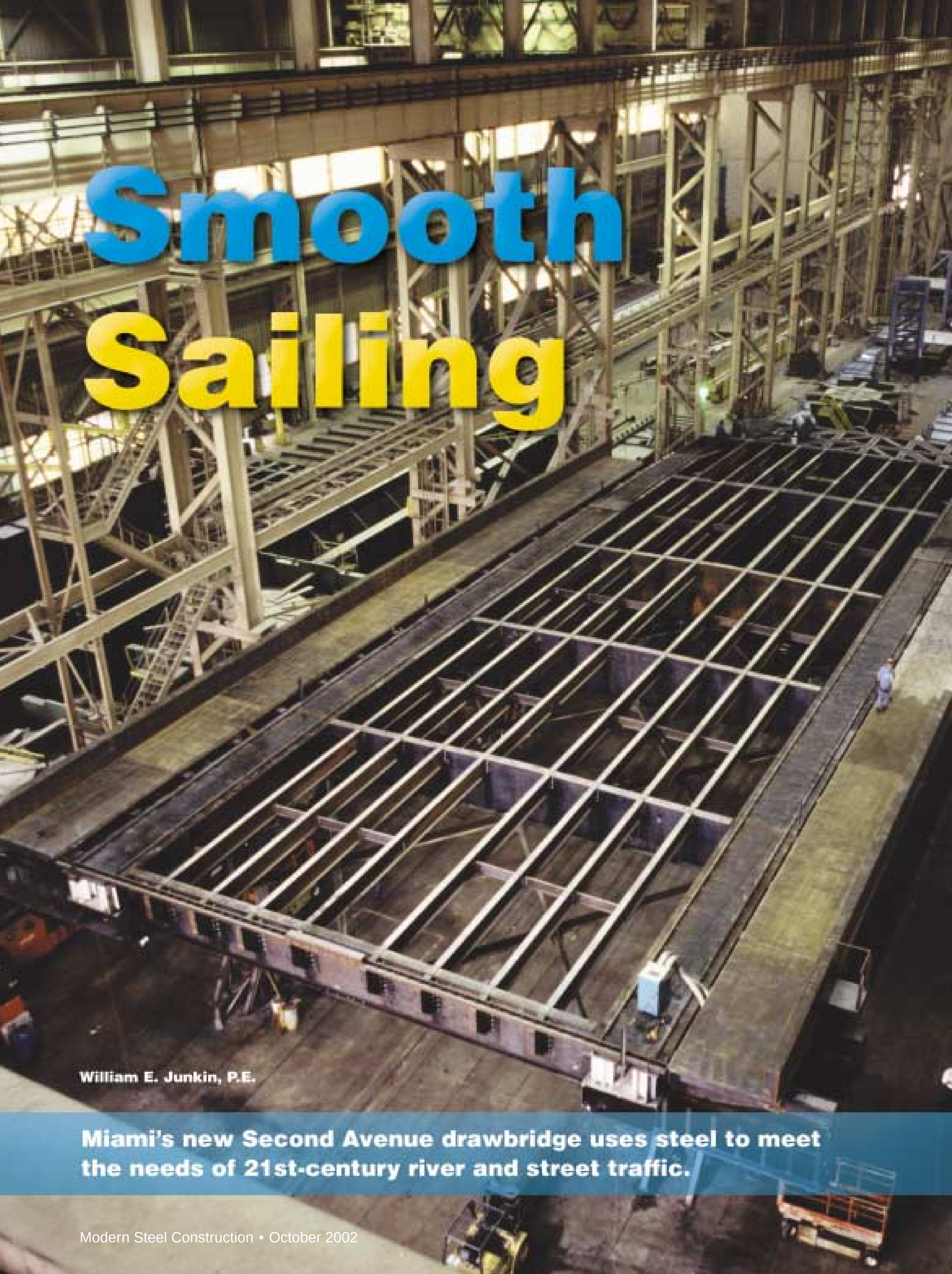
Smooth Sailing



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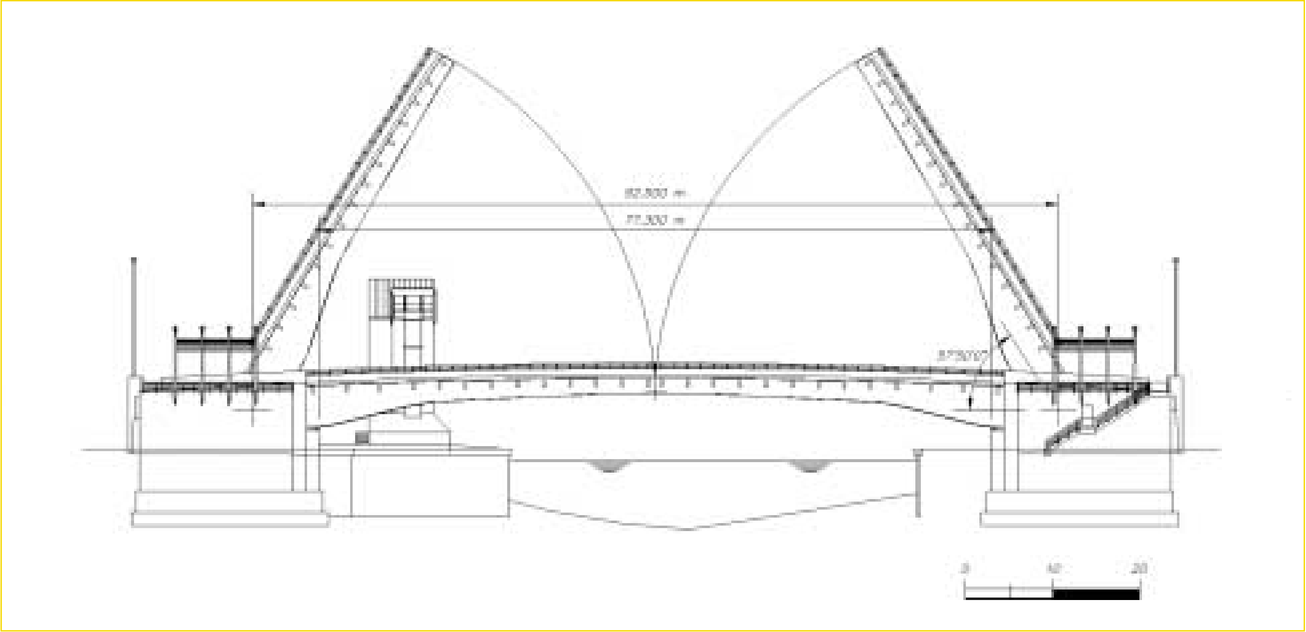
Miami's new Second Avenue drawbridge uses steel to meet the needs of 21st-century river and street traffic.



The New 2nd Avenue Bridge, when completed, will be the longest bascule span bridge in the State of Florida and will contain one of the longest, widest, and heaviest bascule leafs in the world.

Project at-a-glance	
Fabricated Structural Steel:	2300 tons
Counterweight Steel Ballast:	2400 tons
Cost:	$44 million

The Southwest Second Avenue Bridge Project in Miami, FL, is a plan to replace the existing 75-year-old bascule drawbridge with a modern bascule drawbridge to meet the demands of vehicular and marine traffic.

The bridge crosses the Miami River Canal at 2nd Avenue in the central business district of the City of Miami. The Miami River is a navigable shipping channel under the jurisdiction of the U.S. Army Corps of Engineers. The project channel width is 150 feet with a project channel depth of 15 feet. Marine vessels vary in size and type, the largest of which are commercial ships with deadweight tonnage (DWT) on the order of 3,000 tons.

The owner of the 2nd Avenue Bridge is Miami-Dade County, and the Florida Department of Transportation is responsible for overseeing the construction of a new bridge. Federal, state and local funds are involved in both the design and construction, with the construction funds coming primarily from the Federal Off System Bridge Replacement Program

