Making it Fit – Toronto's Lake Shore East Boulevard Bridge Across the Don River

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Abstract

This paper concerns the design of the bridge carrying Lake Shore Boulevard East across the mouth of the Don River in the City of Toronto. The river's outlet into Lake Ontario was recently reconstructed to increase flow capacity, thereby reducing annual upstream flooding. That effort included widening the mouth the river, which necessitated replacing the existing bridges carrying Lake Shore Boulevard East – a major arterial road that connects downtown Toronto to the eastern neighbourhoods of the City – with a much longer bridge. The existing site consisted of an eastbound bridge and a westbound bridge, each comprised of two-span, 50m-long, slab-on-steel girder superstructures on conventional concrete abutments and piers. A new, four-span, 98m-long, 37m-wide, prestressed concrete bridge with semi-integral abutments was designed to replace the existing bridges. Collaboration with the short-term owner – Waterfront Toronto – and the eventual owner – the City of Toronto – was paramount to the project's success. The design was driven by significant geometric challenges in the built environment.

The bridge was designed on the same alignment as three previous Lake Shore bridges, several dock wall structures, and the second-level Gardiner Expressway, all of which included deep foundations that the new design had to avoid or address. The east end of the bridge terminates within the intersection of LSBE and the Don Roadway. High flood elevations and the need to minimize the grade raise necessitated a more slender superstructure than could be achieved using concrete NU-girders. The existing abutments and centre pier were partially reconstructed and widened for re-use in the new bridge to reduce dewatering and demolition costs, including reinforcing the existing west abutment to become the centre pier in the new structure and the point of longitudinal fixity for inertial loads. Complicated staging was necessary to maintain vehicular traffic, to enable construction of the many utilities that cross the bridge, and to facilitate dredging of two new spans of the bridge. Many design adjustments were necessary during construction to address found conditions on the site. The bridge recently opened to traffic after four years of staged construction.

Background

Lake Shore Boulevard is a major arterial road following the shoreline of Lake Ontario in the City of Toronto. The road crosses over the mouth of the Don River along the Lake Shore Boulevard East (LSBE) Bridge. The Don River deviates sharply to the west from its north-south alignment immediately south of the LSBE Bridge to outlet into the Keating Channel. This abrupt deviation has resulted in annual problematic upstream flooding of the Don Valley. The Don Valley includes the Don Valley Parkway, Bayview Avenue, and the GO Transit Richmond Hill regional transit line, all of which are vital north-south transportation arteries that bring travellers into and out of the city from the north.

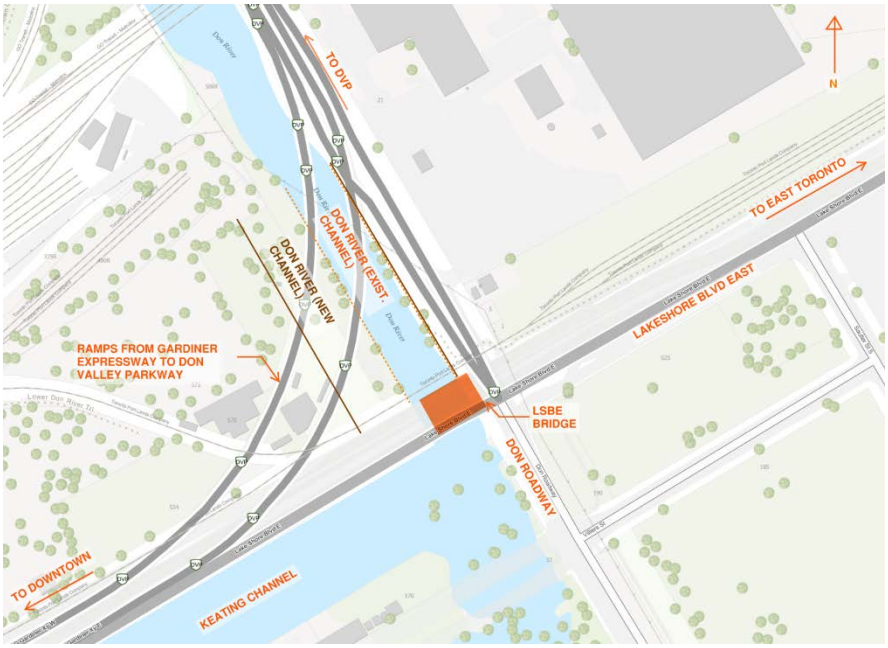
To address this issue, Waterfront Toronto, the City of Toronto, and the Toronto and Region Conservation Authority have collaborated over the past 20 years to design and implement the Port Lands Flood Protection (PLFP) Project. The main goal of the project is to naturalize the mouth of the Don River by rerouting it along a gently curved floodplain through the industrial Port Lands area of Toronto to reduce the risk of upstream flooding in storm events. This project included the need to widen the mouth of the river at the LSBE Bridge, necessitating a longer bridge[1].

