HEAVY MOVABLE STRUCTURES, INC.

NINTH BIENNIAL SYMPOSIUM
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COST CONTROL ON BASCULE BRIDGE CONSTRUCTION; A PARTNERING APPROACH

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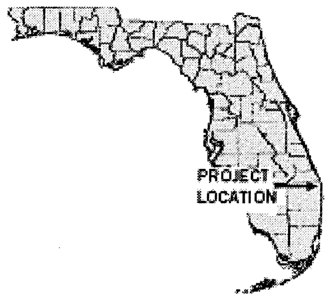
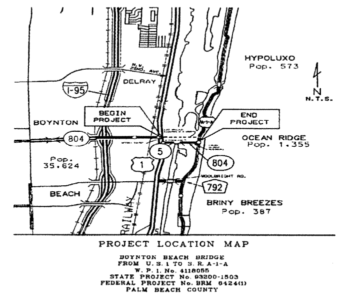
Background and History

Project Location:

The Boynton Beach/Ocean Avenue Bridge spans over the Intracoastal Waterway (ICWW) in Palm Beach County, Florida. The bridge connects the City of Boynton Beach and the Town of Ocean Ridge where the alignment ends at a T- intersection with SR A1A.





The replacement of this bridge had been a priority project for District 4 of the Florida Department of Transportation (FDOT) for 25 years prior to final design. The existing bridge which was constructed in 1936 was 121 feet long and 31 feet wide carried two (2) narrow lanes of traffic with sidewalks on both sides. The bridge was a double leaf steel rolling lift bridge fabricated by Scherzer Bridge Company. It provided 90 feet of horizontal clearance between the fender system and 10 feet

Existing South Elevation

of vertical clearance with the bridge in the closed position. The structural inventory appraisal classified the bridge as functionally obsolete. By the time the final design started, the bridge underwent several structural repairs and required continual monthly maintenance due to the severe deterioration. The structure was posted for 15 tons.

The initial Project Development and Environmental (PD&E) process began in 1970. A northern alignment, which would have been an extension of Boynton Beach Boulevard, had already progresses to the Right of Way acquisition phase when a property owner who would have been impacted by the acquisition filed a law suite. The owner alleged that the Department did not follow the required project development process. The suite went to arbitration. The ruling was in favor of the owner. The outcome of the arbitration caused the Department to put the project on hold for several years. During the Departments next attempt at the PDE study, the process followed the Federal Highway requirements exactly.

Two major alignments were studied in detail. The first, a logical northern alignment was the continuation of the existing Boynton Beach Boulevard, a direct connection between the Coast and the Turnpike, with direct access to I-95, the major North-South expressway through the State.

The second alignment was the existing or south alignment approximately 650 feet south of the north alignment. It was an indirect route to the Turnpike and to I-95 which are on the west end of Boynton Beach Boulevard.

Either alignment would replace the existing bridge with a two-lane bascule bridge with 21 feet minimum vertical clearance, bicycle lanes and sidewalks.

Opposition to both alignments was strong from the local community. In addition to the Community's opposition, the Environmental Agencies were strongly opposed to the north alignment where unspoiled land covered with high quality wetlands and protected vegetation such as mangrove forests and sea grass beds had to be crossed to connect to A1A.

The Department's efforts to resolve all the issues were time consuming and tedious. Finally, in 1983 the FDOT began the submittal process of a conceptual permit application for the northern alignment. After several requests from the Department of Environmental Protection (DEP) for additional information, sighting environmental impact as the reason, the permit was rejected in September 1994, leaving the south alignment as the only option.

Once the existing alignment was selected a community involvement program was implemented to gain public support.

Commitments to the Public:

Commitments were made to the community as follows:

1. Close coordination with the Coast Guard during construction to minimize impact to the navigational traffic.

2. An aesthetically pleasing bridge design.

3. Solid concrete deck, instead of the open steel deck to reduce noise.

4. Defined protective measures to manatees and sea turtles during construction.

The community involvement task team was carried throughout the design and construction phase of the project.

