Conference reports

The 70th Canadian Geotechnical Conference and the 12th Joint CGS/IAH-CNC Groundwater Conference, Ottawa, Canada

GeoOttawa 2017, the 70th Canadian Geotechnical Conference and the 12th Joint CGS/IAH-CNC Groundwater Conference, was held at the Shaw Centre in Ottawa, Ontario from October 1 - 4, 2017. It was a successful event with over 900 delegates in attendance. The trade show was sold out with 75 booths, and 23 companies participating at all sponsorship levels. 400 papers were approved for presentation at **GeoOttawa 2017**, with authors from all over Canada and numerous countries around the world. The extensive conference program featured daily plenary sessions with well-known and respected keynote speakers, technical, specialty, and poster sessions, as well as a diverse range of short courses and workshops. The top contributors in the field were celebrated with awards and recognition throughout the week. On the 70th anniversary of the Canadian conference, outstanding Canadian Geotechnical Achievements were celebrated. The organizing committee led by Dr. Mamadou Fall, University of Ottawa, hosted a wonderful intellectually challenging and celebratory event.

An impressive group of keynote speakers were included in the program; Richard Bathurst, Professor of Civil Engineering at the Royal Military College of Canada, gave the CGS's R.M. Hardy Keynote Address, titled "*Load and Resistance Factor Design and Calibration for Simple Soil-Structure Limit States in MSE Walls*". Dr. Kamini Singha, from Colorado School of Mines, presented the IAH's Darcy Lecture. Her lecture was titled "*A Tale of Two Porosities: Exploring Why Contaminant Transport Doesn't Always Behave the Way It Should*". The Hydrogeology Lecture was given by Mark Jensen, Director of Deep Geologic Repository Geoscience and Research at the Nuclear Waste Management Organization, titled "*Radioactive Waste Management in Canada: The Role of Geosciences*", while the Geotechnical Lecture was presented by Robert Blair. Blair, a senior hydrogeologist and engineering geologist with a private consultancy in Ontario, lectured on "*Refinements in Bedrock Geology Understanding of Downtown Ottawa*". Dr. Greg Brooks of the Geological Survey of Canada, Natural Resources Canada delivered the CGS Lecture, "*Prehistoric Sensitive Clay Landslides and Earthquakes in the Ottawa Valley*". On the final day of the conference, delegates were treated to a lecture titled "*The geotechnical assessment of railway infrastructure reliability*" from the 2017 CGS Colloquium speaker, Dr. Michael Hendry. In addition to acting as Associate Director of the Canadian Rail Research Laboratory, and a Principal Investigator for the Railway Ground Hazard Research Program, Dr. Hendry is an Assistant Professor at the University of Alberta.

Before the conference started, **GeoOttawa 2017** offered four short courses and one workshop, which was an excellent opportunity for professionals and students to participate in a learning environment before the conference officially began. Excellent short courses were given on trenchless technologies, liquefaction and seismic remediation of dams, construction dewatering, aquifer test interpretation, and geotechnical and geoscience research grant applications.

In celebration of **GeoOttawa 2017** being the 70th annual Canadian Geotechnical Society conference, the Canadian Geotechnical Achievements initiative was a highlight of the week. A compilation of 29 significant geotechnical projects throughout the history of Canada were selected from numerous submissions by CGS members, engineering companies, and geotechnical professionals across the country. These projects were showcased during the Geotechnical Achievements Luncheon, and on posters for the duration of the conference. Selected achievements are highlighted in the following pages. The 29 projects showcased at **GeoOttawa 2017** are as follows:

- Kenney Dam; Kemao Tunnels and Powerhouse, British Columbia
- Confederation Bridge - Geotechnical Investigations and Foundation Design, New Brunswick / Prince Edward Island
- Beaufort Sea Islands - Design and Construction, Northwest Territories
- Empress Hotel - Foundation Settlement Measurements and Analyses, British Columbia
- Alex Fraser Bridge - Geotechnical Investigation and Design, British Columbia
- Deltaport Container Terminal; Caisson Wharf - Geotechnical Design and Construction, British Columbia
- Highland Valley Copper Tailings Dam - Geotechnical Design and Construction, British Columbia
- Seymour Falls Dam - Geotechnical Design and Seismic Upgrade, British Columbia