This paper explains the design development for the new LSBE Bridge across the Don River as part of the PLFP Project. The project site presented significant geometric, structural, and operational complexities. Designing and integrating the new structural components within this site required meticulous construction phasing and continuous coordination with all stakeholders. Focus is given to the challenging geometry at the site that was influenced by existing infrastructure.

Existing Site

The new bridge site is located to the east of downtown Toronto per the key plan in Figure 1 below. The bridge connects downtown Toronto to the eastern neighbourhoods of Riverdale, Leslieville, and The Beaches, as well as the industrial Port Lands area.

Figure 1. Key Plan

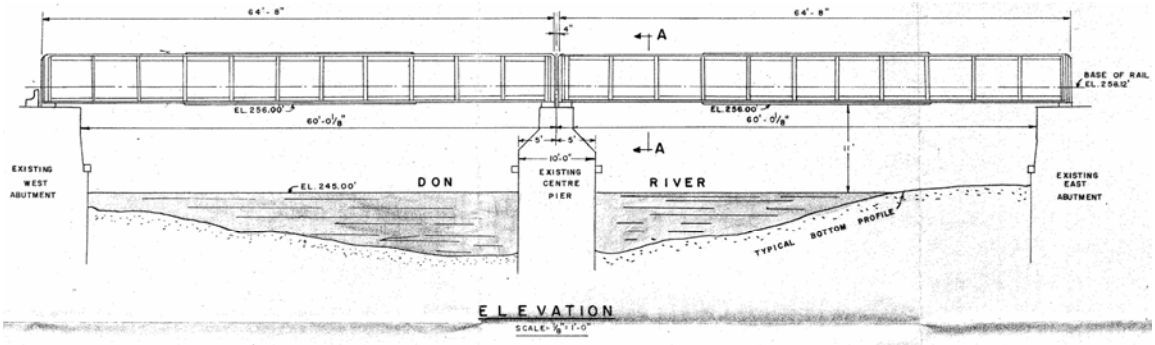


Source: City of Toronto – Toronto Maps[2]

Existing Rail Bridge

Several bridges were previously constructed at the project site. The first known bridge was a half-through steel plate girder structure built during the First World War. It carried a single line of tracks across the Don River along two simply-supported spans of approximately 19710mm length each. The abutments and pier were founded on round timber piles. Several long dock wall structures lining the edges of the Don River and the adjacent Keating Channel were also have been constructed at this time, all of which were founded on round timber piles. The superstructure of this bridge was replaced in the 1960's and rehabilitated in 2018. Figure 2 shows an elevation of this bridge from the 1960's superstructure replacement.

Figure 2. Existing Rail Bridge Showing 1960's Superstructure Replacement



1930's Road Bridge

A half-through steel plate girder road bridge with sidewalks was constructed at the site in the early 1930's. This bridge was constructed south of the rail bridge as shown below in Figure 3. It carried four

lanes of traffic across the Don River along two simply-supported spans of approximately 19050mm length each. The existing dock walls along the Don River were locally reconstructed at the bridge to become the new abutments. Three new, large, +/- 2438mm x +/- 3099mm reinforced concrete caissons were constructed down the bedrock to support each new abutment, as shown below in Figure 4. These caissons were enclosed by steel sheet piling. A centre reinforced concrete pier was also constructed on similar caissons.

