
Garrison Crossing, Toronto, ON
Canadian Consulting Engineering
Awards 2020
PEDELTA
CREATE TO
Dufferin
Construction
A division of Holcim (Canada) Inc.

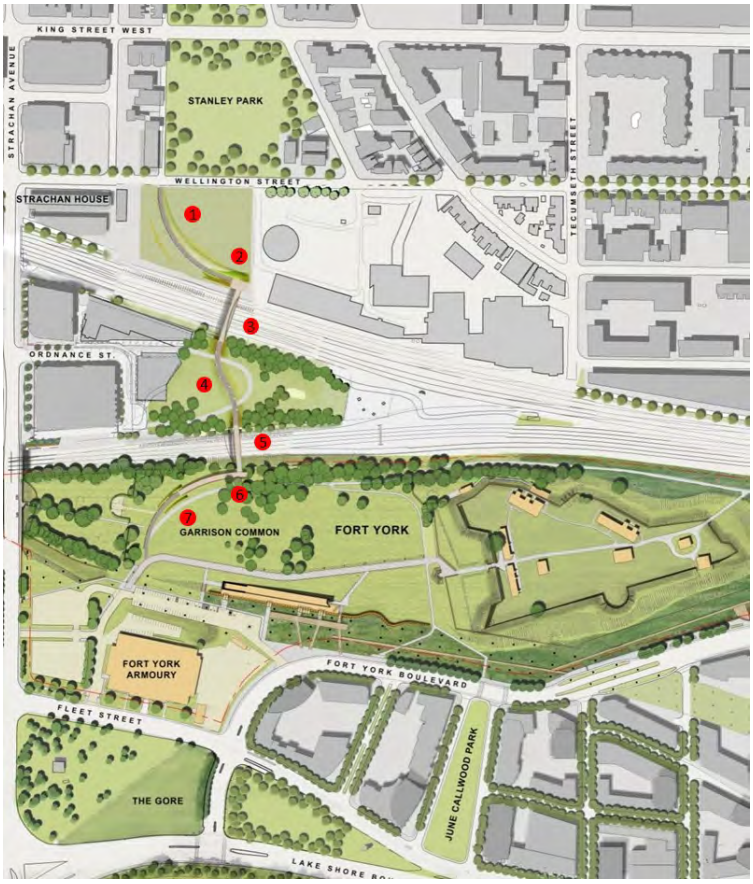
Executive Summary

On behalf of the City of Toronto, CreateTO accepted proposals for the Garrison Crossing design-build project, which provides a key link between Stanley Park and the historic site of Fort York over two of Canada's busiest rail corridors. Pedelta designed two pedestrian and cycle bridges utilizing Duplex Stainless Steel for the entirety of the structure; an unprecedented technical innovation in North America, providing a durable long-term asset with premium aesthetics for the community.

Project Highlights

Garrison Crossing, formerly named "Fort York Pedestrian and Cycle Bridge", was needed to enhance accessibility and foster connectivity of expanding communities around the historic setting of Fort York, providing a new pedestrian and cyclist link to the Waterfront in Toronto. The project was first initiated in the early 2000s but was canceled for cost reasons. In 2014, Toronto City Council approved a $19.7 million budget for the project to be procured using a design-build model. The City appointed CreateTO, its real estate and development corporation, to manage the project. In December 2014, CreateTO shortlisted three teams to participate in the Request for Proposals. In November 2015, CreateTO awarded the proposal to Dufferin Construction's team, with Pedelta as the lead designer.

The project is located just west of the main downtown area of Toronto and provides a key link between Stanley Park to the north and the historic area of Fort York – the birthplace of Toronto. The project features two bridges crossing two of Canada's busiest rail corridors. Construction started in August 2016 and the project was opened to the public on October 1st, 2019.



