have long believed that connecting with our heritage fosters a sense of identity and pride. Also, as members of a profession that relies heavily on empiricism, we are well aware of the importance of re-examining past projects and learning from our experiences. Furthermore, as ably summarized by Petroski (2001), we believe that the degree to which our profession's history is known, remembered, preserved, and honoured influences how we are acknowledged and respected outside of the confines of our practice.

As anyone who tries to summarize the history of a place or a group knows, the task is both wide and deep, and discovering the full story is difficult. Each new finding generates new questions. In the end, leaving gaps and neglecting contributions is unavoidable. While the title of this paper may suggest completeness, in fact, we present it as an introduction to the topic, and hope that others will continue writing where we left off, filling in some of the gaps. We also apologize for any omissions or inaccuracies.

2 HERITAGE

2.1 Origins

The city of Calgary had its origins in tiny Fort Brisebois, a police outpost constructed by the North-West Mounted Police in 1875. It was renamed Fort Calgary in 1876. The arrival of the Canadian Pacific Railway (CPR) in 1883 was a key factor in the growth of Calgary as an urban centre. Although it was incorporated as a town in 1884, and as a city in 1894, it appears that no major buildings were constructed until the early 1900s, during one of the city's many economic booms. An important building constructed during that time that remains in use today is the Palliser Hotel (currently known as the Fairmont Palliser). It was designed by Architect Lawrence Gotch (of E. and W.S. Maxwell of Montreal), and constructed for the CPR between 1911 and 1914 by the Peter Lyall and Sons Construction Company, also of Montreal. The original hotel was 12 storeys, with an additional three floors and a penthouse added in 1929 (Bobrovitz, 1998). It stood as Calgary's tallest building until 1958 (wikipedia.org). Like many other historic buildings constructed in what is now downtown Calgary, the Palliser Hotel was built on footings and likely without the benefit of any formal geotechnical input.

2.2 The Modern Era

The birth of modern geotechnique in Calgary – as in the rest of Alberta – is closely associated with Dr. R.M. (Bob) Hardy (1906-1985). Hardy graduated in civil engineering from the University of Manitoba in 1929, and later completed a Master's degree in structural engineering at McGill University. He joined the Faculty of Engineering at the University of Alberta as a sessional lecturer in 1930, and became an associate professor in 1937. Hardy took a sabbatical in 1939-1940 to pursue post-graduate studies in soil mechanics at Harvard University under Arthur Casagrande, after which he returned to the University of Alberta. In 1946, he was appointed chair of the Department of Civil Engineering, and dean of the Faculty of Engineering (Leonoff, 1994; Harris, 1997).

For Hardy, the line between the academic and consulting worlds was a thin one. Although he was based in Edmonton, he was involved in a considerable amount of work in southern Alberta dating back to the 1940s, especially highway and airport construction incidental to

the war effort (Goodman, 1981). In 1951, Hardy and Leroy "Chick" Thorssen (1916-1996) established Materials Testing Laboratories (MTL) in Edmonton (Leonoff, 1994). In 1953, Keith S. Goodman (1921-2010) was transferred from Edmonton to Calgary to open MTL's second branch. Despite its name, MTL engaged in much more than materials testing, undertaking numerous assignments related to foundation engineering and slope stabilization (Goodman, 1981). MTL appears to have been Calgary's first geotechnical firm, and Goodman likely has the distinction of being Calgary's first geotechnical engineer.

MTL remained active until 1972, when its operations were consolidated under its parent company, R.M. Hardy and Associates (Photo 1). The firm went through several mergers and acquisitions over the years, and is currently part of AMEC Environment & Infrastructure, one of the leading geotechnical groups in the city.

Photo 1. (Left to right) Jack Clark, Keith Goodman, Harold Morrison (standing) and Bob Hardy at an R.M. Hardy & Associates business meeting in 1972 (Harris, 1997).

2.3 The Calgary Geotechnical Society

The 1960s were exciting times for those interested in soils. The Sixth International Conference of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) was held in Montreal in 1965, spawning interest in geotechnique across Canada.

