Heavy Movable Structures, Inc.

SIXTH BIENNIAL SYMPOSIUM

October 30 - November 1, 1996

Doubletree Resort Surfside
Clearwater Beach, Florida

Bascule Bridges - Functionality, Elegance and Durability

by

Siamak Pourhamidi, P.E., HNTB Corporation

BASCULE BRIDGES - FUNCTIONALITY, ELEGANCE AND DURABILITY

By: Siamak Pourhamidi, P.E. [1]

INTRODUCTION

In 1988, HNTB was selected by Ocean County, New Jersey, to perform engineering services for the replacement of the Beaver Dam Bridge. This paper addresses the myriad of design constraints and the evolution of the unique design which fits a new rolling bascule directly in line with existing structure. The design is now complete and the notice to bid on this project will be given in the second half of 1996.

EXISTING CONDITIONS

Geometry and Features

The roadway is identified as Beaver Dam Road in Point Pleasant Boro and Fifth Street in Brick Township. The dividing line between municipalities lies near the middle of the waterway.

In the Boro, Beaver Dam Road varies in width from 40-ft to 25-ft, generally centered within the 60-ft wide publicly owned ROW. In Brick, Fifth Street varies in width from 25-ft to 32-ft, centered within a 50-ft wide ROW.

Due to the lack of proper vertical curvature, stopping sight distance approaching the bridge is deficient for the operating speed of 35 mph.

The current AADT for the Beaver Dam Road is 7,290 with a 1.4 seasonal increase factor.

Utilities

Utilities cross the Creek overhead and underwater. Major underwater utilities have been identified: a 20-inch sanitary sewer forced main, a 6-inch gas main, a Bell Atlantic submarine cable. Overhead there is a Jersey Central Power and Light Co. Transmission line. There are also cable television facilities along the roadway.

Land Use

Within the project site, there is a mix of commercial and residential properties.

Bridge Structure

The existing bridge, a balanced swing span, built in 1931, crosses Beaver Dam Creek, joining Point Pleasant Boro and Brick Township. The road carried by the bridge is known as Beaver Dam Road in the Boro, and Fifth St. In Brick, the municipal boundary being located in the waterway, near mid-channel. In length, the project site extends from West End Drive in the Boro to Princeton Avenue in Brick, a distance of approximately 1,000 ft.

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The existing balanced swing span furnishes two navigation channels, each forty feet wide with the north channel having much shallower depth and not being used by marine traffic. The new bridge provides a single navigable channel with sixty feet of horizontal clearance for marine traffic. The existing fourteen feet vertical clearance above mean high water is maintained so not to impact the nearby intersection controls.

STUDY PHASE - SCHEME SELECTION

The existing bridge is structurally, geometrically, and functionally deficient. The objective of the replacement was to design a new bridge and plan improvements to road geometric. Given the volume of traffic which crosses over the bridge and the marine activity surrounding the site, the improvements are planned to accommodate equally the needs of motorists and mariners. The new bridge will provide an aesthetically pleasing alternate to match the marina environment, blending in well with the neighborhood. The selection of the structure proportions, materials and color strives to present a minimum degree of obtrusiveness.

Studies were conducted to identify feasible bridge design types to replace the existing Beaver Dam Bridge. Along with structure type studies, four alternative roadway alignments were studied. Two alternatives comprised 40-mph alignments which departed from the existing road (off-line), so that traffic may be maintained during construction. For on-line alternates, two vertical alignments (35 mph and 40 mph) were studied for locations generally coincident with the existing road.

The off-line alternatives entail major property encroachments and require long structures to bridge the waterway. Functionally, they are inferior to the on-line alternates. On the other hand, on-line alternates require traffic to endure trip delays during construction associated with detour distances ranging between two to four miles in length. The detour is expected to be in place during most of the construction period, estimated to be 19 months.

Permits for the on-line alternatives will be minimal inasmuch as impacts are slight. Small areas of ROW are needed, with no major utility involvement. In addition to property acquisition, off-line alternatives require business relocation and tideland conveyances. Estimates indicate that the least expensive off-line alternative cost $700,000 more than the most expensive on-line alternative, without including the added costs of ROW damage. For the on-line alternative, the 40 mph design costs about a half-million dollars more than the 35-mph design.

Navigation clearance proposed for the new bridge are 60 ft horizontal, 14 ft vertical. The Coast Guard has accepted these clearances as being reasonable for the site.

Bridge type studies for the movable span considered counterweighted swing, vertical lift, and single leaf bascule types; for the approach spans, prestressed concrete and structural steel superstructures were investigated. Operating system studies included both mechanical and hydraulic systems with various types of electrical drives.

