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David Elwood, P.Eng.

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Education:

University of Western Ontario, Ontario – B.E.Sc. (2000)
Queen's University, Ontario – M.Sc. (2007)
University of Alberta – Ph.D. (2014)

Experience:

Golder Associates (2000 – 2001) Geotechnical EIT
Sarafinchin Associates (2001 – 2004) GeoEnvironmental Engineer EIT
Geo-Canada Ltd (2004 – 2007) Geotechnical Engineer and Hydrogeologist
Thurber Associates (2007 – 2009) Geotechnical Engineer and Hydrogeologist
AECOM (2009 – 2014) Geotechnical Engineer
University of Saskatchewan (2014 – present) Associate Professor
Arup Canada (2016 – 2018) Senior Consultant
Clifton Associates (2014 – Present) Principal Geotechnical Engineer

Affiliations:

Association of Professional Engineers and Geoscientists of Alberta – Member
Association of Professional Engineers and Geoscientists of Sask. – Member
Engineers and Geoscientists British Columbia – Member
Engineers and Geoscientists Manitoba – Member
Canadian Geotechnical Society – Member
Tunnelling Association of Canada – Member
Canadian Society of Civil Engineers – Member

I am an associate professor in geotechnical engineering at the University of Saskatchewan. I have published on the topic of soil mechanics and site characterization and am a standing member of the Technical Committee for Ground Property Characterization from In-Situ Tests (TC-102) as part of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) as well as an associate board member of the Canadian Geotechnical Journal. I was also the primary author of the Site Investigations Chapter of the upcoming Canadian Foundation Engineering Manual (CFEM 5th Edition). The Site Investigations chapter represents a significant update from the previous editions.

Over the years, I have been (and continues to be) an active consultant as a geotechnical engineer both nationally and internationally. I have over 20 years of consulting experience as a "boots on the ground" engineer for wide range of heavy civil projects including design of foundations, tunnels, slope stabilization, dam stabilization, embankments on soft ground, sensitive soils, tailings facilities, liquefaction potential and deep retaining structures/coffer dams. As part of this design, I have extensive experience with in-situ testing and site characterization and development of material properties for a wide range of geo-materials.

In 2020, I was invited to deliver a short course for the Canadian Geotechnical Society virtual conference held as GeoCalgary on the topic of pressuremeter use and implementation. The course was co-delivered by Robert Whittle of Cambridge InSitu Engineering of Cambridge, UK. Recently, I have been asked to deliver a series of short courses with Dr. Jason DeJong on site investigations in cities across Canada. Most recently, I was an invited lecturer for a series of keynote lectures on site investigations and characterisation given in Europe.

Research Focus

My research has focused on the characterization of hard, overconsolidated soils and soft rocks (argillaceous formations) for a variety of applications, including slope stabilization, foundation design and tunneling applications. Furthermore, I have designed instrumentation and monitoring programs for a wide variety of geotechnical projects including slope stability; embankment construction; tunnel excavation; and temporary support systems for deep excavations.

My particular area of research that I am pursuing is the in-situ determination of stiffness in ground and how this information can be translated to geotechnical design. My focus has been on developing better stiffness degradation and damping curves based on several points of modulus with strain. These moduli look at not only seismic modulus, but also the relatively small strain moduli obtained from barometric compensation as well as unload-reload moduli from pressuremeter testing and larger strain moduli from laboratory scale tests. This information is far more scalable for engineering applications. Furthermore, these datasets may also be used for determining the degree of sample disturbance from laboratory tests. Currently, I have several research projects focused on the use of the pressuremeter in Cretaceous shales and within potash formations located in Western Canada. Additional studies are underway that also examine the role the pressuremeter has in identifying liquefaction potential of loose sand tailings.

Project Experience

Clifton Associates Ltd. (Principal Geotechnical Engineer 2018 – Present)
2222-30 Avenue NE, Calgary, AB T2E 7K9

Fission Uranium Corporation - Patterson Lake South Uranium Mine

Dr. Elwood was a senior reviewer for the feasibility design of the proposed tailings management facility (TMF) at Patterson Lake South. As part of this role, Dr. Elwood provided guidance on the laboratory testing of the site materials in preparation for the design of an out of pit tailings facility. The feasibility study was focused on the suitability of the native soils for design of the TMF and associated dyke structures. Because the native materials consist primarily of a loose to medium dense fine sand, both static and seismic liquefaction potential were key. Following parametrization of the site materials, I oversaw the hydrogeologic and geotechnical numerical modelling of the proposed TMF. Modelling consisted of the use of both 2D and 3D coupled non-linear elasto-plastic finite element models that assessed the overall short and long-term performance of the TMF and its associated facilities.