The path configuration is inspired by the character and shifting, curving alignment of Garrison Creek. It seeks to achieve visual continuity throughout its length with a consistent and distinctive approach to ma-teriality, landscaping, and lighting and identity signage elements.

1. South Stanley Park
2. Stanley Lookout
3. North Bridge
4. Ordnance Lands
5. South Bridge
6. Garrison Lookout
7. Structural South Landing

Innovation

The awarded design proposal includes an unprecedented technical innovation in North America: the use of Duplex Stainless Steel for the entire structure. The pioneering use of this forefront technology provides premium aesthetics within a unique setting, in addition to a safe and durable asset for the community. The structure has an extended life cycle, is more corrosion-resistant and requires less maintenance, thus reducing its overall cost.

The Design-Build Team proposed a unique arch design consisting in a tied stainless-steel network arch, with a distinctive crossing diagonal hanger pattern, and a triangular profile, with a single arch rib inclined at 18 degrees to provide a slender, transparent and elegant structure. The two arches tilt in opposing directions to create a more dynamic and intriguing visual experience for users. The structures are configured differently but still retain a continuity of expression. The structural system selected for both bridges is similar, with the geometry differing slightly.

North Bridge: The bridge has a single span with total length of 52 m. The arch has a parabolic elevation with a maximum height over the deck elevation of 9 m, resulting in a dynamic and relatively flat rise-to-span ratio of 1:5.8, which was intentionally selected for aesthetics reasons. The hollow rib has a triangular cross-section that is 900 mm wide and 450 mm deep, with a central web made from steel plates with thicknesses ranging between 15 and 40 mm. A triangular cross-section was selected to enhance the structure-sunlight interaction, which is already benefited by the visual characteristics of the stainless steel, as well as to reinforce its visual slenderness and facilitate the practicality of fabrication by utilizing standard hot-rolled steel plates.

The arch is connected to the tie-girder at both ends and by two families of inclined hangers that cross each other once. The hangers are inclined 60 degrees to the horizontal and consist of 36 mm diameter stainless steel rods, which provide a clean a smooth appearance compared to traditional cables. This arch system is a very efficient structure; the arch works like a truss, with minimum bending moments and shear forces, even for asymmetrical live loads (unlike arches with vertical hangers). The triangulation of hangers provides restraint to the horizontal component of load due to the inclination and against buckling. Therefore, both the arch and tied-girder are able to have cross-sections with relatively slender dimensions that make the bridge more transparent and lighter overall. The hangers only take axial forces and work in tension. Also, an eye-fork fitting at both ends of the rods provides length adjustment. The forks are connected to both the arch rib and the deck with steel plate gussets to create an elegant and simple pinned connection.

The steel deck system is connected to a 180 mm deep concrete slab on top. The slab is reinforced with stainless steel reinforcing bars and acts in composite action with the box girder and ribs to take advantage of the strong suits of the individual materials. The concrete deck, unlike other lighter deck system alternatives, provides the least mass and higher damping ratio required to prevent excessive vibrations that would otherwise be uncomfortable for users.

South Bridge: Unlike the north bridge, the south bridge links the Ordnance Triangle to Fort York, which has a 5 m elevation difference that imposes a different bridge design concept. After an assessment of various arch alternatives, the solution that best fit the site constraints is a one-span arch connected to a V-shaped pier on the south end. This unusual structural system is very efficient, as it transforms the thrust of the arch into a set of axial forces in the V-pier and also provides a greater openness underneath the crossing.

The 49 m long bridge crosses the rail corridor with a straight alignment perpendicular to the rail corridor to minimize the length of the structure. The span length between the axis of the abutment and the pier is 44.5 m. The bridge platform extends to the south to blend with a curving approach structure oriented to the west with a projecting lookout to the east.