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- Terzaghi Dam - Geotechnical Design and Construction, British Columbia
- Underground Research Laboratory (URL), Manitoba
- Keele Valley Landfill Site - Geotechnical Engineering and Hydrogeology Design, Ontario
- Hwy 417/Mississippi River Twin Bridges - Geotechnical Investigation and Design, Ontario
- Toronto Subway System - Geotechnical Investigation and Design of Tunnels, Ontario
- Romaine-2 Hydroelectric Development - Asphalt Core Rockfill Design, Quebec
- La Grande Hydroelectric Development - Geotechnical Conditions and Designs, Quebec
- Manic-3 and Péribonka Dams - Deep Foundation Cutoff Walls, Quebec
- Transcona Grain Elevator - Failure and Righting, Manitoba
- Canadian Liquefaction Experiment Project (CANLEX), Canada
- St. Mary River Irrigation Project - Geotechnical Foundations, Alberta
- Kelsey Dam - Design and Construction of Water Retention Dikes on Discontinuous Permafrost, Manitoba
- District of North Vancouver – Geohazards Risk Management Program, British Columbia
- Downie Slide – Very Large Rockslide Stabilization Project, British Columbia
- Edmonton Light Rail Transit System - Geotechnical Excavations, Alberta
- Gardiner Dam - Geotechnical Conditions and Design, Saskatchewan
- Collaboration to Characterize the Quaternary and Cretaceous Deposits in Saskatchewan, Saskatchewan
- Steep Rock Iron Mine - Construction, Operation, and Decommission, Ontario
- Charles Creek - Debris Flow Mitigation Structure, British Columbia
- Glacier Skywalk - Geotechnical Investigation and Design, Alberta
- Les Terains Aurifères (LTA) - Cover with Capillary Barrier Effects to Control Acid Mine Drainage, Quebec

Further details and photos of each of the Canadian Geotechnical Achievements projects can be found on the CGS Instagram account. The CGS extends its thanks to Project Managers Doug VanDine and Lisa McJunkin, who were supported by Michel Aubertin and Mamadou Fall, for their extensive contributions to the project. In addition, we wish to thank the Review Committee of Jean Côté, Mamadou Fall, James Graham, Heinrich Heinz, Fred Matich, Suzanne Powell, and Doug VanDine, as well as Translators Valérie Fréchette, Thomas Pabst, and Michel Aubertin, and Poster Designer Hartley Facultad. Our appreciation goes out to those who submitted projects, as the final product would not have been possible without quality submissions from all over Canada. Everyone in the international geo-community are invited to attend and participate in the 2018 GeoEdmonton Conference 23-26 September 2017. Further details are available at http://www.geoedmonton2018.ca/.

Photo 1. Dr. Richard Bathurst receiving recognition from Dr. Mike Bozozuk for giving the opening keynote lecture, the Hardy Address

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Photo 2. Zhong Han (2nd from right) receiving his Graduate Student Presentation Award from (L to R) Dr. Dennis Becker, Canadian Foundation for Geotechnique, Dr. Sumi Siddiqua, Administrator of Student Competitions and Dr. Dharma Wijewickreme, President of the Canadian Geotechnical Society.

Photo 3. CGS President Dr. Dharma Wijewickreme giving opening remarks.

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Photo 4. Dr. Doug Stead, Simon Fraser University, receiving the R.F. Legget medal from Dr. Dharma Wijewickreme, the highest honour in the Canadian Geotechnical Society.

Photo 5. Colour night at Canadian War Museum.

Emily Fournier, Communications Coordinator of Canadian Geotechnical Society
Greg Simens, Editor for North America

Confederation Bridge
Geotechnical Investigations and Foundation Design

Geographical location

Confederation Bridge spans 12.9 km across the Northumberland Strait and provides a permanent link between Cape Tormentine, New Brunswick and Borden, Prince Edward Island.

When it began or was completed

Investigation, design and construction was carried out over 44 months. Assembly of the bridge was carried out over 11 months. Confederation Bridge officially opened in June 1997.