In Calgary, a construction boom in the 1960s proved to be the source of many foundation-related issues that challenged established beliefs and stimulated innovation. Ongoing projects at the time included new buildings at the University of Alberta's "Calgary Branch" (as the University of Calgary was known prior to 1966), the Foothills Provincial General Hospital (now called the Foothills Medical Centre), and the 626-foot tall Husky Tower (presently known as the Calgary Tower; see Section 3.2 below).

In 1966, the Soil Mechanics Interest Group (later to become the Calgary Geotechnical Society) was formed (Clark, 2003). Its original participants included academics and practitioners in geotechnical and structural engineering, geology, groundwater, geophysics and geography. Key members were J.I. (Jack) Clark, P.Eng. (1932-2010), Henry H. Ricketts, P.Eng. (1917-2010), and Peter Gretener, P.Geol., P.Geoph. (1926-2008).

Clark was well known in the geotechnical community, having made a wealth of contributions to our profession. He was editor of the Canadian Geotechnical Journal from 1988 to 1992, and became a Fellow of the Canadian Academy of Engineering in 1992. Clark's many awards included four honorary doctorates, the Canadian Geotechnical Society R.F. Legget Award in 1983, and the Order of Canada in 2003. He also received the Calgary Geotechnical Society Award in 2003 (Photo 2, below).

Ricketts was a structural engineer involved with the design of the Husky Tower. His consulting firm, Ricketts, Evers & Associates, is recognized as the structural designer of the tower (calgarytower.com). It was later absorbed by the Simpson Lester Goodrich Partnership, which eventually became part of the current Stantec Group (Clark, 2003).

Gretener (or "Pore Pressure Pete", as he was fondly known amongst his colleagues at the University of Calgary) was an academic who believed strongly in inter-disciplinary dialogue. He was an enthusiastic teacher who was concerned with sustainability and the environment long before it was in vogue (The Calgary Herald, 2008; Osborn, 2014).

Photo 2. Dr. Jack Clark (centre) receiving the Calgary Geotechnical Society Award from Heinrich Heinz (left) and Brad Ellingwood (right) in 2003.

The activities of the Calgary Geotechnical Society intensified in the late 1960s and early 1970s, as newly realized possibilities for developing and transporting Arctic oil and gas generated much local discussion and study (see section 2.4 below). The group, in cooperation with the University of Calgary, was instrumental in organizing the Calgary-Banff Canadian Geotechnical Society Conference in 1970. The society also hosted numerous world-renowned consultants to speak at its monthly meetings, including Nathan M. Newmark (1910-1981), Frank E. Richart (1918-1994), and G. Geoffrey Meyerhoff (1916-2003).

The Calgary Geotechnical Society continues to be very active today. It has hosted national conferences in 1980, 1992, 2001 and 2010, as well as periodic symposia on topics of local interest. Presentation meetings take place each month and attendance is free thanks to funding by local geotechnical consultants and contractors. The annual schedule of presentations includes two Cross-Canada Lecture Tours (CCLTs) sponsored by the

Canadian Foundation for Geotechnique, as well as a keynote presentation by a distinguished geo-professional at the group's Annual General Meeting each spring.

The Calgary Geotechnical Society Award was introduced in 1998 to recognize individuals who have demonstrated exceptional effort, energy, and/or contributed to the art of geotechnique in Calgary. The first recipient was Milos Stepanek, P.Eng., a geological engineer who, together with Hardy and Clark, conducted several landmark slope stability and slope stabilization studies in the Calgary area (e.g., Hardy et al., 1980). In 2004, a Student/EIT Award was initiated to provide financial support for a graduate student, engineer, or geoscientist in training to attend the annual national conference of the Canadian Geotechnical Society. The intent of the award is to encourage young professionals to join in the society's activities and to become its future leaders.

2.4 Northern Developments

Following the 1968 discovery of oil in Prudhoe Bay, Alaska, an increase in exploration in northern Canada generated widespread interest in geotechnical issues associated with northern developments. In 1969, the Associate Committee on Geotechnical Research of the National Research Council of Canada (NRCC) organized a conference on permafrost problems related to mining and oil and gas production in the North. The conference was held at the University of Calgary and attracted around 380 participants from across North America (NRCC, 1969), with Dr. Bob Hardy chairing one of the sessions. Keith Goodman and other icons of Canadian geotechnique such as Carl Crawford and Chuck Brawner were also in attendance.