Figure 3. Cross-Section of 1930's Road Bridge (Looking East)

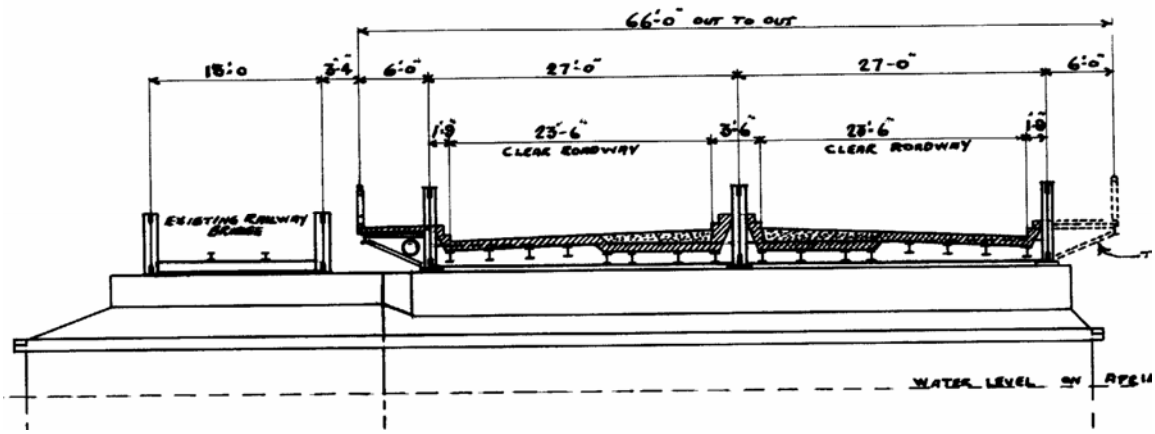
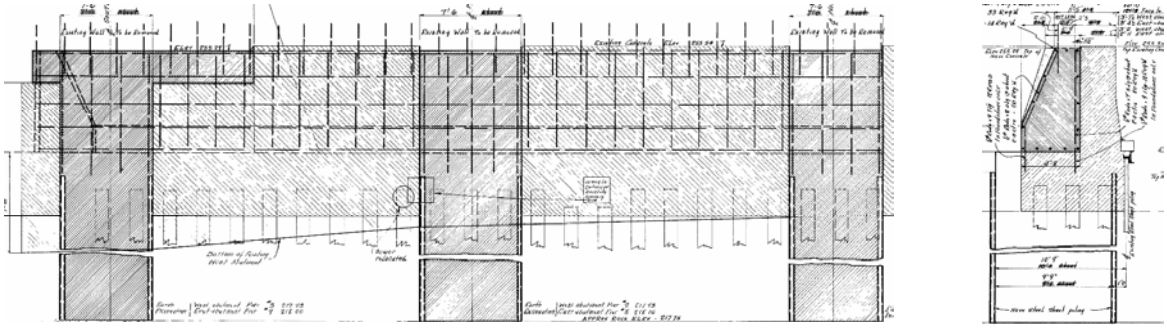


Figure 4. 1930's Road Bridge Abutment Details (Elevation View, Left; Cross-Section, Right)



1960's Road Bridge (Existing LSBE Bridge)

The 1930's road bridge was removed and replaced in the early 1960's with a pair of composite slab-on-steel bridges, one carrying westbound (WB) traffic into downtown and the other carrying eastbound (EB) traffic out of downtown. Figure 5 shows a cross-section of this bridge. Each bridge carried three lanes of traffic across the Don along two simply-supported spans of approximately 24690mm length each. The spans were lengthened relative to the 1930's bridge so that the 1960's bridge could be supported on new abutments positioned behind the abutments and dock walls for the 1930's bridge. These new abutments were cast-in-place concrete cantilever abutments founded directly on bedrock as shown below in Figure 6. The abutments for the 1930's bridge were abandoned in place.

