JOHN JAMES AUDUBON BRIDGE

The western hemisphere's longest cable-stayed bridge

The centerpiece of the Audubon Bridge Design-Build Project is the central 482m cable-stayed main span across the Mississippi River. The cable-stayed unit is comprised of five spans, symmetrically arranged about the navigation channel. The central span is flanked on each side by 189m side spans, supported by the stay cables, and 49m transition spans.

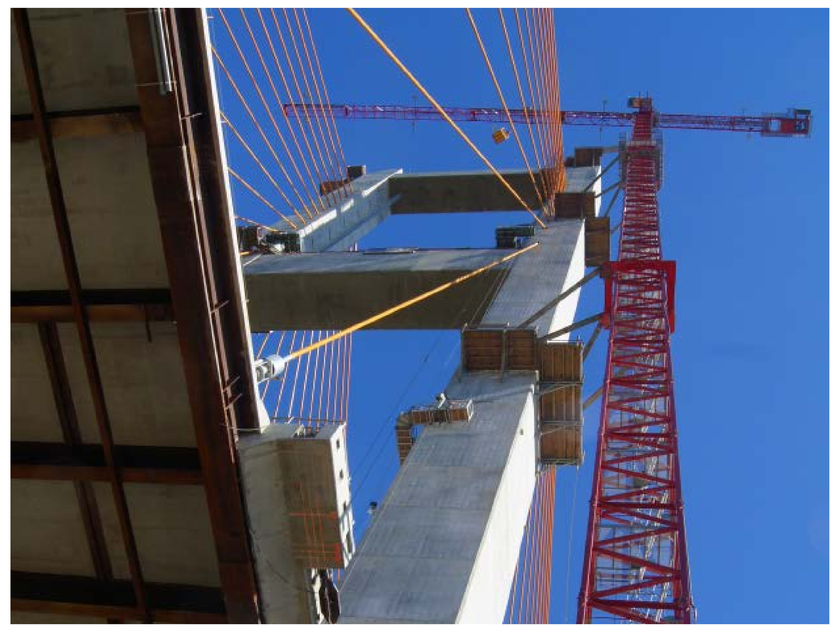
It is the longest cable-stayed bridge in North America and is the first design-build bridge project ever undertaken in the State of Louisiana.

THE NEW BRIDGE:

- DURABLE
- EFFICIENT
- SUSTAINABLE
- AESTHETIC
- CHALLENGING
- CONSTRUCTABLE

TheFoundation

Founded on 56m long 2.4m diameter tip-grouted piles, the tower pedestals were constructed in deep cofferdams designed for 65 MN barge train impact forces applied at a river level fluctuating by up to 15.5m.



TheInnovation

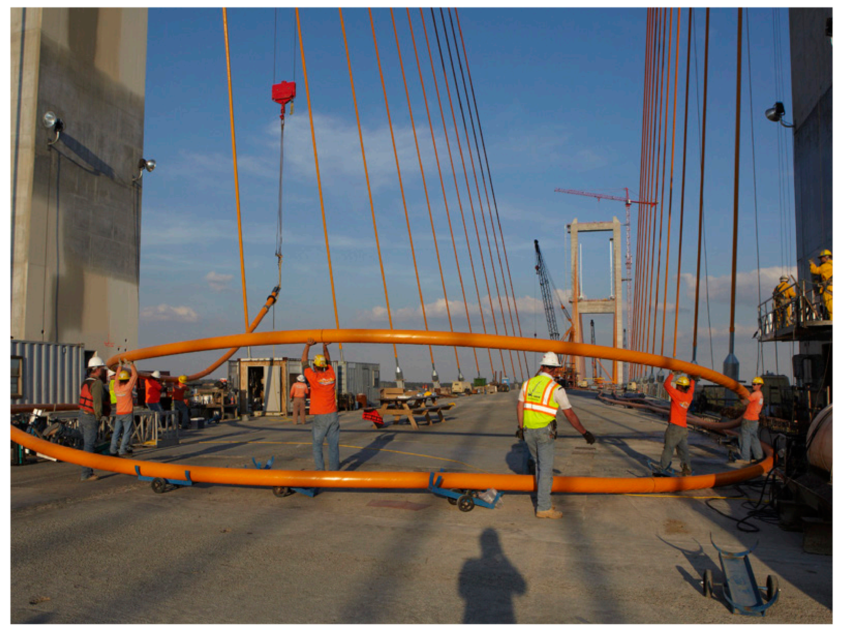
The bridge deck is supported on simple corbels constructed on the inside face of the tower eliminating a lower crossbeam, which was instead placed at the tower top to provide the bridge dynamics necessary for aerodynamic stability.

