HISTORY OF GEOTECHNIQUE IN CANADA

CGS – Diamond Jubilee Conference

24th October, 2007

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The 2007 Diamond Jubilee Conference is a milestone in Canadian Geotechnique. It is an opportunity to briefly review our history and accomplishments during the 60 years following the first conference that was held in 1947. First we acknowledge some of our pioneers who taught and practiced soil mechanics prior to this time.

Pioneers

Prof. I.F. Morrison (1889-1958)

Figure 1. Prof. I.F. Morrison (1889-1958)

I.F. Morrison came from Massachusetts to the University of Alberta in 1912 as a lecturer in civil engineering and became Professor of Applied Mechanics in 1922. He taught himself German and translated the German edition of Terzaghi's book "Erdbaumechanik" into English. Prof. Morrison recognized the importance of soil mechanics as an engineering subject and introduced a course on Foundations to the final year of civil engineering in 1925 in which he introduced some concepts of soil mechanics.

Prof. Morrison spent his whole career at the University teaching the first graduating class and every subsequent ones until his retirement. The University of Alberta awarded him an Honorary Doctorate of Laws in 1953 Convocation before he retired as Emeritus Professor in 1954.

Prof. R.M. (Bob) Hardy (1905-1985)

Bob Hardy graduated in 1929 from the University of Manitoba as a Gold Medalist in Civil Engineering, and obtained a M.Sc. degree from McGill University in 1930. He became a lecturer at the University of Alberta in applied mechanics in 1930 and introduced what was probably the first full course in soil mechanics in Canada in 1932. In 1939/40 he attended Harvard University. Returning to the University of Alberta, he started a soils engineering laboratory and became a leading authority in soil mechanics and foundation engineering. In 1943 he started the first graduate program in Geotechnical Engineering in Canada. Prof. Hardy held positions as Professor, Chairman of the Department of Civil Engineering, Dean of Engineering, Research Professor, and Professor Emeritus when he retired in 1971.

Figure 2. Prof. R.M. (Bob) Hardy (1905-1985)

Bob co-founded R.M. Hardy & Associates Ltd., in 1951, the forerunner of Hardy Associates (1978) Ltd. (Figure 3), which engaged in foundation engineering and design, construction of earth dams and airports, investigation of structural failures, muskeg and permafrost terrain constraints, pipeline construction, and mining of tar sands.

Figure 3. R.M. Hardy & Associates, Annual Meeting, 1972. L. to R. Jack Clark, Keith Goodman, Harold Morrison, Bob Hardy.

Dr Hardy received many honours and awards: the Engineering Institute of Canada's Keefer Medal in 1947, Fellowship in 1965, Julian C. Smith Medal in 1978, and the R.F.

Legget Award in 1971. He was a Fellow of the Royal Society of Canada, and an Officer of the Order of Canada.

Robert (Bob) Peterson (1918-1969)

Figure 4. Robert (Bob) Peterson (1918-1969)

Mr. Peterson graduated in Civil Engineering with Great Distinction from the University of Saskatchewan in 1939. He joined the Prairie Farm Rehabilitation (PFRA) on water conservation projects and developed a great interest in soil mechanics during his first year with them. He took graduate studies at Harvard University, earning a M.Sc. Degree in Civil Engineering in 1941. Upon returning to PFRA he became Chief Soil Mechanics and Materials Engineer responsible for all soil and concrete investigations and research, and the design of earthworks for numerous projects. He developed a highly expert Soil Mechanics Division which carried out geotechnical investigations and designed over 500 dams and projects. However, the instability of slopes in swelling shales due to rebound posed very difficult problems which could not be solved effectively using the Residual Strength Theory. He stated “In the solution of practical problems the use of empirical methods and personal experience with similar situations is often more reliable, a confirm-as-you-go approach may be more appropriate than a design-as-you-go approach”.

Bob Peterson was a pioneer who made a great contribution to the development of soil mechanics in Canada. The Canadian Geotechnical Society (CGS) honoured him posthumously by presenting him its first R.F. Legget Award in 1970. The same year the engineering building at the University of Saskatchewan was renamed the “Robert Peterson Building” in his honour.

Dr. Norbert (Nordie) R. Morgenstern.

Nordie graduated in Civil Engineering from the University of Toronto in 1956. He went to the Imperial College of Science and Technology in 1957 on an Athlone Fellowship where he conducted graduate studies in Soil Mechanics. He became a Research Assistant

in 1958 and Lecturer in Civil Engineering in 1960. He received a PhD in Soil Mechanics from the University of London in 1964 and a D.Eng. from the University of Toronto in 1983.

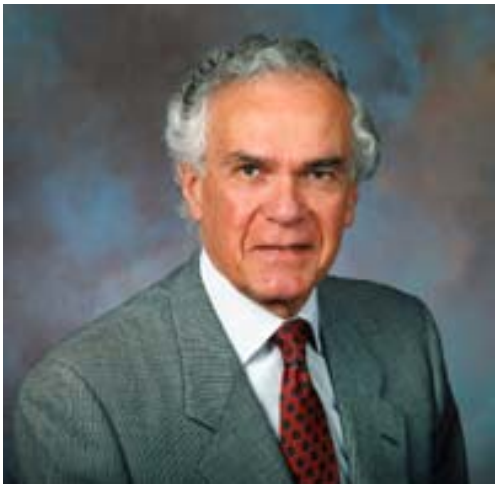

Figure 5. Norbert (Nordie) R. Morgenstern

Dr. Morgenstern joined the University of Alberta in 1968 where he became Professor of Civil Engineering and Chair of the Department of Civil and Environmental Engineering. He is recognized internationally as an authority on stability of slopes, landslides in shales, permafrost engineering, and on geotechnical problems associated with the development of the Alberta Oil Sands. He has worked in over 40 countries on six continents. He retired in 1999 and is presently Prof. Emeritus in Civil Engineering.

In 2001, a symposium was organized by Nordie's former students and colleagues at the University of Alberta, marking 40 years of teaching and research in Geotechnical Engineering (Figure 6).

Dr. Morgenstern is a Fellow of the Royal Society of Canada, the Engineering Institute of Canada (EIC) and Canadian Academy of Engineering (CAE), a past president of the Canadian Geotechnical Society (1989-90) and of the International Society for Soil Mechanics and Foundation Engineering. He received the R.F. Legget Award in 1979.

Figure 6. Norbert R. Morgenstern with his Former Students and Colleagues at the Symposium Organized by the University of Alberta marking 40 years of Teaching and Research in Geotechnical Engineering (April 26-27, 2001)

Dr. Jack D. Mollard

Figure 7. Jack Mollard

Dr. Mollard received Civil Engineering degrees from the universities of Saskatchewan (1945), Purdue (M.Sc, 1947), and Cornell (PhD, 1952). He joined PFRA in 1947 and worked for three years on air photo interpretation (Figure 8). He taught air photo interpretation at Cornell and Harvard Universities, and ran similar short courses at the

University of Alberta. The University of Regina conferred an honorary Doctor of Laws on him in 1995.