Throughout the early 1970s, many highly skilled engineers were attracted to Calgary to study the technological and economic feasibility of constructing crude oil and gas pipelines from Alaska and northern Canada to Alberta, mostly through permafrost areas. Notable "paper pipelines" include the Beaufort Delta oil pipeline project, the Canadian Arctic Gas Project (commonly referred to as CAGSL), Polar Gas East, Foothills (South Yukon) pipeline project, Dempster Highway lateral, and the Polar Gas West (Oswell, 2014).

Those projects routed along the Mackenzie Valley were placed on hold as a result of the Berger Inquiry report released in mid-1977. That Inquiry recommended a ten year moratorium on pipeline construction while the First Nations land claim issues were to be resolved. Subsequent economic imperatives and discovery of hydrocarbon reserves in southern Canada have essentially stranded the northern gas and oil resources. Government approval for the Mackenzie Gas Project was granted in 2010, following numerous engineering and environmental studies undertaken by Calgary-based consulting teams.

In the early 1980s, a small diameter (302 mm) oil pipeline was proposed, approved and constructed from Norman Wells, Northern Territories, to Zama Lake, Alberta. This oil pipeline was designed in Calgary by local engineering consultants. It remains in operation as of today and is one of the few pipelines in permafrost terrain designed on strain based principles (Oswell, 2014).

The Arctic Institute of North America at the University of Calgary is a repository of much of the engineering and environmental studies and regulatory documentation from the pipeline studies in the 1970 and early 1980s.

Continued interest in the arctic reserves in the 1970s led the federal government to establish programs to promote geological, geophysical and geotechnical research in the area (e.g., Hill et al., 1990). These efforts, as well as those of the oil and gas industry, resulted in numerous contributions to both onshore and offshore geotechnique by Calgary-based geotechnical engineers (e.g., Jefferies et al., 2007).

3 DOWNTOWN DEVELOPMENTS

3.1 Geology

The Calgary downtown area has been built on a relatively flat alluvial terrace, where the overburden soils, which contain both fill and alluvial sediments, are frequently generalized as "Bow River Gravels". A deep pre-glacial channel has been identified running approximately northwest to southeast, and bisecting the city's core area roughly in half (Oswell et al., 1998, Thurber, 2007).

Over the eastern portion of the channel, the gravels are in direct contact with bedrock, at a depth in the order of six metres below ground surface. On the west side of the pre-glacial channel, the surface of the bedrock is deeper, with the thickness of gravels remaining roughly the same. The channel is infilled with fine-grained silt and clay sediments which have been alternately termed till and/or glaciolacustrine. The nature of these fine-grained soils is complex, and they have been associated with geotechnical issues, as discussed below.

The surficial soils are underlain by bedrock belonging to the non-marine Paskapoo Formation, of Tertiary age, and comprise mostly sub-horizontally bedded weak sandstones, siltstones and mudstones. The groundwater table (GW) is generally above the bedrock and the silt and clay sediments. A conceptual West-East stratigraphic section, based on published data, is shown on Figure 1.

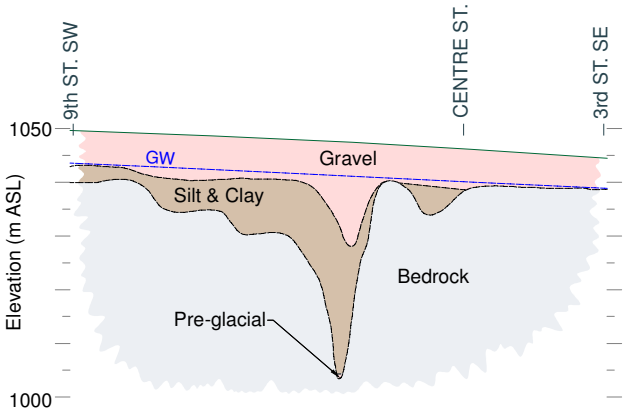

Figure 1. West-East stratigraphic section of Calgary's downtown core along 8th Avenue (Thurber, 2007).

