HEAVY MOVABLE STRUCTURES, INC.

EIGHTH BIENNIAL SYMPOSIUM

NOVEMBER 8 – 10, 2000

Grosvenor Resort
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"17th Street Causeway Bridge - A Construction Update"

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17TH STREET CAUSEWAY BRIDGE
A CONSTRUCTION UPDATE

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ABSTRACT

A new mid-level bascule bridge at SE 17th Street Causeway in Ft. Lauderdale, FL was made possible b implementing unique construction phasing techniques. The bridge blends segmental concrete construction wit movable bridge technology to create a stunning "signature" bascule bridge, which forms the gateway to the cit known as the "Venice of the South". This paper presents the details of the construction-phasing program tha allowed the new bridge to be constructed on the existing bridge alignment while maintaining four lanes of traffic.

INTRODUCTION

The SE 17th Street Causeway Bridge is located in Ft. Lauderdale, Florida and spans the Atlantic Intracoastal Waterway just north of the ocean outlet at Port Everglades. Port Everglades is a major freight and passenger terminal. The ocean outlet at the port does not have a vehicle crossing thereby causing all north–south traffic to divert inland at this point. As the first bridge north of the port, the 17th Street Bridge (State Road A1A) provides the primary northbound access point to Ft. Lauderdale's famous beaches. Ft. Lauderdale is an international center for yachting that hosts major yachting events and is home to several marinas that service some of the worlds largest and most impressive yachts. Given these conditions, the navigational clearance requirements at this site are unique. The required horizontal and vertical clearance requirements for a fixed bridge are 38.1 and 41.1 meters respectively. Right-of-way acquisition opportunities are limited at all four corners of the site by existing or planned development. Since the waterway width is only 245m and the site is constrained by development, a movable span bridge is required.

In 1994 FDOT hired a consulting team to design a replacement for the existing bridge which provided insufficient vertical clearance for marine traffic and was structurally and functionally obsolete. The first phase of the project included development of design and maintenance of traffic concepts in concert with an extensive public involvement plan. Several detailed prior studies had been conducted, including a Project Development and Environment Study.

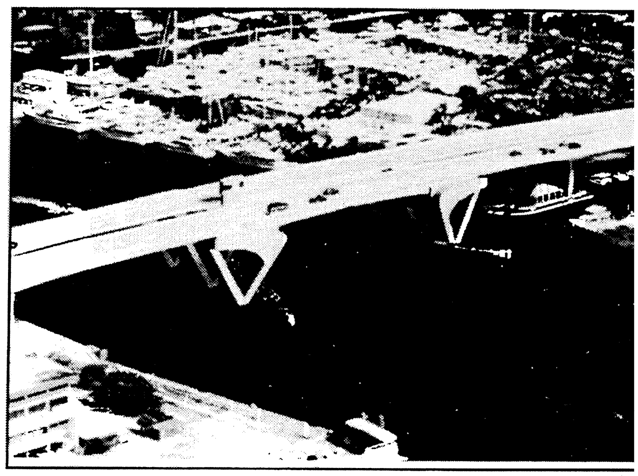


FIGURE 1 – COMPUTER GENERATED RENDERING

These studies established critical project objective for the new facility, including the following:

- Construct a mid level bascule bridge providing a minimum horizontal clearance of 38.1m (12 feet) and a minimum vertical clearance o 16.7m (55 feet) with the movable span in th closed position
- Provide a bascule span with a solid ridin surface
- Maintain four lanes of traffic and the navigationa channel throughout construction
- Construct the new bridge parallel to an centered about the existing bridge's alignment
- Give the new bridge FDOT's highest level o aesthetic consideration, Level III.

The selected design concept consists of twin bridges, each carrying two 3.6m lanes of traffic, a 3.0m combined shoulder/bicycle lane and a 2.4m sidewalk. Each dual bridge has a width of 16.295m. The total bridge length is 581.50m including a bascule span of 97.6m (64.0m between trunnions). A five span continuous unit (34.4, 62.5, 62.5, 62.5, 51.3) on the west and a four span continuous unit on the east (51.3, 62.5, 62.5, 34.4) make up the segmental concrete box girder approaches.