The south bridge landing includes a 58 m long structural ramp on the west side, terminating with a cantilevered lookout on the east side. The ramp is a continuous reinforced concrete girder with typical spans of 12 m to minimize the structure depth and provide as much open viewing space underneath as possible. The structure is continuous with the bridge and integral with the pier to minimize future maintenance. The piers have a trapezoidal cross section and are made of concrete. The two side faces of each pier are clad in permanent weathering steel and provide a natural material contrast with the stainless steel, which helps to visually ground the bridge in its heritage setting.

Complexity

The bridge project was faced with many considerations that needed to be integrated from the beginning of the project, including strict budget and timeline, high-quality design, technical requirements, considerations for future rail electrification, the need for flexibility with material design standards, the number of stakeholders involved in previous consultations, and surrounding transportation constraints.

Design Challenges: The key design challenge was the need to achieve an appropriate landmark quality in this special heritage setting within a very tight budget. The south approach lands on the Fort York Garrison Common – the open space west of the walled Fort, historically significant as one of the important battlefields in the War of 1812. In order to minimize impacts on the cultural heritage landscape of Fort York, the bridge and approach ramp within Garrison Common at Fort York has a minimal footprint.

Another key consideration was to design and build the bridge over the existing railway corridors, placing the substructure out of the right of way of the rail corridor and maintaining a vertical clearance of 7.44 m above the top of the railway. The bridges were required to have an unobstructed width of 5 m to accommodate both pedestrians and cyclists and must provide universal access. The bridges cross over two active rail corridors, so consideration had to be given to the protection, safety, and security of both the railway operations and the pedestrians and cyclists using the bridge.

Due to the lack of specific Canadian codes for the design of stainless steel structures, the structural design strategy was to comply with the loading and safety requirements of the Canadian Highway Bridge Design Code (CSA S6) and the provisions of specific Stainless Steel Eurocodes for matters relating to the structural capacity of elements and other design considerations.

Fabrication with Stainless Steel Challenges: Fabrication and erection were carried out in accordance with the Design Guide for Structural Stainless Steel of the American Institute of Steel Construction (AISC). Stainless Steel is not a difficult material to work with. However, for some aspects, it is different from carbon steel and should be treated accordingly. It is crucial to preserve the superior surface appearance of the stainless-steel surfaces throughout fabrication with simple precautions and good engineering practice. In order to restore the stainless-steel surface and maintain its corrosion resistance after welding and fabrication work, it was necessary to conduct a post-fabrication treatment such as pickling, brushing, and blasting, to remove all scale and contamination and obtain a consistent uniform dull finish with a silver colour. There was a limited number of fabricators with the needed experience and certifications to manufacture in duplex stainless steel. Mariani Metal, a steel fabricator specialized in architectural work for buildings with experience in stainless steel, fabricated the bridges in its facilities in Etobicoke, Ontario. Pedelta prepared a specific material and fabrication testing and inspection plan for the stainless-steel fabrication. Testing was conducted by specialized firms.

Construction Challenges: The construction of the bridges had its own set of challenges. The bridges were conceived to minimize interference with the rail and streamline the construction time. Most of the bridge components were prefabricated at the shop and assembled at the site to accelerate construction and ensure quality of the final product. The steel elements were prefabricated in sections to facilitate transport to the site. Both the tied girder and arch were fabricated to the required camber to compensate for deflections due to all dead loads and match the design profile elevation.

A key element of this strategy was to minimize the number of iterations of construction mobilization. Upon completion of the accesses to the assembly areas, the bridges were assembled and erected on the accesses to minimize noise and disturbances to neighboring residential areas in the north and to the area around Fort York. Upon delivery of the sections to the site, the arch and tied-girder sections were assembled in pre-set positions on temporary supports at close intervals without hangers. The main field splices were designed for field welding with aesthetic in mind. After completion of the arch and once it was connected to the tied girder, the arch was released to form to its true shape. Next, the hangers were installed and hand tightened, and the intermediate supports of the tied girder were removed to let the hangers get tensioned from their steel dead load. The 130-ton bridge superstructures were hoisted into the final position with a 600-ton hoisting capacity crane placed at one end. The lift of the two bridges was done during a weekend night in July and October 2018 to minimize rail traffic disruption.

