The 2013 Canadian Consulting Engineering Award Nomination of:

# THE CHARLOTTETOWN CONVENTION CENTRE FOUNDATION AND SEAWALL

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EASTPOINT ENGINEERING

## INTRODUCTION

Investment in tourism and infrastructure is a major component of economic activity in Prince Edward Island. Ranging from the construction of the Confederation Centre of the Arts to the Delta Prince Edward and from golf courses to the Confederation Bridge, infrastructure has played a significant role in growth and development of tourism on Prince Edward Island. The construction of the Prince Edward Island Convention Centre is the most recent phase in this evolution of a tradition of tourism and infrastructure investment. The Prince Edward Island Convention Centre is a project that is being built on the Charlottetown waterfront on the site of the former Canadian Coast Guard facility. The design of this facility calls for a 36,000 square foot complex to be built to hold receptions for up to 3000 people and dining events for up to 1500 people. The estimated cost is $17.5 M, this is cost shared between the Federal and Provincial Governments, and the expectation is that this new Convention Centre will double Prince Edward Island's capacity for hosting meetings and it should add a further $6.5 M in annual tourism business to the Provincial economy.

The site of the Charlottetown Convention Centre lies on the waterfront in Charlottetown and required the extension of the shoreline into the harbour through the construction of a steel sheet pile (SSP) sea wall combined with structural fill capable of providing the necessary support for the new facility. Reclamation of land from Charlottetown harbour was intended to provide an attractive waterfront location for the new Convention Centre project. This presented the project with a challenging location. The process used for construction involved the driving of steel sheet piles around the site and the backfilling with in-situ, native material. During this backfilling process the SSP seawall experienced a failure of the temporary anchorage system. A number of attempts were undertaken to correct this failure and it was during this period that EastPoint Engineering was contacted to provide advice and leadership in the correction and completion of the foundation and seawall project.

When EastPoint was engaged to review and provide advice to the Charlottetown Area Development Corporation (CADC), it entered a project in which the constructed SSP seawall was 1500mm out of plumb and leaning into an untenable position into the harbour, the site was flooding during tidal cycles, and the backfill, which had been partially placed, was no longer capable of supporting vertical loads from pedestrians let alone the construction equipment which the project would require during remediation.

This required that the team devise a solution to two challenges; the first challenge consisted of addressing the poor soil conditions prevalent throughout the site and turning the back fill into a material which would provide sufficient vertical stability to permit the intended construction to be undertaken on this site and did not affect the SSP seawall adversely with horizontal loads, the second challenge was the straightening of the out-of plumb SSP seawall preferably by repairing the existing SSP seawall rather than replacing it.

## SOIL STABILIZATION

Once a dewatering system had been implemented the first phase of this project involved the stabilization of the existing granular materials that were used as backfill behind the wall and the balance of the in-filled soil on the inboard side of the SSP wall such that it minimized lateral loading upon the SSP wall and provided a structural base upon which the Convention Centre could be built. EastPoint's challenge was to find a methodology of strengthening the soil so that it could be reused as structural fill in a manner that would not result in an unfit base. This was achieved by adopting the same technology that was being used at the Tar Ponds remediation project in Sydney, NS to solidify and seal the toxic soils that exist at the Tar Ponds site. In Sydney the soils were mixed with dry, Type 10 cement. The primary purpose of the cement mixture was to solidify the toxic material and prevent the migration of toxins to a wider area by migration through the water table. A residual effect of this method of soil remediation was the strength of the remediated soil and its ability to withstand loads from construction equipment one day after mixing.

As a first step samples of the in-situ material were taken to a local testing lab and various mix designs with varying degrees of cement concentrations were prepared and tested. It was determined that a mix consisting of 15% cement, by weight, would provide the desired soil characteristics and achieve compressive strengths greater than 600 kPa.

Once the desired concentration was established equipment was mobilized to site and the soil remediation began. The 15% cement concentration translated into 35 MT of cement being mixed with 240 MT of soil and the mixing was completed in blocks consisting of a 6M x 4M footprint and a mixed depth of 5M. Site constraints and mixing methods would only permit the mixing of four blocks per day. The soil remediation progressed from the inboard edge of the infill area out to the SSP seawall and was completed while new anchor blocks and tie rods for the SSP seawall were being installed adjacent to the area where the remedial work was being undertaken.

The mixing of the cement into the soil created a structural stability which minimized the transfer of horizontal forces to the SSP seawall and would ultimately provide a stable base for construction to proceed. This soil remediation operation turned existing soils that one could not walk on into a working platform for an excavator the next day.