Post tensioning connects the precast segmental concrete box girder of the approach spans with the inverted delta shaped bascule pier to form an integral rigid frame that supports the approach span, movable span, counterweight, machinery, and control equipment. The resulting structure is a multispan continuous structure, supported on expansion bearings along the concrete box girder and on a fixed mudline foundation below the "V" shape of the bascule pier. This structural system was developed specifically to address the unique requirements of the site and the local community's desire for a signature structure.

The bascule span consists of four movable leaves, each weighing 10,400 kN. Each pair of leaves on one side of the channel is supported on one bascule pier. To allow the two counterweights to swing freely below the superstructure, each bascule pier is formed of three parallel delta shaped elements. The outer deltas curve out from the center and down as they approach the channel. This feature provides a desired pedestrian overlook on the piers. A front diaphragm between the deltas provides support for the movable leaf's forward load shoe. Similarly, a rear transverse diaphragm provides the transition element connecting the pier with the approaching segmental concrete boxes.

For consistency with the approach spans, steel box girders were used for the bascule span. The deck and framing system were developed to provide a clean, uncluttered look, consistent with the timeless contemporary style. Using an exodermic deck system spanning longitudinally between floorbeams, stringers and lateral bracing were eliminated. Box girders provided the opportunity to minimize bottom flange width outside of the web and eliminate external stiffeners. Combined, these features provide a design with smooth lines and a minimum of visually distracting elements.

MAINTENANCE OF TRAFFIC DEVELOPMENT

Initially, it appeared that the only way of maintainin four lanes of traffic while replacing the bridge on th existing alignment was to construct a four-lar temporary detour bridge, with a movable main spa just south of the existing bridge. This approach ha two major shortcomings. First, the cost of right-o way acquisition and construction of the four-lar temporary bridge could exceed 20 million dolla ($12 million construction estimate alone). Secon the temporary bridge would block off access frontage roads serving adjacent hotels.

A solution to the maintenance of traffic issu presented itself when the design team wa examining constructability of the new bridge. T locate new bascule pier foundations clear of th existing piers and avoid potential conflicts require lengthening the movable span from approximate 64 meters between trunnions to 70 meters. With th new bridge vertical clearance requirement of 16.7 significantly higher than the deck of the existin bridge, an opportunity was created for an innovativ construction phasing concept, one that reduced th temporary detour bridge to two lanes and eliminate the need for additional right-of-way acquisition. Th maintenance of traffic scheme implemente consisted of the following basic construction phase

PHASE 1:	Construct a two-lane tempora detour bridge just south of th existing bridge
PHASE 2:	Shift two lanes of eastbound traff from the existing bridge to the ne temporary bridge
PHASE 3:	Shift two lanes of westbound traff from the north half of the existin bridge to the south half of th existing bridge
PHASE 4:	Demolish the north half (existin westbound) of the existing bridg approaches – maintain the existin bascule span in service
PHASE 5:	Construct the north half of the ne bridge – construct the new bascul span above the north half of th existing bascule span
PHASE 6:	Shift all four lanes of traffic from th existing and temporary bridges t the north half of the new bridge
PHASE 7:	Remove the temporary bridge

PHASE 8:	Demolish the remainder of the existing bridge, including the bascule span
PHASE 9:	Construct the south half of the new bridge
PHASE 10:	Shift the two eastbound lanes to the new south half of the bridge and restripe the north half for two lanes westbound

CONSTRUCTION BY PHASE

The following is a detailed description of each phase of construction.

