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Design and Construction of the Pont Bacalan-Bastide Vertical Lift Bridge

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ABSTRACT:

The Pont Bacalan-Bastide is new vertical lift bridge over the Garonne River in Bordeaux, France. The bridge has a lift span of approximately 118 m and an out-to-out width of approximately 43 m. The bridge has a lift height of approximately 50 m and is expected to operate roughly 120 times per year for the passage of large vessels to the ports surrounding Bordeaux. The lift span is supported by four individual pylons and was the winning entry in an international design competition. The design-build joint venture included an international consortium of experienced bridge designers and constructors.

The lift span structure has symmetric cross-section and carries four traffic lanes-two mass transport tracks and two outboard sidewalk/bikeways. Four, independent pylon towers-one at each corner of the lift span – support the span weight and permit the movement of the counterweights vertically inside each pylon. Due to the visual character of the bridge and the limited size of the pylons the bridge operating machinery, one set of drive machinery per end of the span, is housed in the concrete plinths that join each pair of pylons (Rive Gauche and Rive Droite). The span operating machinery utilizes a two-way operating rope system with uphaul ropes connected to the bottom of the counterweight. The downhaul ropes extend from the operating drum over a deflector sheave at the pylon top and connect to the top of the individual counterweights.

Due to the potential for significant wind loads through the project area and the airfoil-type section of the orthotropic box-girder lift span, detailed wind and span balance studies were performed to optimize the machinery design. The bridge is configured without auxiliary counterweights due to owner requirements so special care was required in the span balance selected.

This paper will address the design constraints of this project with respect to the complexity of a structure's architecture as well as the interaction of the design conceptor, the design studies consultant team and the constructor and fabricators for this design-build joint venture. The detailed design and execution phase is on-going and the structure is planned for completion at end 2012.

Introduction

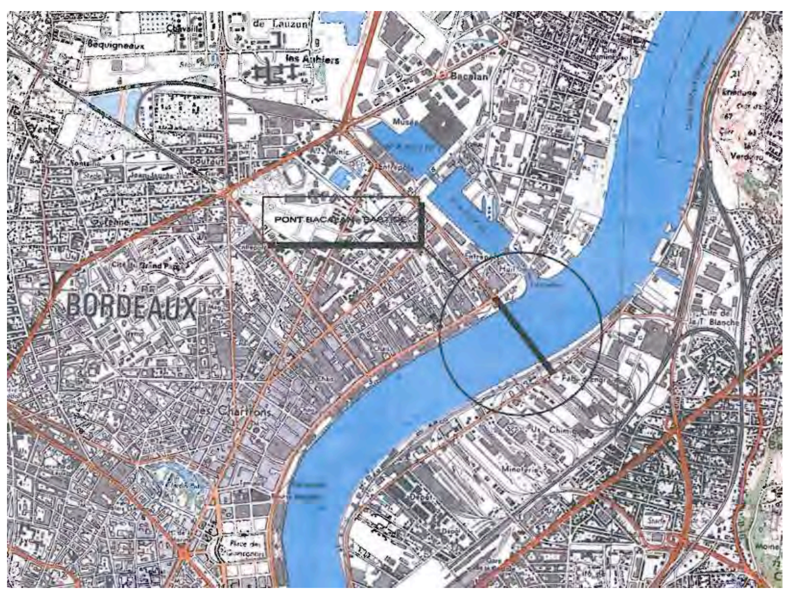
The Pont Bacalan-Bastide is the latest modern vertical lift bridge being constructed in France. The bridge is located in the city of Bordeaux and marks a new crossing over the Garonne River from the historic city center. The bridge is a landmark structure that was designed by an international team which was led by an experienced design-builder. The project is currently in the Execution phase and is scheduled for completion of construction by 2012.

This paper describes the project development process as well as details of the design, both study and detailed level, and the on-going construction.

Project Process

The project was initiated through a design competition. The competition entrants were invited by the owner, La CUB (Urban Community of Bordeaux), to propose on the design and construction of the new structure. The project site was selected by the owner through their preliminary studies. The competition requirements, referred to as the functional program, were described in detail by the owner. The competition was judged based on best value with the overall design and visual character of the bridge being highly weighted. The design competition initiated in early 2003 and the proposal packages were due in September 2004.

Subsequent to the submission, the competition panel judged the entries for compliance with the competition requirements, design quality, engineering efficiency and overall value. After nearly two years of rigorous review of the competition entries, the competition panel determined the proposal of the design-build joint venture led by GTM was the winner in January 2006. This team consisted of GTM, Vinci Construction and Cimolai for the construction component. The design joint venture was led by EGIS Jean Muller International with Michel Virlogeux as the bridge design consultant, Lavigne-Cheron as the bridge architect and Hardesty & Hanover International as the movable bridge specialist.