Upon completion of the feasibility study, I provided an outline for additional field and laboratory testing. Because the initial field study was conducted by others, there was no input on the nature or extent of the field program. Because the initial study identified substantial data gaps, additional in-situ testing and advanced sampling methods were prescribed to further the TMF design and to provide additional information required for the preliminary design numerical modelling in preparation for a regulatory submission.

City of Edmonton, Valley Line LRT P3 Independent Checker (Marigold Partners)

Recently, Clifton Associates was retained by Marigold Partners, the Design/Build P3 holder (Parson's Construction) to carry out an Independent Check (IC) review for major geotechnical structures for the West Valley Line LRT (Valley Line Phase 2). The IC review requires evaluation of the selected design parameters, design methods and associated models submitted as part of the overall design package. Reviews are required for the 87th Avenue elevated guideway structure from 182nd Street and 164th Street including two elevated stations at the West Edmonton Mall (WEM) and the Misericordia Hospital, and the crossing of Anthony Henday Drive.

Dr. Elwood's role was as the lead IC reviewer responsible for assessing the completeness of the design, appropriateness of the input parameters and numerical models as well as ensuring that the recommendations and designs were in accordance with the Project Agreement (PA). The assessment required the independent development of site parameters based on borehole and laboratory data provided by the Design Engineer,

assessment of the bored pile capacities using conventional design methods and assessment of pile settlements using both analytical and numerical methods. Upon final approval of the design, an IC Certificate is provided to the City of Edmonton.

Arup (Sub-Consultant 2016 – 2018)
2 Bloor Street East, Suite 2400 Toronto, ON M4W 1A8

Clifton Associates Ltd. (Principal Geotechnical Engineer 2018 – Present)
2222-30 Avenue NE, Calgary, AB T2E 7K9

City of Edmonton, Valley Line LRT P3 Design Build Team (TransEd Partners)

Part of the detailed design team retained by the Civil Joint Venture (Bechtel/Ellis Don) to complete the geotechnical design for the Valley Line LRT in Edmonton. As the only member of the design team with previous experience in the City of Edmonton, Dr. Elwood was responsible for the design of the Quarter's twin tunnels; shallow and deep foundations; temporary works (retaining systems); and surface track designs. He was a 3rd party reviewer for the Grierson Hill and Connor's Road slope stabilization works, and the Operations and Maintenance Facility. Dr. Elwood was responsible for the drafting of the various geotechnical specifications and Design Basis Reports, Detailed Design and specifications. In areas where the project required a higher level of evaluation, Dr. Elwood was responsible for providing a research level white paper of the subject including a feasibility report, design recommendations and instrumentation and monitoring plans. Dr. Elwood's direct involvement (EoR) was for the permanent works of the Churchill Connector excavation; the Quarter's mined tunnel; surface track; stops and utility complexes.

With respect to site characterization, Dr. Elwood was responsible for the planning and implementation of the detailed geotechnical investigation in terms of site work feasibility; *in situ* testing in soils and bedrock typical to Edmonton using a pressuremeter. Dr. Elwood was also responsible for the laboratory testing and interpretation, evaluation of surface and downhole geophysical testing in terms of site characterization and potential impacts on construction. Responsible for the design of the instrumentation and monitoring program to be conducted as part of the mined tunnel construction and slope stabilization works.

As part of the slope stabilization projects related to the Grierson Hill and Connor's Road stabilization works, Dr. Elwood has been responsible for site characterization for input parameters; 2D and 3D model evaluation; remediation assessment and evaluation as a 3rd party reviewer; and assessment of allowable displacements in both the temporary and permanent works scenarios. These criteria assessed the allowable movements under an observational based framework where temporary stabilization or altered work methods would be required based on the level of ground displacements during construction. [2016 to present]

AECOM

17007 107 Avenue
Edmonton, AB T5S
1G3

City of Edmonton, South East LRT Design Review, Edmonton, Alberta.

Provided input based on previous experience with the North LRT tunnel construction for the preliminary design of the future SE LRT twin tunnels and Grierson Hill slope stabilization. Additional input was provided in terms of potential constructability of the proposed tunnel, tunnel portal headwalls, slope stabilization methods and potential environmental conflicts. A review of the prime geotechnical consultant's work was carried out to help designers develop clear questions to help obtain relevant geotechnical information as needed to provide a safe design.