Figure 5. Cross-Section of 1960's Road Bridge (Looking West)

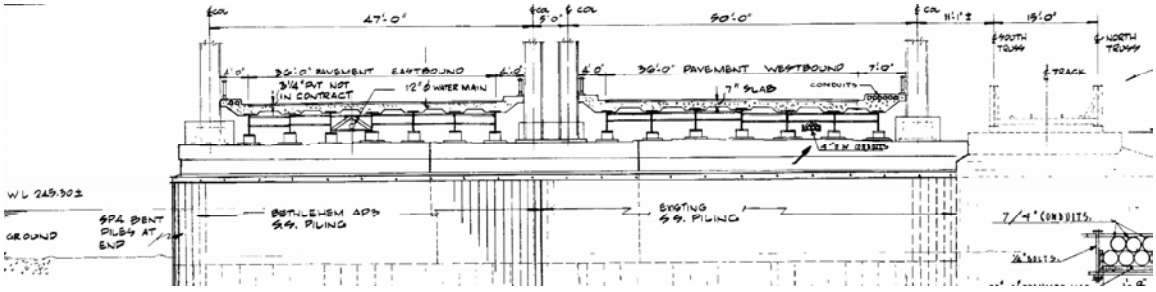
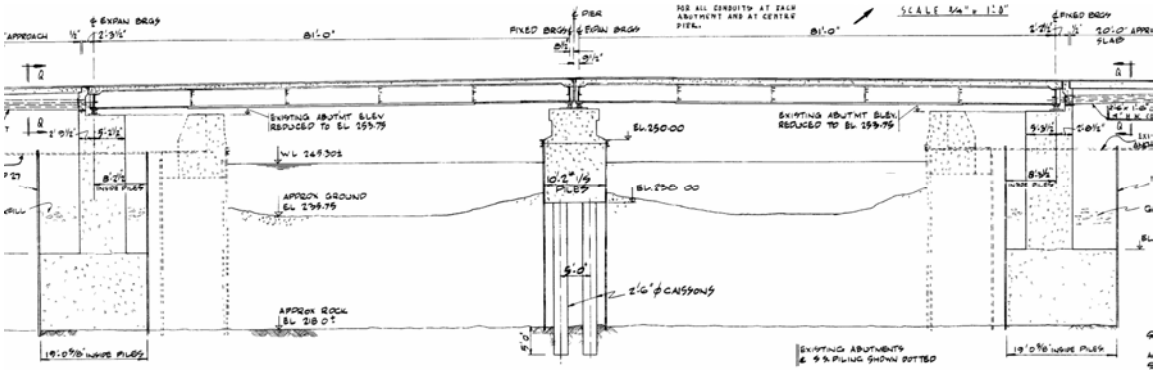


Figure 6. Longitudinal Section of 1960's Road Bridge (Looking North)



The 1960's bridge was constructed as part of the construction for the Gardiner Expressway (the "Gardiner"). The Gardiner is a municipal expressway following the shoreline of Lake Ontario in Toronto. The segment of the Gardiner that passes through downtown Toronto is elevated above the local streets. At the LSBE Bridge site, the Gardiner was constructed above and parallel to Lake Shore Boulevard East, carrying expressway traffic to and from downtown, just like the LSBE Bridge. The Gardiner was supported on steel columns that were founded on the abutments and pier of the 1960's LSBE Bridge. The columns are visible in Figure 5 and below in Figure 7.

Project Site at Outset of PLFP Project

Figure 7 shows the existing site at street level in June 2019 at the outset of the portion of the PLFP Project to replace the LSBE Bridge. The image was taken from the east abutment looking west towards downtown. The EB and WB Gardiner Expressway structures are visible overhead.