3.2 Buildings

As noted above, construction in the 1960s included the 626-foot tall Calgary Tower (Photo 3). The tower's shallow, ring foundation on Bow River floodplain gravels was the subject of several advanced technical studies. Completed in 1968, the Calgary Tower is reportedly the first project in Calgary for which reliable data on both *in situ* ground properties and settlement performance were obtained. This provided the basis for more economical designs in the city's downtown core, which at that time was experiencing rapid development (Clark, 2003). The late 1960s also witnessed the construction of the 36-storey International Hotel, reportedly the first major high-rise structure since the Palliser Hotel built half a century earlier (Semchuk, 2003).

Photo 3. Construction of the Husky Tower in 1967 (Glenbow Archives)

Oswell et al. (1998) published a comprehensive review of the historic developments in downtown Calgary; however, their paper is unfortunately not well known. According to these authors, during the 1960s the majority of the buildings constructed in the downtown core were found on spread and strip footings based on the upper sands and gravels. Allowable bearing capacities were initially limited to a range of 200 kPa to 300 kPa, but as experience and knowledge increased, these values were increased to up to about 700 kPa.

After 1970, basements of new structures in the city's core area began to become deeper due to the city's requirement for off-street parking (Semchuk, 2003). That stimulated the development of a local practice of shoring, as well as pre-construction and permanent dewatering systems. Oswell et al. (1998) noted that historically, the most common method of supporting deep excavations in downtown Calgary has been with soldier piles and timber lagging. In the early 1970s, the soldier piles consisted of pipe piles which were driven into the ground and the lagging was connected to the face of the pipe piles with "Nelson studs". By the mid-1970s the pipe piles were replaced with steel H-sections. Drilled cast-in-place tangent and secant pile walls are nowadays used for deep excavations, as well as soil nailing; however soldier piles with tie-back anchors seem to remain the method preferred by local contractors.

It is interesting to note that the silt and clay unit shown on Figure 1 sometimes displays a very high silt content (around 90% silt has been measured), and is essentially cohesionless. Silt horizons below the groundwater table can run through the timber lagging boards of conventional soldier pile walls, creating significant loss of ground. Such was the case during the 1987 excavation of the east Bankers Hall tower underground parkade, where the shoring walls tilted, a crane toppled, and cracks formed along 9th Avenue SW (Osborn and Rajewicz, 1998). This resulted in extensive litigation, which was finally resolved in 1998, with a judgement in favour of the geotechnical engineers and the shoring contractor (Court of Queen's Bench of Alberta, Action No. 8901-05540, February 13th, 1998).

The 52-storey Bankers Hall towers, as well other tall structures such as the First Canadian Centre (41 storeys) were founded on the silt and clay unit and incorporated raft foundations. A few other buildings such as the Western Canadian Place tower were supported on rock socketed piles (Semchuk, 2003). The recently completed 58-storey Bow Tower is also founded on a raft, placed on weak bedrock. A few papers have been published on the excavation and shoring system of this project, and raise the potential issue of occurrence of a shear band in the layered bedrock (Lo, 2011).

4 CLOSURE AND ACKNOWLEDGEMENTS

In 1998, a "Heritage Working Group" was formed within the Calgary Geotechnical Society, led by Heinrich K. Heinz and Tai T. Wong, members of the Group's Executive at the time. The working group remains unofficially active, and the writers hope this introductory paper will trigger some interest in its resurgence.

Over the years, information was collected from various sources, and interviews conducted with individuals involved with the development of geotechnique in Calgary. The writers would like to acknowledge the contribution of a number of individuals to this paper, in particular the late Dr. Jack Clark, Mr. Walter Semchuk, Dr. Jerry Osborn, Dr. James Oswell, Dr. Dennis Becker, and Mr. Douglas Goodman. A number of other active and retired engineers have provided information which the writers plan to incorporate in future heritage-related papers.

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