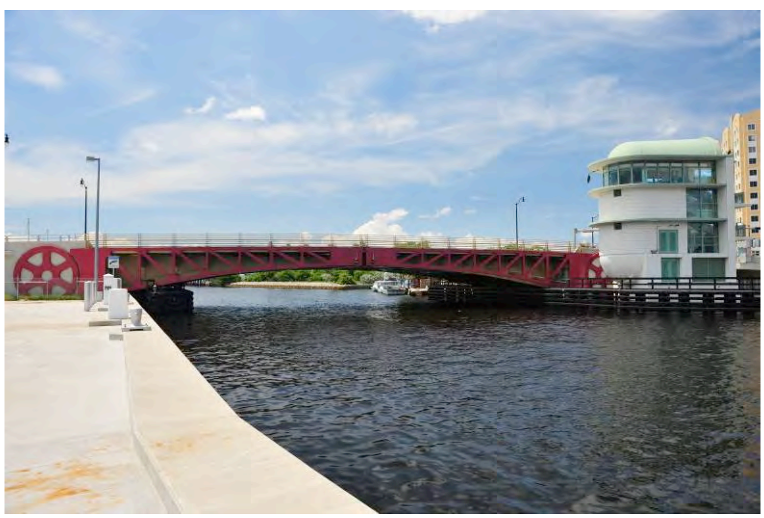
HEAVY MOVABLE STRUCTURES, INC.
THIRTEENTH BIENNIAL SYMPOSIUM

October 25 - 28, 2010

SR-7/NW 5TH Street Bascule Bridge over the Miami River

Integrating Function and Aesthetics on the Miami River



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Introduction

For 80 years, the SR-7/NW 5th Street Bridge over the Miami River (5th Street Bridge) had provided an important link between the communities presently referred to as East Little Havana on the river's south bank and Overtown to the north in downtown Miami, FL while allowing vessel passage for the region's vital cargo ship economy.

Owned by the Florida Department of Transportation (FDOT, District 6), the original bridge consisted of a 134 ft. (100 ft. trunnion to trunnion) bascule span and a 40 ft. south approach span. Following eight decades of service the now demolished 5th St. Bridge bascule span was considered functionally obsolete along with having a substandard navigable channel. Moreover, the leaves of the original bascule span did not clear the channel in the open position. This impediment to navigation through the channel along with difficult steering currents resulted in numerous vessel collisions with the bridge and produced an uneasy passageway for cargo ship vessel captains.

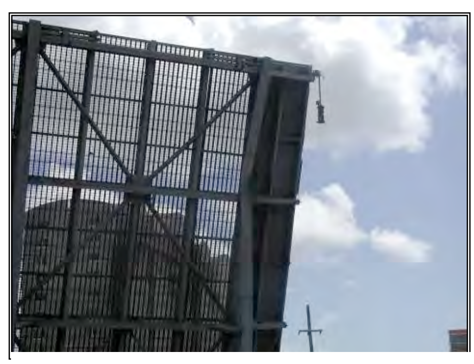
Original 5th St Bridge

There were 17 vessel collisions in the last 35 years of the life of the bridge. These functional deficiencies have prompted the replacement of the 5th St. Bridge with focus on improvements to the bascule span's ability to safely accommodate the Miami River's thriving cargo industry. Concurrently, the City of Miami's plan to revitalize the region evoked community involvement regarding the aesthetics of the new bridge.

Cargo Ship Navigating through Original 5th St Bridge

Two vessel collisions in the summer of 2005 caused serious damage to both the vessels and bridge superstructure. To insure safety to both vehicles and vessels the bridge was locked in the open position such that the leaves did not interfere with vessel passage. The bridge was subsequently demolished.

This impelled the local shipping industry, community groups and the United States Coast Guard to encourage FDOT to expedite the design and construction schedule of the new 5th Street Bridge. Following a fast pace design schedule the new bridge construction was completed in March 2010 and opened to traffic on April 1, 2010.

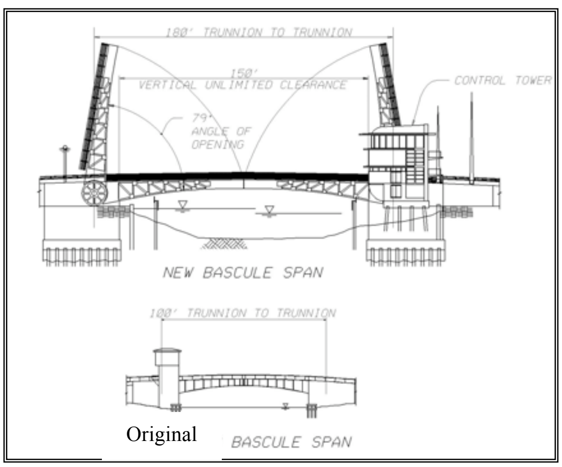


Damage to East Bascule Girder Following 2005 Vessel Collision

Original Bridge in Open Position
Following Collisions of 2005

Demolition of Original Bridge

Significant increase in size is the most salient feature change from the original bridge. The new bascule span cross section is over 20 ft. wider than its predecessor. With an overall length of 240 ft. the new bascule span dwarfs the original by over 100 ft. This increase in span size is necessary in order to increase the channel width from the original substandard 74 ft. to the USCG requirement of 110 ft. with an unlimited vertical clearance.



