MAIN BRIDGE DESIGN AND CONSTRUCTION INNOVATIONS OF THE AUTOROUTE A-25 PROJECT

THOMAS SPOTH, PE

JOE VIOLA, PE, LEED AP

SETH CONDELL, PE,
LEED AP

AUGUSTO MOLINA, PE,
LEED AP

BIOGRAPHY

Mr. Spoth is Vice President and Deputy Chief Bridge Engineer for Parsons' New York office. He has over 27 years of experience in suspension bridge design and rehabilitation and served as Bridge Design Manager for the subject project, the new Tacoma Narrows Bridge, and the new Al Zampa Memorial Bridge across the Carquinez Straits in California. He has also performed design and/or inspection on over 25 major bridges in the United States and abroad.

Mr. Viola is a Principal Project Manager with Parsons with over 27 years of bridge and tunnel experience. He served as Deputy Bridge Design Manager for the subject bridge as well as Engineer-of-Record for the new Tacoma Narrows and Mt. Hope Bridge rehabilitations in Rhode Island. Mr. Viola has also worked on the design rehabilitation, and/or inspection on over 20 major bridges.

Mr. Condell has 13 years of experience in major bridge design, rehabilitation and inspection. As the Cable Stayed Bridge work package lead for the A25 Project and Suspended Structure Lead for the new Tacoma Narrows project. He also served on the design team for the Al Zampa Memorial Bridge and construction engineering team for the Lions Gate Bridge reconstruction.

Mr. Molina has 15 years of experience in major bridge design, rehabilitation and inspection. He served as the Approach Span work package lead for the subject project and Suspension System work package lead new Tacoma Narrows Bridge. He also served on the design team for the Al Zampa Memorial Bridge.

SUMMARY

This paper discusses the Main Bridge at the Rivière-des-Prairies, the centerpiece of this 7.2 kilometer and $500 million project.

The Main Bridge is approximately 1,200 meters long and consists of a cable-stayed bridge with a 115-280-115 m span arrangement, a seven-span continuous constant-depth steel girder structure with interior spans of 96 m, and two 24 m continuous prestressed concrete girder approach spans. The A-25 main bridge carries six lanes of traffic and a 3 m wide multipurpose path. It is expected to be traveled by an average annual daily traffic of 68,000 vehicles.

The main bridge design was performed to Canadian Standards and local codes, with project specific criteria developed as needed. Structural steel proved the perfect material for criteria compliance, schedule demands and delivery means and methods. Included in this paper are particulars of design development inclusive of unique design criteria, structural systems, analysis techniques and schedule challenges.

The new structure is a graceful, low-lying bridge blending well with the environment and not competing with it. In addition to project compliance, the A25 project also serves as a model of sustainability for multiple reasons, enumerated herein.

Main Bridge Design and Construction Innovations of the Autoroute A-25 Project

Abstract

In June of 2007 the Ministry Transports Québec (MTQ) selected Concession A25 S.E.C. to finance, design, build, maintain and operate the long planned Autoroute A-25 connection between the island of Montréal and Laval to the north. The Joint Venture of Kiewit-Parsons served as the design-build entity for the public private partnership (PPP). An accelerated construction schedule and successful project execution resulted in an early project opening in July 2011. While the design service life was a minimum of 75 years, the term of the PPP was only 35 years, after which a detailed inspection will need to demonstrate that the conditions of all bridge elements stated in the Partnership Agreement meet or exceed minimum requirements to turn the facility over to MTQ.

This paper discusses the Main Bridge at the Rivière-des-Prairies, the centerpiece of this 7.2 kilometer and $500 million project. The Main Bridge is approximately 1,200 meters long. From north to south, the crossing consists of a cable-stayed bridge with a 115-280-115 m span arrangement, a seven-span continuous constant-depth steel girder structure with interior spans of 96 m, and two 24 m continuous concrete girder approach spans (see Figure 1). The A-25 main bridge carries six lanes of traffic and a 3 m wide multipurpose path. It is expected to be traveled by an average annual daily traffic of 68,000 vehicles. The new structure is a graceful, low-lying bridge blending well with the environment and not competing with it. It is configured in this manner to satisfy very specific geometric, aesthetic and environmental objectives set forth in the Partnership Agreement. These objectives include a limit on the number of piers in the river, the absence of piers in the natural Atlantic Sturgeon spawning pool below the main cable-stayed span, an L/20 depth-of-structure criterion, a clearance envelope for sea planes that use the river for takeoff and landing, a strict limitation on tower height, and a predetermined river crossing alignment. Structural steel proved the perfect material for criteria compliance and delivery means and methods. Included in this discussion will be particulars of design development inclusive of unique design criteria, structural systems, analysis techniques and schedule challenges.