Why a Canadian geotechnical achievement?

When constructed, Confederation Bridge was the world's longest bridge over 'ice-infested' waters. The project is unique in that it was one of the earliest use of design, build, operate, and transfer project delivery in Canada. The bridge fulfilled a 100-year aspiration and promise of Canada to physically link Prince Edward Island to the mainland.

The foundation concepts for the bridge were developed by Keith Kosar and David Walter of Golder Associates, and were advanced with input from some of Canada's most renowned geotechnical engineers including Norbert Morgenstern, Jack Clark, Norman McCammon, Don Bassett, Victor Milligan, Dennis Becker and Ryan Philips. The ring footing foundation units had to be robust enough to withstand the harsh environmental conditions of the Northumberland Strait, yet economical and constructible within an unforgiving marine environment.

Key design issues included a bridge deck as high as 60 m above the sea water level, depth to seafloor up to about 35 m, large lateral and eccentric loads on the structures due to ship impact, wind, waves, and ice, complex geology and variable strength bedrock, and a short seasonal construction window due to ice and bad weather. The design used newly developed limit states methodology and was confirmed through numerical modeling, full scale field tests, and centrifuge modelling.

The bridge is operated by Strait Crossing Bridge Limited.

Submitted by

Keith Kosar (Kiewit Engineering Group), David Walter (Amec Foster Wheeler), and Dennis Becker (Golder Associates)

Key References

Kosar, KM, Burwash, WJ, Milligan, V and McCammon, NR. 1993. **Geotechnical foundation design considerations for the Northumberland Strait Crossing**. Proceedings CSCE Annual Conference, Fredericton, NB , pp 381–390.

Kosar, KM, Walter, DJ, and Burwash, WJ. 1994. **Design of foundations to resist high lateral loads for the Northumberland Strait Crossing**. Proceedings 4th International Conference on Short and Medium Span Bridges, Halifax, NS.

Becker, DE, Burwash, WJ, Montgomery, RA and Liu, Y. 1998. **Foundation Design Aspects of the Confederation Bridge**. Canadian Geotechnical Journal, Vol 35, pp 750-768.

Photographs

After completion of construction (1998).

Construction of large diameter battered drilled concrete shafts for approach spans (1994-1995).

Terzaghi Dam
Geotechnical Design and Construction

Geographical location

Approximately 20 km west of Lillooet, British Columbia

When it began or was completed

Construction began in 1955 and was completed and first filled in 1960.

Why a Canadian geotechnical achievement?

Terzaghi Dam, originally named Mission Dam, is located in the Bridge River valley approximately 45 km upstream of its confluence with the Fraser River. It is a 55 m high earth and rockfill dam that impounds the Carpenter Lake reservoir. Water from the reservoir is conveyed through two tunnels into steel penstocks to a powerhouse on Seton Lake approximately 410 m in elevation below.

Karl Terzaghi designed the dam. Site construction monitoring was carried out by Ripley and Associates (primarily Cyril Leonoff and Mark Olsen). Terzaghi Dam was arguably Terzaghi's most challenging project with considerable post-construction settlement predicted and the need for a massive grout curtain, unprecedented at the time, to cut off deep pervious soils.

After Terzaghi died in 1963, a commemorative issue of *Géotechnique* was published with just one technical paper Terzaghi and Lacroix, 1964). Terzaghi Dam was chosen for the commemorative issue because of the profound difficulties in understanding and adapting to the complex foundation conditions beneath the dam. In the words of Arthur Casagrande, "This project demanded more extensive use of Terzaghi's experience and professional knowledge ... than any other single consulting assignment".

Mission Dam was renamed Terzaghi Dam, in 1965. The dam is owned and operated by BC Hydro.