TheConstructability

Efficiency is delivered through the 152m H-frame towers, which are designed with an emphasis on constructability permitting rapid tower construction with significant overlap between tower and deck construction.

TheSite

The aerodynamics of the bridge were optimized using advanced climate modelling to predict site specific hurricane force winds, wind fairings to shape the main span deck edges and refinement of the tower form to control the dynamic response.



TheAesthetics

The burnt umber colored cables together with the clean lines and soft white coating of the towers creates a striking and harmonious addition to the skyline of the Bayou region.

AN ICONIC BAYOU CONNECTION FOR THE REGION

Prime Consultant/Contractor:
Audubon Bridge Constructors JV (consisting of)
Flatiron Constructors / Granite Construction / Parsons

Other Consultants:

- Parsons Transportation Group
- RWDI Consulting Engineers
- Touchstone Architecture
- Dan Brown Associates

BUCKLAND & TAYLOR | COWI

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA
ASSOCIATION DES FIRMES D'INGÉNIEURS-CONSEILS | CANADA

A

PROJECT INFORMATION

Project Information

Project Name
John James Audubon Bridge

Location
St. Francisville to New Roads, LA, USA

Year Completed
2011

Category
B. Transportation

Entering Firms
Buckland & Taylor
101 - 788 Harbourside Drive, North Vancouver, BC, V7P 3R7

Role of Entering Firm
Subconsultant - Responsible for design of superstructure and erection engineering of the Bridge

Project Leaders
Don Bergman, P.Eng. - Project Principal
Armin Schemmann, P.Eng. - Project Manager

Three Contact Names
Kristine Majlath - Communications/Marketing/Public Relations and Management/Administration
Don Bergman, P.Eng. - Project Principal (Engineering Inquires)

B

PROJECT OUTLINE

Executive Summary

South-central Louisiana is now home to the longest cable-stayed bridge within Canada and the United States of America, the 482 m John James Audubon Bridge, which crosses the storied Mississippi River.

The cable-stayed unit is comprised of five spans, symmetrically arranged about the navigation channel. Buckland & Taylor's scope of work include the detailed design of the cable-stayed main span structure above the foundations and the detailed construction engineering for the structure.

PROJECT HIGHLIGHTS

Innovation

The towers are a dominant element of the cable-stayed unit - not only by their prominence in the landscape, but by their impact on the overall construction schedule and cost, and ultimately the ability to deliver a cost effective design concept. The primary objective of the conceptual design was to provide a highly constructible tower that would satisfy technical, economical and schedule requirements. The final tower design was developed during the pre-bid design phase and evolved through progressive refinement of no less that twelve concepts.

In order to maximize constructibility, an H-frame tower with vertical tower legs and a single crossbeam above the deck was initially selected. The vertical legs would allow for efficient jump form construction with minimal requirements for geometry control that would also permit for significant overlap between tower and deck construction. The cross beams stiffen the tower in the transverse direction thereby reducing bending demand in the tower legs. The below-deck cross beam is positioned to provide clearance for a underslung maintenance traveller. However, the concept came to a brief halt when the dynamic analysis of the design revealed the ratio between the fundamental deck torsional and vertical natural frequency ($\omega t/\omega v$) to be less than 1.58. With the deck exhibiting width to depth aspect ratio of 12.7, the low $\omega t/\omega v$ frequency ratio was expected to result in a relatively low critical wind speed of 52 m/s at which onset of aerodynamic instability, similar to Tacoma Narrows, could be expected. The fundamental torsional frequency had to be increased to address aerodynamic stability requirements.

Recognizing the limited benefit of the below-deck cross beam, the early H-frame concept was modified by essentially relocating the below-deck cross beam to the tower top, where the beam would remain clear of the cable anchorages and provide the much needed boost to the torsional stiffness and torsional frequency. The $\omega t/\omega v$ frequency ratio which is critical to aerodynamic stability increased to 1.79 leading to an expected critical wind speed of 58 m/s. The resulting tower form is efficient and unique for this type of cable-stayed bridge and provides a striking visual on the skyline of the Louisiana lowlands.

JOHN JAMES AUDUBON BRIDGE

The structure was to incorporate the use of visual continuity through the use of a palette of common design elements; use horizontal and vertical line features to correspond and contrast with the landscape; and colour of features were to harmonize with the natural setting

Complexity

Towers

The weak soil conditions required the use of an innovative tip grouting technique to reinforce the bearing capacity of the 42 drilled shafts. After casting the pile caps inside 15 m high coffer dams, the 152 m towers were erected using jump forms to speed up the process (4 m lift/5 days). Steel anchor boxes are cast inside the hollow tower section to anchor the stay cables.