2D limit equilibrium and coupled strain softening finite element modelling was undertaken to independently assess the efficacy of the proposed design and the constructability requirements. Because the proposed tunnel portal was to daylight within the Grierson Hill, the models had to accommodate large strain analyses within discrete bentonite layers within the clay shale bedrock. [2012-2013]

City of Edmonton, North LRT Twin Tunnel Design, Edmonton, Alberta.

Geotechnical engineer responsible for providing an evaluation of the in-situ materials and the predicted performance of the ground to be tunneled through. Author of the Geotechnical Baseline Report (GBR) and Design Basis Memorandum (DBM) forming the base geotechnical parameters required for tunnel design. Designer of the surface-monitoring program as part of the NLRT construction to protect the Owner's interests and nearby surface infrastructure during construction. Owner's Engineer site representative responsible for the observing the geotechnical and geological performance of the NLRT twin tunnels. [2009-2012]

Thurber Associates Ltd.
2010 Winston Park Drive Oakville, ON
L6H 5R7

Ministry of Transportation Ontario, Leamington Dock Tangent Pile Wall Design Parameters, Leamington, Ontario. Geotechnical engineer responsible for overseeing an in-situ testing program involving, self- bore and pre-bore pressuremeters, seismic CPTu, dilatometer and triaxial testing for the settlement of a legal claim against the ministry. A full review of all of the data was completed to confirm the findings prior to issuing the data publicly including all interpretation of all of the in-situ test results. A numerical model was then developed to model the expected strains of the sheet pile wall during dredging activities. The result of several lateral load tests carried out on the caisson reinforcement indicated a difference in strain of less than 1% when compared to the results of the numerical model. [2008-2009]

Ministry of Transportation Ontario, Highway 7-Duffins Creek Bridge Twinning, Whitby, Ontario. Geotechnical engineer responsible for the twinning of a highway bridge over a deeply incised creek valley. The subsurface investigation indicated extremely high artesian pressures below the confining layer at a depth of 10 m and very loose cohesion-less material to a depth of 35 m below the ground surface. Due to spatial and environmental constraints near the creek valley battered piles were not an option. A special foundation design was implemented to both allow the driving of H-piles to a depth of 35 m while still developing the required lateral resistance and minimizing the risk of fines migration up the length of the piles. [2008-2009]

Ministry of Transportation Ontario, Highway 404 Regional Wellhead Protection Study and Construction Dewatering Program, Newmarket, Ontario. Hydrogeologist for a detailed wellhead protection study and construction dewatering program as part of the development of nearly 15 km of new highway proposed through the Oak Ridges Moraine. The Oak Ridges Moraine is one of Ontario's most valuable groundwater resources and provides nearly 3 million residents as a primary potable water source. The program involved a detailed study of the local and intermediate groundwater flow regimes and the potential impact on residents during the construction of approximately 10 bridge structures within the upper aquifer formation. Recommendations were provided for short-term construction dewatering and permanent dewatering requirements for deep cut sections through the moraine sediments. [2008-2009]

Geo-Canada Ltd. (now WSP Canada)

90 Nolan Court Markham, ON L3R 4L9

Ministry of Transportation Ontario, Highway 69 Twinning, Sudbury, Ontario. Geotechnical engineer responsible for the design and installation of nearly 200 settlement monitoring instruments for the construction of approximately 10 m of fill placed over nearly 60 m of soft glacio-lacustrine clays. The program included the use of deep wick drains to increase the time of consolidation in order to expedite the preloading process. In each case, the instruments were connected to dedicated data logging systems that uploaded the results to an ftp site on a daily basis for all interested parties to review. Of particular

interest was the construction of embankment and bridge foundations adjacent to an arterial rail line constructed on organic materials. [2006]

City of Barrie, Water Pollution Control Centre Expansion, Barrie, Ontario. Geotechnical engineer and hydrogeologist responsible for the design of the pile foundation system required to found the future structures in an unstable wet silt. The project required a detailed study of the construction dewatering requirements and the potential impact on the surrounding area including the potential interference with the nearby Kampenfelt Bay. Previous studies had indicated that high levels of TCE and hydrocarbons were present in the groundwater and special monitoring and treatment programs had to be implemented in order to minimize the risk associated with an inadvertent release of discharged groundwater. [2006-2009]

Sarafinchin Associates Ltd.