Submitted by

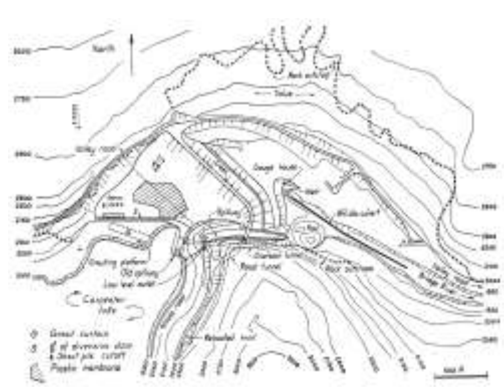
Klohn Crippen Berger

Key Reference

Terzaghi, K and Lacroix, Y. 1964. **Mission Dam: An Earth and Rockfill Dam on a Highly Compressible Foundation**. Géotechnique, Vol 14, pp 13-50.

Photograph and Figure

Terzaghi Dam Spillway (2015).



Site Plan from Terzaghi and Lacroix, 1964.

Keele Valley Landfill Site
Geotechnical Engineering & Hydrogeology Design

Geographical location

City of Vaughan (Maple), Ontario

When it began or was completed

The former sand and gravel pit was purchased by Metro Toronto in 1983. Construction of the clay liner and leachate collection system commenced in 1983 and was completed in 1994. Landfilling operations began in 1983 and the site was closed in 2002.

Why a Canadian geotechnical achievement?

Geotechnical engineering and hydrogeology were extremely important in the design and construction of the Keele Valley Landfill Site (KVLS) to prevent leachate contamination of the underlying Oak Ridges Moraine aquifers. Design and staged construction of a 1.2 m thick compacted clay till liner (permeability <$1x10^{-8}$ cm/s) provided the necessary barrier to leachate contaminant migration.

During operation, the KVLS was the largest landfill in Canada, and one of the largest in North America. The 376 ha site included a fill area of 99 ha and a total capacity of approximately 33 million m^3. The KVLS was one of Canada's first fully engineered landfill sites. Engineered components included a compacted clay till liner, a leachate collection system (French drains and HDPE pipes), a landfill gas collection/utilization system, a final cover and an extensive monitoring system. The performance and integrity of the clay till liner was monitored by numerous devices installed within, below and above the liner. The interaction between the landfill leachate and the liner was analyzed in a liner-leachate compatibility testing program involving both field and laboratory testing.

Experience gained at the KVLS fostered research in the design of clayey barrier systems for many other waste disposal facilities, and the development of the Ontario Landfilling Standards – O. Reg. 232/98.

Submitted by

David Staseff (Ministry of Transportation Ontario), on behalf of the many geotechnical engineers and hydrogeologists involved in the project.

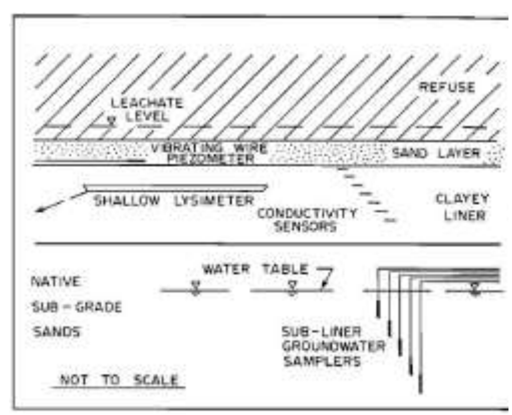
Key References

King, KS, Quigley, RM, Fernandez, F, Reades, DW and Bacopoulos, A. 1993. **Hydraulic conductivity and diffusion monitoring of the Keele Valley Landfill Liner, Maple, Ontario.** Canadian Geotechnical Journal, Vol 30, pp 124-134.

Many other papers that reference the KVLS are included in the Canadian Geotechnical Journal.

Photograph and Figure

Aerial view of the Keele Valley Landfill Site taken in the mid-1980s.



Liner performance instrumentation (from King et al, 1993).

Transcona Grain Elevator Failure and Righting

Geographical location

Winnipeg, Manitoba

When it began or was completed

Failure 1913; righting was completed in October 1914

Why a Canadian geotechnical achievement?

