The residents of Quebec, Canada, have long been waiting for improvements to the highway system surrounding the city. And the recent completion of the much-anticipated, $500 million Autoroute 25 Completion (A25) project will improve travel and encourage development by providing sustainable and innovative benefits. Expected to soon open to full traffic operations, the 7.2-kilometer stretch of toll highway includes a four-lane connector highway, 10 grade-separation bridges, three interchanges, a 1.2-kilometer main bridge crossing the Riviere-des-Prairies, a multipurpose path, and reserved public transit lanes.

The new thoroughfare will support community growth in the island of Laval’s northern suburbs—where a population increase of 500,000 people is expected by 2021—by providing congestion-free vehicular travel for commuters accessing the island of Montreal from Laval’s north shore.

The Quebec Ministry of Transportation (MTQ) initiated its first public-private partnership (PPP), selecting the Concession A25 consortium to design, build, finance, operate and maintain a portion of the completion effort for A25. In conjunction with the developer, Macquarie, the consortium includes the design-build joint venture of Kiewit-Parsons, with the Miller Group fulfilling the operations and maintenance role. MTQ handled the right-of-way and first-tier permits, and the second-tier permitting process was the design-build team’s responsibility. Parsons managed and led the design and quality assurance services with team partners, including Genivar, International Bridge Technologies, Golder Associates and RWDI.

**Framing it up**

Carrying six lanes of traffic and a 3-m-wide multipurpose path, the new cable-stayed and multispans steel girder bridge crossing the Rivière-des-Prairies is the central feature of the project; it is expected to be traveled by an average annual daily traffic of 68,000 vehicles. From south to north, the crossing consists of two 24-m continuous concrete girder approach spans, a seven-span continuous constant-depth steel girder structure with spans up to 96 m and the cable-stayed bridge with a 116-, 280-, 116-m span arrangement.

The cable-stayed bridge towers consist of twin 50-MPa reinforced concrete columns rising no more than the 70-meter height restriction imposed by the project. As a visual advantage, the tower columns include only a single horizontal cross-strut concealed beneath the superstructure, eliminating above-roadway cross struts. The global structural system aligns the superstructure’s steel edge girders in the same vertical plane as the upright tower columns. While the alignment of each tower column with its mating edge girder provides an efficient structural system, in this configuration the tower columns obstruct the in-line continuity of the edge girders between the main and side spans, which is necessary for transferring thrust from one side to the other.

The solution was an innovative steel framing system designed to provide continuity with an offset edge girder just inboard of each tower column. This unique framing system includes a 1.9-m-wide and 9-m-long steel transition box girder used on the main and side span sides of each tower column. In the transition zone adjacent to the face of each tower column, the outside web of the box girder also serves as the web of the I-shaped edge girder, whereas the inside web of the box girder serves as the web of the offset I-shaped girder passing between the tower legs. The rigid structural properties of the box girder and full-moment connections to the transverse I-shaped floor beams provide an efficient framing system at each tower. As with the typical superstructure framing throughout the full length of the cable-stayed spans, the concrete deck is fully composite with all steel-framed elements in the transition zones at each tower.

The 7.2-kilometer stretch of toll highway includes a four-lane connector highway, 10 grade-separation bridges, three interchanges and a 1.2-kilometer main bridge.

The superstructure is supported by 80 stay cables—composed of 15.7-millimeter-diam. seven-wire tendons varying from 29 to 84 tendons per stay cable—arranged in a modified fan configuration and anchored to the steel edge girders at 13.5-meter intervals. The tendons are protected by a triple-layer anticorrosion system consisting of galvanized steel wires, corrosion-inhibiting wax to fill interstices between wires and a tightly extruded high-density polyethylene (HDPE) sheathing.

Housing the triple-protected and
bundled tendons is a HDPE helically ribbed stay pipe to provide further protection from the elements and suppress wind- and rain-induced vibrations. VSL’s SSI 2000 system was selected for anchoring the cables within the tower columns and to the stay anchors along the line of the edge girders.