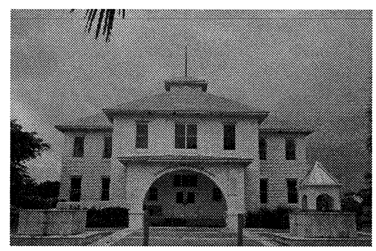
Design Highlights

The following are the highlighted elements of the design of the Boynton Beach Bridge:

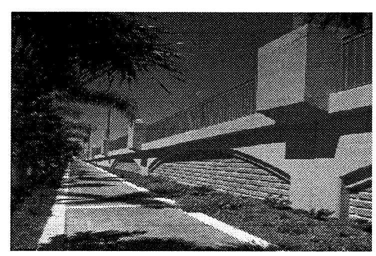
- Arch Features of the Structure
- Thru-Girder/Handicap Access
- Approach Spans/Inverted T-Beams
- Foundation Issues
- Counterweight Pit

Arch Features of the Structure

The task force formed by the Department during the preliminary design phase included the design team, the Department and residents of the City of Boynton Beach and the Town of Ocean Ridge. During the preliminary design phase, which included several meetings with the task force, it was clear that the City of Boynton Beach wanted the new bridge tied in with the current downtown revitalization. The Department wanted both communities input into the final bridge because it was such an important feature for the area. The historic 1913 elementary school just west of the bridge along Ocean Avenue was recently rehabilitated into a children's museum with decorative light fixtures, a new gazebo with an arched trellis artwork, and restoration of the stone finish wall surfaces, including an arched entrance way. In addition to this, there was a new marina proposed on a site just north of the bridge within Boynton Beach, which would enhance the view along the (ICWW). The architect who was working for the City on all these changes was also part of the design team. Based on the above information, the designer proposed several additional architectural features that would not normally be incorporated into a standard FDOT project.



Children's Museum



Arched Feature of Structure

Gazebo at the Children's Museum

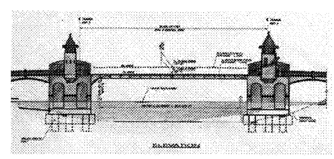
To tie in with the rehabilitation of the historic school west of the bridge, the following features were proposed:

1. Approach roadway walls with a similar stone finish surface, with the top of the walls having arches.
2. Circular column bridge towers with a custom arched trellis supported by square columns at both bascule piers.
3. Bridge paint and coatings with similar colors.
4. Light fixtures to match fixtures used at the historic school and on the improvement project along Ocean Avenue just west of the project.

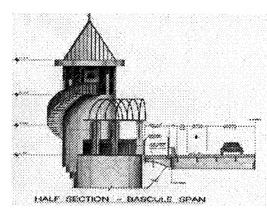
Thru-Girder/ Handicap Access

The PD&E proposed a new bascule bridge over the ICWW that would provide a 90 ft. horizontal clearance between the fender system and 21 ft. vertical clearance with the leaf in the closed position. Based on these criteria, the PD&E had a 6% profile for the approach roadway and the height of the bridge at the centerline of channel was approximately 33 feet above water. The City of Boynton Beach and Town of Ocean Ridge were not pleased with the overall height of structure and the size of the new bridge. They felt that the new bridge would impede their current view of the ICWW. In addition to this, the 6% approach slope exceeded ADA requirements. This meant that the approaches to the bridge for pedestrians would have to be specially designed to accommodate this slope. This would include longer approach sidewalks with several landings due to rest area requirements.

The design team proposed a thru-girder design for the main bascule span over the ICWW. This design allowed us to lower the proposed roadway approximately 6'-0", while still maintaining the clearance requirements. This reduction in height provided a 5% approach slope, which met ADA requirements, and reduced the overall height of the structure. No special design was necessary for the approach sidewalks, which reduced the cost of design and overall construction costs. In addition to this, the depth of the bascule superstructure was very slender compared to the typical bascule leaves in south Florida. This satisfied the City of Boynton Beach and the Town of Ocean Ridge because it enhanced their view of the ICWW and reduced the height of the overall structure. The architect proposed aluminum plates to be installed along the fascia line of the main girders to give an arched look to the main span and further tie the bridge to the downtown revitalization.