Balance of each 3,000,000 lb leaf requires a 2,000,000 lb counterweight framed between the two bascule girders. Sufficient depth within the new enclosed bascule pier was provided for the counterweight to rotate downward thus allowing the leaves to rotate and clear the channel. This was provided by a new bascule pier that is significantly larger than its forerunner. Measuring 45 ft. longitudinally and 80 ft. transversely the new 35 ft. deep bascule piers allow the 180 ft. leaves to rotate 79 degrees and clear the 110 ft. channel. This in comparison to the original bascule piers which are 28 ft. long, 62 ft. wide and 15 ft. deep.

This paper and corresponding presentation will explore the impacts to design and construction caused by replacing a modest sized bascule bridge with a much larger structure in an urban area. The architectural and right-of way constraints imposed on the project resulted in design and construction challenges that shaped the key bascule span design features, geometry and construction methods. Some of the associated facets that will be discussed are the following:

- Space saving steel trunnion towers to avoid right-of way impacts
- Architectural fascia truss
- Geometrically efficient steel counterweight
- Maintain pre-existing vertical clearance to mitigate right-of way impacts - floor system framing , half filled deck grating
- Architecturally themed control tower with two levels of bascule pier access bridges
- Riverwalk located beneath approach spans

Assessments carried out during the Project Development and Environmental Study included coordination with the Untied States Coast Guard (USCG), Miami River Commission and local community groups. This corroboration resulted in the recommendation of replacing the existing structure with a new low level double leaf bascule span bridge. During the subsequent design phase our task was to determine the most appropriate type of construction to be used for the bridge replacement. Among the key constraints determined during the PD&E Study was to increase the horizontal clearance. In addition, the bridge replacement project was aesthetically classified during the PD&E Study as "Level Three" (FDOT Plans Preparation Manual, Chapter 3). The aesthetics developed during the PD&E Study and agreed upon by community groups was a trussed bascule span profile with a "spoked wheel" at the center of rotation.

Original Bridge

Spanning over the Miami River in Miami, Florida along the SR-7/US 441 corridor, west of downtown Miami, the original 5th St. Bridge carried three northbound and two southbound vehicular traffic lanes. Pedestrian traffic was accommodated with sidewalks located on each side of the bridge. The structure consists of a double leaf bascule span and an approach span on the south side. Signalized intersections are located at the end of each approach roadway to the bridge.

Classified as a minor urban arterial roadway, the original bridge section consisted of an undivided five lane section comprised of three 9.3 ft. northbound lanes, two 10 ft. southbound lanes and 6 ft. sidewalks on each side of the roadway. The centerline of the bridge was skewed with respect to the Miami River at an angle of approximately 77 degrees.

The bridge was constructed in 1925 and has undergone several rehabilitations, most recently in 1992. Following 80 years of service the bridge had a "functionally obsolete" sufficiency rating (62.7/100). A similar sufficiency rating of 62.8/100 was assigned during the most recent biennial inspection (July 2003. Maintenance logs revealed that the mechanical and electrical systems require frequent repairs.

Vertical and horizontal clearances were substandard with respect to USCG guidelines. The original vertical clearances were 11½ ft. at the centerline of channel and 5.6 ft. at the fenders. USCG guidelines for the Miami River recommend a minimum vertical clearance of 25 ft. at centerline of channel and 21 ft. at the fenders. The original horizontal channel clearance was 74 ft. USCG guidelines for the Miami River recommend a minimum horizontal clearance of 90 ft. The United States Corp of Engineers (USACE) requires a 150 ft. minimum hydraulic channel to allow adequate flow for flood control.

Structure Type

The predecessor bridge was comprised of a 133½ ft. double leaf bascule span with a south approach span. There were unique characteristics of the bascule span. Most notably was the three-girder superstructure system. A rack gear was connected to the center girder. Bridge operation was accomplished by driving the rack through an electro-mechanically driven six stage open gear set. The original electrical system was a stepped resistance control using desk mounted drum switches operating a wound rotor motor. There was also minimal relay based control system. In 1992, the electric motor driven gear train operating system was replaced with two hydraulic/planetary gearmotors directly driving each of the central racks.

Open Gear Set Similar to Original 5th St Bridge

Hydraulic Motor Drive on Original 5th Bridge

There are eleven movable bridges (all bascule type) over the Miami River between Biscayne Bay and the Miami International Airport. It is noteworthy that six of the eleven movable bridges were originally three girder system bridges designed and constructed around the same time (1925) by Howard Harrington & Ash, predecessor to HNTB.

The floor system consisted of rolled wide flange floorbeams and stringer sections supporting a 5 in. open steel grating over the waterway and concrete slab over the bascule piers. Each girder was fixed to a simply supported trunnion, each rotating in trunnion bearings supported on a pair of parallel longitudinal steel plate trunnion girders supported at each end of the bascule pier.

The bascule pier was a closed pit type consisting of reinforced concrete walls supported by cast-in-place concrete footings founded on timber piles. Flanked on the south side by steel beams supporting a cast-in-place concrete deck the original approach span was 40 ft long. The deck over the counterweight on each side of the movable span consisted of a cast-in-place concrete deck supported by stringers spanning transversely from the trunnion girders.