Figure 8. Jack Mollard, North of the Arctic Circle, 1975

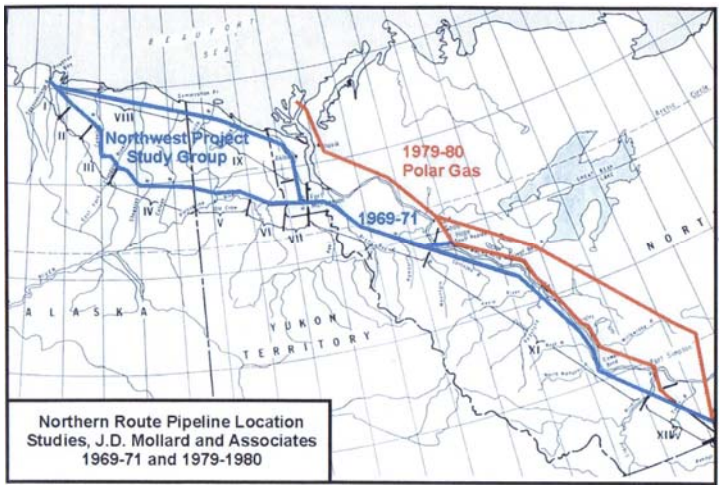

Figure 9. Northern Route Pipeline Locations from Air Photos

He formed J.D. Mollard and Associates in 1956 and has consulted on over 4000 assignments in Canada, six continents and on Mars. His research and consulting work have included locating construction materials for road construction, finding ground water for prairie towns, selecting town sites and transportation routes in Northern Canada and Alaska, prospecting, and the selection of oil pipeline routes through permafrost terrain (Figure 9).

Dr. Mollard is an active member of several professional and technical societies. While a member of the Fund Raising Committee of the Canadian Foundation for Geotechnique, our own charitable organization, he helped it back to financial stability.

Dr. Mollard has received the American Society of Photogrammetry and Remote Sensing Award, the Royal Canadian Geographical Society Massey Medal, and the R.F. Legget Award.

Branco Ladanyi

Figure 10. Branco Ladanyi

Dr. Ladanyi received a Diploma in Civil Engineering from the Technical Faculty of the University of Zagreb in Yugoslavia in 1947, and a Doctorate in Applied Sciences in Soil Mechanics from the University of Louvain, Belgium in 1959. He came to the University of Laval in 1962, and in 1967 joined Ecole Polytechnique, University of Montreal, where he is presently Professor Emeritus at the Department of Civil, Geological and Mining Engineering. He was in charge of the Northern Engineering Research and Documentation Centre of Ecole Polytechnique since 1972.

Branco has been a pioneer in his teaching, research and development of practical solutions in permafrost, rock mechanics, tunneling, and geotechnical engineering. Considered as “Mr. Permafrost” in Canada, he has built an international reputation collaborating with Alaska, Norway, Sweden, and Russia, where he conducted several important field studies and experiments to solve ice and permafrost problems (Figure 11). In Canada, he consulted on numerous projects such as the northern pipelines, major northern facilities, underground storage of liquid natural gas, and nuclear waste disposal.

Figure 11. Branko Ladanyi Testing the Strength of Sea Ice Cover in Newfoundland, 1990

Prof. Ladanyi has been very active with learned societies such as the Canadian Geotechnical Society and worked on numerous technical committees. He received numerous awards including the R.F. Legget Award, the Roger J.E. Brown Memorial Award, and the Julian Smith Medal. He is also a Fellow of several societies including the Royal Society of Canada, the Engineering Institute of Canada, and the Canadian Academy of Engineering.

Gordon C. McRostie

Gordon graduated in Civil Engineering from the University of Toronto in 1944. He came to Ottawa and found there was no demand for geotechnical engineers. About 1950, he left municipal engineering and surveying and began his own geotechnical engineering practice in Ottawa. At first there was little demand but it gradually increased with time. By 1960 he had a staff, laboratory, a drill rig, and was doing about 50 projects per year. Some early major projects included the construction of the Ottawa Queensway, and the Ottawa Interceptor Sewer Tunnel through sensitive marine clay (Figure 12). His consulting practice continued to grow and his services were always in demand. In 2005 his firm merged with Golder Associates Ltd. in Ottawa.

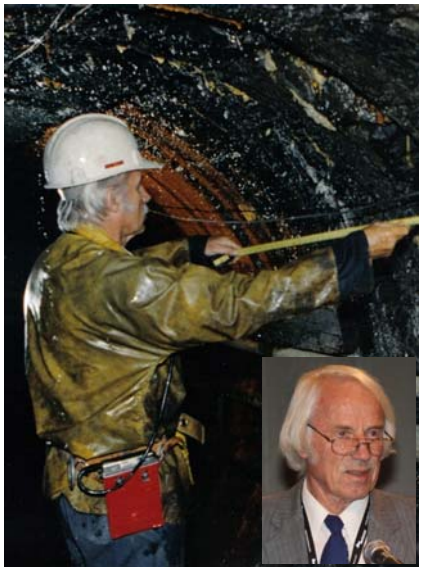

Figure 12. Gord McRostie Inspecting a Sewer Tunnel

Gordon helped organize the First Canadian Conference on Soil Mechanics and Foundation Engineering in Ottawa in 1947, and was one of forty to attend this historic event. He also helped to establish the Canadian Geotechnical Society (CGS). He worked on the organizing committee which formed the Geotechnical Engineering Division (GED) of the Engineering Institute of Canada in 1961. The Geotechnical Engineering Division began organizing the Annual Soils Conferences and in 1963 with Gordon McRostie as Chairman of the Division, organized the 16th Conference in Ottawa.

The Canadian Geotechnical Journal was started in 1963, and Gordon was one of 20 sponsors who signed a guarantee bond required by the publishers.

Gordon was recognized for his long continuing support for the Canadian Geotechnical Society and the geotechnical community by receiving the R.F. Legget Award in 1997.

Professor Hugh B. Sutherland

Hugh Sutherland attended the 1947 soils conference in Ottawa. At that time, he was studying at Harvard University and was a Research Associate for A. Casagrande on the Panama Canal Research Project. In 1946 he met Lionel Peckover of Division of Building Research (DBR), National Research Council of Canada (NRCC) who was also at Harvard at that time and was invited to Ottawa. Hugh met Dr. R.F. Legget, who was then the Director of DBR. Dr. Legget invited him to this first national soil mechanics conference along with L.F. Cooling and Geoff Meyerhof who came from the U.K. to participate.

Dr. Legget invited Hugh after he completed his studies at Harvard to work as a consultant at Steep Rock Iron Mines investigating the stability of varved clays, before he returned to Glasgow, Scotland. In 1949, Hugh came back to Canada to work on the traffic trolley bus vibration problems in Winnipeg, and as Advisor to the River and Streams Protection

Authority. Hugh was recognized for his assistance by being awarded an Honorary Citizenship of Winnipeg by Mayor Juba.

When he returned to the University of Glasgow, he became Head of the Department of Civil Engineering. He conducted research on the Winnipeg clays, and continued collaborating with his friends in Canada by frequent exchanges of visits and lecture tours. Hugh received numerous awards. The one he is very proud of is shown in Figure 13 receiving the Medal O.B.E., (Officer of the British Empire), from Her Majesty the Queen, in 2003, for "Services to Education and Engineering".