Profile Comparison – PD&E versus Final Design

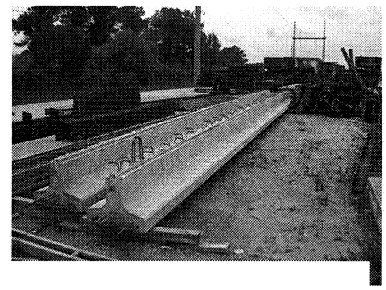


Half Section showing Thru-Girder & Tender's House

Approach Spans/Inverted Tee Beams

The City of Boynton Beach wanted a promenade along the west side of the ICWW as part of the downtown revitalization. Several issues had to be addressed to accomplish this; including safety concerns for the public, keeping the aesthetics of the underside of the deck pleasing and providing public access where previously there was none. They did not like the look of concrete AASHTO beams or rolled steel beam spans, preferring instead a flat concrete surface on the underside.

The design team considered several different support systems for the approach spans, with concrete box beams being the only one that satisfied the City concerns. However, the Department did not have great success with the performance of adjacent concrete box girders due to the differential movement typically associated with that type of construction. The FDOT Structures Design Office in Tallahassee suggested the use of a new inverted Tee beam that was being developed by the University of Nebraska. The Inverted Tee Beam is very good for short to medium span bridges and is lightweight. This meant that smaller construction equipment could be used to lift the beams into position and a smaller construction work zone, which existed at the site, would not be an issue. The design team contacted the University of Nebraska and reviewed the details of the proposed beam. Based on the span length of the approaches, construction staging area and desired look for the span underside, this beam satisfied most of the City's concerns. The design team proposed an arched fascia beam along both sides to tie the approaches and main span together architecturally. The Inverted Tee Beams cost more to fabricate than the standard concrete boxes or AASHTO beams because there were no form liners to fabricate these beams. However, the FDOT decided that the Inverted Tee Beam could be a new standard beam and utilized for short and medium span bridges in the future. In February 2000, Engineering News Record (ENR) magazine voted the use of the Inverted Tee Beam one of the top 25 newsmakers for 1999.



Inverted Tee Beams used for Approach Spans Superstructure

The intermediate pier was also arched in a similar fashion. A promenade along the north and south side of the west approach walls was provided for pedestrians, with benches along the ICWW under the bridge approaches. The area was fully landscaped and fully illuminated with lights. Also included wan an additional access point off the north side of the bridge at Bent 2 by designing a spiral staircase down to the promenade.

Northwest Promenade

Foundation Issues

The foundation design was a challenge for the design team. Based on the existing and new borings taken, the soil strata included a deep layer of muck, which increased in depth closer to the ICWW. Therefore, supporting the approaches and the bascule leaf would require some deep foundations. Several different alternatives for the approaches were considered, including piles, a matted foundation, and a cellwall structure and surcharging the approaches with MSE wall approaches. Based on several discussions between the geo-technical experts of the FDOT and the design team, the decision was made to proceed with a surcharge program designed to remove most of the primary settlement, followed by a two- phase wall construction to prevent the exterior wall panels from settling during secondary settlement. The roadway had to be supported on a geo-textile fabric because of these poor sub-base conditions.