Under normal service, the superstructure is longitudinally connected to the west tower only using steel fixed links for a rigid connection but during high winds, lockup devices are activated to also connect the superstructure at the east tower. This system is highly efficient, allowing both towers to share any short-term or dynamic wind loading, allowing the structure to “breath” under slowly applied thermal movements without building up large restraining forces.

Superstructure

The composite deck uses a steel grillage with precast panel system, which are post-tensioned at the end of the back spans and at the middle of the main span.

Every 14 m, each cable-stay is protected against vibration by a friction damper. Their performance has been confirmed through testing after construction. To facilitate installation in the tower, the stays were stressed one strand at a time. The relative flexibility of the superstructure requires the stressing of the stays in two stages: the first to lock in the correct deck forces and geometry when the concrete deck is constructed and the second to obtain the correct final cable forces and bridge geometry.

COMPLEX BRIDGE TOWERS

The bridge superstructure is not supported on a cross-beam, but simple corbels that were constructed on the inside faces of the tower legs. Vertical and lateral bearings support the superstructure at two locations on each tower.

The upper and lower cross-beams were constructed on falsework supported on the tower legs after they were completed to the necessary elevation.

Social and/or Economic Benefits

Social Sustainability and Economic Aspects

The Bridge is Louisiana's first use of the design-build delivery method, allowing concurrent design and construction, resulting in one year saved compared to the traditional design-bid-build method. Audubon Bridge Constructors (ABC) introduced an ISO 9001-compliant program to ensure successful delivery of a high-quality design and final product. They also helped develop and implement the project's site-specific safety program, and regular safety audits.

The bridge opened to traffic on May 5, 2011 in tandem with closure of the ferry system due to the Mississippi River's dangerously high flood levels. The emergency opening accommodated traffic that has lost river-crossing access when the ferry closed. Now that the Bridge has been opened, the ferry, which carried approximately 720 vehicles per day according to 2009-2010 LADOTD statistics, became permanently closed.

Economic Benefits

- Simple vertical towers legs which were easily jump formed and permitted simplicity of reinforcing details
- Tower cable anchorages connected by stay in place formwork to simplify fabrication, enhance geometry control and eliminate complicated formwork between the anchorages
- Use of simple modular repetitive prefabricated deck elements
- Simple open deck system composed of easily fabricated and erected 3-plate edge girders and floorbeams
- Simple easily fabricated and erected rectangular precast panels making up the deck
- Cast in place joints between precast deck panels over the girders and floorbeams requiring no formwork
- Simple direct cable connections to the top flange of the main girders
- The use of weathering steel reduces the initial cost and the life cycle costs of the project by eliminating painting

SOCIAL AND ECONOMIC BENEFITS

The Bridge is Louisiana's first use of the design-build delivery method and allowed one year saved in comparison to traditional design-bid-build delivery.

Environmental Benefits

The surrounding wetlands is habitat for the threatened Louisiana black bear, so 10 bear crossings were incorporated into the project, exemplifying the spirit of conservation inspired by John James Audubon. Fencing was used and tunnels were constructed under the roadway for the bears to travel through and to provide a continuous habitat. These crossings are combined-use features, as they double as drainage structures at high water levels.

Fly ash, which is a waste product from coal fired power plants, was used in place of cement in the concrete, which resulted in a more durable product.

Meeting the Client's Needs

Below are the features incorporated in the design and construction of the Bridge in order to enhance the durability of the structure and address the 100 year design life, thereby meeting the Client's needs:

- A corrosion protection plan was developed in order to deliver the target service life for the Bridge. This plan provided the concrete properties required to ensure the full design 100 year design life of the bridge would be achieved before ingress of chloride ions into the concrete, initiating corrosion.
- The structurally critical concrete deck of is also protected by a relatively impervious 2 inch thick overlay composed of latex modified concrete. The overlay is sacrificial and can be replaced over the life of the structure as necessary to preserve the underlying concrete deck.
- The structural steel utilized for the bridge is atmospheric carrion resistant steel, develops a stable patina of oxide, serves to protect the underlying steel from corrosion over the life of the bridge and eliminates life cycle costs associated with repainting.
- The pedestals supporting the main towers are protected at the water line from vessel impacts by ultra high molecular weight polyethylene panels attached the outside faces. The dense panels protect against abrasion and reduce the force of glancing vessel collisions due to their low friction coefficient.
- Anchorage of the cable-stays in the towers provide access for stressing and facilitates their unlikely future replacement, as the cable-stay system provides three levels off corrosion protection.

THE END RESULT

The resulting bridge is an outstanding achievement in the design and construction of bridges within Canada and the US.