Social and Economic Benefits

The long-awaited Garrison Crossing is an important piece of active transportation, city building infrastructure that connects key downtown communities north of the rail corridor, with Fort York and the Waterfront, linking parks and green spaces. The project is not just simply a new addition to Toronto's physical infrastructure, it is a social device that promotes the sustainable human interaction with one's environment, as well as emphasizing the cultural heritage of the city.

The bridge structures are made of Duplex Stainless Steel Grade 2205. One of the key points considered at the preliminary design phase, when evaluating the use of the stainless steel option from an investment perspective, was the life-cycle cost. The higher capital cost of stainless steel is offset by the extended structure life-

cycle due to the increased corrosion resistance, and reduced maintained as a result, which in turn reduces the overall cost of ownership. This represents a net advantage for the asset owner, in addition to improving safety and long-term durability.

For this project, the Pedelta design team leveraged its extensive international bridge design experience, especially from the design of bridges using stainless steel. Pedelta also pulled from past experiences for other design and aesthetic features, such as the use of single rib arches and triangular hollow shapes that nicely catch the sunlight, to achieve an innovative and elegant structure.

Environmental Benefits

The final design touches on all three pillars of sustainability: environment, economy, and society. The City played a significant role to achieve sustainable design by promoting environmentally friendly design approaches and avoiding irresponsible concepts that were only driven by a short-term cost-effectiveness. Stainless Steel is recognized as a sustainable material with a lower environmental impact than carbon steel due to the reduced CO_2 emissions during fabrication, lightweight construction, and low maintenance and deconstruction cost over the bridge lifespan, as well as one of the highest recycling rates of any material. The design is aligned with other recognized sustainability practices such as minimizing consumption of materials, even with solutions that require more labour, through a sound and optimized structural concept, and providing an extended lifespan and easy maintenance even if the initial cost is slightly higher as well the use of LEED lighting. Also, with the elegant approach ramps, the bridges are easily accessible by all members of the public.

Meeting Client's Needs

Garrison Crossing has successfully enhanced accessibility and connectivity of the communities around the Fort York, providing a new pedestrian and cyclist link to the Waterfront. The bridges were designed to add a distinctive visual element with a clear identity to the City of Toronto, without dominating the skyline, and natural beauty of the surrounding neighborhoods and parks. The bridges present substantial curving forms within the landscape that are bold in a visual sense, while withholding a minimal, understated and elegant physical presence, with the goal of just lightly gracing the historic setting. The design was focused on both structural efficiency and pleasing proportioning of the geometry, while complementing both the historic roots and looking to the future growth and prosperity of the city.

The bridges were required to be designed for a 75-year service life. Durability was an especially important issue to consider for this project, from practicality, cost, and sustainability perspectives. The bridges will be permanently exposed to a potentially corrosive environment and de-icing salts in the winter. Since the Grade 2205 Duplex Stainless Steel boast exceptional corrosion resistance, the maintenance requirements for the structure is limited to regular pressure washing with water to remove the accumulated de-icing salt. In addition, stainless steel is particularly beneficial for structures with significant maintenance constraints, such as bridges over rail corridors, as it will eliminate the need of major associated costs.

This project illustrates the importance of the engineering profession in our society and the engineer's ethical responsibility to embrace innovation, sustainable practices and context sensitive design to achieve quality of public spaces that serve the public and generations to come.