PHASE 1: TWO-LANE TEMPORARY DETOUR BRIDGE

This phase included construction of a two-lane temporary detour bridge on the south side of the existing bridge. As with the existing bridge, the temporary bridge included a bascule span at the navigation channel. The temporary bridge was designed to meet the following criteria:

- Provide horizontal clearance of 30.5m (skew angle of 77°28'05") and a minimum vertical clearance of 8.1m with the bridge closed (unlimited with the bridge open) - these clearances meet or exceed those of the existing bridge
- Provide for two 3.3m lanes of one-way traffic and a 1.8m sidewalk
- Design for ease of construction with provision to relocate the bridge to another site
- Design for lowest cost, considering salvage value

Through a detailed study, evaluating single and double-leaf designs as well as trunnion and rolling configurations, a single-leaf Dutch-style bascule with overhead counterweight was selected for the movable span. This design offered the following advantages:

- Least amount of structural steel
- Only one set of drive machinery
- Less exacting alignment requirements
- No dry counterweight pit required
- Most adaptable to new sites with low underclearance
- Modular construction for ease of erection and relocation

The temporary movable span consists essentially o a steel support frame, bascule leaf with hee trunnion, "A" frame towers, counterweight, balanc frame with overhung trunnions, and link arms. Th center of gravity of the leaf and counterweight ar located along parallel lines that intersect the respective pivot points. A parallelogram, defined b the four pivot points (heel trunnion, counterweigh trunnion, and 2 link arm bearings) is maintained i all positions of span rotation so that the syster remains balanced.

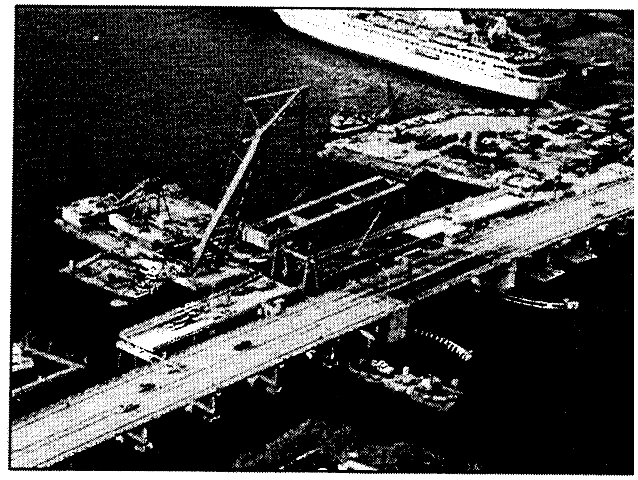


FIGURE 2 – ERECTION OF BALANCE FRAME

To simplify erection and relocation, the counterweight has three main elements. Precas concrete panels that stack between the balance frame main girders provide 167,400 kg of ballast Cast-in-place concrete in the balance frame bo girders provides an additional 171,500kg of ballast Final adjustment is made with 24,900 kg of stee ballast plates bolted to the top of the balance frame.

The bascule leaf is 40.5m long and 11.57m wide out to out. To fully clear the channel in the oper position, the bascule leaf rotates 82.5°. Power anc control are provided by a 59.6 kW (80 HP) open loop hydraulic system by way of two, 320mm diametei bore – 180mm diameter rod heavy-duty mill-type hydraulic cylinders. The cylinders are mounted between the support frame and the leaf and pull the bridge open or push it closed in approximately 70 seconds.

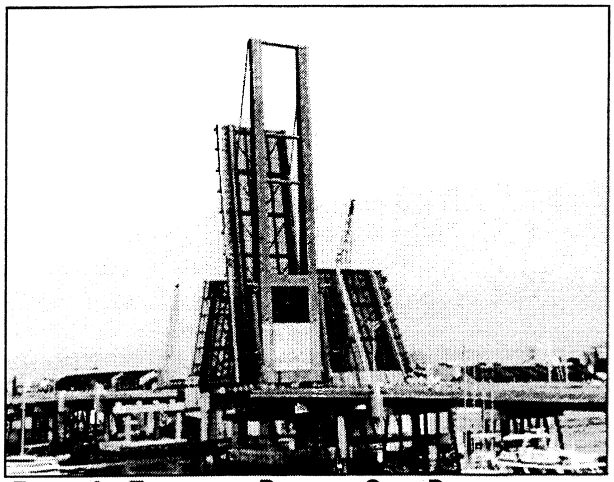


FIGURE 3 – TEMPORARY BRIDGE IN OPEN POSITION

PHASE 2: SHIFT TWO LANES TO THE NEW TEMPORARY BRIDGE

This phase consisted of shifting the two eastbound lanes of traffic from the south half of the existing bridge to the temporary bridge.

