Welcome to Emerald City

ANCHOR SHORING & CAISSONS LTD. AND PARTNERS OVERCOME CHALLENGES TO CONSTRUCT THREE CONDO TOWERS SIMULTANEOUSLY

BY DAWN TATTLE

The Emerald City Condominium project by ELAD Canada is part of an award-winning major community plan located in Toronto, Ontario. This condominium project offers spectacular panoramic views of Toronto and provides easy access to the Sheppard Subway, major highways, and shopping. The three towers include 1,200 units, and are up to 36 stories in height with four levels of underground parking. They include amenity and retail space, and the buildings connect to the adjacent TTC Subway Station.

PCL Constructors Canada was retained by ELAD Canada as construction managers, while the design/build contract for

Anchor Shoring Bauer BG40 rig drilling CFA piles. Concrete is pumped into the centre of the hollow stem auger from the top as the auger is extracted.

the shoring and deep foundation work was awarded to Anchor Shoring & Caissons Ltd. The schedule developed by PCL and ELAD for the project was very aggressive and required an early start of construction with the fast track design pushing to keep ahead of the site work to achieve the milestone dates. PCL facilitated the coordination between owner, consultants, and contractors to ensure the site work was able to continue while the design was being optimized, ensuring no delays to the project.

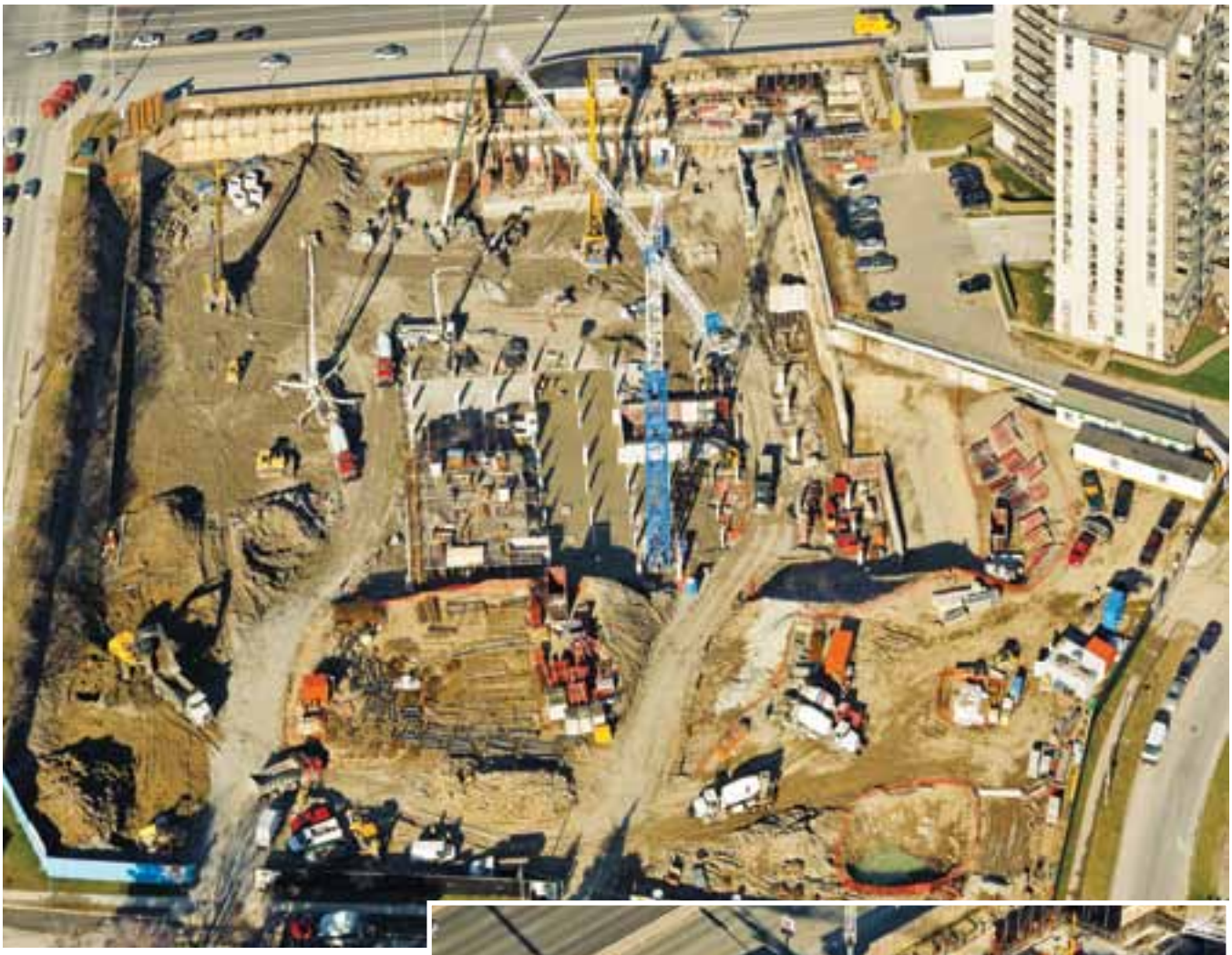
Both the design and construction aspects of the subsurface work presented many challenges to overcome. Among them were difficult soil conditions and close proximity of the excavation to streets and subway structures. Attenuating site congestion also posed a challenge, with construction of all three towers occurring simultaneously and being serviced by a single access point. Various foundation designs were investigated and through iteration and testing, an optimal design incorporating a combination of structural caissons and Continuous Flight Auger (CFA) piles was finalized. Developing a constructible and economical foundation design required teamwork from all parties in the construction team to arrive at the final solution that was installed by Anchor Shoring.