Garrison Crossing – "The First Duplex Stainless Steel Bridges in North America"

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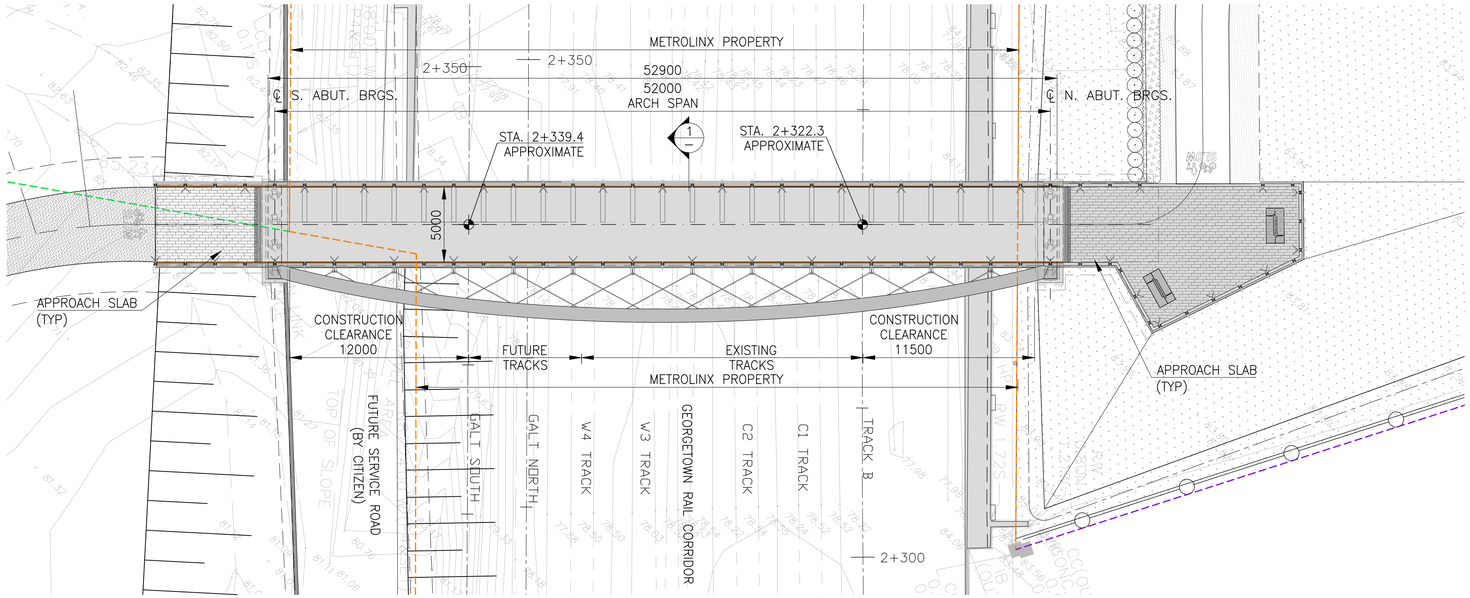
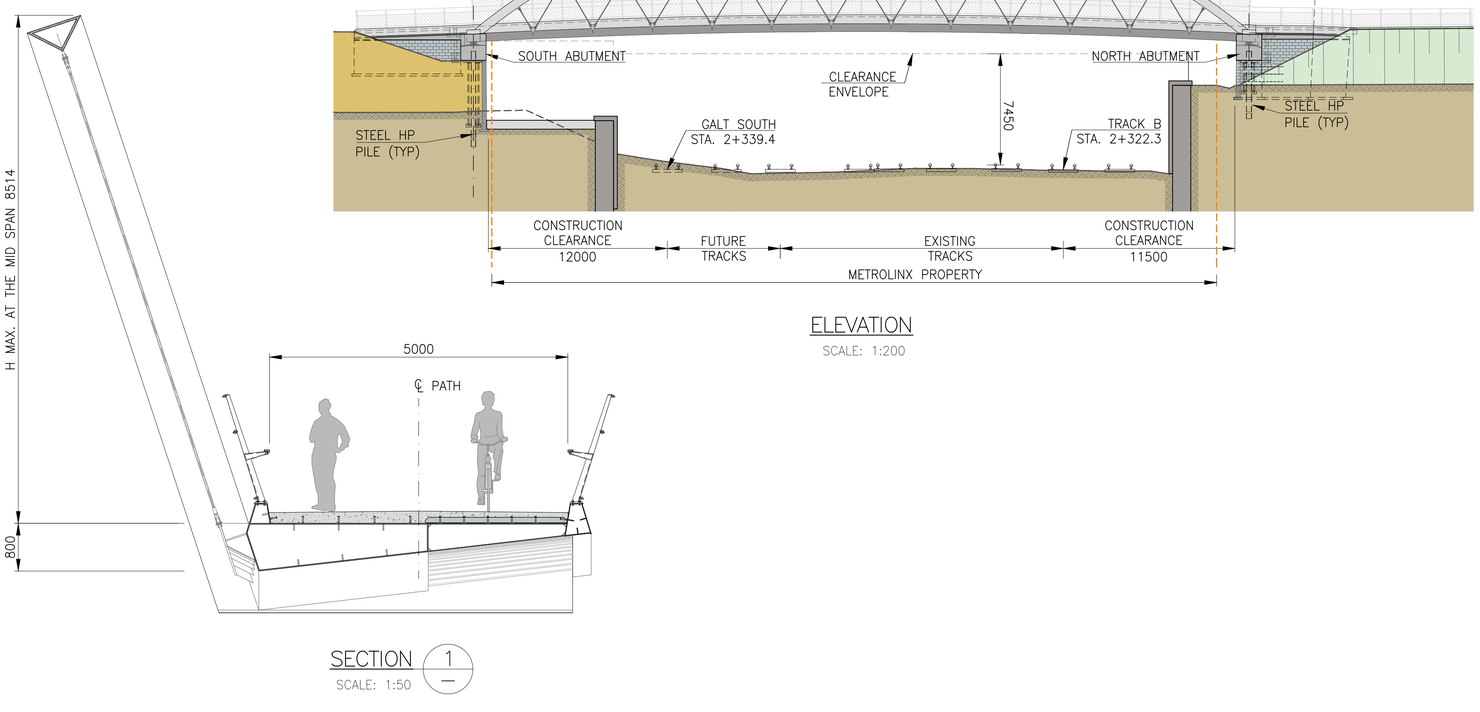