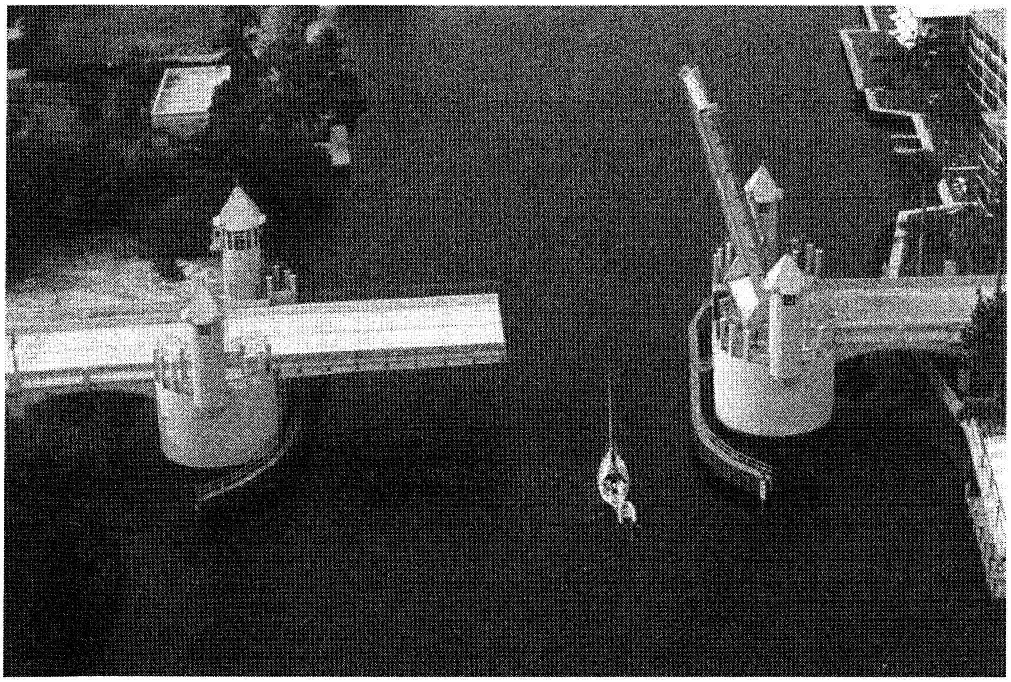
The approach piers and bascule piers were supported on drilled shafts. The bascule piers had ten 75 foot deep six foot diameter drilled shafts with rock sockets. The approach piers had four feet diameter drilled shafts at shallower depths.

Counterweight Pit

The preliminary design for the main span was for a 90 foot clear span between the fender system with a 21 foot minimum vertical clearance in the closed position. All preliminary engineering was complete and the design team was in the process of doing final design plans when the horizontal clearance between fender systems was changed from 90 ft. to 125 ft. This change drastically affected the layout of the structure and design calculations because the bascule piers were set in size and proportion to match the towers. Increasing the pier sizes would affect the aesthetics of the structure and constrict the overall channel cross section.

To accommodate the increased span length, trying to minimize the increased length of the counterweight to minimize the increase in bascule pier size. Several alternatives were evaluated to compensate for the additional mass of each leaf, including all steel counterweights, steel framing with dense concrete counterweights and steel framing with normal weight concrete counterweights.

The Department did not like an all steel counterweight, and the dense concrete option created a mix design problem because of the aggregate needed. The third alternate, a mixture of normal weight concrete with steel plates, was chosen. Six inch thick plates for the counterweight girder flanges and webs work now, and also for the stiffeners between the girders. Fifteen percent (15%) of the pockets were left unfilled to accommodate for balance adjustments. The counterweight opened into a dry pit that will flood for extreme flood events. The backwall is set at just above the 10-year flood elevation. The pit was fitted with 2 large pumps that are capable of removing the floodwater within one hour after the water level falls below this backwall elevation.



The completed bridge opening a single leaf during functional testing.

Construction & Partnering

The Partnering Process

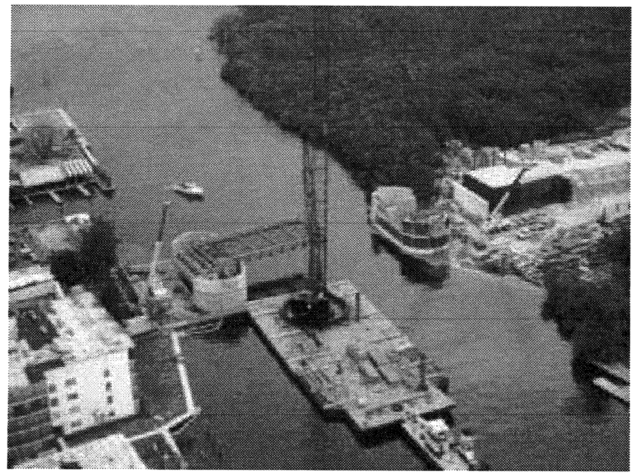
The success of the Boynton Beach project can be attributed to the partnering effort of the FDOT, District Four Construction, Lichtenstein Consulting Engineers (EOR), Archer-Western Contractors, and the URS Construction Services (CEI) team members.