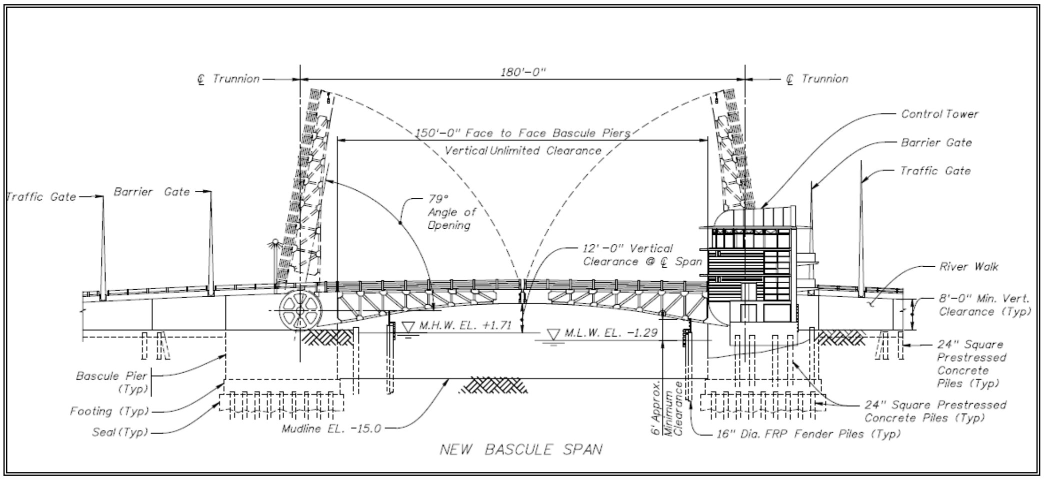
Rehabilitation History

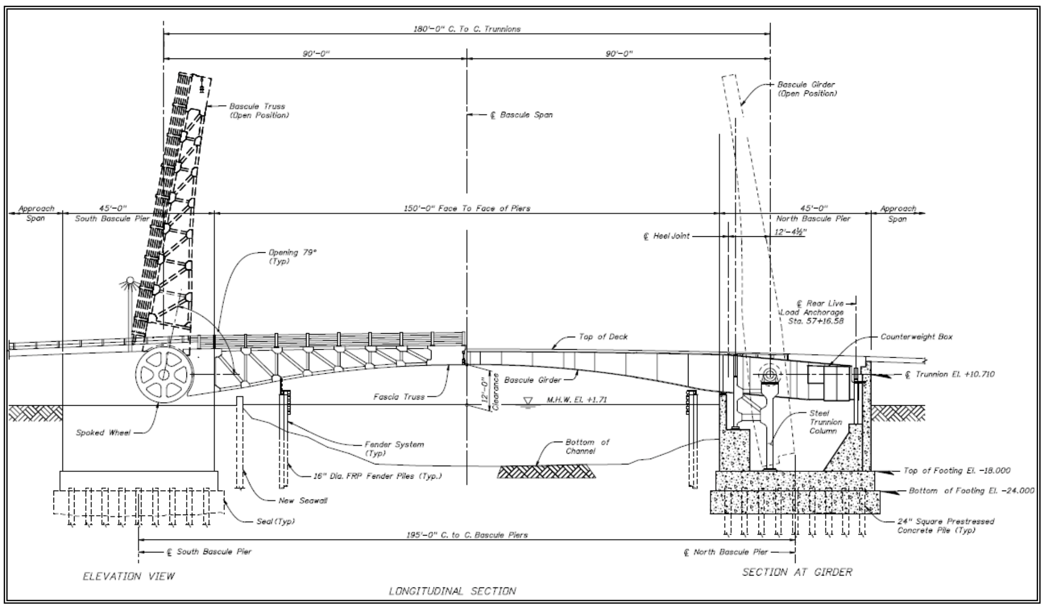
The original bridge has undergone several rehabilitations during its 80-year history, most significantly and recent occurring in 1992. In addition, to the operating system replacement discussed above, the electrical system was replaced with a new relay based control system. Speed control of the hydraulic motors was accomplished with position feedback to the amplifier cards with proportional control valves in the hydraulic circuitry. New warning gates were also installed in 1992. A new control house was constructed on the south bascule pier, replacing the original control house on the north bascule pier. The northeast bascule girder was also repaired due to a collision with a navigable vessel during the 1992 rehabilitation. In 2001, repair of the northeast bascule girder and pier wall was required again due to an errant vessel colliding with the bridge. The bridge was closed to vehicular traffic for 180 days due to the damage and necessary repairs.