Figure 13. Hugh Sutherland receiving the Officer of the Order of the Empire (O.B.E.) Medal from Her Majesty, 2003

Professor George Geoffrey Meyerhof

Geoff obtained his B.Sc degree in Civil and Municipal Engineering in 1938 at the University College at the University of London. Later, he was awarded the Master of Science (Engineering) and Ph.D degrees in 1944 and 1950 respectively from the same university. In 1947 he became a member of the Foundation Research Committee of the Institution of Structural Engineers. In 1953, he immigrated to Canada to join the Foundation Company FENCO in Montreal. Geoff joined the Nova Scotia Technical College in 1955 where he became Dean of the Faculty of Engineering during the period 1964-1970.

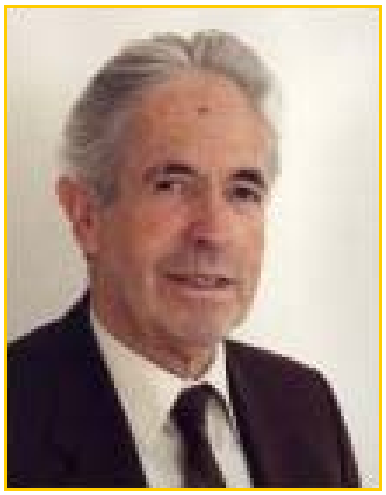

Figure 14. Geoff G. Meyerhof

Geoff is well known for his work in the area of bearing capacity and settlement behavior of piles. He was instrumental in encouraging the use of limit state design for geotechnical design and wrote a number of papers on this subject. He became the first President of the CGS (1972 – 74), and conducted two Cross Canada Lecture Tours in 1967 and 1983. He won the Legget Award (1974). The Meyerhof Award was instituted by the Canadian Geotechnical Society in 1995.

Associate Committee on Geotechnical Research of the NRCC

In 1945 during wartime, an Associate Committee on Soil and Snow Mechanics (ACSSM) was formed by the National Research Council to co-ordinate and to stimulate research on the engineering and physical aspects of the terrain in Canada with Prof R.F. Legget as Chairman. After the war, its work developed along the following lines: Soil Mechanics, Snow and Ice, Permafrost, Organic Terrain/Muskeg, Urban Terrain, and Marine Engineering. In 1965 the ACSSM was renamed the Associate Committee on Geotechnical Research (ACGR) which continued its mandate through established Subcommittees in each of these fields with the following terms of reference, "*to define problem areas in their assigned field, advise the Associate Committee on research needs, follow through actively in promoting research and assisting in the publication and application of the results of research*".

The Committee established local geotechnical groups in the major cities across Canada which later became the present sections/groups for the Canadian Geotechnical Society. They organized local geotechnical meetings, workshops and specialty conferences and hosted the Cross Canada Lecture Tour speakers.

In April 1947, under Dr. Legget's direction the Committee with help from G.C. McRostie, and F.L. Peckover, Head, Soil Mechanics Section of Division of Building Research (DBR), organized the first national soil mechanics conference in Ottawa to take advantage of a visit to Canada by L.F. Cooling and Geoff G. Meyerhof from the British Building Research Station. It was a successful conference with an attendance of forty representing most Canadian provinces, England and Scotland. It was the first of many conferences that evolved into the Annual Geotechnical Conferences. By 1960 it had become so popular that it was necessary to find alternative means for running them. In 1962 a Geotechnical Engineering Division of the Engineering Institute of Canada (EIC) was formed and it assumed responsibility for organizing the conferences. In 1972 this Division became the Canadian Geotechnical Society (CGS) which adopted the conference as its annual meeting.

The Canadian Geotechnical Journal was started by the Toronto Geotechnical Group with sponsorship of the National Research Council (NRC) through the Associate Committee on Geotechnical Research (ACGR) and through the Geotechnical Engineering Division of the EIC. Publication began in 1963. The NRC provided grants to help cover publication costs in 1967 and 1968. In 1969 the NRC assumed responsibility for publication of the Journal at the request of the Associate Committee on Geotechnical Research (ACGR).

A Canadian National Committee was set up with Dr. Legget as Chair to organize the sixth International Soil Mechanics and Foundation Engineering Conference (ISSMFE) in Montreal in 1965. Over two thousand delegates attended from all parts of the world. Approval was obtained from the ISSMFE and NRC to use the income from the sale of the proceedings to establish the Canadian Geotechnical Fund (CGF) in 1970. Revenue from the Fund was used to support the CGS Awards, the Colloquium Lecture, and the Cross

Canada Lecture Tours. In 1989 it was transferred to Geo Contributions, a self governing charitable organization (operating at arms length from Canadian Geotechnical Society), and in 2000 to the Canadian Foundation for Geotechnique (with similar terms of reference).

The ACGR and its subcommittees played a major role in the development of Geotechnique in Canada. Thanks are due to the dedicated effort of many individuals from various geotechnical disciplines, and the financial support from the National Research Council. The Division of Building Research (DBR) provided the secretariat for these Committees and for the Canadian Section of the ISSMFE.

On March 31, 1991 the ACGR was phased out. Golder Associates marked this historic event by hosting a special dinner at the Rideau Club in Ottawa on August 23, 1991 to honour the past chairmen, technical advisor, executive secretary and some special guests. (Figure 15).

Figure 15. Golder Associates Hosting a Special Dinner at Close of ACGR. L. to R. Carl Crawford, Victor Milligan, R.F. Legget, Bill Eden, Don Shields, Jack Clark, Michael Bozozuk, Lorne Gold, Tony Stermac

Robert Ferguson Legget, (1904-1994), Chairman (1945-66)

Figure 16. Robert F. Legget

Dr. R.F. Legget was born in Liverpool, Scotland in 1904. He graduated from the University of Liverpool with a B.Eng. in Civil Engineering and Geology in 1925, and an M.Eng. in 1927. He worked on construction projects in Scotland before coming to Canada in 1929. Dr. Legget worked in construction for a total of 11 years. He taught a further 11 years first at Queen's University and then at the University of Toronto where he initiated short courses and evening lectures on soil mechanics and foundation engineering for practising engineers.

Figure 17. R.F. Legget Testing a Carrying Seat for Wounded Soldiers, Switzerland, 1946

In 1947 Dr. C.J. Mackenzie, President of the National Research Council of Canada, knowing that Dr. Legget had a keen interest in research invited him to develop and direct a Division of Building Research (DBR) to support the Canadian building industry. Its purpose was to be a source of information based on world literature, supplemented by field and laboratory work on problems of special interest to Canada. DBR was officially opened in 1947! (60 years ago!). Under his direction DBR established the Associate Committee on the National Building Code. The original Code was updated, and revised every five years. By his retirement in 1969 the Code was in use across Canada.

Dr. Legget received numerous awards including the Royal Bank Award in 1994 for "*his outstanding accomplishments contributing to human welfare and the common good*". He was one of the founders of the Canadian Academy of Engineering. The Canadian Geotechnical Society (CGS) established its most prestigious "R.F. Legget Award" after him. Following his death in 1994 the Award was changed to the "R.F. Legget Medal" in 2000. In 1995 the National Research Council chose to perpetuate the memory of this man by renaming the Building Research Centre the "R.F. Legget Building".

He was appointed an Officer of the Order of Canada in1967 and elevated to Companion in 1989.

C.B. Crawford, Chairman (1966 -76)

Figure 18. Carl Crawford

Carl graduated in Civil Engineering from Queen's University in 1949, received a M.Sc. degree in Soil Engineering from Northwestern University in 1951, a DIC in Soil Engineering from Imperial College in 1957, and LLD, Honorary, from Concordia University, Montreal in 1984.