EastPoint's original concept was to remediate the complete area to a depth of -8.0M chart. This was not successful because the equipment mobilized to "core" through the top 5M of stabilized soil and mix cement in the underlying soils was prevented from doing so by the presence of timber piles from wharves previously constructed on the site.

The soil underlying the remediated layer had a gelatinous texture and because the cement mixing efforts were unsuccessful as a result of debris from previous structures a relieving platform, consisting of a concrete deck and supported on steel H-piles had to also be installed in the remediated area to protect against interlock failure of the SSP seawall.

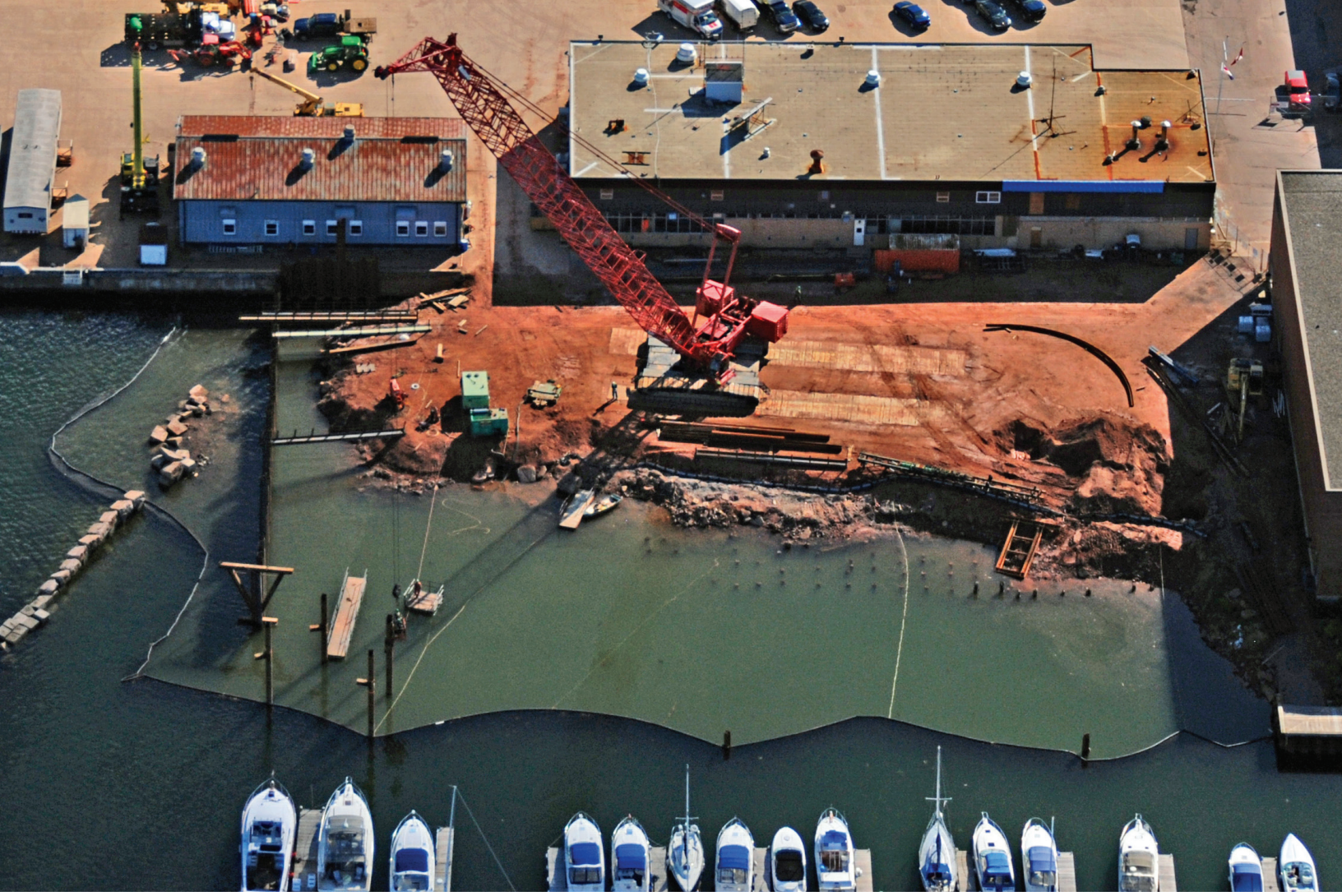
## REPAIRING THE SEAWALL

With the remediated site soils providing a platform from which to work the second phase of the project began, the straightening of the SSP seawall. While the toe of the SSP seawall remained in its original position the seawall failure consisted of a "fanning" of the top of the SSP wall, leaning outward into the harbour. Straightening of the SSP seawall was viewed as an option which was more cost effective and could be more rapidly executed, rather than the removal and re-driving or replacement of the seawall.