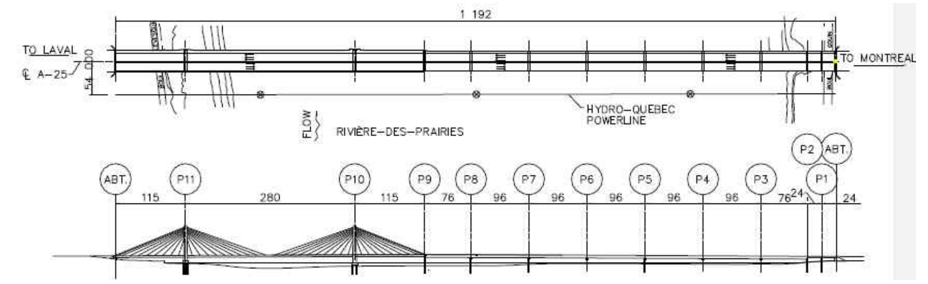

Figure 1 - A25 Main Bridge Span Arrangement

Figure 2 - Approach Girder Span Typical Section

Steel Components

The main bridge design was performed to Canadian Standards (1) (2) and local codes (3), with project specific criteria developed as needed. From the Montreal side, the river crossing consists of seven steel girder spans from Pier 2 to Pier 9, followed by three cable-stayed spans stretching to the Laval Abutment. The steel girder spans (see Figure 2) consist of an efficient structural system comprised of five 3.7 m deep welded composite plate girders spaced at 7.18 m, supporting a 32.97 m wide deck

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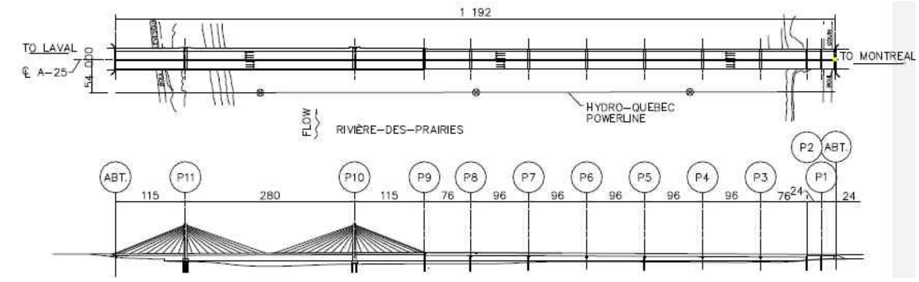

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substringers between girder lines to provide deck spans in the range of 3.5 m. This configuration was conducive to constructing the deck using 100 mm thick prestressed concrete stay-in-place panels and an integral cast-in-place reinforced concrete 150 mm thick topping with galvanized reinforcement. The girder/substringer spacing was maximized to optimize the deck design. Lateral bracing between girder lines G1 and G2, and between G4 and G5 provided stability during construction and remain in-place as an integral element of the overall system.

This configuration of deep welded plate girders and shallow rolled W-shape substringers results in an efficient use of steel and concrete, and minimizes the number of heavy girder segments to be fabricated and erected. The girders are continuous for the seven spans with a total length of 632 m, thus eliminating intermediate expansion joints and the resulting maintenance difficulties. The length, height and weight of the individual girder segments were optimized for shop handling, shipping and erection.

The cable stayed bridge superstructure framing system consists of 2 m deep steel edge girders, spaced at 36.525 m, and floorbeams spaced at 4.5 m, both composite with the 240 mm thick concrete slab. The concrete slab was constructed from full-depth precast panels. Each panel spans between floorbeams in the longitudinal direction, arranged in a grid four panels wide. Deck panel support beams are used under each of the four longitudinal joints between the deck panels. Thus, all deck cast-in-place infill concrete is placed without removable formwork or a need for access from below the deck. The deck is of conventional reinforced concrete with galvanized reinforcement and no post-tensioning.

An aggressive construction schedule, stringent environmental criteria, difficult river access, icing and cold weather conditions (see Figure 3) led to innovations that guided many of the design decisions. Short construction windows favored steel over concrete for most superstructure spans, as steel erection was able to proceed further into the winter construction season than concrete placement.