Carl joined the Soil Mechanics Section of DBR/NRCC as Research Officer in 1949. He was promoted to Head of the Section in 1953, Assistant Director of the Division (DBR)

in 1969 and Director in 1974, a position he held until his retirement in 1985. After 1985 he became Adjunct Professor of Memorial University of Newfoundland and University of British Columbia.

He was a keen researcher, with particular interest in the long term settlement studies of building foundations in clay soils. For example the Empress Hotel, Victoria, had experienced significant differential settlements since its construction. His paper of 1971 is based upon a long term settlement record spanning 65years!

Carl Crawford was an ardent supporter of professional and technical engineering societies, associations and Boards. He was recognized with numerous awards some of which are: the Hogentogler Award (ASTM), the Robert F. Legget Award (CGS), the Julian C. Smith Medal (EIC), and in 1994 became Fellow, Canadian Academy of Engineering.

Victor Milligan, Chairman (1983-88)

Figure 19. Victor Miligan

Mr. Milligan received a B.Sc. in Civil Engineering, Queen's University, Belfast, 1951, and a M.Sc., Soil Mechanics from the same University in 1952. He was a Research Fellow at Purdue University, USA, 1954-55. He was the co-founder and Principal of Golder Associates Ltd. in 1960, which became a world wide top geotechnical consulting firm. He became President in 1974 and Senior Principal in 1984.

Victor Milligan's contributions to the profession and community have been impressive. In particular, he was the founding Editor of the Canadian Geotechnical Journal started by the Toronto Geotechnical Group in 1963, and served in that capacity until 1968. Subsequently published by the National Research Council (NRC) from 1969, the Journal is considered today to be the top of its kind in the international geotechnical community. Mr. Milligan has received the R.F. Legget Award, the APEO Engineering Medal for Excellence, and the Julian C. Smith Award from the EIC.

Donald H. Shields, Chairman (1988-91)

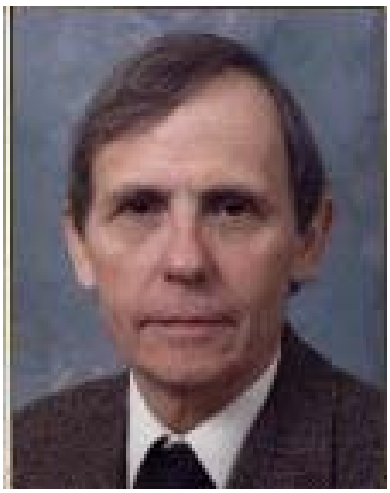

Figure 20. Donald H. Shields

During his term as Chairman Prof. Shields became aware that the Associate Committee on Geotechnical Research (ACGR) would be phased out in the near future. He was concerned that its closure could mean the loss of the Canadian Geotechnical Fund and its Account. He obtained permission from the NRC to transfer it to Geo Contributions under the auspices of the CGS. However, Treasury Board granted approval in 1989 for Geo Contributions to operate at arms length from the CGS as an independent not-for-profit charitable organization. On March 31, 1991 ACGR and all other Associate Committees of National Research Council (NRC) were closed.

Prof. Shields is a Past President of the Canadian Geotechnical Society (1977-78) and recipient of the R.F. Legget Medal in 2000.

William (Bill) J. Eden (1926-1994), Technical Advisor (1951-85).

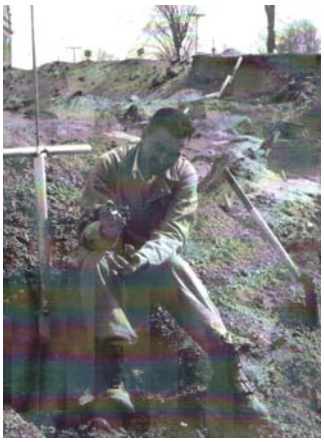

Figure 21. Bill Eden at Nicolet Landslide, 1955

Bill attended the University of Toronto and graduated in 1949 with a B.Sc., in Civil Engineering. Upon graduation he joined the Soil Mechanics (Geotechnical) Section of the Division of Building Research of NRCC, where he worked as a Research Officer until his retirement in 1985.He was meticulous in his research and worked on numerous projects in sensitive clays including landslides, farm silo failures, tunnelling (Figure 22), soil testing and sampling. He became well known nationally and internationally as the "Technical Secretary" of the ACGR.

Figure 22. Instrumenting a Steel Tunnel Liner for the Ottawa Sewer Tunnel. Bill Eden, Michael Bozozuk and Lynn Boyd, 1956

Bill was the founder of the Canadian Geotechnical Society News (CGS NEWS) and from the beginning nurtured it with great dedication. It kept everyone in touch and well informed which helped to develop and strengthen our geotechnical community. A real pioneer! In 1983 CGS News was replaced by Geotechnical News, published by John W. Gadsby. He became a Fellow of the Engineering Institute of Canada (EIC) in 1989.

Jack I. Clark, Chairman of Geotechnical Research Board.

Dr. Clark is a graduate of Acadia University in math-physics, and in Civil Engineering from Nova Scotia Technical College, 1957. He took graduate studies from University of Alberta and obtained his Ph.D. from Nova Scotia. In 1993 he received an honorary Doctor of Engineering degree from the Technical University of Nova Scotia.

He started his career in 1957, worked for R.M. Hardy Associates, Golder Associates, and J.I. Clark and Associates. Since 1984, Dr. Clark has been President and CEO of C-CORE

- Centre for Cold Ocean Resources Engineering and developed it into a world class research corporation.

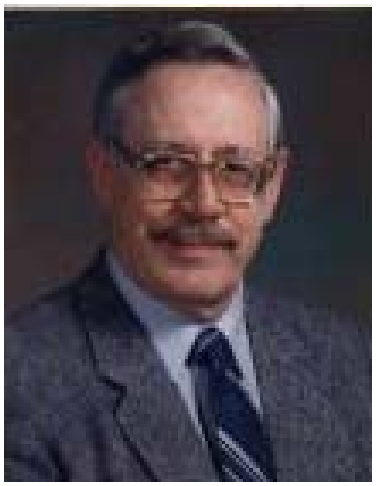

Figure 23. Jack I. Clark

In addition to his professional practice on many civil engineering projects, Jack continued his research in geotechnical engineering, particularly in the solution of permafrost problems. He consulted on numerous major projects such as Hibernia, the Vancouver Sky Train, and the Confederation Bridge.

Jack is a Past President of the CGS (1979-80) and Past Associate Editor of the Canadian Geotechnical Journal. Jack received the R.F. Legget Award, was appointed an Officer of the Order of Canada, and on October 11, 2006, C-CORE honoured him by renaming its Centrifuge Building the “Dr. Jack Clark Geotechnical Engineering Building”.

Michael Bozozuk. Executive Secretary, (1985-91)

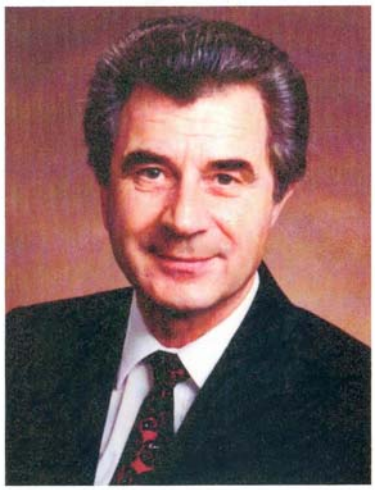

Figure 24. Michael Bozozuk

Mike graduated from the University of Manitoba with a degree in Civil Engineering in 1952, and a M.Sc., for Soil Mechanics in 1954. In 1972 he received a Ph.D., in Geotechnical Engineering from Purdue University.