EXISTING BRIDGE

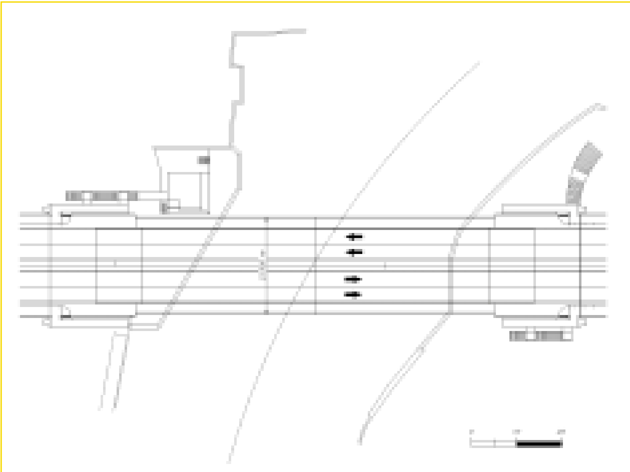
The existing bridge is a double-leaf, bascule bridge carrying two lanes of vehicular traffic with flanking sidewalks. It was slated for replacement because of its poor structural, mechanical and electrical condition in combination with its structural and functional obsolescence. The bridge was constructed in the 1920s, with a clearance above mean high water of 11 feet, and a clear opening between bascule piers of 115 feet, which accommodates a shipping channel width of 75 feet at a skew angle of 40 degrees. However, the crossing is somewhat unique in that it occurs at a location where a P.I. (Point of Intersection) had been introduced into the canal alignment, not only creating a significant skew at the draw, but requiring the need for significant maneuvering by large vessels as they traverse the draw. In addition, the bascule leafs encroach on the vertical envelope of the clear opening at a height below the minimum navigational vertical clearance requirement of 75 feet. Given the combination of the existing bridge configuration, channel alignment, and increase in vessel sizes utilizing the river, the bridge has been struck on numerous occasions resulting in significant damage to the leafs and piers and prolonged closures to the traveling public. The leaf and pier damage also caused extensive misalignment in the machinery components that, for all practical purposes, could not be corrected thus accelerating the deterioration of the bridge mechanical systems.

NEW BRIDGE

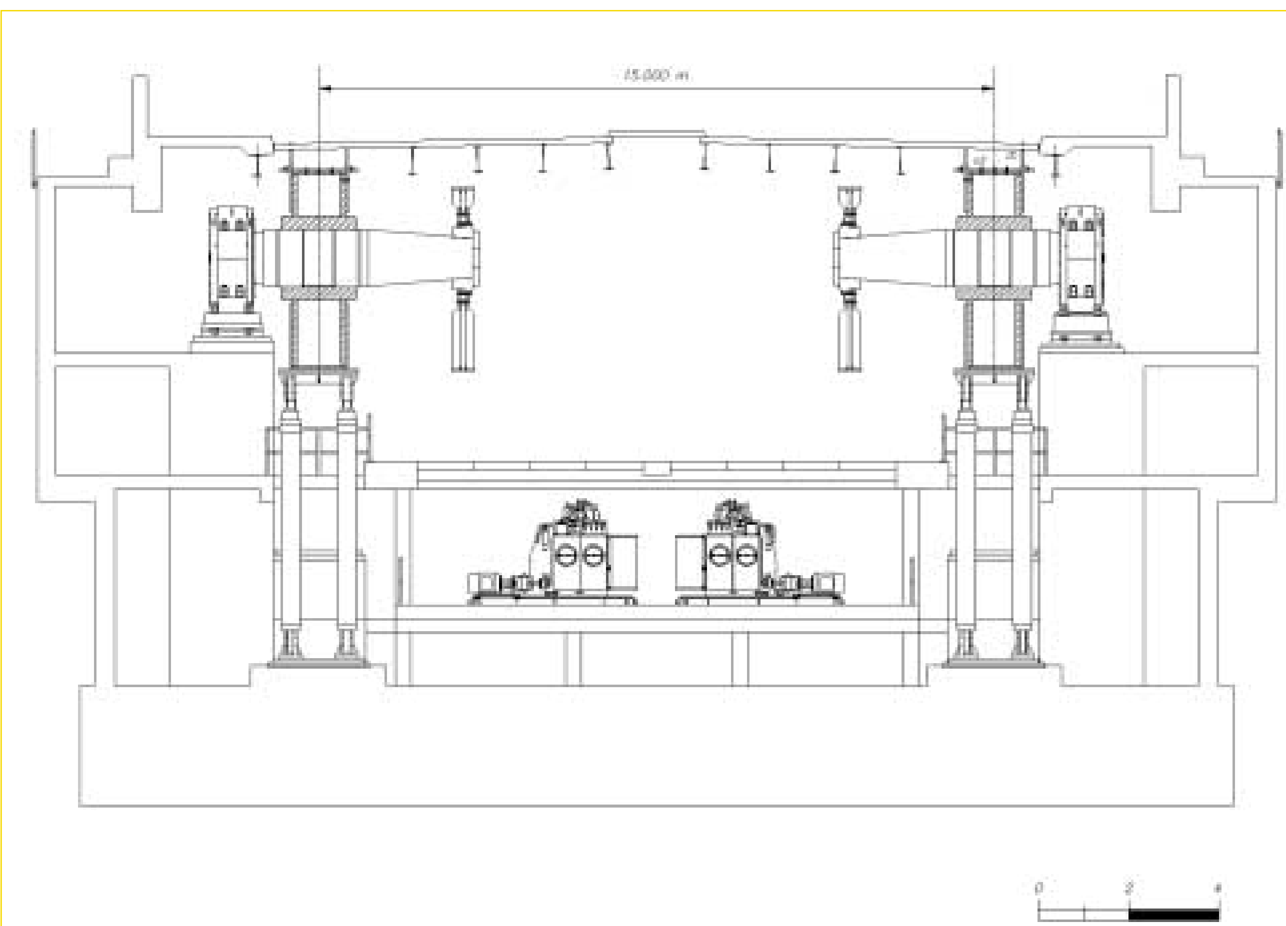
The New 2nd Avenue Bridge will be a significant improvement over the existing bridge and will accommodate four lanes of vehicular traffic with flanking sidewalks. Like the existing bridge, the new bridge is a single span, double leaf bascule bridge, with a nominal width of 72 feet, a distance of 253.6 feet face to face of bascule piers, a distance of 303.5 feet centerline to centerline of trunnions, and a clearance of 25.5 feet above mean high water at centerline of channel.