PHASE 3: SHIFT TWO LANES TO THE SOUTH HALF OF THE EXISTING BRIDGE

This phase consisted of shifting the two westbound lanes of traffic from the north half of the existing bridge to the south half of the existing bridge. Because Florida DOT movable bridges half both on-coming and off-going traffic gates, no new gates were required for this shift. The bridge control system was modified so that the existing off-going gates were operated as on-coming traffic gates and the existing on-coming gates operated as off-going gates.

PHASE 4: DEMOLISH THE NORTH HALF OF THE EXISTING BRIDGE

Once the traffic was shifted off of the north half of the existing, bridge demolition could proceed. For the approach spans leading up to the bascule span from either side, the bridge was saw cut near the center and the north half removed. Timber brackets were installed along the cut edge of the superstructure to support the cantilevered deck. The existing piers are a three-column configuration with each column supported on a waterline footing. The south and center columns were left in place to support the remaining superstructure. Wiresaws were used to cut the struts between footings.

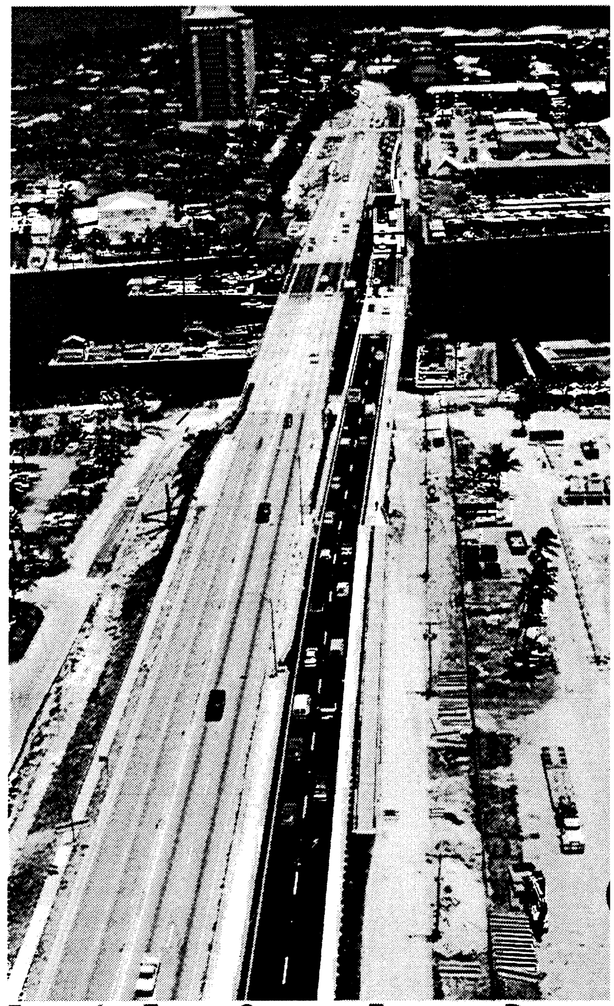


FIGURE 4 – TRAFFIC SHIFTED TO TEMPORARY BRIDGE AI SOUTH HALF OF EXISTING BRIDGE

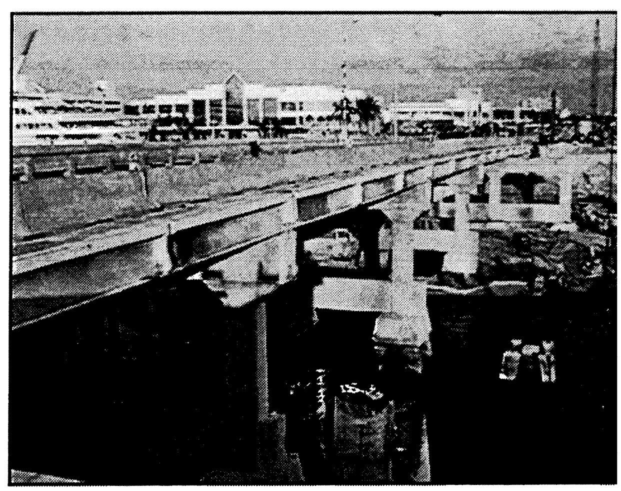


FIGURE 5: HALF OF EXISTING BRIDGE APPROA SUPERSTRUCTURE REMOVED