PLAN VIEW

SCALE: 1:200



ELEVATION

SCALE: 1:200

SECTION 1

SCALE: 1:50

PROJECT:
FORT YORK PEDESTRIAN AND CYCLE BRIDGES

DRAWING TITLE:
NORTH BRIDGE
GENERAL ARRANGEMENT

DRAWNG NO.
NB–S001

SCALE 1:200

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NOTES:
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2. METROLINX FENCE (EXISTING OR FUTURE) THAT DEFINES DE RIGHT OF WAY OF THE RAIL CORRIDOR IS NOT CONNECTED TO THE BRIDGE. METROLINX FENCE TO BE MAINTAINED OR BUILT BY OTHERS.

- - - - METROLINX PROPERTY LINE

- - - - BUILD TORONTO HOLDINGS (ORDNANCE) INC/ELDONVIEW INVESTMENTS PROPERTY LINE

- - - - CITY OF TORONTO PROPERTY LINE

COORDINATE SYSTEM

ALL PLAN VIEWS ARE REFERENCED ACCORDING WITH MTM ZONE 10, NAD83 (ORIGINAL), METRES, AND THE VERTICAL DATUM CGVD28 – 1978 ADJUSTMENT

LICENSED PROFESSIONAL ENGINEER — J.A. SOBRINO ALMUNIA — 100174531 — 12/18/2017 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — F.J. JORDAN GARCIA — 100194763 — 12/18/2017 — PROVINCE OF ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING (22x34)