The project followed the typical process for European design projects. Subsequent to the competition, the design team initiated the Project Study phase. In this phase the competition design was advanced to level sufficient to refine the design intent as well as the materials and quantities. During the process, the design team's work was reviewed by the owner's agents for compliance with both the competition requirements as well as the project proposal. The Project Study design was initiated in December 2007 and extended to the end of 2009. During this time, the design-builder began the process of contracting with vendors and the primary subcontractors for the various portions of the project.

During this phase, the design was modified to take into account the potential need for a tram-train mass transit system supported by the bridge in the future. It varied principally in terms of loads carried by the structure from the ordinary tram originally previewed.

In addition, the conception team had to change the architectural design due to the city of Bordeaux decisions regarding its Unesco classification for world heritage. These changes included modifications to the pylon shape and the inclusion of additional walkways near the pylons to serve as emergency access to the roadway.

The Execution phase initiated in May 2009. The Execution phase can be compared to the detailing and construction phase in the United States. In the European system, the contractor, or specialty sub-contractor, is responsible for the detailed design of the components. This detailed design results in shop drawings used for fabrication. Unlike the process in the United States, the Subcontractor is also responsible to submit computations that justify the detailed design drawings (shop drawings). During this phase the designer acts as a verifier and checker to ensure the detailed design is consistent with the original design intent documented in the study phase. The designer is also responsible for the checking and approval of the detailed drawings. In this manner, the design consultants and the contractors work in close coordination to ensure the selected components meet the original design intent but also work together as a system.

In addition to the review of the documents within the design-build team, the owner also has a representative review the documents to ensure the work is consistent with the requirements and the project proposal. This system of checks and balances works in a collaborative manner with all parties sharing information on a common project document control database. The database is a key part of the project due to the diverse geographical locations of the various team members. Key personnel from the team partners are located at the local project offices but other support staff are located throughout France and the United States. The database permits the sharing of information in a timely manner to ensure the project schedule is maintained.

Bridge Design

As noted above, one of the key criteria for the design competition was the visual character of the bridge. The overall design of the bridge was led by Michel Virlogeux and architect Charles Lavigne. The team developed a vertical lift bridge with four independent pylons for its dramatic character. The four pylons were formed out of concrete and each house one of the four counterweights that balance the bridge.

This decision led to the clean, classic lines of the structure which is modern in nature but does not compete with the historic character of the city from which it extends. The bridge in the closed position offers a distinct presence but does not look like the utilitarian vertical lift bridge that it is.

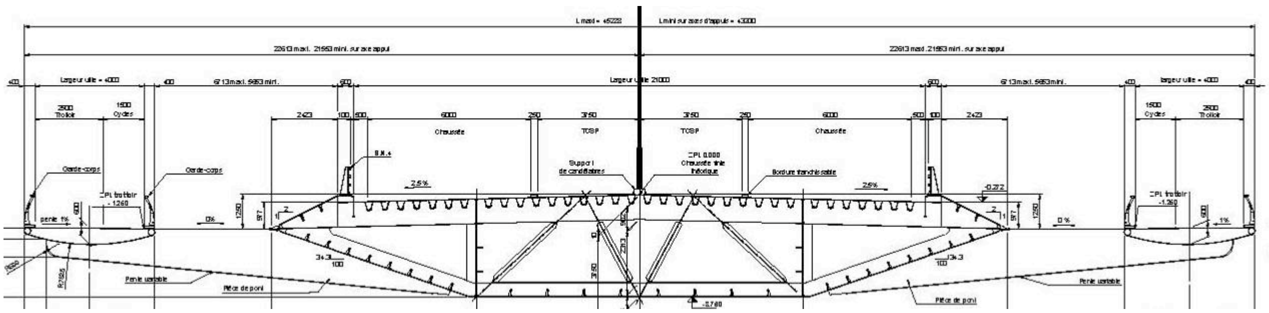
The architecture of the structure is striking and impressed the competition jury. The true beauty of the design, however, lies in the fact that the form follows from function. The tower shapes were developed considering the wind effects at the site as well as the structural need in bending of the tall, relatively thin pylons.

Much like any bridge, the geometry of the structure is governed by the use. The overall bridge length, including the two approach spans that flank each side of the lift span, is 433 m. The bridge has a lift span of approximately 118 m in length. In the closed position the bridge has a vertical clearance over the waterway of approximately 13 m and a horizontal clearance for navigation of 106 m. The lift height is 47 m.