The cable end anchors are protected from corrosion by water-tight and pressure-tested assemblies filled with anticorrosion compounds.

At deck level, the stay cables terminate within pipe anchors that are part of larger weldment assemblies—sometimes referred to as fin-plate anchors. The cable anchors feature angular guide deviators, individually guided strands and friction dampers to suppress dynamic vibrations most often caused by wind-induced oscillations. The overall configuration of the cable anchorage accommodates strand-by-strand adjustment and strand replacement if necessary.

At the request of the project’s steel fabricator, Strucal of Quebec, the all-welded stay-anchor assemblies are connected to the edge girder webs by way of bolted lap splices. The edge girder top flange is slotted to receive the fin plates that pass through the individual slots and are bolted to the outside face of the I-girder webs.

**Easier to install**

The main river crossing required design and construction innovations as a result of stringent environmental criteria, physical site constraints, difficult river conditions and an aggressive project schedule. Adding to this were owner-imposed criteria, including physical constraints on structure height, a limit on the number of river piers and an off-limits zone in the river where water depths exceeded 5 m.

To achieve project compliance and also to maximize shop fabrication opportunities during project-site shutdown in the dead of winter, the approach spans were created from the seven-span continuous steel girders with a total jointless length of 632 m. The length, height and weight of the girder segments were optimized for over-land shipping and erection efficiencies, and shear studs were all shop-installed to minimize fieldwork. Each girder is supported on lead core rubber bearings, which through their deformation accommodate the thermal movements of the continuous girders and distribute the horizontal loads uniformly to each pier, resulting in standard-size pier columns that make good use of the “uniformity” of pier capacity.

This innovative structural system avoided the old-school design of individual strong piers to resist horizontal forces transferred from fixed bearings. Each pier consists of multicolumn, reinforced concrete bents with integral cap beams, and each of the 1.68-m-diam. columns is positioned directly below each of the five girders of the multigirder superstructure. The columns extend directly into drilled shafts that are typically 1.80 m in diameter and socketed into bedrock. Cylindrical steel casings used in construction of the drilled shafts remain in service, serving as armor against ice abrasion. Designed for simplicity and repeatability of construction tasks, this pier configuration benefited the construction schedule, particularly with regard to the limited time available for in-water work.

Providing an efficient structural system, the approach steel girder spans each consist of five 3.7-m-deep welded composite plate girders spaced at 7.18 m, supporting a 32.97-m-wide concrete deck. Structural cross frames spaced at 6.4 m support substringers centered between each main girder, and bottom
lateral bracing between exterior girders ensured stability during construction and remained in place as an integral element of the overall system. This configuration of deep-fabricated girders and rolled W-shaped substringers allowed the efficient use of steel and concrete and minimized the number of heavy girder segments that were fabricated, transported and erected.

Putting a charge into the schedule

Extremely cold weather, 1-m-thick river ice conditions and construction access needing to avoid hazards associated with adjacent power transmission lines challenged the team’s ability to meet the design and construction schedule. Adding to the obstacles, Atlantic sturgeon are known to spawn in the deep waters below the main span, which made these areas off limits to permanent or temporary construction work. Further, the river’s southern shoreline is moderately constrained by shallow water depths during the peak of each construction season, in part due to river flows regulated by the upstream hydroelectric dam; the latter precluding barge access for heavy equipment.

Quality and schedule objectives were met by using off-site fabrication and precasting, particularly for critical-path and long-lead items such as structural steel and most components of the concrete deck. All girders were designed within constraints established early in the design stage to ensure on-time shipping and delivery. And the over-land transport of structural steel fabricated in Quebec was considered for girder segment delivery, both in terms of size and weight. The larger segments were delivered via rail to a siding in Montreal, where they were off-loaded for truck transport to the project site.

To mitigate any hazards associated with Hydro-Quebec’s 315-kilovolt aerial power transmission lines that are directly adjacent to the new bridge alignment, a temporary rock causeway and trestle access system were constructed on the downstream side of the bridge. Custom-designed gantry cranes were then used to span the entire width of the new bridge.