REVISIONS	No.	BY	DATE	DESCRIPTION
	3	JS	05/09/16	IFC SUBMISSION
	2	JS	03/11/16	95% SUBMISSION
	1	JS	12/18/15	50% SUBMISSION
	0	JS	12/16/15	FIRST ISSUED
DESIGN:SC/DS		CHK: JS	CODE: FY	
DRAWN: YV		CHK: JS	SITE: FORT YORK, TORONTO, ONTARIO	

REV. No.	DATE	DESCRIPTION
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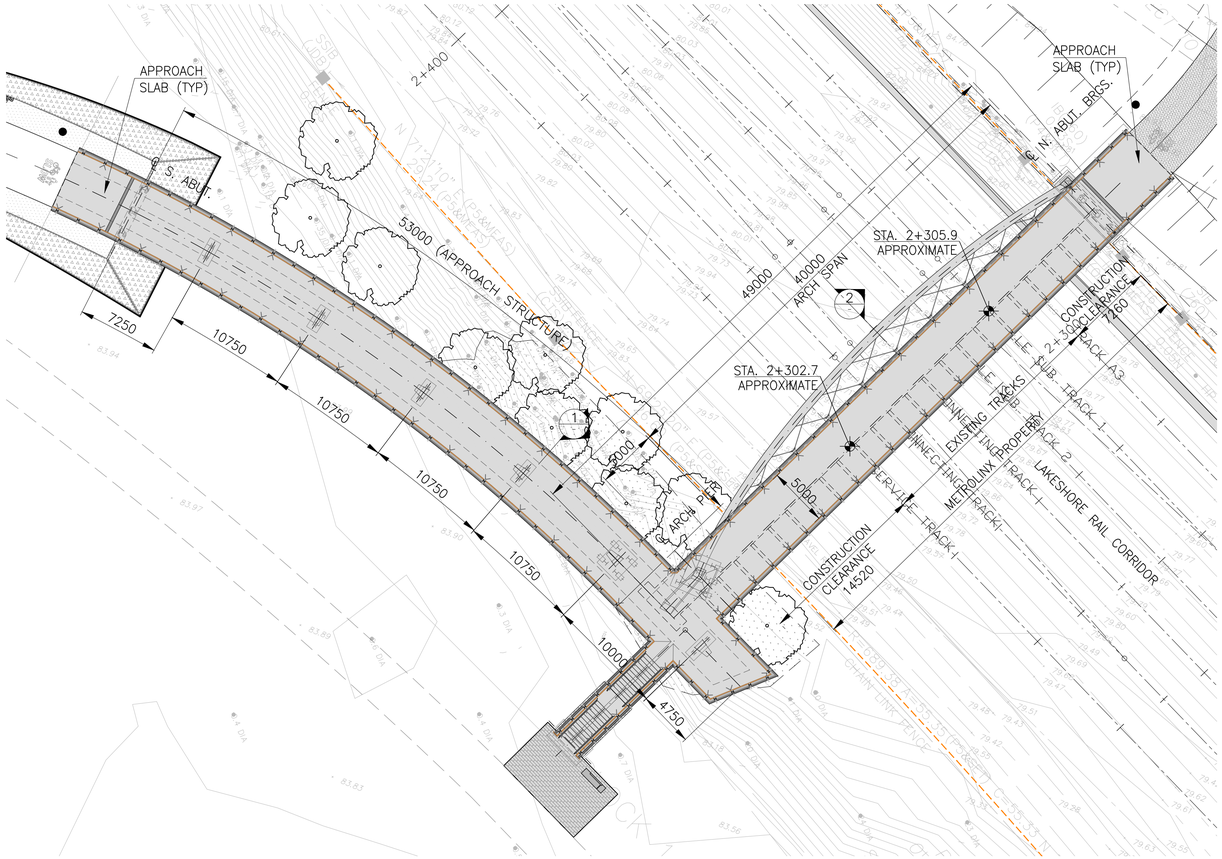
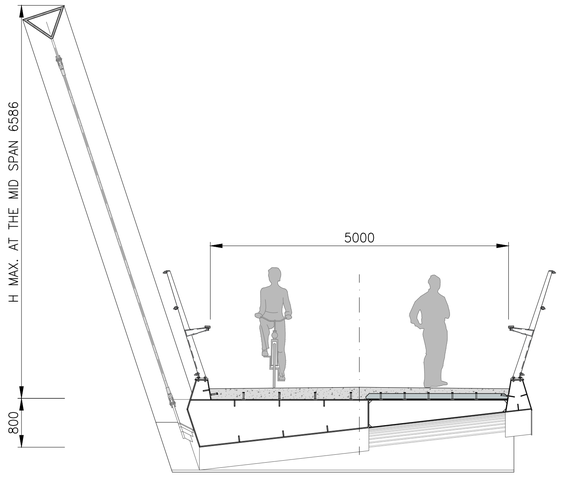
2	09/21/16	RFI #7 09/16/16