Since the SSP wall had experienced a "fan" like distortion, it was necessary for a straightening process to exert a uniformly distributed load along the face of the wall in order to cause the wall to return to its original vertical position without kinking. A number of options were considered to accomplish this, involving the pulling of the wall from the landward side into a straight line. Because of the difficulties involved on the site in achieving both uniform load and sufficient pressure to return the wall to its original constructed position, a unique and novel approach was selected. This approach involved using the hydrostatic pressure exerted on the wall during tidal cycles.

The first step was to determine the equilibrium between the forces exerted by hydrostatic pressure and the horizontal forces from the backfill material and at what depth of excavation behind the wall this would occur. After several iterations were completed the parameters were chosen and with the existing site solidified using the methods described above the wall straightening began. Throughout the entire straightening exercise the site was dewatered.


Charlottetown Convention Centre Site : Seawall Fanning



Charlottetown Convention Centre: Infilling

Prior to the wall straightening the areas of wall that were not affected by the failure were anchored so they would not be affected by the straightening process. This anchoring consisted of the installation of tie rods and concrete anchor blocks. This step ensured that the unaffected areas of the SSP seawall remained vertically plumb during the straightening efforts.

On a rising tide the excavation behind the SSP seawall was carried out using an excavator working from the stabilized soils. The material immediately behind the wall was removed to the required depth and back far enough from the “fanned” position so, when the tide rose, the hydrostatic forces exerted a uniform load on the wall and returned it to a vertical position. At this stage the wall was anchored in the new position and this length of SSP seawall was secured with tie rods and anchor blocks.

Using nature’s tidal force, the “fanned” section of seawall was returned to its original position and anchored to a newly constructed tie back mechanism consisting of a series of concrete anchors installed across the site and buried in the backfill. This remedial work placed the seawall in a position from which completion of the structural infill could be undertaken.

## KEY ACCOMPLISHMENTS

This project demonstrates the following:

### Excellence in Engineering

Two aspects of the Charlottetown Convention Centre Foundation and Seawall Project constitute engineering excellence. The first is the manner by which a structural failure was corrected using the hydraulic forces inherent in a rising tide to provide a uniform load along the failed wall allowing it to be straightened in a uniform manner and replaced in its intended position. The second aspect of this project which demonstrated engineering excellence was the creation of structural back fill utilizing a soil stabilization methodology to make use of what was otherwise unsuitable material. This use of local material in an area of our region in which good structural material is unavailable constituted a design approach which significantly mitigated the owner's costs.

### Sustainability of Work

The use of existing, contaminated, soils mixed with cement to create a structural fill constituted a sustainable solution to a very difficult challenge in Charlottetown where volumes of sufficient structural strength were only attainable with difficulty. This approach of utilizing local materials in a sustainable form prevented excessive material costs as well as a significant time delay in the execution of this project, each of which enhanced the projects sustainability. The Environmental Assessment dictated that the soils remain on site or be disposed of offsite at an approved landfill site capable of disposing of contaminated materials in the proper manner. The excavation of the site would have required the removal of 9,000 M3 of contaminated soil through the streets of Charlottetown in the middle of winter.

Charlottetown Convention Centre Site : Steel Sheet Pile and Seawall Tiebacks

## Engineering Creativity

The repair of a bent and twisted steel sheet pile wall is a challenge at any time. The concept of utilizing hydraulic pressure created by a rising tide to create a uniformly loaded force to straighten the deformed seawall was a novel and creative approach to solving a vexing problem.