In 1953 he joined the Division of Building Research of NRCC as a Research Officer in the Soil Mechanics Section where he worked until his retirement in 1989. He conducted research on numerous projects involving sensitive clays such as the consolidation settlement of structures and earth fills, damage of house foundations by trees, bearing capacity failures of farm tower silo foundations, landslides, tunnelling, negative skin friction on piles, in-situ soil testing and field instrumentation (Figure 25) . Many of the projects were carried out in cooperation with researchers from several Canadian universities.

Figure 25. Load Testing a 49 m Floating Instrumented Steel Pipe Pile Preloaded by Downdrag over 10 years, Berthierville, 1980.

Mike maintained an active interest in Society affairs, university programs and technical committees. He was Chairman of the Ottawa Geotechnical Group, Associate Editor of the Canadian Geotechnical Journal, Vice President and Executive Director of the Engineering Institute of Canada (EIC), and President of the Canadian Geotechnical Society (1987-88). He was Treasurer of the Canadian Geotechnical Fund, President of Geo Contributions and Canadian Foundation for Geotechnique.

Dr. Bozozuk received Fellowships from the Engineering Institute of Canada (EIC), Canadian Academy of Engineering (CAE), Canadian Society of Civil Engineers (CSCE), Canadian Society for Senior Engineers (CSSE), and the following awards: the John B.

Stirling Medal and the Canadian Pacific Railway Engineering Medal from the Engineering Institute of Canada (EIC), and the R.F. Legget Medal from the Canadian Geotechnical Society.

Anthony G. (Tony) Stermac (1921-2002), Director General of CGS.

Figure 26. Anthony G. Stermac

Tony, a Civil Engineering graduate from the University of Zagreb in 1949 and assistant professor, came to Canada from Croatia in 1960. He joined the Department of Highways of Ontario (Ministry of Transportation) and served in increasingly senior positions, retiring in 1987 as Director of the Transportation Technology and Energy Branch.

He helped start the Canadian Geotechnical Journal, and served as its Associate Editor and Editor for a number of years. He served on the National Research Council (NRC) Committee for revisions to the National Building Code of Canada and was instrumental in obtaining the Canadian Foundation Engineering Manual for the Canadian Geotechnical Society, publishing the first edition in 1978.

Tony Stermac, was President (1983-84) and Director General of the Canadian Geotechnical Society (CGS). In 1976, he received the R.F. Legget Award. He is a Fellow of the Engineering Institute of Canada (EIC) and was awarded its John B. Stirling Medal in 1996. In 1999 the Canadian Geotechnical Society renamed its Distinguished Service Plaque the “A.G. Stermac Award” for service to the Society.

Lorne W. Gold, Chairman (1976-83)

Figure 27. Lorne W. Gold

Lorne graduated from the University of Saskatchewan in 1950 with a B.Sc., in Engineering Physics. In 1952 he obtained a M.Sc., in Physics from McGill University and later in 1970 received a Ph.D., from the same university.

In 1950, he joined the Division of Building Research, NRC, as Research Officer. In 1953 he became Head, Snow and Ice Section and in 1969 became Head of the Geotechnical Section. In 1974 he was appointed Assistant Director of DBR and in 1979 Associate Director. He retired in 1986, became a Guest worker in 1987 and Researcher Emeritus of the Council in 1988.

Figure 28. Lorne Gold (left) Demonstrating Trimming of Ice Specimens to Dr. Legget in the Cold Room, Snow & Ice Section of the Division of Building Research

Lorne's research contributions have been in the mechanics and physics of ice. However, he had a major influence on permafrost engineering by providing guidance and direction to the Permafrost Group at Division of Building Research (DBR) (Figure 28).

Dr. Gold worked on committees for the Royal Society, the Canadian Geotechnical Society Board, and was Associate Editor for the Canadian Geotechnical Journal. He supervised the compiling of the most extensive inventory of research projects in Canada's north and served three years as President of the International Glaciological Society.

He was recognized with Fellowships from the Royal Society of Canada, the Engineering Institute of Canada (EIC), Canadian Society of Civil Engineering (CSCE), Canadian Society of Senior Engineers (CSSE), and the Canadian Academy of Engineering (CAE). He received the Roger Brown Award from the CGS and the Leipholz Medal from CSCE.

Selected Projects

Permafrost

Permafrost underlies about one half of the land area of Canada and the problems it poses is a major consideration with regard to engineering design and construction when any northern operation or development is undertaken. Difficulties arise primarily from the ice contained in the perennially frozen ground. If thawing occurs because of natural or man-made disturbances, serious settlement and stability problems may result.

A major program to collect information on the occurrence and distribution of permafrost in Canada and to improve engineering design and construction of foundations in this ice rich frozen material was begun by the Division of Building Research, NRC. In 1953 two Research Officers, R.J.E. Brown and G.H. Johnston were engaged to spearhead the research (Figure 29).

Figure 29. The Permafrost Twins, Hank Johnston and Roger Brown

Roger J.E. Brown (1931-1980)

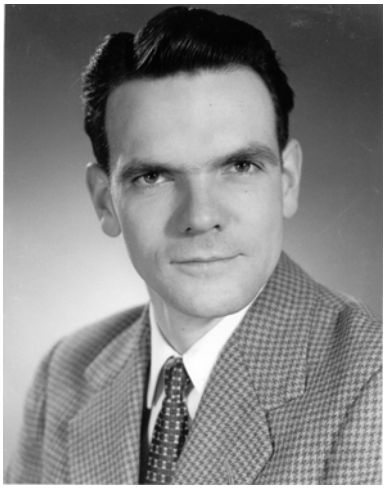

Figure 30. Roger Brown

Roger Brown received his B.A. (1952), and M.A. (1954) from the University of Toronto, and his Ph.D in geography from Clark University in 1961.He joined DBR in 1953 and immediately began studies to determine the distribution of permafrost in Canada and to investigate the climatic and terrain factors that affect the formation and stability of permafrost. Every summer was spent in the field and every winter in the office digesting the results of his field observations. Much of his detailed research was carried out at the new town of Thompson, Manitoba from 1959 onwards. From 1962 through 1968 he surveyed the southern boundary of permafrost from coast to coast traveling by aircraft, helicopter, canoe, train, car, and on foot. His extensive studies led to the production, in collaboration with the Geological Survey of Canada, of the Permafrost Distribution Map of Canada (Figure 31), published in 1967 and updated at later intervals. He is the author of a book "Permafrost in Canada, Its Influence in Northern Development" 1970.

In recognition of his meritorious work he was awarded the prestigious Queen's Silver medal in 1977 and the R.F. Legget Award in 1980. The Society honored him by establishing the Roger J.E. Brown Award in permafrost.