Figure 3- Conditions on the Rivière-des-Prairies Guided Design Decisions

Girder Spans

The steel girder spans between Piers 2 and 9 utilize a substringer framing system and form a continuous structure that is absent of expansion joints for its full 632 m length. The interior spans from Piers 4 to 8 are all 96 m, while the flanking end spans are 76 m each. The structural system consists of five welded plate girders with full-depth cross frames longitudinally spaced every 6.4 m. The cross frames serve as live load distribution elements, support the intermediate substringers between each line of girders, and stabilize the girders during erection (see Figure 4). A constant girder depth of 3.7 m was chosen for these spans to comply with the L/20 depth to span limitation defined in the partnership agreement and to facilitate shipping from Structal’s fabrication plant in Québec City.

Figure 4 – Galvanized Cross Frames and Substringers - Interior Framing

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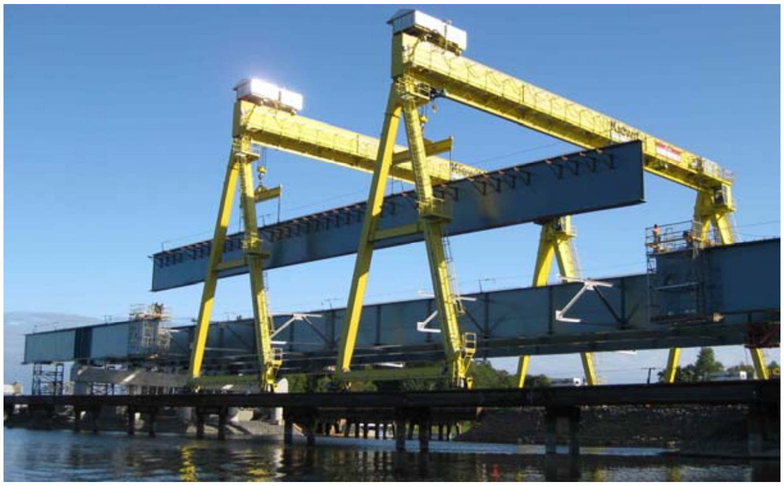
Each main girder is supported on lead-core rubber bearings designed to distribute horizontal thermal, wind and seismic loads more uniformly among the supporting piers. This accommodated consistency of pier design and construction methods for the drilled shaft substructure system, as these bearings distribute loads to substructure units much more uniformly than using a few select fixed bearings. The isolation bearings at Piers 2 and 9 measure 840 mm in diameter and 400 mm in height and contain a lead core with a diameter of 110 mm. At Piers 3 through 8 the bearings measure 1,060 mm in diameter and 416 mm in height and contain a lead core with a diameter of 225 mm. Expansion at each end of the steel approach span is accommodated by conventional steel finger plates supported by under-deck steel framing (see Figure 5). Stainless steel gutters are used to shield the underlying steel framing and pier cap beams from the corrosive effects of roadway debris and deicing chemicals that pass between the finger joints.

Figure 5 - Finger Joints and Supporting Steel Ready for Installation

The substringer framing system used on the girder spans is relatively uncommon but is a structurally efficient and cost competitive configuration for span arrangements as adopted in the A-25 project. Standard, code-applied, live load distribution equations would have likely resulted in unsatisfactory results due to the differences in stiffness between the deep girders and intermediate substringers. More rigorous attention was therefore directed to the live load effects in conjunction with the global analysis effort. A full-bridge 3-D beam-and-plate computer model was developed to optimize the steel design using SAP 2000 software. The model represents all structural steel elements, the concrete deck, the lead-core rubber bearings, and the structural interaction with concrete substructure columns and rock-socketed drilled shafts. The steel girders and concrete deck were modeled as plate elements while all other components were modeled as beam elements. By taking advantage of the full-bridge 3-D model of the global structural system and the moving live load generator in SAP 2000, accurate live load distribution effects were determined for the girders, cross frames and substringers. As an independent quality check, complementing computer models that represented the composite girders and substringers as beam elements were also used.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The deep fabricated plate girders received a Ministry Transport Québec (MTQ) standard 3-coat zinc-epoxy-urethane system, shop applied to provide better environmental control and produce a high quality coating. Cross frames, substringers and multipurpose path brackets were hot-dip galvanized, as were the horizontal lateral bracing members between exterior girder lines that provide stability during erection and remain as an integral element of the structural system. Considering the desired service life and this environmentally sensitive Rivière-des-Prairies site, the project-wide approach to corrosion protection was selected for durability, cost competitiveness and the advantage that it precludes the need for wholesale field painting while improving quality and minimizing future maintenance painting needs. Field-installed high-strength bolted connections were galvanized, which allowed the design-build team to maintain the integrity of the shop applied paint at connections because sandblasting "black" bolts would have resulted in consequent adverse overblast effects on the structural steel coating.