The studies indicate that the swing span is least expensive, the bascule span most expensive. For the project site, the swing span is an awkward construction, occupying most of the narrow waterway; while the lift span is an aesthetic misfit for the neighborhood. A rolling bascule, on the other hand, provides a good fit for the location together with attractive operational features.

Approach span studies indicate that the prestressed concrete superstructures are less expensive and more appropriate than structural steel superstructures.

All factors considered, the following were recommended for the project:

a. For the roadway alignment, an on-line alternate having 40-mph geometrics.
b. For bridge deck two 12 ft travel lanes, 8 ft shoulders and a 6 ft sidewalk.
c. For the movable span type, a rolling bascule having a solid deck.
d. For approach spans, prestressed concrete superstructures.

The local public, through opinions expressed at the August, 1989 Public Information Center, overwhelmingly supported the choice of an on-line replacement and a bascule span.

PRELIMINARY / FINAL DESIGN

An on-line replacement was determined to be preferred from the standpoint of function, cost, and impact on environment. The new Beaver Dam single leaf rolling bascule bridge provides a profile which eliminates the site distance deficiency as a result of existing high vertical grade and increasing the operating speed. The improvements are achieved through design of a low profile structure consisting of continuous bascule girder and longitudinal stringer framing. The framing of multiple longitudinal elements provides redundancy in the structure, minimizing the fracture critical members and associated requirements.

BASCULE SPAN STRUCTURAL SYSTEM:

Superstructure

The single leaf rolling bascule superstructure has a span length of 73 ft from center of roll to centerline of bearing at the toe of the leaf. In order to span this distance and maintain the low profile of the superstructure, high strength structural steel was used for bascule span structural members.

To meet the constraints imposed by the site, vertical profile of the bridge in combination with navigational clearance, a reduced structure depth was needed. As a result of limited structure depth, framing for the bascule span consists of two welded bascule girders at 43.75 ft centers flanking six intermediate longitudinal stringers spaced at 6.25 ft. The framing plan is shown on page 6 with the longitudinal section shown on page 7 and the typical cross sections on pages 8 and 9.

The stringers and girders are continuous from the toe of the span to the counterweight. The use of this system together with a lightweight concrete composite deck, allows a reduced structure depth to meet the constraints imposed by the site.

The roll radius of the segmental girder is 9.25 ft with a travel of 10.37 ft and an opening angle of approximately 64.2 degrees. Two track girders support the segmental girders and provide a rolling surface for the leaf. The opening diagram is shown on page 10.

Deck Slab

The bascule girders and stringers are composite with the 7-inch lightweight concrete deck. A solid deck of lightweight concrete is provided to reduce corrosion problems associated with open deck systems and provide necessary composite action with the stringers and bascule girders. The construction is sequenced to eliminate permanent tensile stresses in the deck to prolong the integrity of the composite structure.

APPROACH SPANS

There are two approach spans which flank the bascule span; one to the north and one to the south. Each span consists of an 80 ft simply supported prestressed concrete superstructure with an 8.5- inch normal weight concrete deck slab. The roadway and sidewalk cross section is similar to that of the bascule span.

FOUNDATIONS

All piers, abutments and retaining walls will be supported on piles. Borings indicated that the bridge site consists of layers of sand, organic silt and clay down to Elevation -25.00. The sands range from loose to dense, the organic silt ranges from very soft to very stiff and the clay is very stiff to hard.

Below elevation -25.00 to elevation -55.00 the maximum depth of boring, there is a fine very dense sand with varying amounts of silt. Foundations for the new bridge are founded in this stratum.

The piers are supported on 60-ton displacement piles: 12-inch square prestressed concrete piles, founded in the stratum below elevation -25.00. Smaller 30-ton capacity piles are used to support the abutments and retaining walls

SUBSTRUCTURES

The bascule substructure consists of two piers which are in the waterway. One wall type pier supports the toe end of the bascule span and one end of the flanking fixed span. The other, a more massive pit pier, provides the housing for counterweight and support for control house as well as one end of the opposite fixed span.

Once the existing swing span has been demolished, the existing timber piles which interfere with the new piles and cofferdams for both piers will be removed. Both piers will be constructed in cofferdams using tremie seals.

The north and south abutments will be located behind existing bulkheads. Because of the substantial raise in grade of the new profile, the abutment wingwalls will be extended as retaining walls to contain the fill.