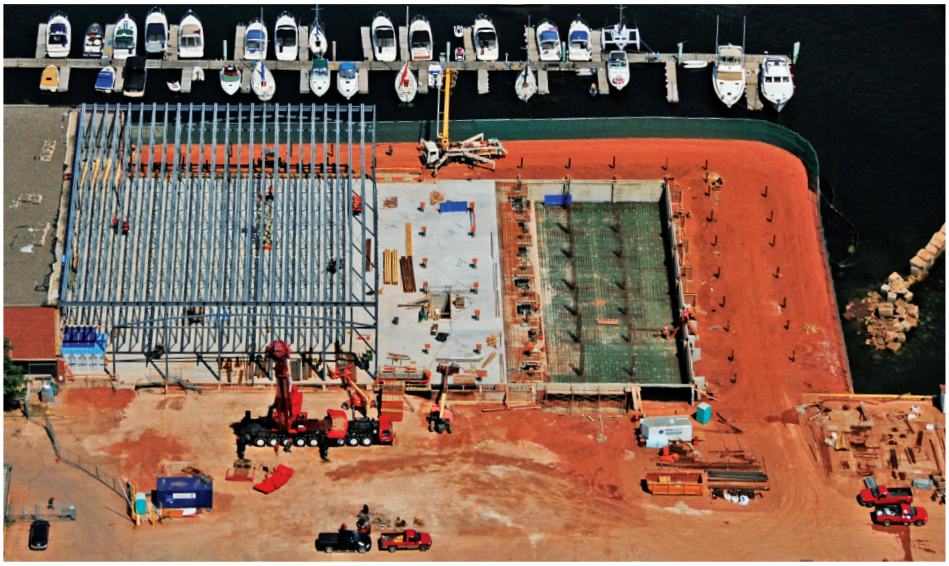
Once this wall had been straightened the use of concrete anchors to tie it back and the use of a local fill which was enhanced through the use of cement addition to create a structural capacity which was otherwise unattainable, demonstrates a level of creativity which recommends this project for the Canadian Consulting Engineering Award.

## Technology Leadership

The utilization of a soil stabilization approach for a project located on the waterfront of a Canadian capital City is a unique use of evolving geotechnical technique for foundation support. The use of a cement/soil mixture to enhance the stability of foundation material is an evolving technology which is still under development, but which is rapidly becoming a time effective and cost effective method of achieving a foundation capability at much less cost and time than would be possible in any other manner.

Enhancement of the Profession of Engineering

A failure is not a good place to start when one is attempting to enhance the engineering profession. However, when a challenge of this nature arises and is dealt with in a cost and time effective manner with a solution which is both expedient and effective, it speaks well of the manner in which engineers come together to solve their problems. EastPoint's solution to this challenge left the client and the public with a sense that when difficulty arises; our profession will rally to find a satisfactory solution to what at the time may appear to be an unsolvable enigma.



Charlottetown Convention Centre: Under Construction

## SELECTION CRITERIA:

The Canadian Consulting Engineering Awards are awarded to projects that demonstrate a high quality of engineering, imagination and innovation. The Charlottetown Convention Centre Foundation and Seawall Project meets these criteria in the following ways.

### Innovation

The Charlottetown Convention Centre lies on the waterfront in Charlottetown, and is a focal point of the waterfront as a destination. The Centre's foundation required extending the shoreline into the harbour, and constructing a steel sheet pile sea wall backfilled with structural fill. Construction involved driving steel sheet piles around the site and backfilling with local material. Unfortunately, during the final phase of construction, the temporary anchorage system failed and the seawall fanned into the harbour – a potentially catastrophic event for the overall project.

At this point, EastPoint was engaged to review and provide advice to the Charlottetown Area Development Corporation (CADC), and the firm committed to providing an innovative and effective solution to the client. The project consisted of a constructed seawall that was 1500mm out of plumb and leaning in an untenable position into the harbour. The site was flooding during tidal cycles and the backfill, which had been partially placed, was no longer capable of supporting vertical loads from pedestrians, let alone the construction equipment which the project would later require.

EastPoint's solution stabilized the soil using a phased "mix and harden" process. Testing confirmed that 15% cement by weight mixed with the placed fill would provide the desired soil characteristics and achieve compressive strengths greater than 600 kPa. EastPoint's design mixed 35 MT of cement with 240 MT of soil in 6M x 4M blocks at a depth of 5M, at a rate of four blocks per day based on site constraints and mixing methods. To maximize efficiency, the soil remediation progressed from the inboard edge of the infill area to the seawall, and completed while new anchor blocks and tie rods for the seawall were installed.

Straightening the seawall was a more cost-effective and sustainable solution than removal and replacement, and the remediated soil provided a platform from which the seawall could be corrected. EastPoint's unique approach to this unprecedented task used natural hydrostatic tidal pressure: On a rising tide the material immediately behind the wall was removed to the required depth and back far enough from the "fanned" position. When the tide rose, the hydrostatic forces exerted a uniform load on the wall and returned it to a vertical position, where it was anchored with tie rods and anchor blocks.

With EastPoint's successful implementation of this innovation project design, the balance of the project was completed on time and on budget.

## Complexity

A particularly complex project, the Charlottetown Convention Centre Foundation and Seawall Project was challenging for two specific reasons. First, the Centre's site is a cornerstone of the city's waterfront, and removing and replacing both the failed soil and seawall would mean moving 9,000 M3 of material through the centre of the city in winter. This option would also require importing rock fill, since local fill on Prince Edward Island is often of poor quality, a significant additional and unplanned cost to the client.