New Bridge Design

Analysis carried out during the PD&E Study resulted in the recommendation of replacing the existing structure with a new double leaf bascule span bridge. The purpose of our preliminary design was to determine the optimal geometry and design features for the replacement of 5th Street Bascule Span Bridge over the Miami River. Design constraints developed during the PD&E Study in working with the FDOT, USCG, Miami River Commission and local community groups were as follows:

- Bridge Replacement using a low level double leaf bascule span bridge.
- Horizontal alignment: 77-degree crossing skew relative to the channel.
- Vertical alignment: 12 ft. clearance at centerline of channel with 30 mph design speed and 5% approach roadway grades.
- Typical Bridge Section: divided five lane section with three 11 ft. northbound lanes, two 11 ft. southbound lanes, a 8 ft. sidewalk on the east side and a 8 ft. sidewalk on the west side.
- Horizontal clearance: 150 ft with a 210 ft. total hydraulic channel and a minimum 110 ft. navigable channel.
- Bascule span superstructure types: Must have steel truss profile with "spoked wheel at center of rotation (on the bascule pier).
- Approach span superstructure: pre-stressed concrete girder (AASHTO Type II).
- Maintain the aesthetics and vertical profile of the bridge developed during the PD&E Study.
- Adherence to Right-of Way obtained for new bridge - both longitudinal and transverse





While the design vertical clearance is an improvement over the existing vertical clearance it remains below the recommended USCG guidelines. In order to accommodate a low-level bascule span bridge in this location while maintaining appropriate grades and design speeds, a compromise between the USCG and FDOT was reached in regard to the minimum vertical clearance required by the USCG.

Alignment

The centerline of the proposed bridge is at a bearing of N48°42’03”E. At the north approach there is a point curvature at Station 57+01.97 with a 150 ft. radius curve.

Crossing Alignment

The construction baseline of the new bridge is a skewed alignment, almost parallel to the existing alignment at approximately 77 degrees with respect to the centerline of the Miami River.

Vertical Profile

The following vertical profile design criteria were developed during the PD&E Study and were verified during our preliminary design:

Design Speed: 30 MPH
Stopping Sight Distance: 200 ft.
Approach Grade: 5% with a 310 ft. crest curve.
Vertical Clearance: 12 ft. at Mean High Water (M.H.W.) centerline of channel.

Horizontal Clearance

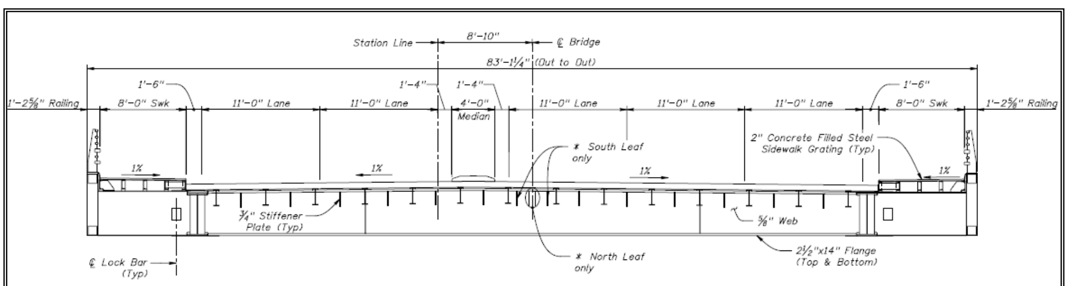
Horizontal Clearance: 150 ft. between bascule piers providing a 110 ft. clearance between fenders for the navigable channel as per the USCG. A 210 ft. hydraulic channel for flood control was provided (30 ft. on either side beneath the approach spans) as per an agreement during the PD&E Study with the USACE.

ADA Requirement

The 5% maximum approach roadway grade proposed is within the permissible grade for sidewalks, according to the Americans with Disabilities Act (ADA).

Typical Section

The typical roadway section of the undivided new bascule span consists of three 11 ft northbound lanes and two 11 ft southbound lanes with 8 ft wide sidewalks on both sides and a 4 ft median. A modified Wyoming TL-4 crash tested bridge railing is located on the outboard side of the sidewalks. Note that the sidewalks transition to 6 ft - 6 in at the bascule piers.



BASCULE SPAN TYPICAL SECTION AT END FLOORBEAM

Navigable Channel

As per the agreement between the USCG and FDOT, the bridge provides a horizontal clearance of 110 ft. between fenders and 150 ft. between bascule piers. With the 77 degree skew with respect to the Miami River, the effective channel is 125 ft.-4 in.

Ship Impact Analysis

FDOT's Vessel Impact Risk Analysis Mathcad program was used to perform the vessel impact analysis. The program uses AASHTO LRFD Method II to calculate the AFC (Annual Frequency of Collapse). This is a statistical method, which determines the time period that has a collapse incidence greater than one. For non-critical bridges, the minimum time period is 1000 years. The required pier capacity to obtain the necessary time period is 5600 kips/pier. This load is used in the Extreme Event II LRFD Load Combination.

Design Criteria
The bridge design meets the latest editions and interims of the following criteria:

- AASHTO LRFD Bridge Design Specifications, Third Edition, 2004
- AASHTO LRFD Movable Bridge Design Specifications, First Edition, 2000
- FDOT Plans Preparation Manual
- FDOT's Structures Design Guidelines for Load and Resistance Factor Design
- FDOT's Standard Specifications for Road and Bridge Construction

Loading
HL93 Live Loading per AASHTO LRFD Bridge Design Specifications and for Florida Department of Transpiration Specified Special Design Vehicles (Strength Design II Limit State).

Environmental Classifications:
Miami River:
Substructure – Extremely Aggressive
Superstructure – Extremely Aggressive

Embankment Soil:
Substructure – Moderately Aggressive
Superstructure – Extremely Aggressive

Site Overlay Rendering of Bascule Span Aesthetics Created Prior to Design

Aesthetics
Proposed aesthetic improvements for the entire project area, developed during the PD&E Study, classify this project as "Level Three" (FDOT Plans Preparation Manual, Chapter 26). This overall project classification requires the bridge to comply with "Level Two" requirements; "[c]onsideration….[to provide] structural systems that are inherently more pleasing".