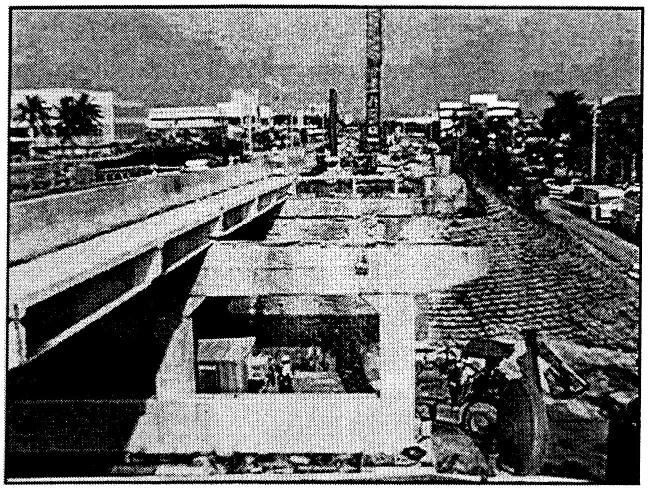


FIGURE 6: HALF OF EXISTING BRIDGE APPROACH SUBSTRUCTURE REMOVED

The existing bascule span is a two-girder system. Because of this, nether the superstructure or substructure could be cut in half for partial removal. However, because the new bascule piers are located behind the existing piers, the entire bascule span, including both bascule leaves, counterweights, machinery, and piers could be left intact through much of construction. The flanking spans, located just either side of the bascule span were cut in half and partially removed, leaving the counterweights exposed. Provisions were made for protection of the counterweights during construction.

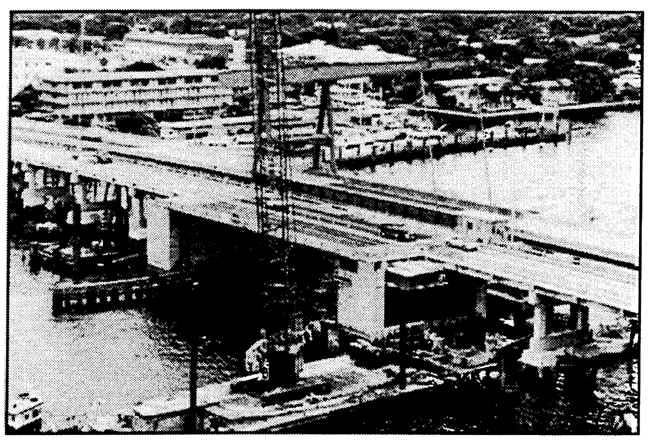


FIGURE 7: EXPOSED COUNTERWEIGHT WITH FLANKING SPAN REMOVED

PHASE 5: CONSTRUCT THE NORTH HALF OF THE NEW BRIDGE

This was the most challenging construction phase. It included construction of the north half of the new bridge, retaining walls, and several temporar structures. Due to the location of the new bridge o the same alignment as the existing, the new bascul spans were constructed partially above the existin bascule spans. Special precautionary requirement were included in the contract documents for workin adjacent to an active roadway and for handlin heavy picks above the existing bascule span.