Figure 7. Project Site at Outset of Project



Source: © 2026 Google[3]

The intersection of Lake Shore Boulevard East and the Don Roadway lies at the east end of the LSBE Bridge, as shown below in Figure 8. The Don Roadway was a local road that was built along the east bank of the Don River to the north of the existing project site. Most of it was integrated into the Don Valley Parkway (DVP) in the early 1960's. The DVP is an at-grade municipal expressway that connects directly to the eastern terminus of the Gardiner, functioning as a north-south connector between the Gardiner and Highway 401 in northern Toronto. The portion of the Don Roadway that did not become the DVP was instead used as the southernmost on/off ramp for the DVP. The close proximity of the Don Roadway intersection to the east end of the bridge influenced the new bridge design.

Figure 8. Don Roadway Intersection (Looking North; Existing Bridge on Left)



Source: © 2026 Google[3]

Existing Geotechnical Conditions

The existing site consists of shale bedrock overlain by layers of fill and native soils. The upper soil layer consists of about 3.4m of very loose to compact fill including organics and construction debris, which is consistent with the site being situated on reclaimed land from the late 19th century. The fill is underlain by about 5.2m of very loose to loose organic silt and sand, which in turn is underlain by about 2m to 5m of very loose to very dense silty sand to sandy silt extending down to bedrock. The bedrock is shale bedrock of the Georgian Bay Formation. The upper 0.0m to 4.6m of bedrock was identified as being highly to completely weathered. The organic silt and sand and the silty sand to sandy silt between elevations 67m and 70m were identified as susceptible to liquefaction under the 2475-year earthquake event, but not liquefiable under the 975-year and 475-year earthquake events[4].

The theoretical riverbed elevation at the outset of the project was +/- 71.18m. Lowering of the riverbed via dredging was anticipated as a measure to afford increased hydraulic capacity to the new bridge.

The top of bedrock was understood to be at an elevation of approximately 66m. The top of pavement elevation at the bridge was anticipated to be at elevations between 78m and 79m. As such, any excavations down to bedrock for construction of new foundations would require substantial shoring and dewatering.

Design Development

As explained in the previous section, the existing project site has a long history of previous bridges and dock walls. These infrastructures greatly influenced the design development, as explained herein.

The objective of the PLFP Project was to construct a new LSBE Bridge that would both enable widening of the mouth of the Don River and that would accommodate additional traffic lanes and a new multi-use

path to improve both vehicular capacity and active transportation connectivity to the greater Port Lands area. The design required development of a widened superstructure that integrated with the complex Don Roadway intersection geometry at the east end of the bridge. The work included new substructure elements to support the additional spans of the new longer bridge, as well as modification and integration of the existing bridge's pier and abutments to accommodate the overall widening. The following sections describe the superstructure and substructure design development in further detail.