Aesthetic features of the bridge developed during the PD&E Study that was maintained, within the limits of practicality, were the "ratchet" or more aptly named and herein referred to as "spoked wheel" concept at the center of rotation and a trussed bascule span profile.

Overall project design features developed during the PD&E Study affecting the bridge structure was the continuation of the Riverwalk along the north side Miami River and the trussed profile with a central "spoked wheel". The location of the Riverwalk is behind the north bascule pier. The approach span and bascule pier design studies were performed in order to maintain the characteristics of the Riverwalk as developed during the PD&E Study. Therefore, the Riverwalk was included in the design and construction of the new bridge. Provisions for a south Riverwalk were included in the bridge design. In addition, the architectural features of the control house that adhere to regional cultural significances were determined during the PD&E Study.

Superstructure

Approach Spans

During the approach span analysis, two options emerged as the preferred alternatives: AASHTO Type II beams and the flat concrete slab. AASHTO Type II prestressed concrete girders are the less expensive and easier option to install. And construction quality control is also easier to maintain. However, any framing on the north approach would have been cluttered. Flat concrete slabs have the advantage of an additional 2 ft. of clearance over AASHTO Type II beams. Also, flat concrete slabs have a clean look that compliments the aesthetic features. In addition, the flat slab virtually eliminates any possibility of pigeons roosting on the superstructure or substructure. These two factors enhance the Riverwalk experience.

Considering these factors, it was decided, for aesthetic purposes to utilize flat concrete slabs for the approach spans at both approaches. This solution provided all the geometric and aesthetic advantages where they are most critical on the north approach span. At the south approach the flat slab, along with a cast in place fascia beam that matches the north approach, provides symmetry and aesthetics. This was prudent considering there is a future plan for the south Riverwalk to integrate with the bridge in a similar fashion as the Riverwalk on the north side.

Superstructure Movable Span

The design constraints discussed related to improved horizontal clearance directed the design of the movable span to a double leaf bascule bridge with two leaves and a trunnion to trunnion span of 180 ft.

In order to provide the bridge profile aesthetics developed during the PD&E Study a two steel plate girder system with placement of the girders at the curb line. The required look of a trussed profile was provided by outboard trusses placed at the fascia. There were maintenance concerns regarding utilizing trusses as main load carrying member expressed the Florida Department of Transportation (FDOT).

The "spoked wheel" was provided by a separate concrete casting attached to the piers using anchor dowels.

East Profile of New Bridge

As per FDOT's design guidelines the trunnion design of the bascule span consists of simply supported rotating shaft configuration. The trunnion bearings are mounted on inboard and outboard steel trunnion towers. More detail of the trunnion assemblies is given below.

Transversely, Right-of Way limitations for the new bridge were unyielding and essentially at the fascia of the 80 ft wide bascule span. This constraint proved to be crucial in the decision between steel and concrete trunnion columns during the design development. Due to construction tolerance advantage there was a transverse space savings of approximately 6 ft using steel trunnion towers over concrete columns.

Floor System

Optimizing the key variables of a solid deck bascule floor system (FDOT preference), floorbeam spacing, stringer spacing and grating depth in addition to the vertical profile constraint results in the following:

Bridge Roadway Decking: In order to meet navigation clearance requirements the depth of the structure had to be minimized. A 5 in. steel grating half-filled with lightweight concrete plus a 1½ in. monolithic overlay (totaling 6½ in. in depth) was used in lieu of an exodermic type deck. Exodermic type decks are approximately 9½ in. deep compared with 6½ in. for the steel half-filled grating.

The steel grating, half-filled with lightweight concrete, spans between stringers and consists of main bearing bars running transversely to the direction of traffic, cross bars running parallel to traffic and diagonal bracing bars (commonly known as a 4-Way Grating). This grating has proven to be the most durable and cost effective grating in regard to fatigue resistance when a tight stringer spacing (less than 5 ft.) is selected. The steel grating is then filled with lightweight concrete half the depth of the grating (116 pcf density) with a 1½ in. overlay and reinforced with #3 bars spaced at 3¾ in. center to center. Galvanized steel pans are provided in between main grating bars to support the wet concrete. Utilization of this closed decking system as opposed to the standard open grid (no concrete fill) provides protection to the steel superstructure, minimize tire noise output, improve tire traction and still maintain a relatively low self-weight (58 psf). These are important benefits that should not be compromised for only a 10% reduction in applied operating resistances and power requirements by providing an open grating deck system. The bridge deck grating and overfill was sloped to a 1% cross slope from the median down to the curb to facilitate roadway drainage via the approach roadway.

Stringers: Steel wide flanged beams running parallel to traffic support the bridge deck and span between floorbeams. Stringer spacing is a maximum of 5 ft. center to center for northbound and southbound lanes to ensure a durable deck system.

Floorbeams: Steel I-shaped welded plate girders spanning between steel plate girders and spaced at 18 ft.-9 in. center to center serve as the floorbeams. Top flanges of the floorbeams follow the deck 1% slope, thus minimizing coping of the stringers at connection locations.