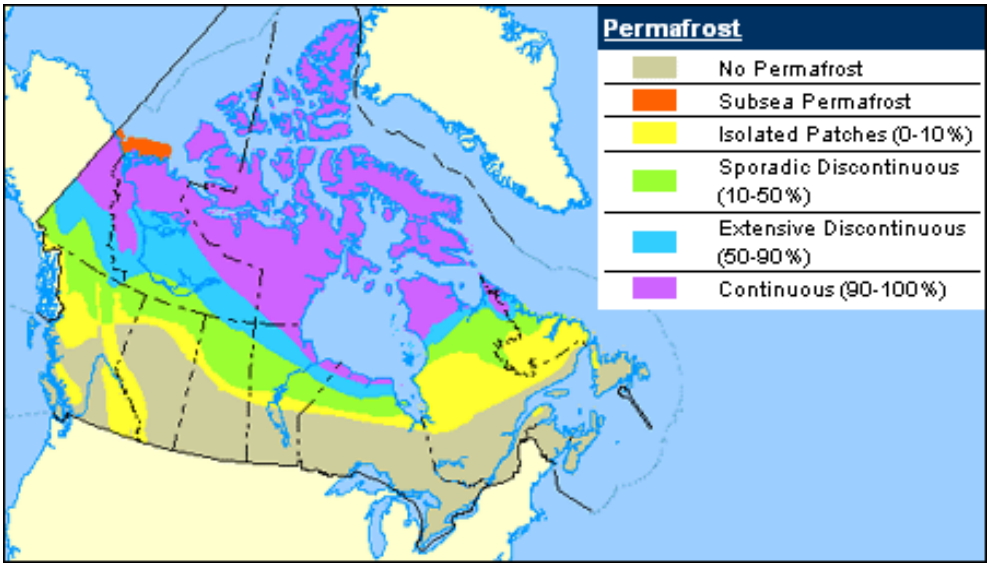

Figure 31. Permafrost Map of Canada

George Henry (Hank) Johnston (1927-1999)

Hank Johnston graduated in Civil Engineering from the University of Manitoba in 1953. In the spring of the same year he joined the DBR/NRCC and went directly to Norman Wells to work with Roger Brown and John Pihlainen. The three were pioneers in permafrost research and engineering in Canada, and in a few years laid a remarkable foundation of knowledge and experience for construction in the North. Hank's particular research interests were concerned with the construction and performance of foundations for engineering structures on permanently frozen ground. Initially, he was involved with

developing drilling techniques and equipment for permafrost and field procedures for photographing permafrost cores.

Figure 32. George Henry (Hank) Johnston

Figure 33. Hank Johnston at Yukon

Hank and his colleague John Pihlainen (1926-1964) were members of the survey team that relocated the old town of Aklavik to Inuvik in 1954, a new site on the East Channel

of the Mackenzie River. The site became a field laboratory where Hank's studied steaming in piles and measured the rate at which the ground refroze around them (Figures 34 and 35). A similar field program was carried out at Norman Wells.

Figure 34. Installing Wood Piles in Permafrost

Figure 35. Heavy Oil Reservoir Supported On Wood Piles in Permafrost

Hank was a Research Advisor and Chair of the Permafrost Subcommittee. He was closely involved with Canadian and International Permafrost Conferences, and a founding member of the International Permafrost Association. The accumulated knowledge and

experience on construction in the North was compiled by the Associate Committee on Geotechnical Research (ACGR) and published in 1981 in “PERMAFROST Engineering Design and Construction” of which, Hank was editor and a major contributor.

In recognition of his research contributions and work in the North, he was made a Fellow of the Engineering Institute of Canada (EIC) in 1989, and Fellow, Arctic Institute of North America in 1995.

Geotechnical Problems in Sensitive Marine Clays

Leda clay is the name often applied to a class of sensitive natural marine soils found extensively in the Ottawa and St Lawrence River lowlands. They range from Kingston, Ontario to east of Quebec City and south into New York State around Lake Champlain and beyond. A large percentage of Canada’s population lives in this huge land area.

The sensitivity of this clay is usually greater than 20, i.e., its undisturbed strength is more than 20 times its remolded strength, but often more than 100 (Figure 36). Its sensitive structure makes it difficult to measure its strength and deformation behavior for engineering purposes from both laboratory testing on “undisturbed” specimens and from in-situ field tests.

Figure 36. Sensitivity of Leda Clay

Landslides- St.Jean Vianney

Figure 37. Professors LaRochelle and Lo observing the St. Jean Vianney Landslide, 1971

In May 1971 a huge flow slide occurred at St.Jean Vianney which took 31 lives and destroyed 40 houses. Observing the disaster are Professors Pierre LaRochelle and Kwan Yee Lo from Laval University (Figure 37).

Pierre LaRochelle conducted graduate studies in Soil Mechanics at Imperial College of Science and Technology, London, England. When Pierre returned to Laval, he was responsible for the construction of a new laboratory building. It has since become one of the best geotechnical laboratories for graduate studies in Canada. Pierre received the R.F. Legget Award in 1977.

Kwan Yee Lo

Kwan Yee (Figure 38), left Laval in 1970 to join the University of Western Ontario. He continued teaching and extended his research to Soft Clay Engineering, Slope Stability, Tunneling in Soft Ground, Tunnels and Foundations in Rock, and Concrete Dams on Rock Foundations. In 2005 a special Symposium was held in his honor which covered his research in these fields.

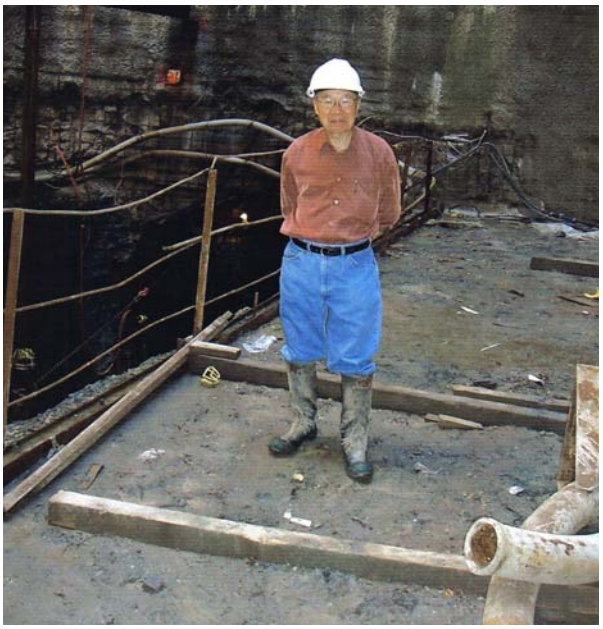

Figure 38. K.Y. Lo In His Field Uniform

Dr. Lo received numerous honors and awards including the R.F. Legget Award. In 1997 the Engineering Institute of Canada (EIC) (with a group of his former students) honored him by establishing the K.Y. Lo Medal to "*recognize significant Canadian engineering contributions at the international level*".

Bearing Capacity Failures of Farm Tower Silos

Concrete tower silos are popular farm structures used to store feed silage for cattle. To have the tallest silo became a sort of status symbol. Unfortunately as the height of silos increased, many began to settle and tilt and some overturned completely having exceeded the ultimate bearing capacity of the soil. Such failures provide a full-scale field test of soil strength. It was an excellent opportunity to test bearing capacity theories, but more importantly, to check out field testing equipment, soil sampling techniques and laboratory soil strength tests. Such studies were performed on a 70 ft (21.34m) high by 20 ft (6.1 m) diameter concrete silo at Vankleek Hill Ontario, which collapsed due to a bearing capacity failure, after it had just been filled for the first time with 540 tons (of corn silage) (Figures 39 and 40). The foundations of several new silos were also instrumented to measure settlements and distribution of pressures applied to the underlying soil during and after filling.

