



## 40 years of Ground Engineering in British Columbia, Canada

This is the first in a series of newsletters highlighting our Ground Engineering practice, the root of the company's foundation some 40 years ago. This issue focuses on our business in British Columbia (B.C.) but also highlights some of the interesting projects being carried out for our clients around the world.



Golder Associates was founded by Hugh Golder in Toronto in 1960, and expanded to BC in 1963. Since that time, our BC presence has grown to more than 300 people and expanded into other technical service areas. Ground Engineering now comprises about 30 per cent of our worldwide business, with 40 percent of it being carried out in Canada. Ground Engineering represents almost half of our business in BC, equally split between Mining and other market sectors, largely infrastructure and Land Development. In addition to our large Mining business and base load of urban geotechnical work, our staff in BC are recognized as specialists in seismic design, marine geotechnique and trenchless technology.

Trevor Fitzell  
*Director and Principal, Vancouver, BC, CANADA*

## Preparing for the 2010 Winter Olympics in Vancouver/Whistler, BC, Canada



BC is "blessed" with many geological hazards - steep slopes, extensive unconsolidated sediments and earthquakes - and these present challenging and interesting work for our staff. As we prepare for the 2010 Winter Olympics in Vancouver/Whistler, we are experiencing one of the most exciting periods in our firm's history in B.C. Golder is involved in many of the major infrastructure projects currently underway in the province, including:

- The 2010 Olympic Nordic Centre near Whistler
- Upgrading of the Sea-to-Sky Highway for the Olympics
- A rapid transit line to the airport
- An expanded Convention Centre, and
- Other major regional transportation initiatives

For more information contact Trevor Fitzell - Vancouver.

Photo: Sea-to-Sky Highway to Whistler Olympic Centre, courtesy of BC Ministry of Transportation.

# Convention Centre Expansion in Vancouver, Canada



Golder is providing geotechnical engineering services for the design and construction of the Vancouver Convention Centre Expansion in Vancouver, B.C. This CAN\$565 million project is expected to be completed in 2008. In 2010, the convention centre will welcome some 10,000 media who are expected to attend the 2010 Olympic Winter Games. The 93,000 m<sup>2</sup> expansion and upgrade of the 17 year old existing Vancouver Convention Centre will allow Vancouver to target conventions of more than 5,000 delegates. The expansion project will include a unique six acre "living roof".



The project site is located in an area reclaimed from Burrard Inlet by placement of heterogeneous fills. Liquefaction of the site soils and potential obstructions to piling are key geotechnical issues. Comprehensive state-of-the-art dynamic soil-structure analyses were carried out to optimize the design ground improvement measures to provide adequate support of the driven pile foundations. A test pile and test densification program was carried out early in the design stage of the project to confirm design parameters

The site will be one of the largest and most challenging sites to be improved by the vibro-replacement technique

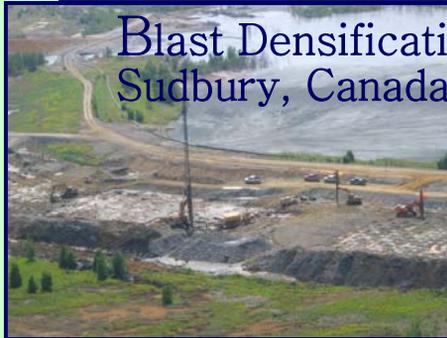


(stone-columns) in Vancouver. With more than 560,000 m<sup>3</sup> of the site soils to be improved and more than 800 piles to be driven and 17 rock-socketed caissons to be installed, foundation construction for the project is expected to be interesting and challenging.

For more information contact M. Yogendrakumar, Associate (Vancouver, Canada)

- Aerial view of site courtesy of Waite Airphotos Inc.
- Artists impression courtesy of VCCEP Ltd.

# Blast Densification at Guindon Dam/Tailings Area, Sudbury, Canada

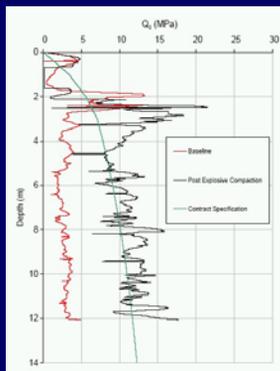


GAIA Inc., Golder's specialty contracting wing, recently completed a ground improvement project in Sudbury, Ontario using a combination of **Blast Densification, Dynamic Compaction, and Rapid Impact Compaction**. A combination of the three techniques was proposed by GAIA as the most efficient overall ground improvement scheme. The goal was to densify about 1 million cubic metres of mine tailings forming the foundation for two 3 km long dam raises.