Lateral Bracing: Steel WT sections running diagonally to the direction of traffic distribute lateral loads to floorbeams and main load carrying members in addition to bracing the floor system in the weak bending axis when the leaf is in the open position. Furthermore, the cross bracing provides the floor system with overall stiffness allowing the span framing to act as one system instead of individual components.

A rear live load anchorage provides to resistance to live load forces in an extreme event. There is also a forward live load bearing located on the main girders that engage strike plates mounted to the front wall of the bascule pier.

Bridge Railings

The bridge railing meets the recommended FDOT minimum TL-4 crash tested loading and as discussed above consists of a Wyoming type TL-4 railing modified for pedestrian use on the bascule span. This railing consists of structural steel tubes and steel plate. Wyoming railing has a clean unobstructed appearance. This maximizes visibility of the waterways for pedestrians. The railings are modified to provide a 4 ft.-6 in.

height to maximize safety for pedestrians. This railing has the added advantage of being light weight in comparison to other crash tested steel railings.

Counterweight

Agreements made during the PD&E Study phase regarding hydraulic channel flow and Right-of Way proved to be an impact on the longitudinal geometry of the bascule span and a challenge for designing the counterweight. The length of the center of trunnion to the toe of each leaf is 90 ft. From the trunnion to the back of the counterweight is 23 ft 9 in. Due to the longitudinal constraints the counterweight is only 12 ft - 3 in long. In order to provide the necessary span balance the 2,000,000 lb counterweight is essentially a steel box with several pockets for adding/removing steel blocks and steel slabs.

Bascule Pier & Substructure

Bascule Piers

It was determined to use closed piers utilizing conventional cast-in-place reinforced concrete construction for the following three reasons:

- Maintain a dry counterweight: Given the mean high water level (+1.71 ft.) and the trunnion elevation (+10.71 ft. approx.) with an open pit the heel of the counterweight will become submerged in the water at the “fully open” position.
- Prevent pedestrians accessing piers from the Riverwalk.
- Closed piers offer better protection and security for the machinery and equipment.

Pier layouts and locations were determined based on navigational channel location and agreements made during the PD&E Study. In order to provide sufficient horizontal clearance during an extreme flood event a 150 ft. hydraulic channel was provided. In addition, there is a plan to continue the Miami River Riverwalk from downtown Miami to 5th Street. Consideration for closed pier alternatives also related to providing the “Level Three” aesthetics for the bascule span “spoked wheel” trussed profile.

Fender System

Fender systems are used for two basic purposes: to provide protection for the pier from vessel collision and/or to provide navigation with protection from collision or guidance through the channel. In order for a fender system to provide sufficient energy absorption to be useful as pier protection, significant space is required between the fender system and the pier. The horizontal clearance restrictions at the site made it unfeasible to provide the required fender structure for pier protection. FDOT current standard fender system design consists of fiberglass reinforced and recycled plastic wales. Their relatively high initial cost is offset by the low long-term maintenance costs.

Control House

During the PD&E Study extensive architectural design of the proposed control house was performed. The community was asked to choose the aesthetic features of the control house. Thus, the architectural design of the control house was determined prior to the design phase.

The location of the control house was determined during the PD&E Study to be detached from the adjacent bascule pier, but have a common foundation with the pier. Location of the control house was determined to be on the northeast side of the bridge to maximize visibility of the river and approach roadways, and minimize ROW takings. A closed circuit television (CCTV) system was implemented to provide redundant observation in addition to the unobstructed view corridors provided by the second story location of the control room.

Foundation

Precast-prestressed concrete piling is the most commonly used bridge foundation type in Florida. Concrete piles range in size from 12 in. x 12 in. to 30 in. x 30 in. Piles sized at 24 in x 24 in along with soil anchors were used resist the large loads of the sheet pile cofferdam system.

Concrete piles are preferred in many cases due to their relatively low cost and ease of installation. Many contractors are familiar with this type of construction and this serves to increase competition and construction efficiency, thus reducing cost. Concrete pile installation potentially involves significant noise and vibration, which can cause damage to adjacent structures and public outcry when construction is near residential or commercial zones. There were no adjacent structures that were affected by the vibrations from pile driving. There was also owner preference (FDOT District 6) for using pre-cast concrete piling over other foundation options.