THE SHORING

As the boundaries of the site are situated immediately next to streets, an existing TTC subway entranceway to the north and a parking structure to the east, earth retention systems were required to allow for excavation of the four levels of underground parking. There was a total of 34,500 square feet (3,200 square metres) of shoring required for this project with different types necessary to address the specific site conditions.

A pile and lagged shoring system was installed by Anchor Shoring next to streets and utilities. This type of system consists of steel beams installed in vertically drilled holes spaced at three metre centres. Once a required steel beam is placed, the hole is backfilled with a concrete toe and lean mix above. The soil between vertical steel beams is retained by horizontal wood sections known as lagging. This lagging is installed behind the flanges of adjacent steel beams and wedged in place as the excavation progresses.

Test frame for CFA load testing. The CFA pile to be tested is located under the centre of the frame. There are two reaction piles at each end.



Aerial photograph of Emerald City site looking north. Anchor Shoring Bauer BG28 and BG40 drill rigs are drilling CFA piles at the top of the photo (yellow machines). The lagged and caisson wall shoring along the north wall is also visible.

Adjacent to the existing TTC subway entranceway the allowable shoring movements were set at the very stringent limit of only three millimetres. As a result, a lagged system could not be used and a more rigid caisson wall system was required. This system was also used along the site boundary adjacent to the existing parking structure to the east. A caisson wall is composed of a series of interlocking drilled holes that are backfilled with a weak concrete mix having a typical design strength of two to four MPa. Steel soldier piles are placed at specified intervals inside the wall to provide lateral and vertical support.

Site work on the shoring began in May 2011. Anchor Shoring drilled over 300 vertical

holes for the lagged and caisson wall shoring systems using a combination of Bauer, Watson, and Texoma drill rigs selected to suit the access, soils conditions, and tight schedule.

Shoring systems, whether they are lagged or caisson wall systems, typically require additional lateral bracing either inside the confines of the site with steel framework or beyond the site boundaries with tiebacks. Tiebacks are composed of small diameter holes drilled at an angle beyond the shoring with steel strands and grout placed in the holes. Once the grout reaches its required strength, the strands are stressed to introduce a preload into the system that resists movements of the wall during the excavation phase.

Tiebacks are the preferable method by which to brace shoring systems because of their minimal impact on the excavation and formwork phases of construction. At this site, it was possible to install tiebacks next to the streets and existing parking structure. Unfortunately, they could not be used in the caisson wall due to the presence of the existing TTC structure behind the wall. In this area, a complicated internal steel bracing system of rakers and walers was unavoidable. Further, due to the exceptionally stringent movement limit criteria imposed on the system, it was also necessary to preload all the rakers to further reduce the possibility of movements.