The project was initially scheduled to begin in December of 1997, but the project team decided that starting major construction before the holidays would be detrimental to the local businesses. A meeting was held with the Contractor and it was agreed to by all parties to change the starting date to January of 1998. The extra month allowed the Contractor and CEI to advance their pre-construction planning efforts. The first step in a successful project is the pre-construction planning efforts.

Constructing a scale model of the bascule pier became the first task for the CEI personnel. This exercise helped the inspectors to foresee the intricate details of the piers, understand the elevation changes, and provided an early start to resolving some of the difficulties of the plan. It also helped to finalize the location of the utilities in the control tower and was used as a visual aid at many of the pre-work meetings to help clarify points of discussion.

Often one of the major issues in bascule bridge construction is the review time of the shop drawings. The first round of submittals often gets rejected because the EOR and the Contractor's supplier are not thinking in like terms. The EOR expects that shop drawings should be complete and so detailed that his review time will be very minimal. On the other hand, the suppliers think that contract drawings are adequate and shop drawings should only provide necessary basic information. Recognizing this industry wide problem, the CEI chose to have a pre-submittal meeting for every major discipline of the bascule construction. These meetings helped to establish common grounds for the shop drawing review process. Each person in the process had met and talked to each of the others involved. This helped phone calls replace letters and accelerated the approval process.

Pre-work Meeting and Partnering



Erection of the west bascule leaf.

Another useful item in keeping the project on schedule was the use of pre-work meetings before any major work activity. The purpose of the pre-work meeting was two fold. It prompted the CEI to thoroughly review the plans and TSPs and set a reasonable set of expectations for the Contractor. For the Contractor, the meeting provided an opportunity to meet with the field inspector and learn about the frequency of the testing and sampling. In all, the project team held 22 separate pre-work meetings. At each of these meetings the CEI team, Contractor and Designer would meet to discuss the best work methods. As a result of these meetings the retaining walls were changed from cast-in-place concrete to pre-cast concrete. This took the retaining walls off of the critical path and help aid in the quality of the final product. Additional layout marks were added to the bascule girders to ensure accurate alignment of the bridge structure during erection. The shop alignment was documented and recorded with layout marks that would be easily surveyed after erection began. The details associated for pre-casting the dummy towers were also improved at one of the meetings. A detail for erection alignment was added to help simplify the erection and add to the appearance of the towers. While many Contractors' feel that these meetings are an intrusion into their ability to plan and execute the work, the partnering process and team spirit was such that the Contractor was a willing participant. The role of the CEI is to help the Contractor provide the Owner, with a successful project. When this commitment to a partnering process remains the focus of the project team many of the hurdles to success are avoided.

Problems Solved During Construction through Partnering

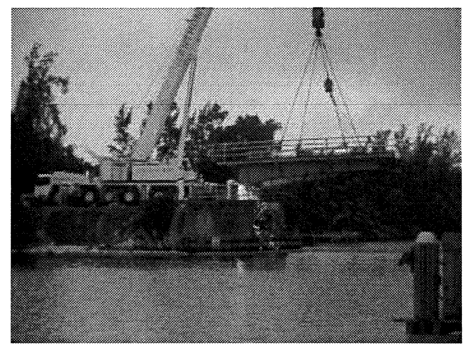
The partnering process was employed throughout the project and contributed greatly to the overall success. Meetings were held at the beginning of the project and again during the course of the project whenever an issue or problem needed the attention of the project team. During the first meeting specific levels of conflict resolution were agreed to and the entire team made specific commitments to help save time throughout the project.