With a capacity rating of 60 tons each, the twin gantry cranes performed all heavy lifting, including the largest girder segments. The causeway was constructed of washed stone. Intermittent openings allowed water to run through the causeway without adversely affecting the river flow in the environmentally sensitive area just downstream of the project.

Breaking the ice

Varying river-bed topography, a hydroelectric dam just upstream of the project site and two islands just downstream on the Montreal side create icing conditions that result in significant ice-flow impact loads on the in-water piers. Understandably, these extreme conditions played a significant role in the substructure design and the

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Project-specific ice loadings were studied in conjunction with Dr. Tom Brown of the University of Calgary and BMT Fleet Technologies of Ontario, Canada. This involved the evaluation of ice flows, ice-sheet breakup, ice growth, ice thickness, thermal ice loads plus wind-driven, and river ice flow impact loads. The project design basis for the 100-year return period river icing conditions resulted in 1-m-thick ice sheets for thermal-related ice loads and 0.9 m for ice sheet breakup-inducing impact loads. The near-shore foundations were most influenced by ice thermal effects and loads imposed from ice growth, while in the deep-water area of the river ice flow impact loads controlled the design.

To combat the icing conditions during construction, battered raker piles were installed to lift the edge of large ice flows, which induced the ice into a cracking mode under its own weight rather than bearing most of the force on the temporary construction works. One construction innovation during early river icing of the project’s first winter included pile-casing installation, whereby drilled holes in the river ice cover served as the positioning and placing template.

Tower of compliance, long list of sustainability

To achieve environmental compliance, construction work on the northern tower was performed from atop a manmade rock island that was later removed. This allowed for uninterrupted construction activities both during the harsh winter construction environment and during the Atlantic sturgeon’s spawning season, all while maintaining the ecological health of the river.

The south tower is similar to the north, except that it was constructed in water depths of 5 m and a sheet-pile cofferdam system was used for in-water construction. Again, to protect the sturgeon-spawning area, construction activities were confined within the cofferdam. The south tower base rises above the level of ice flows via a 2.5-m-tall concrete pedestal that distributes the tower reactions to the footing cap and drilled shafts. As a result, the pier is sturdy enough to receive the full brunt of ice-flow loads during the river’s spring thaw.

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

- Excavated material was used 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;
Corrosion-resistant galvanized steel bar reinforcement was used for lifecycle durability;
Local aggregate was incorporated into the concrete mix design, minimizing energy use in transportation;
Structural steel was fabricated within 200 miles of the site, supporting the regional economy in an environmentally efficient manner;
Efficient rail transport methods were used to deliver the fabricated steel;
Structural bridge details were evaluated and incorporated to effectively manage future life-cycle costs;
Precast deck panels with strict durability criteria, including strict chloride-permeability limits, were specified;
High-strength cable stays with triple-corrosion protection were used;
Issue-for-construction plan sheets and shop drawing submittal processes were fully electronic; and
Planning for all in-water construction activities first considered innovation opportunities benefiting the environmentally sensitive river habitat.

42 months for 35 years

Partnering with environmental stakeholders, Parsons secured the second-tier permits for the A25 project in a record four months following financial close, allowing construction to commence according to schedule. The permitting process was established and negotiated based on the construction-critical path. Starting in June 2007, the design proceeded in line with the permitting process, and the early release of design packages followed only a few days behind the permit approvals. Final design was completed in less than 15 months, with substantial construction completion in only 42 months.

MTQ’s initiation of the PPP delivery method also played a role in meeting the project’s aggressive schedule. This financing approach was recognized by the Canadian Council for Public-Private Partnerships with a Silver Award for advancing the project by nearly two years and, by compensating the private partner through construction payments and shared toll revenue over the concession period, resulting in a savings of $226 million over the 35-year term. 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.

The unique A25 project delivers upon the goals of innovation, sustainability and overall progression by providing the city of Montreal and its northern suburb of Laval with a much-needed—and much-improved—transportation solution that will immediately ease the flow of traffic and accommodate future growth of the region. R&B

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