The bridge is estimated to operate roughly 120 times per year for the passage of large vessels to the ports surrounding Bordeaux.

Structural Design

The bridge structure has a symmetric cross-section and carries four traffic lanes-two mass transit system tracks and two outboard sidewalk/bikeways.



The separation of the sidewalks and bikeways from the main traffic allows a different alignment and longitudinal profile for these two kinds of traffic. Thus, the sidewalks have a slope under 4%, which is the maximum standard limit permitted in France for disabled persons, while the road has a maximum declivity of 4,8%, necessary to ensure both the required gauge for the navigation traffic, and a reasonable slenderness of the lift deck (1/31 ratio).

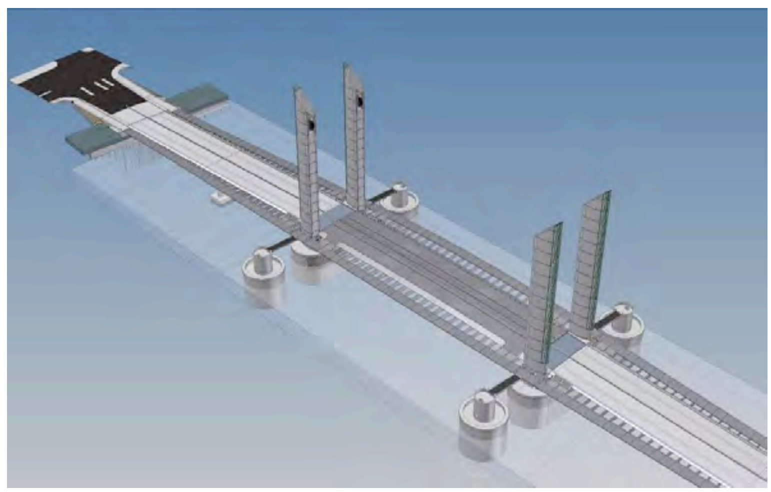


Figure 7-Alignments of Roadway and Bikeways

This conception leads to a difference of levels between the pedestrian and the main decks along the bridge: while at the same level on the abutments, this difference has a maximum of 1,15 m on the center lift span. It gives the bridge cross section a favorable shape towards winds. Under high winds, the bridge indeed behaves as an “inverted” plane wing, and as a result induces positive downward force on the lift span.

In case the wind is perturbated by the topography and becomes upward at the bridge site, the two separated sidewalks - linked to the main deck by strong cross-girders – stabilize it relative to the large width of the overall structure. The profile of the main deck nose has also been shaped to limit the effects of winds, which are important for the stability of the lift span due to:

- the small effective weight of the nearly balanced span
- the need to motorize the span so that the motors can accommodate the wind effects during operations.

This behavior was been confirmed by wind modeling at a 1/50 scale performed by CSTB in Nantes, and advanced dynamic and turbulent wind calculations performed by EGIS Jean Muller International.