An issue that was dealt with successfully through the partnering process was the project schedule near the end of the project. A Primavera scheduling expert was brought in to facilitate the meeting. Only people with a direct involvement in the project were invited and the entire focus of this meeting was how to accelerate the completion of the project. The group looked at concurrent work sites focusing on the critical path activities needing completion before the bridge could be safely opened to the public. The original baseline schedule was used as a basis and modifications to the schedule were made at the meeting so the group would immediately see the results. At the end of the meeting the last six months of construction were compressed into three months of work to be done before the bridge could be opened to traffic.

On this project the CEI team worked more as a construction manager with special emphasis on the schedule management. The CEI developed a baseline schedule independent of the Contractor's schedule and identified critical areas where sequencing of the construction could be changed to help the overall project completion. The Boynton project team's ability to navigate the project through tough times was amply evident when the following arose:

Removal of Existing Structures

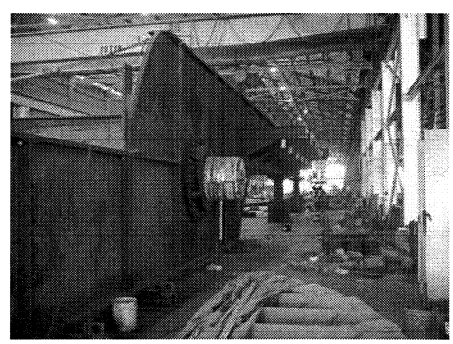
The construction of the Boynton Beach Bascule Bridge presented many challenges to the CEI Team, the Contractor, and FDOT. The new bridge was constructed on the same alignment as the existing bridge so the first task was removal of the existing Bascule Bridge. A 300-ton mobile crane was used to remove the old rolling Lift Bridge in two pieces. Demolition of bascule piers is always a difficult task. The piers are founded on large footings, which are poured on the top of thick concrete seals. The time required for this phase is frequently underestimated by both Engineers and Contractors. The Boynton Beach Bridge was no exception. Complete removal of the span, piers, and piling took approximately six months, three months longer than anticipated.



Demolition of the old bridge.

Jumbo Steel

The first difficult task that presented itself to the project team was the use of foreign steel. The contract contained conflicting information on the use of foreign steel. The Standard Specifications clearly contained language that prevented the use of foreign steel, yet the plan showed a W14X730 section that was only available from a foreign source. At the time of design and plans preparation this section was being rolled domestically but production was discontinued before construction began. During the steel detailing and shop drawings a request for information was submitted to the Contractor by the steel fabricator. The RFI was delayed through the Christmas Holiday break and it was four weeks before it came to the CEI team's attention. By then the steel had already been ordered and the problem existed. The first level of conflict resolution involved the CEI team, in consultation with the FDOT, and the Contractor. The second level was the Dispute Review



Shop assembly of the bascule leaf at PDM Bridge, Palatka, FL.

Board. Ultimately it was determined that both parties were equally responsible and damages for the conflict would be split. This was an important step in the partnering process. Since this conflict came early in the project and involved a significant amount of money, it could have split the team. It was the successful resolution of this difficult problem that gave everyone the confidence that no matter what other problem presented itself, it would be minor in comparison and could be handled in stride.

Dealing with Extra Work

Pricing extra work is always a contentious issue in the relationship of the Contractor and the CEI. Recognizing this, the project team took a different approach in dealing with extra work. As soon as the scope of the extra work was established, the CEI and the Contractor independently priced the work. After a sufficient number quotes for extra work were received, the CEI and the Contractor would jointly go over the numbers to decide on a suitable subcontractor, if the work required one. References on previous work were checked to make sure that the subcontractor provided a quality product in a timely manner. By doing this exercise, the CEI was able to realize the difficulty in getting bids and the Contractor did not have to indulge in protracted and lengthy negotiations to finalize the extra work. On many of the contract changes, the CEI and the Contractor negotiated as a team with the sub-contractor.