Due to the alignment orientation, and history of the existing bridge being struck by marine vessels, the consensus at the initiation of the design was to move the bascule piers to a location out of the river and behind the protection of the channel bulkheads. The new design had to incorporate span and leaf geometry, river alignment, existing bulkhead alignments, a planned community riverwalk at the river's edge, and berthing of ships in adjacent properties. As a result, the bascule piers ultimately were placed at the distance of 253.6 feet. With the setback of the piers, the opening angle of the bascule leafs could be reduced from the typical design of 75 degrees of opening rotation to one of 57.5 degrees, while maintaining the 75-foot vertical clearance envelope between face of bulkheads. This reduction in the leaf opening angle permitted a reduction in the sizing of the hydraulic equipment for the bridge, and more importantly, permitted the pile supported foundations to be raised in order to preclude the underwater excavation of a significant rock layer within the confines of the bascule pier cofferdam.

Although not the longest, widest, or heaviest bascule leafs ever constructed, the leafs for the 2nd Avenue Bridge are of significant length, width and weight, and resulted in design considerations not normally encountered in the design of more typical bascule leafs. Structurally, the framing for the leafs consist of two main bascule box girders, with traditional floor beam and stringer-interior framing supporting steel grid flooring half-filled with concrete, and outboard brackets supporting a steel orthotropic sidewalk deck



The plan view shows a unique aspect of the design: in response to the changing character of the river, the bridge is directly linked with the Riverwalk by grand staircases at the bascule piers, a feature seen in many of the great cities of the world.



The bascule leafs rotate about trunnions that are fixed in the leaf structure and supported outboard of the main girders by two spherical roller bearings in sealed housings.

The fabricator elected to machine the completed girder for insertion of the forged trunnion hubs. The web plates are 6” thick.

Using liquid nitrogen as a cooling medium, the 18’-5”, 50-ton trunnion shafts are cooled to approximately -150° F for insertion into the main girder trunnion hubs.

subject to wheel loadings. The maximum depth of the main girders is 15.6 feet, a relatively shallow depth for the length of the leaf. As a result, stiffness, not strength, became the overriding design consideration in the proportioning of these members. The structural support system for the leaf consists of the traditional trunnion, live-load shoe forward of the trunnion, and end lock arrangement. In proportioning the distance from the live-load shoe to the centerline trunnion, 21.7 feet, consideration was given to the magnitude of the reaction at the live-load shoe, and to the location of the hydraulic cylinders (11.5 feet forward of the trunnion). Ample room was provided for machinery decks and maintenance access.