The shoring design, monitoring, and inspection were carried out by Terraprobe Inc. The monitoring and inspection results verified that even with the exceptionally stringent criteria, the shoring performed well within the specified limits.

THE FOUNDATIONS

The originally considered foundation design system consisted of augered caissons terminating at roughly 16 metres below ground surface. To support the building loads, caissons up to 2,300 millimetres in diameter would be required. The large diameter temporary steel liners, which would need to be installed for these caissons, were problematic due to the stringent vibration criteria imposed on the area of the site in the vicinity of the existing TTC structure.

These concerns led to the exploration of Continuous Flight Auger Piles (CFAs) as a possible foundation solution. A CFA pile, also known as an Augercast pile, is constructed by drilling to the required founding depth with a full-length hollow-stem auger. The auger has a hollow interior and a steel casing with continuous flights welded the full length along its exterior. The auger set up is mounted on a drilling rig. Prior to drilling each hole, a plastic plug is placed in the base of the hollow stem of the auger. Once the required depth is achieved, high slump, 30 MPa concrete is pumped into the centre of the auger from the top, displacing the drilling plug. The auger is extracted with the rig while the high slump concrete is pumped down the centre of the auger replacing the soil and thus ensuring that the perimeter of the hole remains stable at all times.

In order to verify the capacity of the piles to be used in the design, it is necessary to install a CFA specifically for load testing purposes. This was done as early as possible in the project to provide verification of design parameters and allow for any modifications that mayhave been required as a result of confirmed site conditions. In addition to the test CFA, four reaction piles were installed to provide uplift resistance during loading of the test pile.

Installation of the load test and every production CFA pile was carefully monitored for rate of auger extraction, concrete pressure and volumes to verify quality of the finished CFA pile. The Bauer rigs used by Anchor Shoring on this project were outfitted with monitoring equipment which plotted this information on a real-time basis allowing both the operator and the McClymont and Rak geotechnical inspector to confirm that there were no issues such as necking or over-pouring of concrete during the installation. A permanent record of the installation was also generated. The onboard computer measured pump strokes, flow, and pressure through a series of electronic sensors strategically placed on the concrete lines and pump. These sensors were read two times per second to ensure precision. The drill rig's computer was programmed to respond to this information by adjusting the extraction and pour rate, ensuring consistency and efficiency.

The test CFA was successfully loaded to 200 per cent of its design load of 1,300 KN which allowed the design to be finalized and installation of production piles to begin. Anchor installed 1,350 CFA piles 600 millimetres in diameter varying in length from 13 metres to 24 metres as required to suit the load requirements. These were drilled from approximate sub-grade level. Two drill rigs were used for this work to expedite the schedule and accommodate the different drill lengths. A BG28 was capable of installing the shorter piles, while a Bauer BG40 was required for the 24-metre-long piles. A total length of 23,000 linear metres were installed by Anchor on this project. Every pile installed was subject to full time inspection and verification by an inspector from the geotechnical consultant, McClymont and Rak to confirm that the monitoring results generated from the production piles were consistent with the load test and initial integrity tests.

The CFA pile solution provided considerable time and cost savings compared to the large diameter caissons and was the preferred foundation system wherever feasible at this site. Fortunately, it was possible to use CFAs for almost all foundations of towers 2 and 3. However, there were areas at tower 1 adjacent to the caisson wall and existing TTC structure where CFAs could not be used. The rakers constructed to brace the caisson wall created interferences, requiring foundations to be drilled from a much higher elevation, only three metres from existing grade. This would have required CFA drill depths beyond even the limits of the largest available drill rig proposed for this work, the Bauer BG40.

Therefore, Anchor proposed that additional boreholes be completed to determine if there was a bearing stratum at a lower elevation that would provide a higher bearing value for caisson design. The soil at this lower bearing stratum was found to be composed of Sandy Silt Till materials with blow counts in excess of 100 blows per 300 millimetres. This provides a bearing capacity 40 per cent greater than is available in the upper stratum levels, and allowed the caisson diameters to be reduced to a maximum diameter of 1,300 millimetres with a resultant drill length of 30 metres. Accordingly, in areas where CFAs could not be used, caissons could be installed with Bauer drilling equipment. The benefit of this equipment is that it has the ability to install casing ahead of the auger without the need for vibratory equipment.