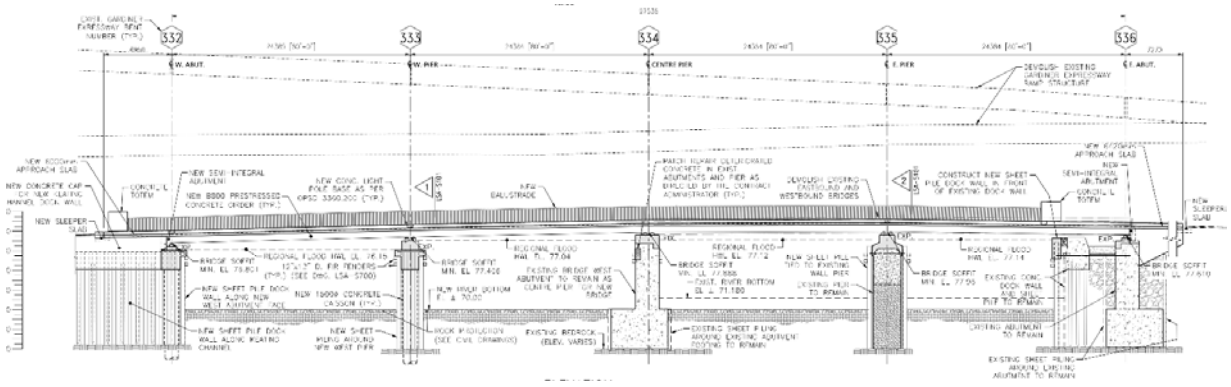
Span Arrangement

The existing LSBE bridge features two spans. Two additional spans were required for the new LSBE Bridge to afford enough of a hydraulic opening to preclude undesirable upstream flooding and to ensure that the new superstructure would remain above the high water anticipated for the design storm event, which was the Regional Storm Event. The Don River was also designed to be dredged at the LSBE Bridge to provide further hydraulic capacity. A hydraulic analysis was completed by a third-party consultant to confirm that the geometry of the new LSBE Bridge design would afford satisfactory hydraulic capacity.

A condition survey and visual inspection of abutments and pier for the existing LSBE bridge found that the existing abutments and pier would be suitable for re-use in the new bridge subject to removal and reconstruction of their upper 1-2m to remove chloride-laden concrete. Localized concrete patch repairs, refacing, crack injections, and application of a concrete sealer would also be necessary.

Several span arrangements were considered for the new bridge, including arrangements that consisted of entirely new piers and abutments and arrangements that re-used the existing pier and abutments. It was ultimately decided to re-use the existing pier and abutment to preclude the significant costs that would come from constructing entirely new substructures. The span arrangement that was ultimately chosen consisted of four equal 24.385m spans, which coincided with the spacing of the Gardiner Expressway bents. The two westernmost spans would be new spans created by dredging to open the mouth of the Don River. The two easternmost spans would be the spans of the existing LSBE Bridge. By taking this approach, the pier and west abutment of the existing LSBE Bridge would become the East Pier and Centre Pier, respectively, of the new LSBE Bridge. Figure 9 shows an elevation view of the new LSBE Bridge.

Figure 9. Elevation of New LSBE Bridge



Superstructure

Road Bridge

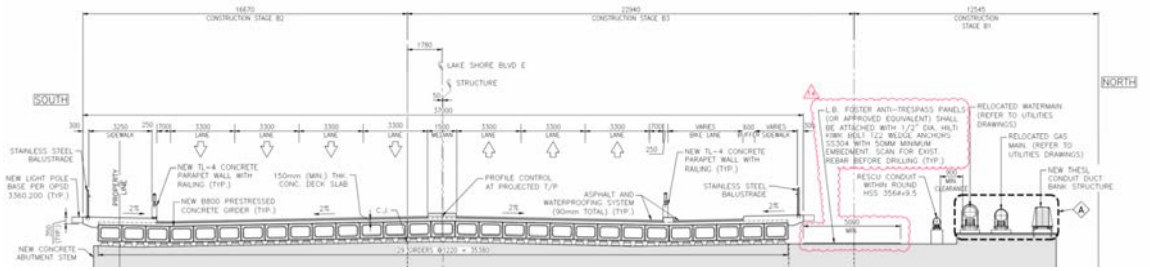
The chosen span arrangement of four 24.385m spans afforded the possibility of using several conventional superstructure solutions for the new road bridge. Three alternatives were considered:

- Alternative 1 – Steel Plates Girders with Composite 225mm Concrete Deck (1110mm total structural depth)
- Alternative 2 – Cast-in-Place Post-Tensioned Concrete Slab (775mm total structural depth)
- Alternative 3 – Precast Pretensioned B800 Box Girders with Composite 150mm Concrete Overlay (950mm total structural depth)

The available structural depth was limited by the need to tie into the adjacent Don Roadway intersection and to afford sufficient hydraulic clearance to the Don River for the design storm event without having to lengthen the bridge spans. Alternative 1 was least preferable for these reasons, as well as durability concerns regarding structural steel positioned closely over the humid river environment. While Alternative 2 had the least structural depth, there were concerns regarding the depth and cost of the falsework required to construct this alternative, as well as on-site construction duration required to construct this alternative. Alternative 3 did not have the least depth, but it precluded the costly falsework of Alternative 2 and was deemed to be the most durable alternative. Accordingly, Alternative 3 was selected as the preferred alternative.