One of the unique aspects of the bascule leaf is that the counterbalancing in the tail or heel of the leaf is, for the most part, provided by steel ballast consisting of steel transition slabs. These slabs, which are housed in tub box girders in the tail of the leaf, are the initial product of the modern steel production process, and weigh on the order of 13 tons each. The basis for utilizing steel as counterweight ballast rather than the more traditional concrete was to avoid the excavation of the rock layer previously noted. The combination of the reduction in leaf-opening angle, the shortening of the tail of the bascule leaf, and the use of steel counterweight ballast made this feasible. Given the length, the type of bridge deck, and the steel counterweight ballast, each bascule leaf when completed will weigh approximately 3,300 tons.

The bascule leaves rotate about trunnions that are fixed in the leaf structure and supported outboard of the main girders by two spherical roller bearings in sealed housings. The nominal diameter of the trunnion shafts is 1,300 mm (51”). The spherical roller bearings are 232 Series bearings with a nominal bore of 1060 mm (42”), and are tapered mount. One bearing is fixed; the other is free to float on a horizontal surface of polytetrafluoroethylene (PTFE) mated to a stainless steel plate, the assembly being external to bearing housing.

The main drive system for the bridge is hydraulic. It consists of four hydraulic cylinders, centralized tandem power units, open loop circuit design and single piece control manifolds, with a system sizing capable of opening and closing the leaf in 65 to 75 seconds.

The control tower for the bridge is free standing, with the control room located three stories above street level. The primary control system for the bridge utilizes a programmable logic controller for maximum safety and reliability, and is backed up by a relay logic-control system in the event of a complete failure of the primary system. In addition to the control room, the control tower houses the motor control center, and a 500 kW standby genera-

Counterbalancing in the heel section of the leaf is provided by steel ballast consisting of steel transition slabs housed in 100-ton tube box girders.

tor set. For emergency operation, each bascule pier is equipped with an independent motor control panel and receptacle for a portable standby generator. Each is capable of starting one power unit motor and one end lock motor in the event that power cables feeding a bascule pier are severed.

SHOP ASSEMBLY REQUIREMENTS

Over the years in Florida, as leafs became longer for double leaf bascule spans, alignment of opposing leafs became a significant issue during field erection. This issue normally presented itself as a "twist" in the end of the leaf, which precluded a satisfactory mating of the leaf ends. In order to improve field erection outcomes, Kunde Sprecher introduced design modifications and implemented provisions into its contract documents in the early 1990s. These contract provisions, new to Florida, required "Complete Structure Assembly" of the bascule leaf in the fabrication shop. These basic modifications and assembly requirements achieved immediate success and have been refined over a series of projects based on knowledge obtained from structural steel fabricators as they moved through their own assembly processes in order to comply with the contract provisions.

Generally, the ability to make and hold trunnion alignment and leaf-end alignment and minimize field reaming are the primary issues associated with the field erection of the leaf. The philosophy of complete shop assembly is to produce an assembled configuration, which is then duplicated in the field by simply reproducing all connection configurations made in the shop. The progression of the shop assembly is key to the success of this philosophy with the requirements generally as follows:

- Assemble main members and bracing in the vicinity of the trunnions utilizing sub-drilled holes and bolting.
- Establish and maintain trunnion alignment throughout assembly.
- Commence drilling/reaming of connections; all holes of all connections are reamed at assembly.
- Progress drilling/reaming, shop bolting and torquing all connections to bring faying surfaces into full contact and to lock in alignment and assembled configurations.
- Progress outward from the trunnion with assembly, drilling/reaming, and bolting of all connections accomplishing complete structure assembly.

For 2nd Avenue, complete structure assembly was defined as the complete shop assembly of all main members, secondary members, gussets, and connections required to assemble these members into one complete assembled unit. Main members include bascule girders, counterweight tub girders, floor beams, stringers, sidewalk brackets, sidewalk deck and barrier assemblies. Secondary members include all cross frames, upper and lower lateral framing, platforms and bracing. The tolerance for trunnion alignment is 0.030 inches positional tolerance.