During the 1980s, in cooperation with the late Prof. J.P. Morin, University of Sherbrooke, the performance of 108 concrete silos founded on the marine clays in Quebec were assessed and correlated to the factor of safety against the ultimate bearing capacity of the soil. The results were incorporated into the Farm Building Code for the design of silo foundations on clay soils.

Figure 39. Bearing Capacity Failure of Farm Silo at Vankleek Hill, Ontario, 1970.

Figure 40. Heaved Foundation Soil due to Bearing Capacity Failure

Seven Outstanding Canadian Engineering Achievements

1. Artificial Oil Drilling Islands in the Beaufort Sea.

Figure 41. Oil Drilling from Artificial Island at Alerk, enclosed by Sea Ice in the Beaufort Sea

In the early 1970s oil exploration in the Arctic offshore regions proceeded rapidly, mostly driven by Gulf Canada, Esso Resources and Dome Petroleum. The deeper waters of the Beaufort Sea required solid structures big enough to house all oil drilling equipment and support staff, and resist the tremendous ice forces. Several kinds of structures were developed but the one at Tarsuit Island is the only “made in Canada” structure. It was made up of four 100 ft long concrete caissons built in Vancouver and towed to the drilling site (Figure 42). They were positioned over a large underwater berm previously prepared of hydraulically placed sand which created a firm level base to support the caissons and sunk to form an octagonal structure (Figure 43). The core was filled with sand forming a horizontal working surface for the drilling operations safely above the level of the surrounding water and /or ice.

Figure 42. Transporting Concrete Caisson to Drilling Site

Figure 43. Assembly of Four Caissons over Submerged Sand Berm

2. The Gardner Dam

In 1957 Prairie Farm Rehabilitation Administration (PFRA) started construction of the Gardner Dam on the South Saskatchewan River. It was a difficult project and the engineers held many review meetings with their consultants. Movements in the abutments and valley bottom became evident at the outset. Pore pressures appeared to be erratic and tilt meter measurements did not confirm surface movements. A distinct movement zone was found 60 m below the base of the dam in a soft bentonitic zone in the hard shale. It was decided to proceed slowly and to apply Peterson's "confirm-as-you-go design procedure".

Figure 44. Meeting of PFRA engineers and consultants for Gardner Dam, 1950: Top L. to R. Charles Ripley, Jim McMorrine, Jack Mollard, Gordon Watson, Arthur Casagrande. Bottom L. to R. Stewart Ringheim, Robert Peterson, Earl Nisbet

The dam was safely completed and officially opened in May, 1967 (Figure 45). It was 64 m high, 5000 m long and 1600 m wide at the base supporting a 225 km long reservoir (Lake Diefenbaker) in the middle of the Prairie. Its construction required 86 million cubic meters of excavation and 65 million cubic meters of earthfill, making it one of the largest earthfill dams in the world. It has been carefully monitored for 29 years. Gradually decreasing movements continued as the reservoir refilled each year, becoming negligible by 1996.

Figure 45. Gardner Dam and Lake Diefenbaker

3. The Red River Floodway

The Floodway is an artificial flood control waterway created by excavating a channel 47 km long. Construction started on October 6, 1962 and finished in March 1968. It was a major undertaking with 76.5 million cubic meters of excavated earth, more than the Canadian section of the St. Lawrence Seaway, or nearly half the excavation of the Panama Canal, or more than what was moved for the Suez Canal.

Figure 46. The Red River Floodway

The Floodway protection system includes dikes along the Red river through Winnipeg and the Brunkild Z-dike which was built during the "Flood of the Century" in 1997. The Z-dike extends westward from the south of the city over very flat terrain to direct the flow of floodwaters. During flood periods, the Floodway diverts part of the river's flow around the city to the east and discharges it back to the river to the north below the dam at Lockport. However, homes remained vulnerable outside the floodway (Figure 47).

The flood of 1997, a 1-in-300 year flood, equivalent to the one of 1826 the largest in Manitoba's history, inundated an area of about 2000 square kilometers up to 40 km wide in southern Manitoba (Figure 48). In 2005, work began to expand the Floodway and modify adjacent structures i.e., bridges and roads, to provide a 1-in-700 year level of flood protection.

Figure 47. South of the Floodway, the Water kept Rising

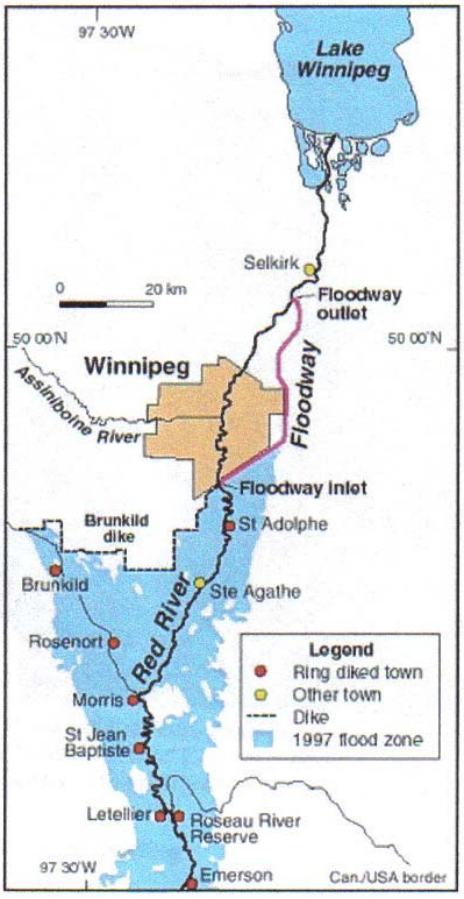

Figure 48. Map of Total Flooded Area, 1997

4. CN Tower

The CN Tower (Figure 49) is part of the Canadian National Railways Metro Centre redevelopment scheme located between the central business district of Toronto and the waterfront. Built between 1973 and 1975 to a height of 1815 ft. 5 in. (553.3 m), it was the world's tallest free standing structure. It is visible from a distance of over 20 miles (32 km), but its foundation, one of the Tower's most important parts is invisible.

Figure 49. The CN Tower, Toronto, Ontario

To provide the required geotechnical data for designing the foundation, four 30 in (762 mm) diameter inspection holes (Figure 50), were drilled into the shale at the centre and corners of the proposed tower to a maximum depth of 120 ft. (36.6 m). After scrubbing them clean and pumping out the water engineer-photographer Professor Eli I. Robinsky Project Consultant was lowered down each hole in a cable-cage to closely examine the rock strata. Outfitted in a silver waterproof suit (Figure 51), as part of his lighting equipment and carrying an oxygen tank, he inspected the rock formation, taking photos continuously throughout the depth of each borehole. At the bottom he installed deformation gauges to permit future studies of the static and dynamic response of the Tower to wind action.