Plan Errors

In all projects a certain amount of plan errors will appear during the course of construction. These can become roadblocks to keeping the project on schedule. The Partnering process was used to help mitigate the delays and cost escalations associated with plan errors. The Design Project Manager attended weekly progress meetings on a regular basis. He became part of the team and offered insights into the design considerations and provided prompt answers to Requests-for-Information, quick turnover of shop drawings submitted for review, and when a plan error surfaced he often had a solution the next day. The most important step in instilling the team member attitude for the Design Project Manager was to have him active in the project and at the site at least weekly.

Johnsonii Sea Grass

The presence of Johnson's Sea Grass posed a new set of problems for the team. This was to be the first plant species listed by the National Marine Fisheries as endangered. As such an effective way to manage the species had not been developed. This plant has a very limited known range that starts in the Lake Worth Lagoon and extends south to Key Largo. In total the project had been permitted to impact 149 square feet of sparse habitat. With this plant becoming endangered the permitted impacts would no longer be allowed. Innovative construction methods were employed and the fender system was revised to eliminate the impacts. Vigilant turbidity monitoring and the generous use of turbidity barriers were employed to insure the health of this plant. This is the type of problem that can become a barrier in the Contractor/CEI relationship. Staging of equipment, planning of construction sequences and the partnering spirit is what kept this mole hill from becoming a mountain.

Reducers

The building and testing of the primary and secondary reducers has become a performance specification in Florida. The design of the reducers is left with the manufacturer and Contractor. In our case the secondary reducers failed the functional testing phase during the 300% load test. The time that it takes for the complete process of producing reducers is extremely long and the rejection could have delayed the opening of the bridge by months. At Boynton the team got together as soon as it became apparent that a second set of reducers would be needed. The designer and CEI specialty inspectors traveled to the new manufacturer's facility and the production of shop drawings were completed with all in attendance. This eliminated the 45 day turn-around period that often ends with "revise-and-resubmit" as the outcome. Days were shaved off of the schedule by the Partnering approach. Shop testing was scheduled with a day's notice and with the accelerated delivery date of the new reducers one might have thought that they were painted on the back of the truck during transit. From the rejection of the first set to delivery of the reducers in use today was just over six months. This is the type of problem resolution that can only be accomplished with the full cooperation of the entire project team.

Measures of Success

The bridge was complete and opened to traffic on March 3, 2001. The total time for the replacement of the bascule bridge, including the demolition of the existing structure, was done one day short of the allowed contract time but 111 days beyond the original contract time. In all the project saw cost overruns of 4.8%, a very modest number for a complex bascule bridge construction project. The Partnering of the Contractor, CEI team, Designer, and FDOT from the start of construction insured a successful project.

Project Specifics
▪ *Project Name:* State Road No. 804/ E. Ocean Avenue (Ocean Avenue Bascule Bridge) over the Intracostal Waterway in Palm Beach County.
▪ *Project Designers:* A.G. Lichtenstein & Associates, Inc.
▪ *Project Inspectors:* The CEI team is lead by URS Construction Services and includes representatives from Bergmann Associates, Target Engineering, Dames & Moore (now URS Corp.), E.C. Driver & Associates, Greenhorne & O'Mara, and Underwater Engineering.
▪ *Start Date:* November 30, 1998. *Completion Date:* March 3, 2001.
Project description: The Bridge serves vehicle, bicycle and pedestrian traffic traveling between the Town of Ocean Ridge and City of Boynton Beach over the Intracostal Waterway in Palm Beach County, South Florida. District Four of the Florida Department of Transportation replaced the existing Bascule Bridge with a new double-leaf Bascule Bridge. The new bridge has a number of special features, which include: 1. The aesthetics of the bridge tower houses, piers and retaining wall, which evoke classic designs from the past. 2. The solid bascule span decks, which reduce grid noise, and improves ridability. 3. The through girder design maximizes the clear channel height while reducing the roadway approach elevations.
▪ *Bridge Cost and Total Project Cost:* The Bridge related construction costs was $17.5 million and the total project costs was $24.4 million.