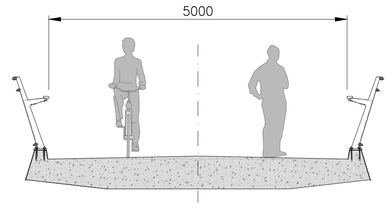
PLAN VIEW

SCALE: 1:250



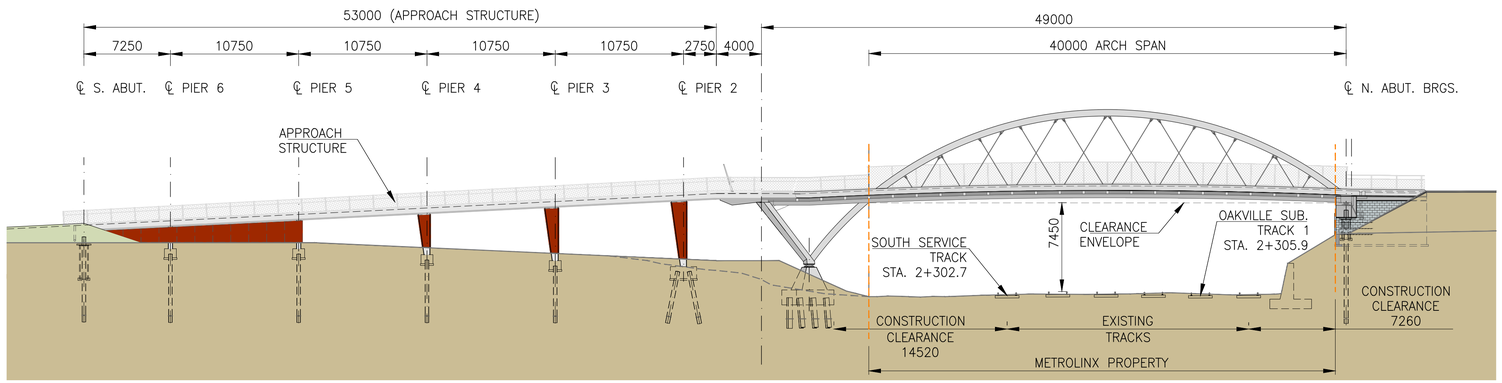
ARCH SPAN. SECTION 2

SCALE: 1:50



APPROACH RAMP. SECTION 1

SCALE: 1:50



DEVELOPED ELEVATION

SCALE: 1:250

PROJECT:
FORT YORK PEDESTRIAN AND CYCLE BRIDGES

DRAWING TITLE:
SOUTH BRIDGE
GENERAL ARRANGEMENT

DRAWNG NO.
SB-S001

SCALE 1:250

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REV. No.	DATE	DESCRIPTION
4	10/27/16	TOP OF MESA WALL DETAILING UPDATE
2	09/21/16	RFI # 7 09/16/16
1	09/07/16	RFI # 4 09/01/16