Constructing a single 37.0m wide bridge was found to be more economical to construct than distinct EB and WB bridges like the existing condition. Figure 10 shows a typical cross-section of the new LSBSE bridge. The bridges carries three lanes of vehicular traffic in each direction. It features sidewalks along its north and south edges and a multi-directional bikeway. Both the sidewalks and bike lanes are seperated from vehicular traffic by TL-4 concrete parapet walls to improve pedestrian and cyclist safety.

Figure 10. Cross-Section of New LSBE Bridge At West Pier



Rail Bridge

The existing rail bridge serviced the Harbour Lead Line. This line had not been in service for several years due to alterations in track infrastructure away from the LSBE site. Future plans had been made to reinstate this line for service. As such, the PLFP Project requirements originally called for replacement of the existing rail bridge superstructure. The intent was to replace the existing superstructure in kind with a new half-through steel plate girder superstructure to suit the lengthen span arrangement of the site. A

new design was completed for tender. However, after tendering the project for construction, the City decided to delete the new rail bridge over concerns that the Harbour Lead Line would never return to service. As such, the existing rail bridge superstructure was removed, and no new rail bridge superstructure was constructed. The new rail bridge would have been constructed in the empty space between the new road bridge and the utility crossings, as shown in Figure 10.

Utility Crossings

The existing site features several utility crossings that required integration into the new bridge design at the north end of the structure, beyond where the new rail bridge superstructure would have been. The utilities included:

- A self-supporting watermain
- A self-supporting gas main
- A self-supporting steel conduit housing a Road Emergency Services Communication Unit (RESCU)
- A newly designed steel box structure housing hydro and telecommunications cables

The utility crossings are shown on the right side of the cross-section in Figure 10.

Substructure

Where feasible, the existing substructures were retained to reduce the amount of demolition required. The original substructure was founded on bedrock on spread footings approximately 10m below grade. Extending the bridge on the same type of foundation would have required extensive excavation, shoring, and dewatering. As a result, the new substructure elements are founded on 1.5m diameter concrete caissons socketed into competent bedrock. This led to hybrid foundation conditions at several locations where the new caisson supported elements were integrated into the existing spread footings.

The substructure design was governed by the challenging geotechnical and seismic conditions at the site. The category of the bridge and the potentially liquifiable soils on site resulted in seismic considerations otherwise not typically required for this geographic area. The presence of a deep bedrock, variable soil stiffnesses, and mixed foundation systems consisting of existing spread footing and new caissons introduced complex load-sharing behaviour.

West Abutment

A new west abutment was constructed west of the existing bridge to support the additional spans. The abutment is founded on a single row of caissons supporting a concrete pile cap. The caisson spacing was governed by the geometric constraints and the need to avoid conflict with the legacy foundations from the former Gardiner Expressway. The new west abutment also featured a sheet pile wall with inclined rock anchors to retain the approach fill. The new west abutment is shown under construction below in Figure 11.

Figure 11. New West Abutment During Construction



Source: Entuitive

West Pier

A new west pier was constructed west of the existing west abutment. The ground between the new west pier and new west abutment, and new west pier and existing west abutment was dredged to create two new bridge spans. Similar to the new west abutment, the new west pier is supported on a single line of caissons with a reinforced concrete pile cap. Similar geometric constraints from the existing Gardiner Expressway foundations were encountered at this location as well, resulting in an uneven caisson spacing. The new west pier is shown under construction below in Figure 12.