Figure 8-Wind model in CSTB soufflerie

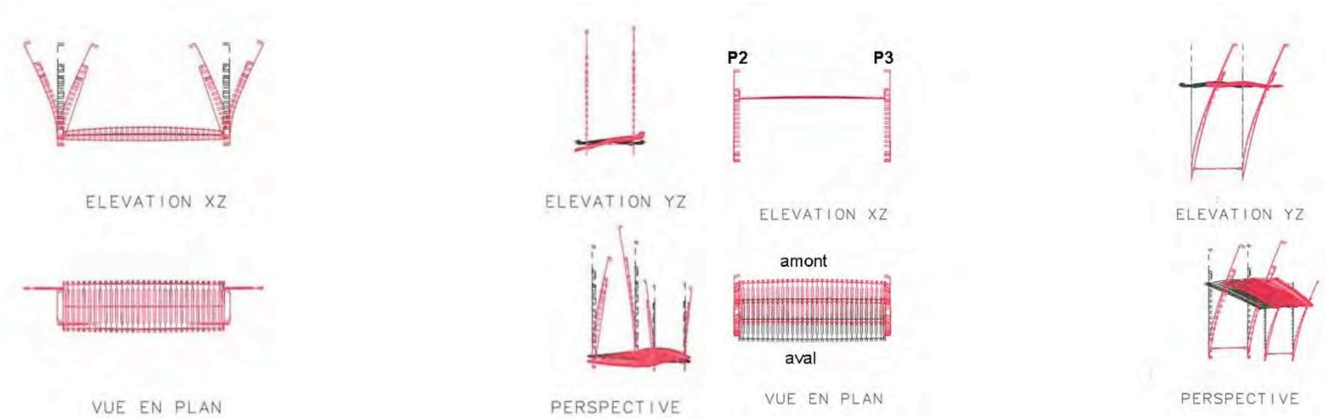


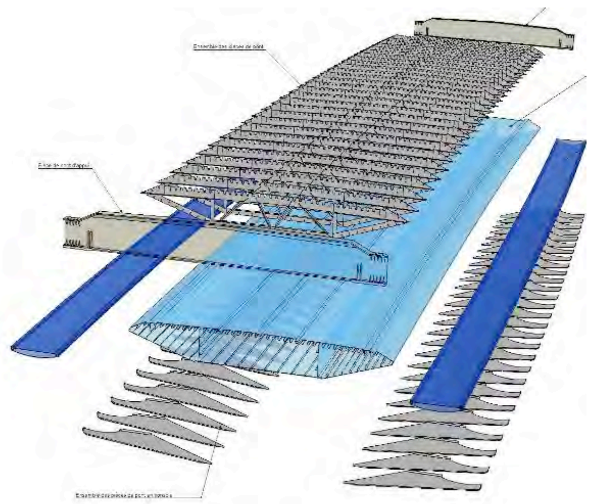
Figure 9-Vibration modes-Seated and raised positions

The lift span is a simply supported orthotropic steel box-girder, with a length of 117,4 m. The box-girder itself is 26,5 m wide, and composed of three cells separated by the two main webs; its total height is 3,75 m. Each 4 meters, the box-girder is stiffened by internal cross girders, composed of an upper and a lower plate, linked together by four I-shape diagonals. These cross-girders are extended to the support the outboard sidewalks. The overall structure has a maximum width of 45,2 m.

The orthotropic plate has a minimum thickness of 16 mm, and has U-shape closed stiffeners located each 0,6 m on center For fatigue reasons, these stiffeners are not interrupted, and welded only in their upper part with the transverse beams.

The bridge was initially configured for a bus mass transit system. The program, however, required provisions be included for the installation of a tram or tram-train in the future. For this reason, stiffeners located under the anticipated rail centers were increased in size to address the fatigue concerns associated with added load from tram-trains.

The sidewalks are steel orthotropic box-girders as well, 4,8 m wide and 0,6 m high. Due to the lighter sidewalk loads an 8 mm thick upper plate was utilized with less stiffening elements required.

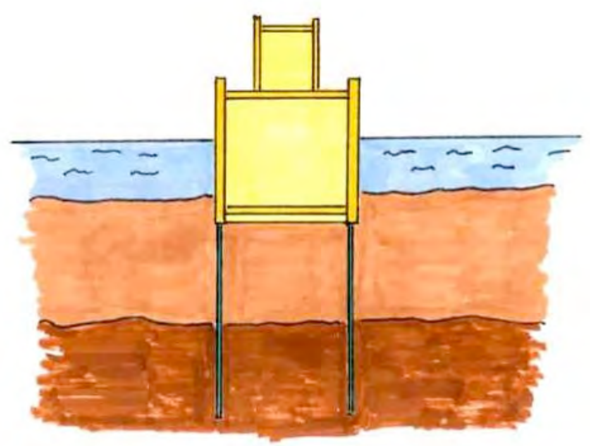


The orthotropic plate is covered by a waterproofing and pavement material. To limit the weight of the lift span, the choice has been made for a 10 mm thick epoxy resin that combines waterproofing and road surface properties. Due to the small thickness of this cover, specific calculations have been performed by EGIS Jean Muller International to confirm the design of the orthotropic plate under high local loads and local fatigue phenomena.

Four concrete pylons surround the lift span at each corner, and house the four counterweights which balance it. The 80 meters high pylons also support the main sheaves around which the suspensions ropes travel, thus connecting the counterweight and the span.

Each pylon is 11 m long and 5,3 m wide in cross-section and comprises two cells . The main cell (6,5 m long) houses the counterweight and the elevators to access the top of the pylon, while the second cell houses emergency stairs under the shelf of a glass viewing structure. The pylon is constructed of reinforced concrete poured in place utilizing a climbing formwork system with a length of 4,8 m.