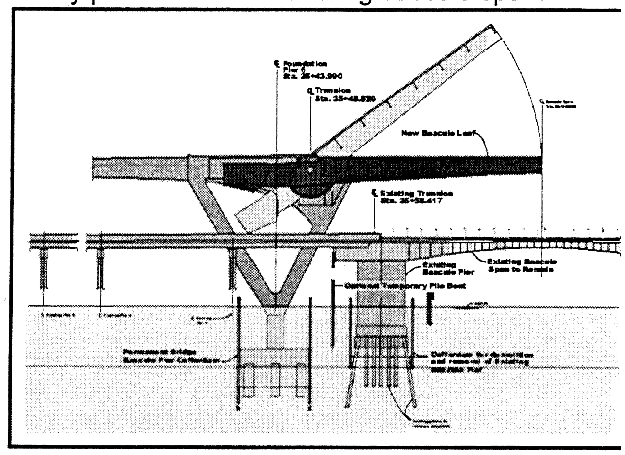


FIGURE 8: RELATIVE POSITIONS OF EXISTING AND NE BASCULE SPANS

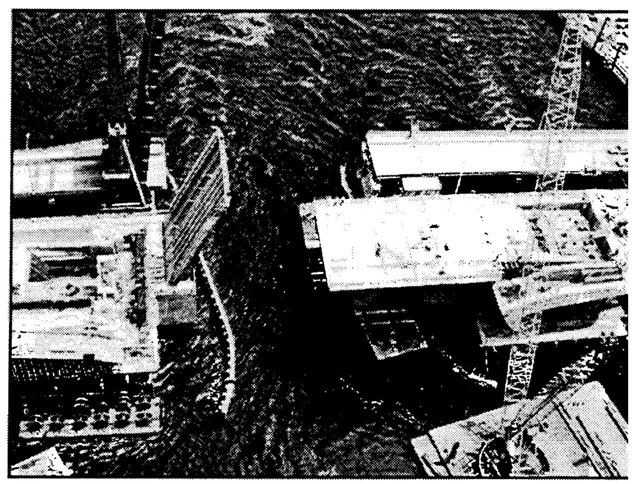


FIGURE 9: CONSTRUCTION OF NEW BASCULE SPAN ABOV EXISTING BASCULE SPAN

Temporary structures required in this phase include wire-faced mechanically stabilized earth walls an steel sheet pile walls for the approac embankments. To provide for four lanes c temporary traffic in Phase 6, the sidewalk on th north side of the bridge was reduced from 2.4m t 1.5m and temporary traffic barriers were installe between the sidewalk and roadway. At the movabl span, a temporary control house and temporar traffic gates were installed.

Key tasks in this phase included construction of 1.22 meter diameter drilled shafts, cofferdams for the bascule piers, cast-in-place concrete construction of the bascule piers and approach piers, pre-casting of segments, and segment erection. For the movable span, the steel superstructure was fabricated and erected. Machinery and control system were shop fabricated, shop tested, and installed. Machinery for the permanent bridge was designed for the heavy loads resulting from use of a concrete deck and to accommodate the geometry of the bascule pier. For improved reliability, the machinery was designed to provide the maximum redundancy practical. During normal operation the entire 10,400 kN of the leaf is supported on two simple trunnions. Each trunnion is 635mm in diameter and is supported on two 600mm diameter spherical roller bearings. In the event that a bearing fails, the girder, trunnion shaft, and remaining trunnion bearings are designed so that they can remain in service with the remaining bearing supporting 5,200 kN. In this situation the trunnion acts as an overhung trunnion supported by the torsional stiffness of the box girder.

Span movement is provided by a pair of fully redundant drives, each engaging a rack attached to a bascule girder. Drives consist of 93.25 kW (125 HP) DC motors and an enclosed gear drive featuring planetary reducers. Racks are ½ diametral pitch with a 3,759.2mm radius. Drives are independent and are each capable of operating the span against the maximum specified AASHTO loads.