Mechanical Systems

Trunnion Configuration

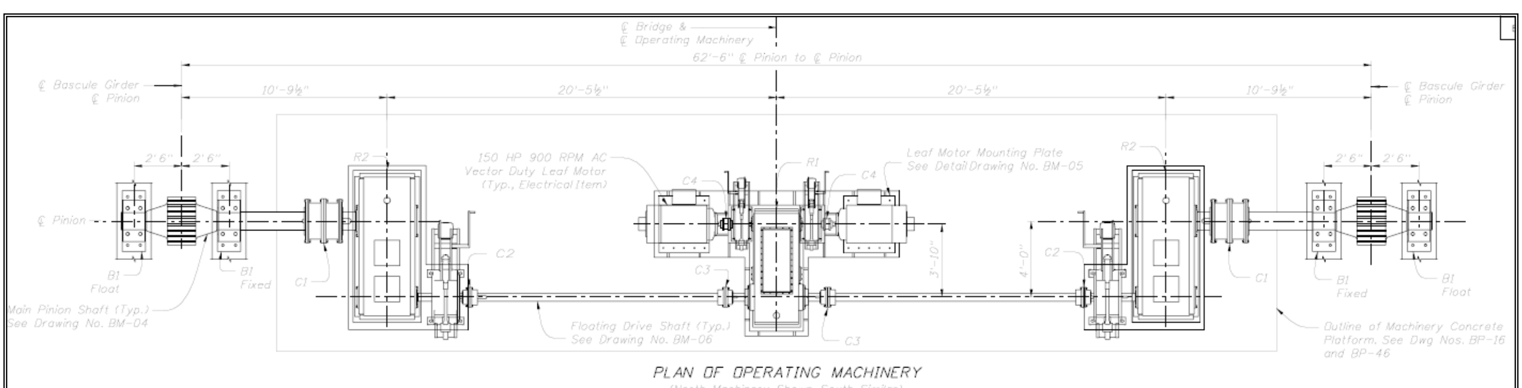
A simply supported trunnion configuration was used to support the bascule span and allow rotation of the two leaves. Each of the four trunnion assemblies consists of the following:

- 8 ft long forged steel trunnion shaft with 27 in journals
- 7 ft diameter carbon steel casting trunnion hub and mating forged steel ring
- (2) carbon steel casting split sleeve bearings with base and cap cast bronze bushings

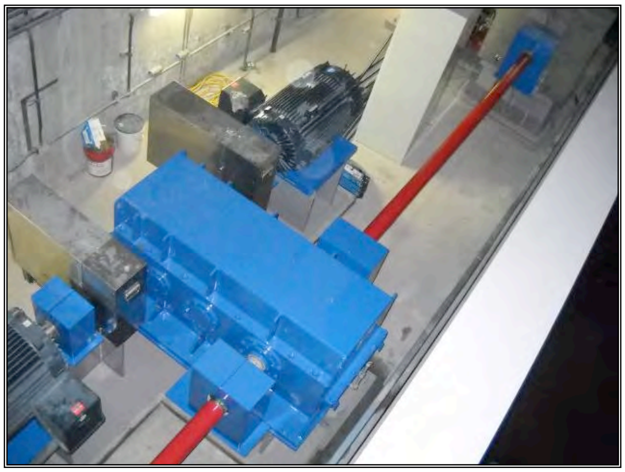
The trunnion bearings are attached to the top plate of the trunnion support columns of the steel trunnion towers.

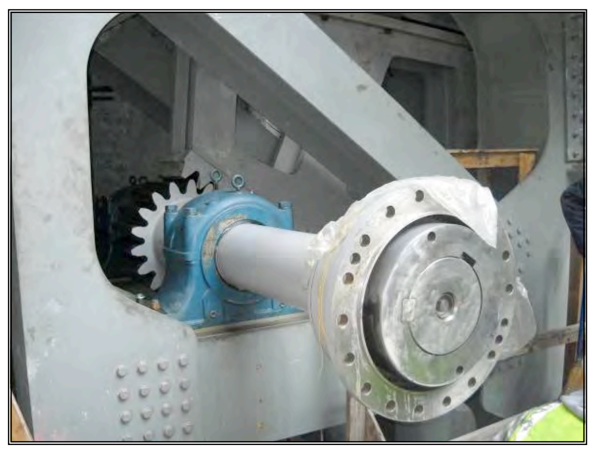
Span Operating Machinery

Owner preference was the predominant factor used to determine the type of operating machinery to be utilized. FDOT prefers a mechanically connected gear train. Two electric motors are provided.



Each motor is attached to the input shafts of a parallel shaft primary differential reducer. One 150 HP AC motor provides the operating power; the other 150 HP motor provides full capacity backup redundant operating power. The output shafts of the primary reducer are coupled to a floating shaft. Each floating shaft is coupled to secondary parallel shaft reducers. The output shaft of the secondary reducers is directly coupled to an integral pinion shaft which is simply supported. Spherical roller bearings support the 11 ½ in (nominal) pinion shaft and are attached to the bottom chord of the trunnion towers. Each pinion engages a rack gear with a 288 in diameter pitch circle. Motor brakes engage the shaft between each motor and primary reducer. Machinery brakes engage the input shafts of the secondary reducers.





Span Center Locks

Span center locks are required to tie the bascule leaves together at mid span to provide live load sharing of the leaves and ensure roadway alignment.

The lock bar was sized for the required shear transfer. Choosing a location for the span lock assembly is dependent on maximization of load transfer, minimization of deflection and out of plane bending of the girder and also maintenance accessibility. These criteria led to the guides and sockets incorporated into the sidewalk brackets outboard of the girders.

Actuation of the lock bars is through a hydraulic cylinder powered by a reversible gear pump and 5 HP 1800 rpm electric motor. Orientation of the lock and actuation is such that the cylinder rod is within the cylinder body when the lock bar is driven (bridge closed to traffic). This provides protection of the cylinder rod. Access for maintenance purposes is hinged hatches in the sidewalk. There are two span lock assemblies; one per girder.

Electrical Systems

Service:

Standard FDOT 480V, 3- phase 4-wire “Wye”. The service is rated at 600 A.