The tailings comprise sands and silts having 35% to 70% silt-sized particles which are generally considered to be extremely

difficult to densify. However, improvement was required for satisfactory stability of the proposed tailings dam raises, and to withstand the design seismic event. Densification targets in terms of CPT tip resistance were developed based on seismic analysis of the proposed dam structure, and these were used as a measure of acceptance for the work.

The specified criteria were generally achieved, and in some cases the CPT tip resistance achieved was over 3 times the original values.



GAIA and Golder combine technical innovation with construction experience, allowing them to provide leading edge design-build services in the ground engineering and environmental sectors. We provide an efficient "results-driven" team with one-point accountability for both design and construction.

For more information contact John Scholte (Vancouver, Canada)

- Aerial view of site, courtesy of Ed LeBlanc of AST
- Densification underway, courtesy of Toivo Pallop, GAIA
- Sample test data before and after treatment

# Brisbane's Inner Northern Busway, Australia

Golder Associates Brisbane office has recently completed work on the Inner Northern Busway (INB) project, a 2.7 km long dedicated busway which services the inner suburbs to the north of Brisbane. The project has been constructed in three stages under separate contracts, and Golder Associates has carried out geotechnical investigation, design and construction inspections for each of the stages. The project was implemented under a Design & Construct Alliance model.

It included several tunnelled sections and large retaining walls requiring innovative approaches to construct the busway through developed urban areas. Some of the challenges included construction of:

- 140 m long tunnel under nine operating rail lines by a combination of top down construction and bored pile walls. The tunnel under the metropolitan rail lines, with a cover of only 2m, was constructed in variable fill, alluvium and residual soil, by a combination of hand excavation adjacent to the abutments, and staged excavation using fibre-glass nails and shotcrete for primary support.

- a 50 m long cut and cover underpass with 5 m lateral clearance to the footing of an 80 year old concrete arch bridge. *This was constructed using a temporary bridge installed over one weekend prior to tunnel excavation, allowing further excavation to take place without interruption to traffic.*
- a 200 m long, 8 m high soil nail wall.
- two sections of cut and cover tunnel, comprising the 290m Victoria Park Tunnel and 130m Fairway Tunnel. An innovative method of forming ledges for support of arch tunnel units was devised using high-strength fibre-reinforced shotcrete.

For more information contact Scott Fidler (Brisbane, Australia)

## Commuter Train Tunnel Under Central, Stockholm, Sweden

The lack of rail track capacity is slowing down the economic growth in the Mälardalen region around Stockholm. Today the southern entrance to the Central station in Stockholm has the same number of tracks it had in 1871, but now they carry more than 500 trains a day. A 6 kilometre long rock tunnel is planned about 20 to 40 metres below the city to increase capacity from two tracks to four.

Golder Associates has been assigned to a number of geotechnical projects within the Citybanan project. We have investigated geotechnical conditions for portions of the tunnel and have applied web-based information systems in monitoring ground water levels in an sensitive to settlements.

Golder Associates, jointly with ELU, is currently designing one of the geotechnically most complicated parts of the project, comprising both the difficult rock tunnel at Tegelbacken and the concrete tunnel under the lake of Riddarfjärden (see photo). The tunnel transitions from rock tunnel to a tunnel under the lake, requiring 20 meter deep water tight excavations on each side. This will be achieved using a combination of steel sheet piles and secant piled walls. Both cast-in-place and immersed tube tunnels are being considered for the water crossing.

For more information contact Gunilla Egnelöv (Stockholm, Sweden)



## Building Transit in Seattle, USA

Sound Transit is undertaking the construction of 14 miles of a system that extends from the City Center to SeaTac International Airport. The route includes 11 stations, a major maintenance yard, elevated guideway sections and a tunnel.