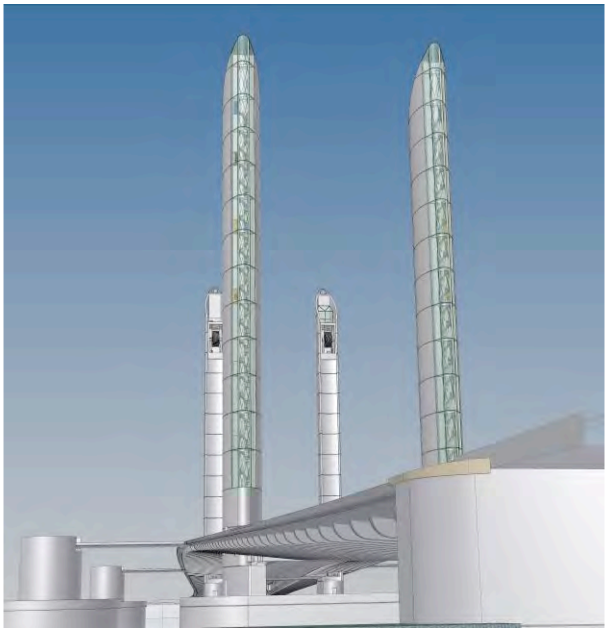
Two pylons are located on each side of the navigation channel with each pylon pair linked at their base by a reinforced concrete cross-girder. This cross-girder also serves function as the support for the fixed approach spans and the ends of the movable lift span when seated.



Each pair of pylons is supported by a common base. These huge concrete structures (44 m long, 18 m wide and 15 m high) are precast in a dry dock located a few kilometers away from the bridge site. After casting, the dry dock is flooded and the floating bases are transported to the bridge site on the Garonne River. The area beneath the base is dredged and the based is founded on twenty piles embedded in the rock.

Each base is protected from a large ship impact by one upstream and one downstream dolphin. They are cylindrical concrete structures of 18 m diameter, and also precast in the same dry-dock. The difference is that these structures are not founded on piles, but anchored by cables grouted in the rock beneath the river. This design leads to a structure that is globally less rigid, but is still capable of functioning during the impact. The wire rope anchors are sized and set to a tension corresponding with 5% of their rupture strength. In the event of a vessel impact, the collision side wire ropes absorb the vessel impact energy by elongating, thereby increasing the tension in the wire rope anchor. The configuration of the wire rope anchors is such that during impact rotation and/or sliding of the dolphin is minimized, thereby preventing a direct vessel collision with the lifting pylon bases.

The approach spans are from a more classical conception. These spans are composite steel girder type structures with two continuous spans on each bank. Their abutment and intermediate pier are classical concrete bridge supports. The ends of the approach spans on the lift span side are also supported by the bases.

Given the size and complexity of the structure, as well as the technical constraints required for this bridge a collaborative effort was required among the team members to ensure all architectural, structural and mechanical program requirements were met. During the conception phase, all structures were fully modeled using 3D software (Autodesk Inventor) in order to anticipate and eliminate any potential interface issues.

Machinery and Electrical Design

The design of the mechanical and electrical systems utilized FEM Specifications For Heavy Lifting appliances where applicable. Due to its predominant purpose as a guide for the design of cranes and other lifting devices, the code does not directly apply to the design of movable bridge machinery. AASHTO Specifications for the Design of Movable Bridges were utilized to supplement FEM and eliminate extrapolation of the FEM requirements.

The bridge machinery is comprised of four main systems:

- Span Support Machinery
- Span Operating Machinery
- Span Lock Machinery
- Span Guidance Machinery

Span Support Machinery
The span support machinery comprises the counterweight ropes, counterweight sheaves and bearings and the counterweights. The span weight is approximately 2720 tonnes (tram-train phase) and is balanced at the four corners of the lift span by the counterweights. The counterweights are comprised of a central spine plate and four quadrant boxes. Each quadrant box is filled with steel ingots specially cast for the interior shape of the quadrant boxes. The ingots are sized to provide the necessary balance with adjustment for final balancing and any future modifications..

The counterweight design was developed to suit the construction means and sequence proposed by the contractor. The central spine plate connects to the counterweight ropes and is the primary load carrying element of the counterweight. The four quadrant boxes were required due to the access requirements at the top of the pylon. The limited size of the access opening required the counterweight box to be inserted in the pylon in pieces and assembled on temporary shoring at the base.

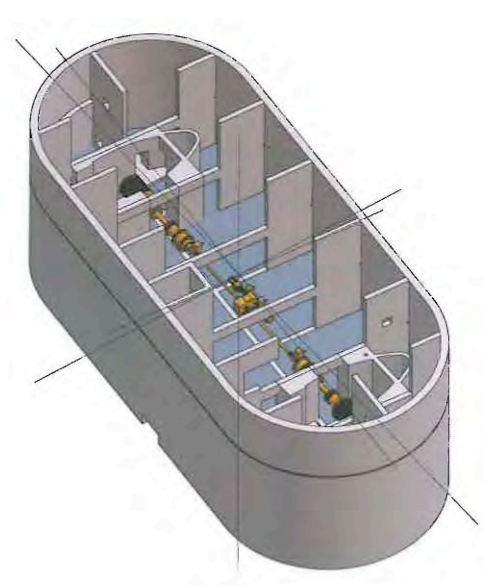
The counterweight ropes are 76 mm diameter rotation resistant compacted strand wire ropes, fitted with open spelter sockets at each end.. The bridge has ten ropes per corner. The counterweight ropes drape of the counterweight sheaves and each counterweight rope is connect to the end diaphragm of the lift span through an adjustable take-up assembly. The opposite end of each counterweight rope is pinned to the counterweight anchorage plate. Due to the concentrated lifting loads the end diaphragms were stiffened and as a result act as an integral lifting girder.