There were 130 structural caissons required of which 62 were up to 30 metres long and up to 1,300 millimetres diameter in order to satisfy the high loading requirements. Further analysis of soil conditions revealed areas where it was possible to found caissons with reduced loading at a higher bearing level. In light of this and to further increase the design efficiency, the required drill length of the remaining 68 caissons was reduced to 18 metres. To address the challenging ground conditions, differing caisson lengths and schedule demands Anchor provided two Bauer drill rigs, a BG40, and BG28, for the caisson installation work. This work was further supported by a LS 208 service crane that was used to place the caisson reinforcing cages.

Developer: ELAD Canada	
Construction Manager: PCL Constructors Canada Inc.	
Shoring, Caisson & CFA Contractor: Anchor Shoring & Caissons Ltd.	
	www.anchorshoring.com
ELAD Canada	
VP Construction	Shahar Davidi
Senior Operations Manager	Adrian Stetter
Project Manager	Ron Weinstock
PCL Constructors Canada Inc.	
Construction Manager	Sean Donovan
Senior Project Manager	Eric Des Gagne
General Superintendent	Shawn Millican
Site Superintendent	Wayne Nivins
Anchor Shoring & Caissons Ltd.	
Project Manager	Toben Jerry
Operations Manager	Mike LeSage
Site Superintendent	William Westlake
Project Consultants	
McClymont and Rak Engineers Inc.	Ladd Rak
Terraprobe Inc.	Tim Orpwood, Mike Porco
Jablonsky, Ast and Partners	Robert Asman

CONCLUSION

The decision to use varied lengths of CFA piles to suit the different loading conditions, and supplementing this solution with caissons founded at the lower dense stratum, provided an optimal foundation design system. Implementing this alternate design resulted in costs on the order of $1,000,000 less than the cost of installing all the caissons at the original large diameters. Movements of the shoring were minimal and the system performed in accordance with the design and the specified limits. The shoring and foundation work was successfully completed in phases to suit the aggressive schedule prepared by PCL, with the last area completed in August 2012. The high productivities and ambitious schedule milestones achieved in the shoring and foundation installation procedures would not have come to fruition without the proactive work and cooperative effort of the geotechnical consultant McClymont and Rak, and the structural consultant Jablonsky, Ast and Associates.

Completion by PCL for the first tower is scheduled for November 2013 with the last of the three towers to be completed April 2014.

ABOUT THE AUTHOR

Dawn Demetrick – Tattle, P. Eng.
President, Partner, Anchor Shoring & Cassions Ltd.

Prior to joining Anchor Shoring & Caissons Ltd. as a partner in 1986 Dawn was a project engineer for a structural engineering consultant. This experience in overall building structure design provides Dawn with the insight necessary to create innovative solutions to soil retention and foundation problems. In 1997, Dawn assumed her role as President of Anchor Shoring.

Anchor Shoring & Caissons Ltd. is a highly respected contracting firm specializing in innovative soil retention and engineered foundation solutions. They have completed over 4,000 projects including such high-profile, complex projects as the Air Canada Centre, BCE Place, Hospital for Sick Children, MaRS Discovery District, Royal Ontario Museum, the Bahen Centre for Information Technology (University of Toronto), Maple Leaf Square Condominiums, Windsor Casino, Airport Rail Link, West Diamond Grade Separation and numerous TTC infrastructure projects.

Dawn focuses on quality control, innovation in designs, superior client service, and rigorous health and safety programs. Dawn makes professional development in both the business and technical aspects of her field a priority for herself and the other members of the Anchor team.

Dawn received an award in the Trailblazers and Trendsetters Category of the Canada's Most Powerful Women: Top 100 awards in November 2008 and again in the Professionals Category in 2010. Dawn also received the University of Toronto 2T5 award in 2010. She is on the board of directors for the Toronto Construction Association and a Fellow of the Canadian Academy of Engineering. ■