238 Galaxy Blvd. Toronto, ON M9W 5R8

Chevron Texaco, Multiple Sites throughout the Caribbean and South America

Geoenvironmental engineer responsible for carrying out up to sixty (60) Phase 2 and 3 investigations throughout the Lesser Antilles and South America. The project required detailed site coordination with local officials and contractors as well as dealing with many different foreign governments and customs officials. In each case, the sites were visited and the subsurface conditions were logged and representative samples of soil and groundwater were recovered and shipped to North America for analyses. Once elevated levels of contaminant were detected. The project changed to oversight of site remediation and disposal of impacted soils. [2003-2005]

Publications (only Journal Publications or Book Chapters are listed)

Elwood, D. (2022). Chapter 5 – Site Investigations. *Canadian Foundation Engineering Manual (CFEM 5th Edition)*; Canadian Geotechnical Society. (in-press).

Sattler, K., **Elwood, D**., Hendry, M. T., Berscheid, B., Marcotte, B., Abdulrazagh, P. H., & Huntley, D. (2021). Field Collection of Geotechnical Measurements for Remote or Low-Cost Datalogging Requirements. *Geotechnical Testing Journal*, *45*(1).

Sattler, K., **Elwood, D**., Hendry, M. T., Huntley, D., Holmes, J., Wilkinson, P. B., & Bobrowsky, P. T. (2021). Quantifying the contribution of matric suction on changes in stability and displacement rate of a translational landslide in glaciolacustrine clay. *Landslides*, 1-15.

Huntley, D., Holmes, J., Bobrowsky, P., Chambers, J., Meldrum, P., Wilkinson, P., Donohue, S., **Elwood, D.**, Sattler, K., Hendry, M. and Macciotta, R., 2020. Hydrogeological and geophysical properties of the very-slow-moving Ripley Landslide, Thompson River valley, British Columbia. *Canadian Journal of Earth Sciences*, *57*(12), pp.1371-1391.

Holmes, J., Chambers, J., Meldrum, P., Wilkinson, P., Boyd, J., Williamson, P., Huntley, D., Sattler, K., **Elwood, D.,** Sivakumar, V. and Reeves, H., (2020). Four-dimensional electrical resistivity tomography for continuous, near-real-time monitoring of a landslide affecting transport infrastructure in British Columbia, Canada. *Near Surface Geophysics*, *18.* (Geoelectrical Monitoring), pp.337-351.

Huntley, D., P. Bobrowsky, M. Hendry, R. Macciotta, **D. Elwood**, K. Sattler, M. Best, J. Chambers, and P. Meldrum. (2019). Application of multi-dimensional electrical resistivity tomography datasets to investigate a very slow-moving landslide near Ashcroft, British Columbia, Canada. *Landslides* 16:5. 1033-1042.

Liu, L., **Elwood, D.E.Y**., Martin, C. D., & Chalaturnyk, R. (2018). Determination of the permeability of overconsolidated clay from pressuremeter pressure hold tests. *Canadian Geotechnical Journal*, 2018, 55:514-527, https://doi.org/10.1139/cgj-2017-0279

Smith L.A., **Elwood, D.E.Y.**, Barbour, S.L., Hendry, J. (2018) Profiling the in situ compressibility of cretaceous shale using grouted-in piezometers and laboratory testing, *Geomechanics for Energy and the Environment*, https://doi.org/10.1016/j.gete.2018.04.003

Elwood, D.E.Y. (2018) Geotechnical instrumentation In. Brobowsky, P., Marker, P (eds). *Encyclopedia of Engineering Geology*, Springer Publishing.

Wong, J. M., **Elwood, D**., & Fredlund, D. G. (2018). Use of a three-dimensional scanner for shrinkage curve tests. *Canadian Geotechnical Journal*, (999), 1-10.

Elwood, D; Martin, C.D., (2016). Ground Response of Closely Spaced Twin Tunnels Constructed in Heavily Overconsolidated Soils, *Tunnelling and Underground Space Technology*, 51 (1): 226 - 237.

Elwood, D., Derek Martin, C., Fredlund, D. G., & Ward Wilson, G. (2015). Volumetric changes and point of saturation around a pressuremeter probe used in unsaturated soils. *Journal of Geotechnical and Geoenvironmental Engineering*, *141*(11), 04015046.

References

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