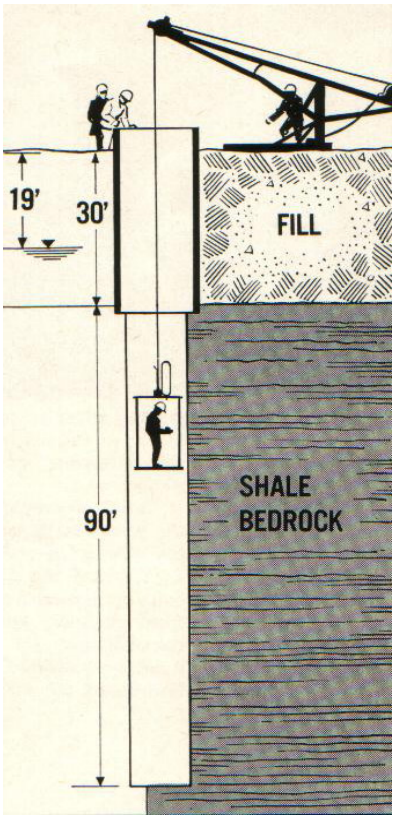

Figure 50. Drilled Inspection Hole

Figure 51. Eli I. Robinsky, In Silver Waterproof Suit before Descending Casing

The foundation was designed and constructed on a triradiate plan as was the Tower. It consists of three post tensioned sections each 62.1 ft (18,9 m) wide by 109.25 ft (33.3 m) long, founded 22 ft (6.7 m) into shale bedrock about 32 ft (9.75 m) below the level of Lake Ontario. It has supported the famous superstructure marvelously.

Eli I. Robinsky came to Canada from Syria in 1953 and received a Ph.D from the University of Toronto. In 1963 he joined the University, earning the title “Professor Emeritus of Civil Engineering” in 1992.

5. St Lawrence Seaway

The construction of the St. Lawrence Seaway was at the time, the most important public project in Canada in which geotechnical engineering played an essential part throughout. It was a shared operation between the St Lawrence Seaway Authority for Canada, and the St Lawrence Seaway Development Corporation with the U.S Corps of Engineers.

Figure 52. R.H. Saunders Dam, Height 53 m., Length 500 m., 1958

It consisted of seven locks, five built in Canada, and a deepened river channel from Montreal to Lake Ontario. In Canadian work alone 40 million cubic meters of earth and 18 million cubic meters of rock (Figure 53) were moved from this section of the project. Add to this the deepening of 43.4 km of the Welland Canal between lakes Ontario and Erie made it possible for ocean ships of 8.23 m draught to bypass Niagara Falls and access all the Great Lakes when the Seaway was opened in 1959. The total lift en route was 183 m.

F. Lionel Peckover was Head of the Soil Engineering Section responsible for all aspects of geotechnical exploration, design, and construction. Professor Jacques Hurtubise of Ecole Polytechnique was the Soil and Foundation Engineering Consultant, responsible for examining all soil samples and rock cores and performed all necessary engineering tests at the University.

In 1996 the Canal was commemorated with a plaque by the EIC for “An Outstanding Canadian Engineering Achievement”.

Figure 53. Dewatering Long Sault Rapids Revealed Huge Slabs of Dislodged Bedrock, Stacked Up Like Playing Cards

6. The Péribonka Dam

The construction of the Péribonka Dam (Figure 54) represents Hydro Québec's outstanding achievements. It is located on the Péribonka River about 100 km north of Chicoutimi. It is 80 m high with a crest length of 700 m. and has a plastic concrete cut-off wall 115 m deep. When the project is completed it will generate 385 MW (megawatts) of power, producing 2.2 TWh (tetra-watt-hours) annually.

Rémy G Dussault, ing. Project Engineer and Administrator, has participated in the construction of several major hydroelectric projects in Canada and abroad. He obtained a Civil Engineering degree from Laval University in 1961, and did post graduate work in engineering hydrology and soil mechanics at Imperial College, University of London under an Athlone Fellowship. He was the 100th President of the EIC during the centennial year in 1986-87, and Past President of the Athlone Vanier Engineering Fellowship. He is a Fellow of EIC, CSCE and ASCE, and was awarded the Sir John Kennedy and John B. Stirling medals two of the highest distinctions of the EIC.

Figure 54. The Hydro Electric Power Development at Péribonka, Québec

7. Confederation Bridge

Figure 55. Confederation Bridge, 12.9 km Long

The 12.9 km long “S” shaped structure (Figure 55) crosses over Northumberland Strait from Borden-Carleton on Prince Edward Island to Cape Jourimain in New Brunswick,

the longest multi-span marine bridge in the world spanning ice-covered waters. Its height is 40 m above the water except at the navigation span where it was increased to 60 m. In October 1993, the project was contracted to Strait Crossing Development Inc. who would own and operate the bridge until the year 2032 when the ownership returns to the Government of Canada.

The bridge was designed for a life of 100 years and constructed by Strait Crossing Joint Venture, a consortium of three firms. Golder Associates Ltd. geotechnical consultants were responsible for site investigations, laboratory testing, foundation design analyses and construction monitoring services

The main bridge deck and the pier foundations consist of special concrete components fabricated on land. The precast pier components were transported to each of 44 locations with the foundation pier being set onto its previously prepared foundation in bedrock. The bridge components consisting of 90 m long main girder segments weighing up to 7500 tonnes, and 60 m long drop in girders were transported and erected into place using the HLV Svanen, a one-of-a-kind heavy lift vessel.

The completed bridge contained three traffic lanes and a utilidor for electrical services, telephone, and other utilities (Figure 56). It was officially opened to traffic on June 1, 1997.

Figure 56. Entrance/Exit to Bridge

John L. Seychuk, President of the EIC and Michael Bozozuk Executive Director unveiled a plaque (Figure 57) to commemorate this historic event on behalf of the EIC and its Member Societies which read: “Confederation Bridge, An Outstanding Engineering Achievement. This Fixed Crossing Connecting Prince Edward Island and New Brunswick, Designed And Constructed By Strait Crossing Joint Venture Is A Great Tribute To Canadian Engineering”.

Figure 57. John L Seychuk, President and Michael Bozozuk, Executive Director Unveiling the EIC Plaque for "Outstanding Engineering Achievement", June 1, 1997

John L. Seychuk graduated in Civil Engineering from the University of Manitoba in 1954 and attended Imperial College in London on an Athlone Fellowship for post-graduate studies in geotechnical engineering. Upon his return to Canada he worked for several years at Geocon before joining a new geo-consulting firm of Golder Associates in 1961. John became its President, Chairman of the Board, and Life Member.

John is Past President of the CGS (1993-94), and EIC, and Vice President representing Canada, USA and Mexico on the ISSMGE Board of Directors. He received several awards including: the Governor General's 125th Anniversary of Canada Commemorative Medal, the R.F. Legget Medal, the Canadian Pacific Railway Engineering Medal (EIC), and John B. Stirling Medal (EIC).

Closing Comments

This presentation was just a fleeting glimpse of our history and heritage. Our heritage is our Geo Engineers, those named and unnamed who through their efforts and achievements/accomplishments, have succeeded to help make Canada the best country in the world in which to live.

Acknowledgements

The brief time allotted for the paper at the conference limited the number of cases that could be presented, and I regret not covering more. Difficult choices were made. I wish to thank the many friends who helped by contributing so much historic information. Furthermore, I wish to acknowledge the assistance from Professors K Tim Law and Sai Vanapalli, the conference Co- Chairs and thank them for their advice and assistance in preparing the manuscript. I also wish to thank W.R. (Bill) Schriever for donating historic photos from DBR, NRCC.