Custom manufactured erection gantries riding on a temporary trestle on the west side and the rock causeway on the east were used to erect the girder segments (see Figure 6) and deck panels. The girder segment lengths, and thus their weights, were designed compatible with the capacity of the gantries and also within the shipping length and weight criteria.

Cable-Stayed Spans


Figure 7 - Section through Cable-Stayed Bridge

The cable-stayed spans include a 280 m main span and symmetric side spans for a total length of just over 511 m, as shown in Figure 1. The deck structure consists of a 240 mm thick full-depth precast reinforced concrete slab composite with two 2 m deep steel edge girders and transverse floorbeams spaced at 4,500 mm. The floorbeams span 32.3 m between edge girders and a cantilever bracket supports the multipurpose path to the east (see Figure 7). Though many alternatives were studied, one major decision made during the project tender phase was to select the composite steel solution over an all-concrete structural system. The composite steel alternative allowed off-site steel fabrication and indoor precast panel production during harsh winter months, presenting a distinct schedule advantage that would otherwise have been difficult to achieve.

During the tender phase, eight cylindrical lock-up type pistons were considered to connect the edge girders to the towers during dynamic loading events such as seismic excitation. This concept allowed nearly free expansion longitudinally for transient loads, but resisted shock loads such as braking live loads, seismic loads and some wind induced conditions. The structural system was conceived to benefit the cost of tower and foundation construction by limiting the size of costly in-water substructure elements. However, early in the design phase, cost and schedule implications for these long-lead items inspired the project team to revisit the selected structural system and relating lock-up devices. As a result, the bridge superstructure articulation was altered to include longitudinally fixed bearings at Pier 10 and free expansion at Pier 11. Although this new approach altered the demand on the substructure elements, it had an overall procurement and schedule advantage to project delivery, eliminated the need for the long-lead lock-up devices and was preferred by the concession's maintenance and operation team.

Figure 8 - Box Girder at Towers

Edge girders were aligned with the towers to maintain the primary support system in two vertical planes to improve constructability. This presents a challenge with the edge girder thrust as it nears the towers. While many alternatives were considered for circumventing the towers in the zone of the pier tables, an innovative solution was implemented, utilizing transitional box girders that "stepped" the steel edge girder inboard of the towers using a 1.9 m offset alignment that eliminated the tower leg conflict altogether (see Figure 8). The offset was accomplished via transitional box girders with each outside box girder web in the same plane as the typical I-girder of the main and side spans and the inside web of the 1.9 m wide box girder in line with the I-girder alignment that fit between the tower legs. Each side of each box girder connects to the abutting I-girder through a full moment splice. The torsionally stiff box girders and the transverse floorbeams neatly resolved the effects of the offset thrust. This option fully balanced edge girder compressive forces around the tower legs, channeling them through the flanges of the rigid box girder elements and the composite deck.

Side spans include the typical stay arrangement supplemented by a parallel pair of backstays anchored through the edge girders by steel rocker links (see Figure 9). Counterweights are also provided between the last two floorbeams at these endspan locations to help accommodate unbalanced live loads relative to the main span and to induce compression in the rocker links under the dead load condition. Under varying live load conditions, as well as wind and seismic load cases, the rocker links are designed to resist compression as well as uplift tensile forces. Articulation of the rocker links is provided via forged steel pins housed within maintenance-free, self-lubricating bronze bushings.

Figure 9 – Installing Backstays. Counterweight and Rocker Link (Behind Shoring) also Shown

Steel wind tongues secure to the bottom flange of the floorbeams at both towers and side span anchor points to provide lateral restraint for wind and seismic loads. These wind tongues are buttressed by bearings set into concrete corbels cast integrally with the tower struts or pier caps, as shown for the towers in Figure 10.