The counterweight sheave is a welded steel design with a 4.0 m pitch diameter. While this D/d ratio is lower than is customary in the United States, the ratio is in excess of the FEM governing code for the design. The sheave hub is fitted with spherical roller bearings and is mounted on a fixed simply supported shaft. The ends of the fixed shaft are supported by fixed bearings that are anchored to the concrete of the pylon.

Span Operating Machinery

Due to the visual character of the bridge and the fact that there are no transverse elements between the two pylons, the design team needed to determine the optimum location for the machinery. The limited space available in the pylon at the level of the sheave precluded the use of low speed, high torque motors and gearing at the sheaves. In addition, if four independent machinery systems were used, they would need to be synchronized electrically which was not preferred due to the independent nature of the counterweights. The design team believed an alternative solution that offered inherent transverse skew control would be a better solution. To this end, the design team developed a machinery layout that is similar in nature to that of a span drive vertical lift bridge. Instead of the operating rope system traveling horizontally from the central machinery room to the ends of the bridge, the ropes extend vertically through the pylons.

The operating machinery is traditional in layout and is mounted in the lower level of the concrete plinth on which the two pylons are founded. The machinery includes two electric drive motors (A and B motors) connected to a primary reducer. The primary reducer output is connected to two floating shafts connecting to the epicyclic secondary reducers. The outputs of the secondary reducers are connected to the operating rope drums by short floating shafts.



Epicyclic reducers were chosen for the secondary reduction due to the spatial constraints within the plinth and the slight skew of the machinery relative to the diaphragm walls of the plinth. The epicyclic reducers do not require an offset from the line of the floating shaft to the operating rope drum so the plan dimensions of the machinery could be minimized.

The bridge operating machinery is housed within the concrete plinths that join each pair of pylons (Rive Gauche and Rive Droite) (See **Figure 13**). This location was beneficial in a number of ways. First, the plinth provided ample room for the machinery and access for maintenance. Second, the location permitted the majority of machinery maintenance to be performed at the base of the bridge rather than the tops of the pylons. Due to the potential for water infiltration into the plinth (the machinery level is located below high water) a sump pump system was included in the design. The controlling case used for the sizing of the sumps was a combination of extreme events and thus ensured the pump would protect the machinery under the most demanding conditions.

The main drive is provided by a two-way rope system from the operating drums. As described above, the drums on each bank (transverse pair of pylons) are mechanically synchronized. The system uses four operating ropes per corner of the span. The operating ropes are 46 mm diameter rotation resistant compacted strand wire ropes and are pretensioned to ensure that tension is maintained in the operating rope system through all operating conditions as required by the functional program.

In order to minimize the length of the drums as well as the fleet angles of the ropes, right and left hand helical grooves were used. In this manner the ropes that are being wound on the drum occupy the grooves vacated by the paying out ropes. The uphaul ropes extend from the operating drum near its transverse center through the core of the pylon and attach to the bottom of the counterweight box at the spine plate. The downhaul ropes extend from the end of the operating drum length (symmetrically about the transverse center) and extend through the core of the pylon up to the sheave level. At the level of the sheave, the each downhaul rope wraps around a 1.70 m diameter deflector sheave and terminates at the top of the counterweight.