Control System

The bridge control system directs and monitors the operation of the bascule span, span locks, warning gates, barrier gates and traffic signals. Two alternatives considered for the bridge control system were a hard-wired, electro-mechanical relay system and a programmable logic controller (PLC). Relay systems incorporate discrete, electro-mechanical devices such as relays, timers, control switches, etc. and are robust but do not provide advanced functionality. PLCs are microprocessor based control systems and do provide a great deal of useful functionality but can be somewhat less reliable in a movable bridge environment.

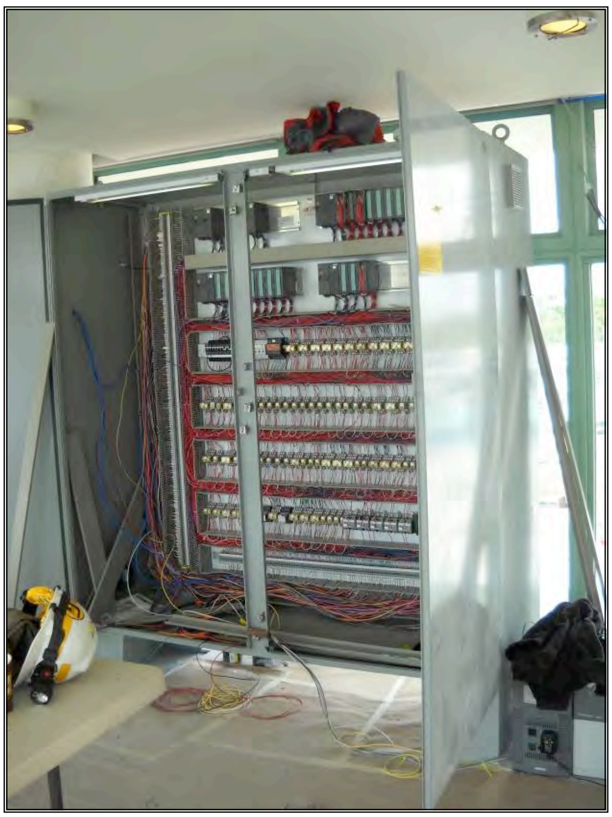
Taking into account the reliability, safety, and maintenance factors, a PLC control system with an independent relay backup was ultimately chosen and is the preferred bridge control system configuration of FDOT D6.

A major component of the bridge electrical system is the submarine cable, which carries power and control cables from the north pier to the south pier. The high energy power cables provide power to the motors. Control cables carry low energy electrical power for various control functions and field devices. The submarine cables are buried on the bottom of the Miami River. Dredge & fill was the method used to install the submarine cable.

Motors and Motor Controllers

Motor controllers suited to provide the precise leaf operating performance using the machinery configurations described above include alternating current silicon controlled rectifiers (AC SCR), regenerative direct current drive (DC drive), and flux vector drives. These drives are only applicable to electric motor driven operating machinery.

The flux vector drive is a state of the art AC VFD motor drive relatively new to the movable bridge industry and was the chosen motor controller for the 5th St Bridge. It offers capabilities similar to the AC SCR and DC drives with the added benefit of precise speed and torque control of a simple squirrel cage motor. A DC drive could have been specified with similar performance characteristics; however the lack of moving electrical connections in a squirrel cage motor greatly simplifies maintenance and can improve life. Operation is provided by one flux vector drive controlling one motor. A backup drive is provided for each leaf.



Backup Generators

The new standard FDOT two-generator system includes one for bridge operation and one for house loads. The larger bridge operation generator is manually started only as needed for span operation to save fuel. The smaller generator provides power to the "always on" loads like air conditioning, lighting, fire alarms, CCTV, and communications.

Traffic Control Equipment

Traffic control equipment provided for the bascule span includes traffic gates, barrier gates, traffic signals and warning ("Drawbridge Ahead") signals. As described above, the sequencing of the traffic control equipment is controlled by the PLC. The relay logic control acts as a fully independent bridge control system, controlling the traffic control equipment in the event the PLC is not functioning. There are four traffic gates, two traffic signals, four barrier gates and two warning signals. Due to the proximity of the north intersection, the traffic signal heads are operated by the bridge control system but are mounted on a mast-arm under the jurisdiction of the local maintaining agency (Miami-Dade County). There is also a preemption system which alerts the north and south intersections that the bridge is opening, causing the traffic signal controllers to direct the traffic appropriately.

Bridge Lighting

Bridge roadway lighting for this project is provided by four Miami Greenway decorative light poles, one located on each corner of the bascule span. The circuitry for the four bridge lights in integral with the bridge electrical system. This allows for the bridge generator to power the lights in the event of loss of electric service. It is important for the roadway and sidewalks to always be properly illuminated to allow the operator to safely open the span.

Project Cost

Construction Bid (Bridge and Control House Only): $44,477,056
Engineer's Estimate: $43, 038,531

Acknowledgements

Owner: Florida Department of Transportation, District Six
Construction Inspection: Pinnacle Consulting Enterprises, Inc.
Contractor: Kiewit Infrastructure South Co.
Steel Fabricator: PDM Bridge, LLC
Machinery Fabricator/Supplier: Steward Machine Co.
Control System Fabricator/Supplier: Electro Hydraulic Machinery Co.
Electricians: Quality Electric, Inc.
Bridge Painting: Gemstone, LLC