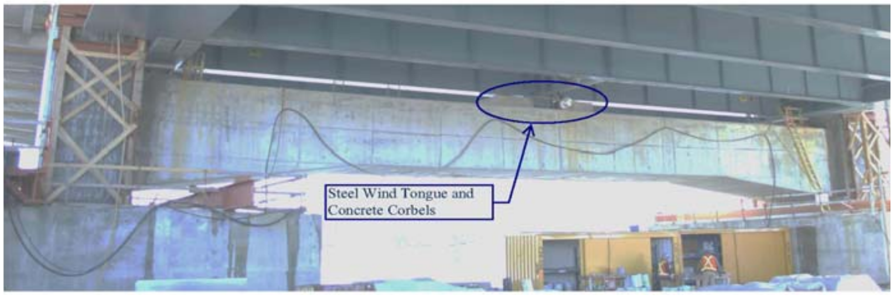

Figure 10 - Wind Tongue for Lateral Restraint

The main span cable-stayed superstructure is supported by eighty stay cables anchored at the four tower legs in a modified fan configuration. These attach to the edge girders at 13.5 m intervals. The stays are comprised of multiple 15.7 mm diameter seven-wire strands varying in number from 29 to 84. Stay diameters range from 180 m to 250 mm. The stays are typically larger on the east side of the bridge than the west due to the increased loads of the multipurpose path that cantilevers outside the plane of stay cables from the east edge girder. The strands include a multi-pronged defense against corrosion consisting of galvanized wire, a petroleum wax to fill interstices between wires, and a tightly extruded High Density Polyethelyene (HDPE) sheathing, i.e. greased and sheathed zinc coated steel wire strand. When assembled, the bundled strands are contained within an outer HDPE stay pipe to further protect them from the elements. The cable end-anchors are also protected from corrosion by way of pressure-tested watertight components with sealed areas filled with soft anti-corrosion compounds that include lubricating properties to benefit fatigue performance and protect against fretting.

Figure 11 - Lower Stay Connection

The stay cables at the deck level are received by fabricated steel stay anchors. VSL's SSI 2000 stay anchoring system was selected as an integral component. Stays at tower tops bear against stay anchor bearing plates that are cast directly into the interior tower walls to receive them. Stressing is accomplished from the top end during bridge erection. This approach allows good access and accommodates the design of a compact anchor plate arrangement connecting the lower stay end to the steel edge girders. Figure 11 shows the general arrangement of the connection at deck level, prior to closure of the HDPE pipe, including the strands described before and the lower end of the friction damper. Cable anchorage features include an angular guide deviator, individually guided strands, damping guide deviators, corrosion inhibiting lubrication and friction dampers to suppress the potential for wind induced vibrations. The overall configuration of the cable anchorage accommodates strand-by-strand adjustment and similar strand-by-strand replacement if necessary in the future. The stay cables and relating steel fabrication are designed for strength and stability under the unlikely catastrophic loss of a stay cable.

Figure 12 - Stay Anchor Connection to Edge Girder

The fabricator was provided a choice of several typical details for attaching the stay anchors to the edge girders. They chose to have the vertical plate bolted to the web of the edge girder, passing through a slot in the top flange, rather than fully welded details. The girder's "free" flange edge was then stitched back to the connection plate with a bolted steel angle. This solution (see Figure 12) saved time, avoided constrained welds that may have necessitated stress relief for some of the larger stay connections, and presents a favorable fatigue category. This connection is also shown from below in Figure 13.

Also shown in Figure 13 is the galvanized multipurpose path support bracket connection. Galvanization offered significant life cycle cost improvements over conventional coatings for smaller components that fit within the galvanizing baths of local galvanizers. Bracing and many smaller details below the multipurpose path and expansion joints were galvanized. Galvanized high-strength bolts were used on all connections as well, precluding the need for field blast cleaning of connections to plain bolt groups. This decision was driven by environmental considerations as well as schedule.