Golder was selected as the Geotechnical Consultant on 4 of the 6 sections which are currently under construction, including elevated segments and the maintenance yard. Most of these sections were underwater 100 years ago, forming part of the old docklands which included several trestle bridges and numerous wooden bulkheads to facilitate hydraulic filling. The fill and deep liquefiable deposits presented challenges to design and construction.

Golder was responsible for geotechnical investigation and design, working closely with the structural engineers to develop ways of improving the seismic response of the elevated sections.

Analyses were carried out to model the behavior of the drilled shaft column foundations during design earthquake. Specifications were developed for ground improvement using stone columns, compaction grouting and deep soil mixing.

Golder is providing construction supervision and assessment of the ground improvement. Construction work ranges from 100 ft deep 10 ft diameter drilled shafts to over 1000 driven piles at the maintenance facility to track subgrade checks. Golder has also been retained as tunnel instrumentation consultant for the Beacon Hill tunnel section.

For more information contact Andrew Walker (Seattle, USA)



Golder is currently involved in upgrading of the port and assessing coastal stability in Barbados. Previously we worked with the Barbados Light and Power Company (BL&P) in expanding the Spring Garden generating station. The main component of the project included the installation of two 30 MW generators, each to be founded on a large concrete pedestal/raft with only 6 m between these rafts. Underlying about 3 m of coralline sand fill, the native overburden consists of about 15 m to 25 m of variable very loose to dense coralline sediments containing cemented zones. Geotechnical and geophysical (crosshole seismic) investigations were carried out at the site to characterize the site. Analysis indicated total settlements could range from about 55 mm to 70 mm with potential differential settlements of up to 15 mm.

In order to increase the relative density of the subsoils, minimize the potential for the presence of voids, and reduce settlements to within tolerable levels, soil improvement by vibrodensification/replacement was carried out on a 2.5 m triangular grid pattern. Pre-augering of the stone column locations to 1.1/1.3 m diameter was required to penetrate cemented zones.

The results of the SPT testing indicate that the treatment was successful in achieving the target level of soil improvement, with a 10% to 300% increase in average SPT N-values. Results of crosshole seismic testing indicated that on average the dynamic shear modulus value increased by about 140%.

For more information contact Paul Dittrich (Mississauga, Canada)

## Ground Improvement in Coralline Sediments, Barbados



### Awards and Recognition:

Congratulations to Dr. Dennis Becker who assumes the role of President of the Canadian Geotechnical Society in January 2005.

Congratulations to Trevor Carter, Mark Telesnicki, Gerry Webb, Daryl Miller, Phil de Graff and their team on winning an Award of Excellence from the Association of Consulting Engineers of Canada (ACEC) for their work on the expansion to the Canadian Library of Parliament. The project involved tricky rock excavation below the historic building.

Golder won the New York Construction "Highway Project of the Year (2004)" for the Interchange 8 Project linking Interstate 87 and Interstate 287 on the east side of the Tappan Zee Bridge. The project involved excavating a mountain while controlling the blasting and rock support program to allow traffic flow of 138,000 vehicles/day. Golder provided geotechnical design and construction monitoring, together with CTE who provided civil engineering project management for the NYS Thruway Authority. Golder key persons included Rich Humphries (Project Director - Atlanta), Pete Ingraham (Project Manager - Manchester, NH), Jay Smerekanicz and Dick Cross (Senior Engineering Geologists - Manchester, NH), and Alan Cameron (Blasting Consultant - Sudbury, Canada).

Golder won the Honors Award for Engineering Excellent from the American Council of Engineering Companies/Georgia Chapter for design of the Scott Candler Reservoir Project in Dekalb County, Georgia. Congratulations to all involved.

Refer to [www.golder.com](http://www.golder.com)

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The *Ground Engineering Group* is responsible for providing leadership and technical support to our geotechnical consultants worldwide – one of our key Technical Service Groups. For more information, go to [www.golder.com](http://www.golder.com).

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**GeoTechnical Speaking** is published for internal use only within Golder Associates. This newsletter includes articles showing innovative and technically challenging projects that Golder professionals have worked on throughout the world. We value your opinions. Please contact **Trevor Fitzell** at **+ 1 604 296 4200** or [tfitzell@golder.com](mailto:tfitzell@golder.com) if you have any questions or comments.