Instead, EastPoint's ingenious design solution used local site materials to mitigate costs and ensure Charlottetown's downtown core was not disrupted. EastPoint's team overcame significant onsite challenges to ensure the success of this design. When an injection auger failed when it encountered timber debris, the construction team used a portion of the site as a mixing bowl, with an excavator as the spoon to place the hardening soil before it set.

The unique straightening of the steel sheet pile seawall was a second project challenge. EastPoint's design used the rising tide to its advantage: It provided an even distribution of loading to the seawall, allowed it to be straightened in a uniform manner, and placed in its intended position. This approach required that the forces supporting the inboard side of the seawall needed to remain intact in areas where no movement was necessary, while the hydraulic force of the tide moved the unsupported wall incrementally into a position where it could be restrained and anchored.

## Social and Economic Benefit

In 2012, the Charlottetown Area Development Corporation faced a near catastrophic seawall failure on the site of the new Charlottetown Convention Centre.  EastPoint was engaged to help prevent substantial, unplanned replacement or repair costs in a highly visible location on the waterfront of a major Canadian tourism and economic centre. In addition to the economic risk, the client and development team faced significant reputational risk, including impact to the profession and the public agency.

In a timeframe of only six months, from concept to completion, EastPoint designed and implemented a solution that avoided the costly removal and replacement of the structural fill and the failed seawall.

EastPoint's design impacted the project significantly, in a number of ways. First, and most importantly, the design ensured the project could continue. Without this solution, the overall project faced failure, since the timelines and costs associated with completely removing and replacing the structural fill and seawall would have prevented the project from ever reaching a successful conclusion. Additionally, EastPoint's approach avoided sending heavy traffic through a densely occupied portion of Charlottetown, and ensured the timely completion of a substantial project with important economic benefits to the city.

Broadly, EastPoint's approach to the Charlottetown Convention Centre project enhances our profession's reputation as professionals who rally to the support of clients and colleagues in challenging circumstances. We are proud to contribute to a long-lasting construction program for one of Canada's most beautiful and popular waterfront tourist destinations.

## Environmental Impact

Enhancing the stability of foundation material is still an evolving technology, but this unique approach is rapidly becoming a time and cost effective way to achieve a strong structural foundation. As a small island without access to large volumes of quality fill material, it was critical that EastPoint's environmentally sustainable solution used existing soil mixed with cement to create a structural fill for Charlottetown's Convention Centre.

The project's initial Environmental Assessment dictated that the soils needed remain on site, or be disposed of offsite at an approved landfill that was capable of disposing of contaminated materials in the proper manner. Any excavation of the site would have meant removing 9,000 M3 of contaminated soil through the streets of Charlottetown in the middle of winter, as well as disposal of it in an approved manner.

EastPoint's approach involved using sustainable materials onsite and in-situ, prevented the removal and disposal of tonnes of material through the streets of Charlottetown, and ensured that the client did not have to import expensive fill materials.

Using local, sustainable material was not only cost-effective solution for the project, but also ensured the timeline remained on schedule, both of which contributed to the overall sustainability of the new Charlottetown Convention Centre.

## Meeting Client's Needs

The Charlottetown Area Development Corporation (CADC) was confronted by a potentially catastrophic problem as the construction of the new Charlottetown Convention Centre began, a high profile project on the waterfront of the Provincial capital and in the centre of one of Canada's most attractive tourism centres.  At the outset of the project in 2012, the seawall, the structural foundation for the Centre, fanned toward the harbour. This unwelcome surprise presented three separate potential complications for the development team:

- First, the cost of remedying this issue was significant, and securing the required funds was difficult.

- Second, a major disruption to the project's timeline would extend the project into summer, meaning that a critical element of the Charlottetown waterfront would be in construction longer and potentially harm commercial and tourism activity in Charlottetown.

- Finally, the reputational harm that could impact the CADC, its project team, and the engineering profession was substantial.

Throughout the project, from concept to completion, EastPoint's goal remained clear: ensure a successful outcome for the client. EastPoint's innovative solution to this challenge built immense goodwill with both the CADC and PEI's citizens. They experienced firsthand that when difficulties arise, professional engineers rally together to find realistic, environmentally sustainable, cost effective and efficient solutions to complex, seemingly insurmountable problems.

**THE ENGINEERS RESPONSIBLE FOR THIS PROJECT WERE:**

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| **FIRM:** | EastPoint Engineering Limited. |
| **SENIOR ENGINEER:** | Bruce Tuck, P.Eng. MBA |
| **INTERMEDIATE ENGINEER:** | Matthew Himmelman, P.Eng. |