Project Innovations – Steel Supporting the Art of Engineering and Sustainability

Figure 13 – Multipurpose Path Bracket Connection

In addition to project compliance, the A25 project serves as a model of sustainability for multiple reasons, as demonstrated through the following measures:

- Excavated material was reused on-site, avoiding hauling disturbances, air emissions, noise, and construction vehicle traffic.
- As often as possible, concrete noise walls were replaced with landscaped dunes made of excavated materials in accord with preferences expressed by local agencies, the public, and the owner.
- Structural steel was fabricated by Structal of Québec within 200 miles of the site, supporting the regional economy in an environmentally friendly manner. This local sourcing resulted in savings of cost, time and carbon footprint, and minimized the need for an extensive on-site storage yard by allowing better coordination with fabrication and shipping. Energy efficient rail transport methods were used to deliver the fabricated steel.
- Shop coating and galvanizing helped provide long-lasting coatings to eliminate VOC emissions on site now and in the future by minimizing long-term maintenance needs.
- Structural bridge details were evaluated and incorporated to effectively manage future life-cycle costs.
- High-strength cable stays with triple-corrosion protection were used.
- Issue-for-construction plan sheets and shop drawing review processes were fully electronic.
- Planning for all in-water construction activities first considered innovation opportunities benefiting the environmentally sensitive river habitat.

- A rock island at Pier 11 and the temporary rock causeway and trestle at the approach spans minimized work in the water that might have created turbidity from additional barges. They also allowed larger gantry cranes to handle larger components during erection, saving time and helping open the facility that early, easing traffic congestion sooner.

This sensitive site environment called for an ecologically vigilant, sustainable approach to design and construction. Located in an environmentally sensitive area, the A25 project team has been equally sensitive to stewardship and management of environmental and social conditions. For instance, the project's toll collection is completely electronic and capable of reading transponders at full traffic speed, resulting in an environmentally friendly fare collection system that also provides congestion-free travel. Continuous traffic flow is further enhanced with variable toll rates that consider vehicle type, axle count, and time of day traveled, encouraging highway travel during off-peak hours.

References

(1) CAN/CSA-S6 - Canadian Highway Bridge Design Code
(2) CAN/CSA W59 - Welded Steel Construction (Metal Arc Welding)
(3) Le Ministère des Transports du Québec (MTQ), *Normes* and *Ouvrages d'Art*

slab. Structural cross frames spaced at 6.4 m support substringers between girder lines to provide deck spans in the range of 3.5 m. This configuration was conducive to constructing the deck using 100 mm thick prestressed concrete stay-in-place panels and an integral cast-in-place reinforced concrete 150 mm thick topping with galvanized reinforcement. The girder/substringer spacing was maximized to optimize the deck design. Lateral bracing between girder lines G1 and G2, and between G4 and G5 provided stability during construction and remain in-place as an integral element of the overall system.

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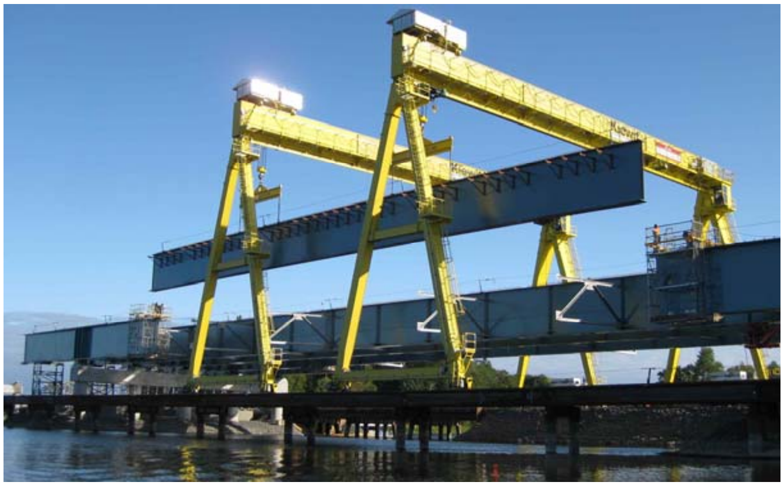
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Figure 7 - Section through Cable-Stayed Bridge

The cable-stayed spans include a 280 m main span and symmetric side spans for a total length of just over 511 m, as shown in Figure 1. The deck structure consists of a 240 mm thick full-depth precast reinforced concrete slab composite with two 2 m deep steel edge girders and transverse floorbeams spaced at 4,500 mm. The floorbeams span 32.3 m between edge girders and a cantilever bracket supports the multipurpose path to the east (see Figure 7). Though many alternatives were studied, one major decision made during the project tender phase was to select the composite steel solution over an all-concrete structural system. The composite steel alternative allowed off-site steel fabrication and indoor precast panel production during harsh winter months, presenting a distinct schedule advantage that would otherwise have been difficult to achieve.