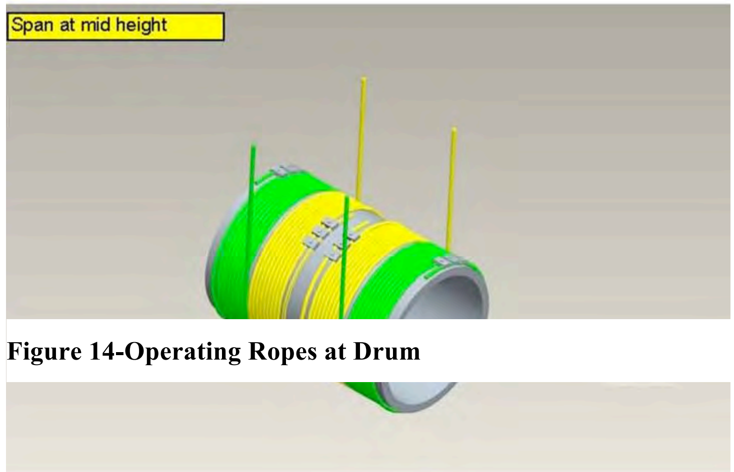


Figure 14-Operating Ropes at Drum

There are a number of advantages of this two-way system. First, the lift span is positively controlled at all positions. The system has the ability to drive the bridge either up or down regardless of the position of the span. This was a major advantage and helped the design team to minimize the imbalance of the span. A number of modern vertical lift bridges in France utilize an extremely span heavy condition compared to US standards. The governing FEM code requires the load (the lift span) to be sufficiently heavy to maintain positive downward force through all conditions including environmental loads. This philosophy, combined with substantially higher wind design loads that commonly designed for in the US, led to a functional program that anticipated a span imbalance of nearly 200 tonnes in the seated position. This imbalance has a dramatic impact on the initial load to lift and the power requirements for the bridge.

As part of the Project Study phase, the design team performed a span balance study. This study evaluated a number of span balance conditions for a one-way rope system (the system conforming directly to the functional program) and a two-way system. The primary concern of the owner was the safety of the system and the ability to ensure the bridge can be lowered from the raised position in the event of a power failure. This was a primary concern since an auxiliary power generator was not required or desired by the owner. As part of the span balance study, the design team advanced the site specific wind analysis. This analysis determined the wind loads anticipated by the functional program were larger than the actual site conditions. Using this site specific data, the design team performed detailed wind analysis and modeling to determine the wind forces on the span for a number of positions of lift and conditions (nominal wind, extreme wind). The results of the span balance study were presented to the owner and the owner concurred with the design team that a seated span imbalance (span minus counterweight) of 100 tonnes and the use of the two-way rope system would be used for the remaining phases of the design and construction. This seated imbalance results in a span neutral balance condition at the full lift height, exclusive of environmental loads, due to the substantial counterweight rope transfer weight. The potential to utilize auxiliary counterweights was evaluated and it was determined through coordination with the builder than the additional cost and complexity of the auxiliary counterweight system was greater than the cost impact of the proposed balance on the machinery and power demands. In addition, the spatial constraints within the pylons made the inclusion of auxiliary counterweights a less preferable option.

A second benefit of the two-way system centers on constructability. The functional program requires that the machinery be load tested in the assembled condition. With the two-way system, the closed loop of the operating ropes and the counterweight could be operated independent of the span and counterweight ropes. This provides the builder flexibility in the sequence of field operations and permitted the time intensive machinery testing to be performed exclusive of the lift span float-in.

Span Lock Machinery
As described above, the initial functional program for the project anticipated a substantial span heavy condition in the seated position. Based on this condition, the functional program explicitly excluded the use of span locks in the seated position.

As a result of the span balance study and the wind analysis, it was determined that span locks would be required to maintain the seated condition under extreme wind conditions. In addition, during the project study phase the potential for inclusion of tram train traffic on the bridge was studied. Based on the positive results of the study, owner decided to include the provisions for tram trains on the structure now rather than at a future date as originally intended. With the inclusion of tram trains, the use of span locks became increasingly more important to ensure that proper seating and alignment of the train rails is maintained.

In addition, the inclusion of span locks was justified by the risk analysis performed at the end of the project study phase. As part of the design verification, the design-builder was responsible to perform a comprehensive risk analysis. This analysis was performed by a specialty consultant and evaluated the potential risk conditions for the moving bridge to ensure the 'machine', as it is defined in European codes, conforms to the European Directorate 2006/42/CE. This document specifies the level of safety necessary for the machine and its constituent parts. The risk analysis determined that the inclusion of span locks was a risk mitigation measure to address unintended movement of the lift span for a number of potential reasons.

Each end of the lift span utilizes two span lock machinery systems that employ a common retractable lockbar setup Each span lock machinery system is comprised of a receiving socket, front and rear guides, a lockbar and an Earle lockbar operator. The lock machinery is mounted to a common machinery base and affixed to the transverse framing of the roadway at the pier bases. The lock bar is rectangular in section with dimensions of 300 mm by 200 mm. The lock bar engages a receiver socket that is mounted to the end diaphragm of the orthotropic box girder.

Span Guidance Machinery
The span guidance machinery evolved through a number of iterations during the project study phase. The guidance machinery is important since the four pylons are not connected and relative movements of the pylons could result in operational impacts. Due to the large magnitude of wind forces, the design team opted to use rollers in lieu of sliding guides. This allowed a better load distribution in the guide track as well as minimized the guidance operating resistances.