PHASE 6: SHIFT TRAFFIC TO THE NORTH HALF OF THE NEW BRIDGE

Once the north half of the new bridge and the temporary structures were completed and tested, traffic was shifted from the existing and temporary bridges to the new bridge.

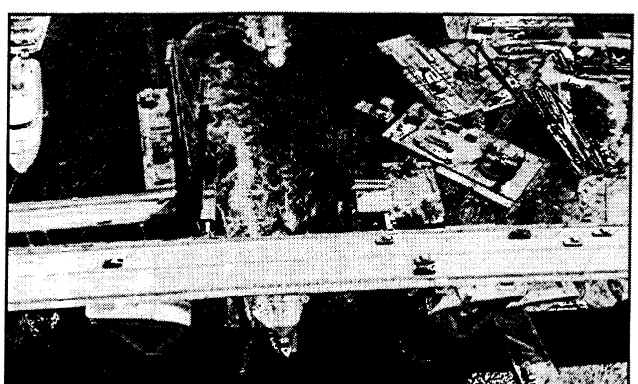
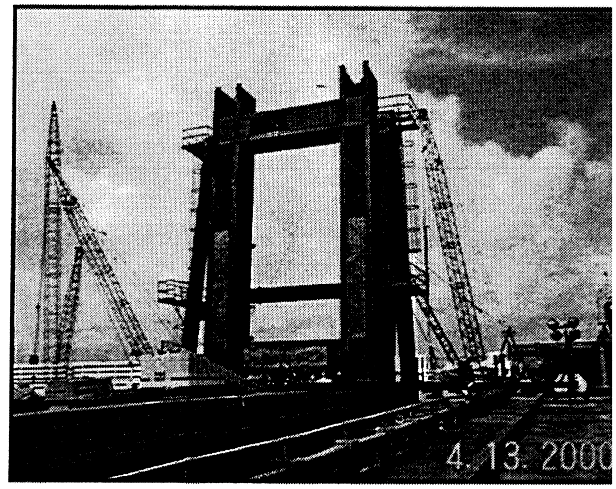


FIGURE 10: NORTH HALF OPEN TO FOUR LANES

PHASE 7: REMOVE THE TEMPORA BRIDGE

With all four lanes of traffic shifted to the new brid the temporary bridge and remainder of the exist bridge could be removed. Those portions structures that interfered with construction of



south half of the new bridge were removed first.

FIGURE 11: TEMPORARY BASCULE REMOVAL

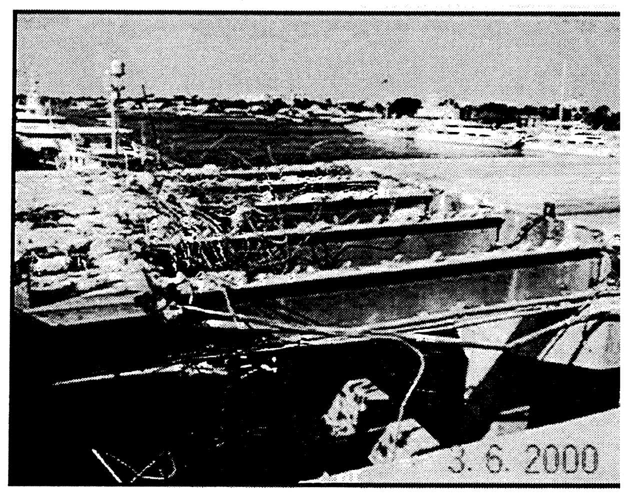


FIGURE 12: TEMPORARY BRIDGE SUPERSTRUCTURE REMOV

PHASE 8: DEMOLISH THE REMAINDER (THE EXISTING BRIDGE

The existing bascule leaves were given t demolition priority because their presence restrict the navigational channel and required clo coordination with operation of the new bridç Demolition included disposal of suitable material an offshore artificial reef site.