During the tender phase, eight cylindrical lock-up type pistons were considered to connect the edge girders to the towers during dynamic loading events such as seismic excitation. This concept allowed nearly free expansion longitudinally for transient loads, but resisted shock loads such as braking live loads, seismic loads and some wind induced conditions. The structural system was conceived to benefit the cost of tower and foundation construction by limiting the size of costly in-water substructure elements. However, early in the design phase, cost and schedule implications for these long-lead items inspired the project team to revisit the selected structural system and relating lock-up devices. As a result, the bridge superstructure articulation was altered to include longitudinally fixed bearings at Pier 10 and free expansion at Pier 11. Although this new approach altered the demand on the substructure elements, it had an overall procurement and schedule advantage to project delivery, eliminated the need for the long-lead lock-up devices and was preferred by the concession's maintenance and operation team.


Figure 8 - Box Girder at Towers

Edge girders were aligned with the towers to maintain the primary support system in two vertical planes to improve constructability. This presents a challenge with the edge girder thrust as it nears the towers. While many alternatives were considered for circumventing the towers in the zone of the pier tables, an innovative solution was implemented, utilizing transitional box girders that "stepped" the steel edge girder inboard of the towers using a 1.9 m offset alignment that eliminated the tower leg conflict altogether (see Figure 8). The offset was accomplished via transitional box girders with each outside box girder web in the same plane as the typical I-girder of the main and side spans and the inside web of the 1.9 m wide box girder in line with the I-girder alignment that fit between the tower legs. Each side of each box girder connects to the abutting I-girder through a full moment splice. The torsionally stiff box girders and the transverse floorbeams neatly resolved the effects of the offset thrust. This option fully balanced edge girder compressive forces around the tower legs, channeling them through the flanges of the rigid box girder elements and the composite deck.

Side spans include the typical stay arrangement supplemented by a parallel pair of backstays anchored through the edge girders by steel rocker links (see Figure 9). Counterweights are also provided between the last two floorbeams at these endspan locations to help accommodate unbalanced live loads relative to the main span and to induce compression in the rocker links under the dead load condition. Under varying live load conditions, as well as wind and seismic load cases, the rocker links are designed to resist compression as well as uplift tensile forces. Articulation of the rocker links is provided via forged steel pins housed within maintenance-free, self-lubricating bronze bushings.


Figure 9 – Installing Backstays. Counterweight and Rocker Link (Behind Shoring) also Shown

Steel wind tongues secure to the bottom flange of the floorbeams at both towers and side span anchor points to provide lateral restraint for wind and seismic loads. These wind tongues are buttressed by bearings set into concrete corbels cast integrally with the tower struts or pier caps, as shown for the towers in Figure 10.

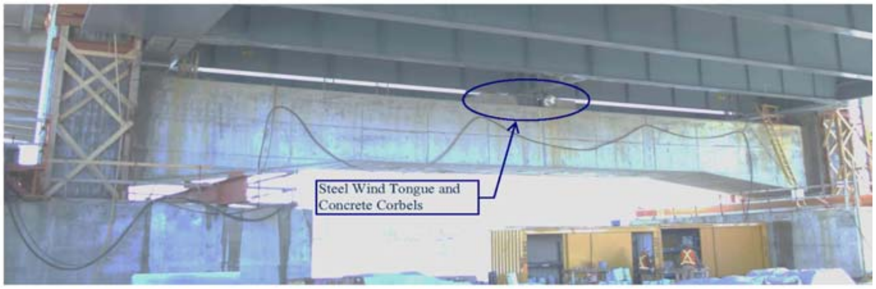

Figure 10 - Wind Tongue for Lateral Restraint

The main span cable-stayed superstructure is supported by eighty stay cables anchored at the four tower legs in a modified fan configuration. These attach to the edge girders at 13.5 m intervals. The stays are comprised of multiple 15.7 mm diameter seven-wire strands varying in number from 29 to 84. Stay diameters range from 180 m to 250 mm. The stays are typically larger on the east side of the bridge than the west due to the increased loads of the multipurpose path that cantilevers outside the plane of stay cables from the east edge girder. The strands include a multi-pronged defense against corrosion consisting of galvanized wire, a petroleum wax to fill interstices between wires, and a tightly extruded High Density Polyethelyene (HDPE) sheathing, i.e. greased and sheathed zinc coated steel wire strand. When assembled, the bundled strands are contained within an outer HDPE stay pipe to further protect them from the elements. The cable end-anchors are also protected from corrosion by way of pressure-tested watertight components with sealed areas filled with soft anti-corrosion compounds that include lubricating properties to benefit fatigue performance and protect against fretting.