FABRICATION AND SHOP ASSEMBLY

Fabrication of the bascule leafs commenced in March 2001, at Steward Machine Company (SMC) in Birmingham, AL, with the major portion of the fabrication work concentrating on the main bascule girders. The bascule girders are

186 feet in length with a single field splice located just forward of the live-load shoe. The heel or tail section of the girder is 76.3 feet in length with the toe section 109.7 feet in length. The main bascule girders are conventional, closed-cell vertical web-box girders and are classified as non-redundant, load-path carrying members with flanges classified as fracture critical material (FCM). While the size and weight of the heel section presented unique fabrication and handling problems, the most interesting aspect of this piece involved the area in the vicinity of the trunnion. The fabricator chose to use the contract alternate of 6” web plates in the trunnion area and then machine the completed girder for receipt of the forged trunnion hubs. The fabrication of the main girders, machining for the trunnion hubs, and insertion of the hubs into the main girder heel sections was all completed in the SMC facilities in Birmingham. The trunnion hub outside diameters (ODs) were individually matched machined, with the appropriate interference fit, to the as-built bore of the main girder web plates. Insertion of the hubs was accomplished without incident.

Once the main girder sections were completed with hubs inserted, these piece marks, which weighed approximately 250 tons, were shipped by special transport vehicle to a facility in Cordova, AL, for shop assembly. At this facility, the main girders were positioned for insertion of the trunnion shaft forgings, which weigh about 50 tons each. As with the trunnion hubs, the trunnion shaft ODs were individually match-machined, with the appropriate interference fit to the as-built, as-inserted bore of the trunnion hub, and inserted in all girders without incident. Other piece marks for the leaf were fabricated by SMC and a sub-vendor to SMC, Arkansas Steel Processing, Inc., all of which were delivered to Cordova for shop assembly by SMC.

Lay down and assembly of the south leaf of the bridge commenced with preparatory work in January 2002. This preparatory work involved surveying benchmark and master plate installations, and fabrication of stanchions for trunnion alignment devices and girder supports. Lay down commenced with the main girder heel sections, counterweight tub girders, floor beams and trunnion girders. These components were all independently supported off the shop floor and adjusted as necessary for structural alignment. Trunnion alignment was established, and selective drilling / reaming was accomplished in order to lock in the alignment.

Concurrent with the work in the heel section of the leaf, the toe girders were independently supported into the cambered position and initially free of the heel section. These toe girder sections were then adjusted into the position most favorable for the field splice while maintaining the necessary alignment at the end of the leaf. At this time, the toe girder was locked to the heel section with drilling / reaming of selected holes at the field splices. floor beams, bracing and stringers were likewise assembled into the toe section with selective drilling / reaming.

Once all members required for complete structure assembly were in place, with the exception of some select tub girder upper and lower connection plates, general drilling / reaming of the entire leaf assembly was commenced. As the work progressed, trunnion and leaf alignments were continuously monitored for movement. General

The progression of the shop assembly is key to the success of producing an assembled configuration, which can then be duplicated in the field by simply reproducing all connection configurations made in the shop.

The size and weight of the heel section presented unique fabrication and handling problems. With trunnion hub and trunnion shaft the heel section weighs in at over 300 tons.

Complete structure assembly was defined as the complete shop assembly of all main members, secondary members, gussets, and connections required to assemble these members into one complete assembled unit. After complete structure assembly extensive as-assembled measurements and match marking was conducted by the fabricator prior to tear down and movement of pieces for post-assembly repairs and painting.

drilling/reaming and the complete structure assembly was finished in mid-May 2002, at which time extensive as-assembled measurements and match marking was conducted by the fabricator. Upon completion of the measurements, assembly, and alignment verification, tear down was commenced and pieces were moved for post-assembly repairs and painting.

FABRICATION AND ERECTION STATUS

In June 2002, painting of the main girders for the south leaf was complete and the girders were loaded for shipment by barge to Miami for scheduled erection in July 2002. Securing of steel ballast for the counterweights was nearing completion and being prepped for shipment. Lay down of the north leaf had commenced and is scheduled for shipment in the fall of 2002. Completion of the project is scheduled for fall 2003.

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Steward Machine Company, Birmingham, AL (AISC member)

DETAILER
Tensor Engineering Co., Indian Harbor Beach, FL (AISC and NISD member)