The guide system comprises a running surface of fabricated channel or flat tracks mounted to the pylons and the guide roller assemblies mounted to the end diaphragm of the orthotropic box girder. The longitudinal guide rollers are located at the exterior faces of the River Gauche pylons. Longitudinal guidance is achieved using a pair of rollers engaged in a channel shaped track. A two roller – equalizer set up was chosen to limit the size of the longitudinal guide roller, as well as ensure equal loading to each roller.

During the project study phase, a number of analyses were performed to determine the range of motion of the pylons relative to one another for the various environmental load cases (wind, thermal, differential thermal). These displacements defined the upper limit of the range in which the guides must maintain alignment of the span. In addition, the construction tolerances of the concrete pylons were also discussed in detail with the builder. A specific set of tolerances were defined for the pylon construction to ensure the necessary alignment of the tracks could be achieved.

In order to isolate the guidance system as much as possible from the differential tower movement, the design team determined that transverse guidance of the span could be achieved through the upstream pylons only. The geometry of the pylons includes extensions in the longitudinal direction that support the guide tracks. These extensions act as shear keys and the transverse guide loads are resolved to the pylon through these extensions.

In order to provide on-site adjustability of the guide tracks, the team developed track connection details that permitted adjustment and alignment of the of the track relative to the pylon. The track included cast anchors and grouted pour backs that permitted the installation of the track after the placement of the pylon concrete. In this manner the final geometry of the pylon can be known and the track can be aligned to a best fit for the in place pylon geometry.

Control and Power Distribution Systems
The control system for the bridge is a PLC based system. The control system is utilized to govern the span movement and is used to maintain span level during operation (skew control). Due to the independent drives as well

as the independent counterweights, the risk of potential skew longitudinally as well as transversely was evaluated. In order to monitor the span position, encoders are used at each of the operating drums. These four locations are monitored and compared to one another as well as the other span position data to ensure the four corners of the span are within the acceptable operating parameters.

The bridge is driven by electric motors at each of the operating machinery systems. The system includes four 132 kW motors with each pair configured in and A/B arrangement at each drive system. The ‘A’ motors for each system are the primary motors used for span operation. The ‘B’ motors are considered the back-up motors and are exercised by the control system by being used for each fourth operation.

The motor size was evaluated as part of the span balance study in order to optimize the power input needed for the bridge. The controlling factor in the selection of the motor size was the time of operation. The time of operation from fully seated to fully opened (and vice versa) prescribed by the functional program was 12 minutes. The design time opted for an opening time of 11 minutes. It is customary in the design of movable bridges in the US to select the motor size based on a permissible (instantaneous) overload condition for extreme cases. For a common bridge with an operating time of 60 to 90 seconds, the assumption of overload due to wind or other environmental factors of a few seconds is a reasonable assumption. This assumption was not valid, however, for the Bacalan Bridge due to the time of travel. The span balance investigation and wind study determined that overload was possible for a duration of up to 30 seconds. This duration required the selection of motors with continuous duty rating and overload was not permitted.

As with any movable bridge system design, the machinery systems had to be designed to resist the maximum potential output (stall torque) of the motors. In the case of the selected motors, this equated to approximately two hundred percent of the nominal motor torque. This value was used for the evaluation of the motors for the extreme cases of operation in accordance with the requirements of the FEM.

The bridge is serviced by a single power source from the Bordeaux city side. In lieu of an auxiliary generator, which was precluded by the functional programme, the design team included auxiliary power inputs at each of the pylon bases. In the event of a power failure from the electrical service, truck mounted generators can be connected to the system and transfer switches used to operate the bridge under auxiliary power.

Conclusion

The Pont Bacalan-Bastide is a breath-taking new structure being built in the beautiful city of Bordeaux. The project team sought to conceive a bridge that enhanced the surroundings in both function and form and serves as an additional icon for the historic city. Through the combined efforts of the team members, this goal has been achieved through the design phase and the conception is a testament to the creativity and ingenuity of the designers. This vision is being realized by the constructors as this new landmark is taking shape.

The project is currently in construction and on schedule for completion in end 2012. The detailed design development is in progress as is fabrication of the long lead items. The design-build consortium is in close coordination with one another and advancing the design and construction under the supervision of the owner's team.

The works are progressing in conformity with the schedule previewed, and the three first precast structures have been successfully put in place at mid-June 2010.

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  - EGIS Jean Muller International-Lead Design Consultant
  - Michel Virlogeux-Bridge Designer
  - Charles Lavigne – Bridge Architect
  - Hardesty & Hanover, LLP - Movable Systems Designer
  - Lavigne-Cheron Architects-Bridge Architect