Figure 11 - Lower Stay Connection

The stay cables at the deck level are received by fabricated steel stay anchors. VSL's SSI 2000 stay anchoring system was selected as an integral component. Stays at tower tops bear against stay anchor bearing plates that are cast directly into the interior tower walls to receive them. Stressing is accomplished from the top end during bridge erection. This approach allows good access and accommodates the design of a compact anchor plate arrangement connecting the lower stay end to the steel edge girders. Figure 11 shows the general arrangement of the connection at deck level, prior to closure of the HDPE pipe, including the strands described before and the lower end of the friction damper. Cable anchorage features include an angular guide deviator, individually guided strands, damping guide deviators, corrosion inhibiting lubrication and friction dampers to suppress the potential for wind induced vibrations. The overall configuration of the cable anchorage accommodates strand-by-strand adjustment and similar strand-by-strand replacement if necessary in the future. The stay cables and relating steel fabrication are designed for strength and stability under the unlikely catastrophic loss of a stay cable.

Figure 12 - Stay Anchor Connection to Edge Girder

The fabricator was provided a choice of several typical details for attaching the stay anchors to the edge girders. They chose to have the vertical plate bolted to the web of the edge girder, passing through a slot in the top flange, rather than fully welded details. The girder's "free" flange edge was then stitched back to the connection plate with a bolted steel angle. This solution (see Figure 12) saved time, avoided constrained welds that may have necessitated stress relief for some of the larger stay connections, and presents a favorable fatigue category. This connection is also shown from below in Figure 13.

Also shown in Figure 13 is the galvanized multipurpose path support bracket connection. Galvanization offered significant life cycle cost improvements over conventional coatings for smaller components that fit within the galvanizing baths of local galvanizers. Bracing and many smaller details below the multipurpose path and expansion joints were galvanized. Galvanized high-strength bolts were used on all connections as well, precluding the need for field blast cleaning of connections to plain bolt groups. This decision was driven by environmental considerations as well as schedule.

Project Innovations – Steel Supporting the Art of Engineering and Sustainability

In addition to project compliance, the A25 project serves as a model of sustainability for multiple reasons, as demonstrated through the following measures:

- Excavated material was reused on-site, avoiding hauling disturbances, air emissions, noise, and construction vehicle traffic.
- As often as possible, concrete noise walls were replaced with landscaped dunes made of excavated materials in accord with preferences expressed by local agencies, the public, and the owner.
- Structural steel was fabricated by Structal of Québec within 200 miles of the site, supporting the regional economy in an environmentally friendly manner. This local sourcing resulted in savings of cost, time and carbon footprint, and minimized the need for an extensive on-site storage yard by allowing better coordination with fabrication and shipping. Energy efficient rail transport methods were used to deliver the fabricated steel.
- Shop coating and galvanizing helped provide long-lasting coatings to eliminate VOC emissions on site now and in the future by minimizing long-term maintenance needs.
- Structural bridge details were evaluated and incorporated to effectively manage future life-cycle costs.
- High-strength cable stays with triple-corrosion protection were used.
- Issue-for-construction plan sheets and shop drawing review processes were fully electronic.
- Planning for all in-water construction activities first considered innovation opportunities benefiting the environmentally sensitive river habitat.

Figure 13 – Multipurpose Path Bracket Connection

- A rock island at Pier 11 and the temporary rock causeway and trestle at the approach spans minimized work in the water that might have created turbidity from additional barges. They also allowed larger gantry cranes to handle larger components during erection, saving time and helping open the facility that early, easing traffic congestion sooner.

This sensitive site environment called for an ecologically vigilant, sustainable approach to design and construction. Located in an environmentally sensitive area, the A25 project team has been equally sensitive to stewardship and management of environmental and social conditions. For instance, the project's toll collection is completely electronic and capable of reading transponders at full traffic speed, resulting in an environmentally friendly fare collection system that also provides congestion-free travel. Continuous traffic flow is further enhanced with variable toll rates that consider vehicle type, axle count, and time of day traveled, encouraging highway travel during off-peak hours.

References

(1) CAN/CSA-S6 - Canadian Highway Bridge Design Code
(2) CAN/CSA W59 - Welded Steel Construction (Metal Arc Welding)
(3) Le Ministère des Transports du Québec (MTQ), *Normes* and *Ouvrages d'Art*