Figure 12. New West Pier During Construction



Source: Entuitive

Center Pier

The west abutment of the existing LSBE bridge was repurposed as the centre pier in the new LSBE Bridge. The existing structure is a large concrete cantilever abutment founded on a spread footing seated on the weather shale bedrock. The existing abutment was extended laterally to the north using a single row of caissons and a new pile cap. This resulted in a combined shallow and deep foundation system that reduced construction costs, but which complicated the seismic behaviour of the bridge. The new centre pier is shown under construction below in Figure 13.

Figure 13. New Centre Pier During Construction



Source: Entuitive

East Pier

The pier of the existing LSBE bridge was converted into the east pier of the new LSBE Bridge. Similar to the new centre pier, the new east pier was widened by adding caisson-supported foundations and a pile cap at the north end of the existing structure. The new east pier is shown under construction below in Figure 14.

Figure 14. New East Pier During Construction

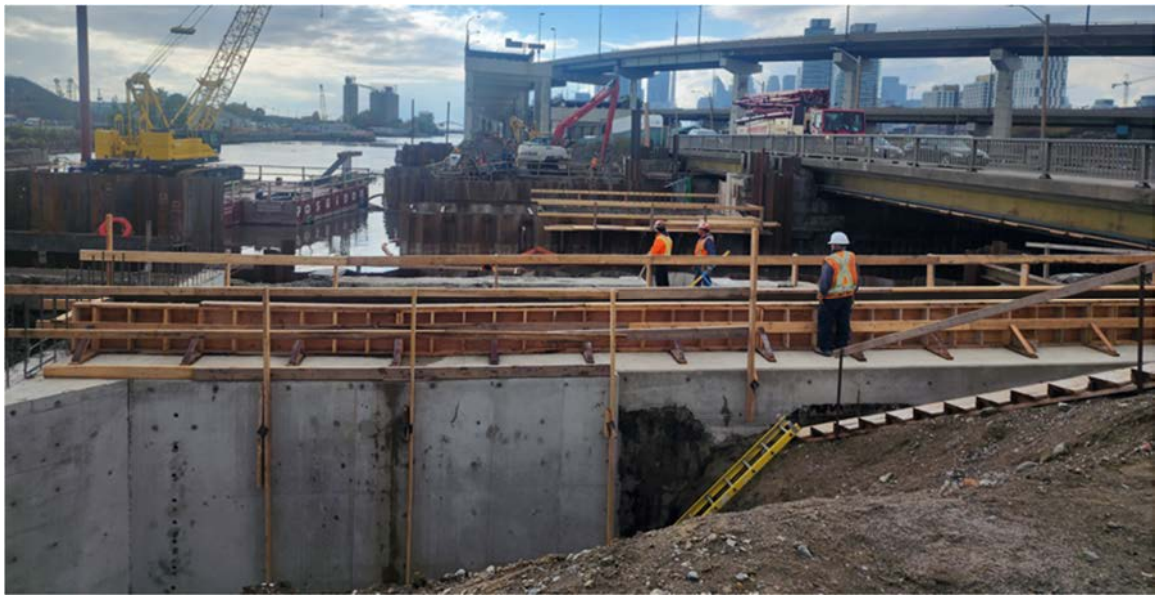


Source: Entuitive

East Abutment

The existing east abutment was retained and locally widened to accommodate the new superstructure. The widening was supported on a concrete pile cap founded on steel-lined, 325mm diameter concrete micropiles socketed into bedrock. A dock wall was constructed in front of the abutment to delineate the east limit of the Don River. The existing east abutment was used as a deadman for this new dock wall by use of steel rod anchors grouted into the stem of the existing abutment. The rehabilitated east abutment is shown under construction below in Figure 15.

Figure 15. Rehabilitation of Existing East Abutment During Construction



Source: Entuitive

Conclusions

The new LSBE bridge was opened to traffic in December 2025. Its design is an example of the challenges and solutions of building a new bridge at the same site as previous infrastructure. The complicated geometric, substructure, and foundation challenges were solved through collaboration with the client (Waterfront Toronto), the owner (City of Toronto), and the Construction Manager/General Contractor (EllisDon).

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