The foundation failure and righting of the Transcona Grain Elevator is a geotechnical achievement. The failure occurred during loading, after bearing pressures exceeded the limiting shear resistance of the underlying clay foundation soil. While the mat foundation for the elevator was likely designed to tolerate large settlements, its susceptibility to a deep-seated base shear failure was neither understood nor expected (Allaire, 1916). Early foundation engineers recognized this unique opportunity to compare the loading at failure with that predicted by classical bearing capacity formulae (Skempton, 1951). Subsequent studies demonstrated that the ultimate theoretical bearing capacity of 6,420 psf (307.4 kPa) was remarkably close to the actual observed bearing capacity at failure of 6,200 psf (296.9 kPa) (Blatz and Skaftfeld, 2003).

More remarkable was the effort to right the elevator by excavating under and lowering the high side and gradually raising the low side. Initially, a trench was excavated along the high side of the structure to the underside of the mat foundation. Drifts were then excavated beneath the mat foundation and a row of 14 piers was sunk to bedrock. The structure was raised using shoring screws and timber rockers installed on the tops of successive rows of piers. To assist, twelve timber pushers were placed against the side of the bins. On October 17, 1914, two days behind schedule, the elevator was back in its vertical position having been raised about 12 feet (3.7 m).

The elevator has been successfully used since this time and is now owned and operated by Parrish and Heimbecker Limited.

Submitted by

Ken Skaftfeld, Winnipeg, Manitoba

Key References

Allaire, A. 1916. **The failure and righting of a million – bushel grain elevator**, Transactions of the ASCE, Vol 80, pp 799-832.

Blatz, J and Skaftfeld, K. 2003. **The Transcona grain elevator failure: a modern perspective 90 years later**. Proceedings, 56th Canadian Geotechnical Conference, Winnipeg, MB, pp 8-22 to 8-29.

Skempton, AW. 1951. **The bearing capacity of clays**. Division I, Building Research Congress. London, England, pp 180-189.

See also: http://cgs.ca/virtual_archives_projects.php?lang=en

Photographs

Elevator after failure.

Shoring screws used to lift structure.

Downie Slide
Very Large Rockslide Stabilization Project

Geographical location

Along west side of Revelstoke Reservoir; 65 km north of Revelstoke, British Columbia.

When it began or was completed

Downie Slide was identified in 1956; investigations and initial drainage works began in 1974; the main drainage system was installed between 1977 and 1981; monitoring, assessment and maintenance continues.

Why a Canadian geotechnical achievement?

Downie Slide is located on the Columbia River within BC Hydro's Revelstoke Reservoir. The slide is in mica schist/gneiss bedrock with multiple water levels. At nearly 10 km^2 in area, 250 m deep and approximately 1.5 billion m^3 in volume, this is the world's largest known landslide stabilization project.

Construction of the Revelstoke Dam was contingent on the stabilization of Downie Slide. Key safety issues were the potential for reservoir blockage, a landslide-generated wave, and upstream flooding of Mica Dam, approximately 70 km to the north. After a thorough site investigation by BC Hydro and many consultants, and an extensive public consultation, drainage was selected as the appropriate method for stabilization

The drainage included 2,450 m of adits, primarily located in the bedrock slide mass, and 24,000 drain holes advanced from within the adits. The achieved drainage has been calculated to have increased the stability of the slide by nearly 10%, and more than offset the raising of the reservoir which impounded the toe of the slide. The stabilization allowed the construction and the safe operation of the Revelstoke Dam and reservoir for over 30 years.

Monitoring and maintenance of the drainage system is the responsibility of BC Hydro.

Submitted by

Tom Stewart (BC Hydro)

Key References

Imrie, AS, Moore, DP and Enegren, EG. 1991. **Performance and maintenance of the drainage system at Downie Slide**. In *Landslides*, D Bell (editor), Balkema, Rotterdam.

Kalenchuk, KS, Hutchison, DJ and Diederichs, MS. 2009. **Downie Slide - Interpretations of complex slope mechanics in a massive, slow moving, translational landslide.** Proceedings, Canadian Geotechnical Conference Halifax, NS, pp 367-374.

Photographs

Aerial view of Downie Slide (outlined in red) looking up the Revelstoke Reservoir and Columbia River valley.

Typical conventional drill and blast, horseshoe-shaped, extensively supported adit