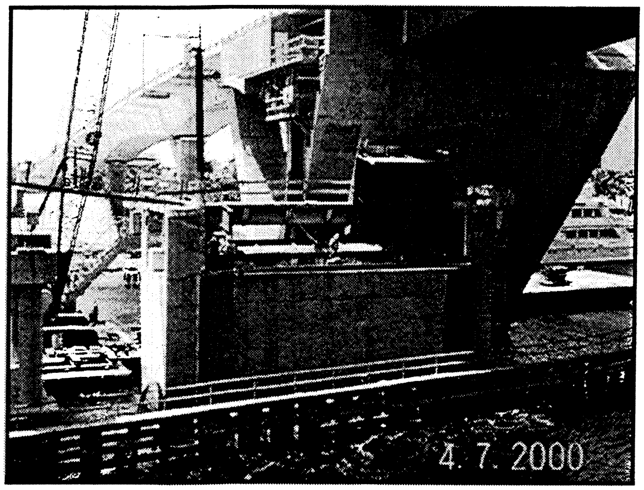


FIGURE 13: TEMPORARY BASCULE LEAF REMOVAL

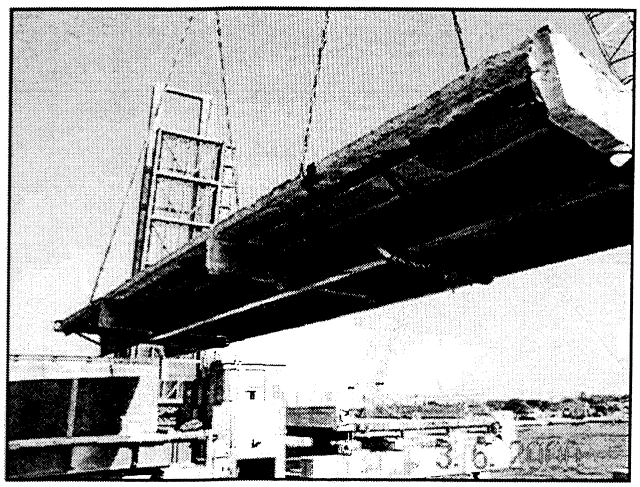


FIGURE 14: TEMPORARY Bridge Superstructure REMOVAL

PHASE 9: CONSTRUCT THE SOUTH HALF OF THE NEW BRIDGE

This is the active phase of construction at the time of this writing. This phase is similar to Phase 5, except that it includes construction of the permanent bridge control house, which is located between the twin bridges.

PHASE 10: SHIFT THE TWO LANES TO THE NEW SOUTH HALF OF THE BRIDGE

Shifting traffic to the final configuration will require several sub phases. The temporary barrier and traffic separator installed on the north half of the bridge will be removed and the permanent barrier installed such that a 2.4m sidewalk is provided on the north side of the bridge. The temporary gate and control house will be removed. Final testing an pavement striping will be completed and the ne "Gateway to Ft. Lauderdale will be complete."

CONSTRUCTION SUMMARY

The temporary bridge movable span design wa fast-tracked and let in advance while the permaner bridge design was in progress. The temporar bridge contract was bid in May of 1996 and receive a low bid of $5,881,666. This work included th movable span, movable span piers, and fou approach spans for a total structure length of 140m The following lists some of the key data on th temporary bascule bridge:

- There are 188,800 kg of structural steel in th bascule leaf and balance frame
- The total movable span mass is 334,000 kg

The permanent bridge was bid in June of 1997 an received a low bid of $61,348,263. This wor included 210m of approaches to the temporar bridge. The following lists some of the key data o the permanent bridge:

- There are 868,800 kg of structural steel in th bascule leaves and steel counterweight box
- The counterweight boxes contain 778 m^3 c heavyweight concrete
- The Bascule Piers contain 8,463 m^3 of concrete including 1923 m3 of microsilica concrete in th pier legs in the splash zone
- The bid price of the bascule span alone wa $26,470,000 or about $8,020 per square meter
- The bid price for the approach spans wa $11,450,000 or about $880 per square meter