SEISMIC DESIGN

The bascule span structure has been designed for a 0.124g ground acceleration in the closed position, and 0.07g acceleration coefficient in the open position. As in a fully balanced span, the center of gravity of the dead load acts at the center of roll, with the longitudinal seismic reaction being taken by the interlocking of the bascule girder tread plate with the pintles of the track girders, and then transferred through the track girders to the substructure. The stiffeners of the bascule girder are designed to transfer the transverse seismic loads.

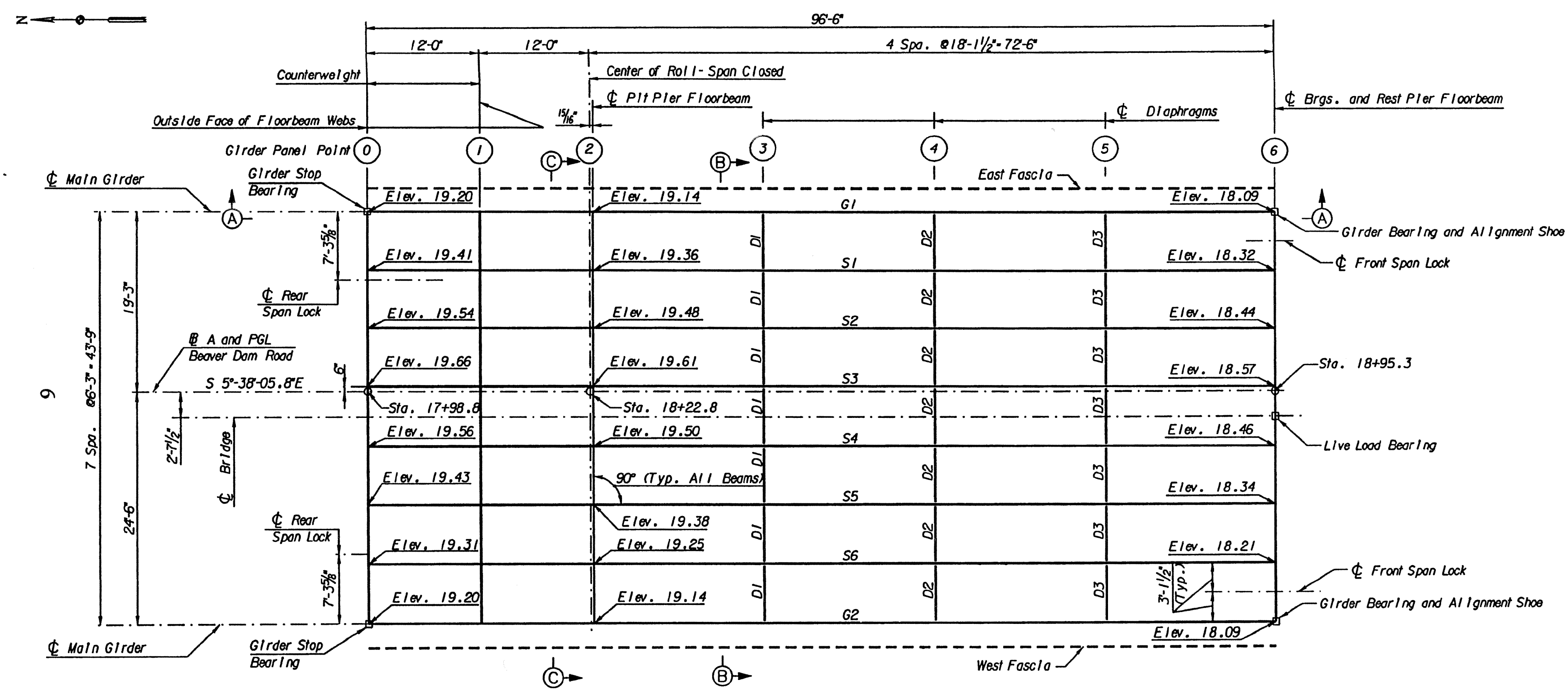
HYDRAULIC SYSTEM

The bridge is operated using two hydraulic cylinders, one for each bascule girder. Each cylinder is pinned to the pit pier walls and connected to the bascule girder at the center of roll with a bearing allowing for rotation. Operation of the bascule is performed by the hydraulic cylinders pulling the span open or pushing it closed. Both hydraulic cylinders are operated by a common power unit consisting of motor, pump and reservoir to ensure synchronous operation. The use of hydraulic cylinders eliminates the need for mounting the operating machinery on the movable span, inasmuch as the motor, pump and reservoir are located in the pit pier and connected to the cylinder with hydraulic lines. This arrangement is advantageous since the hydraulic lines do not flex during the operation.

CONSTRUCTION

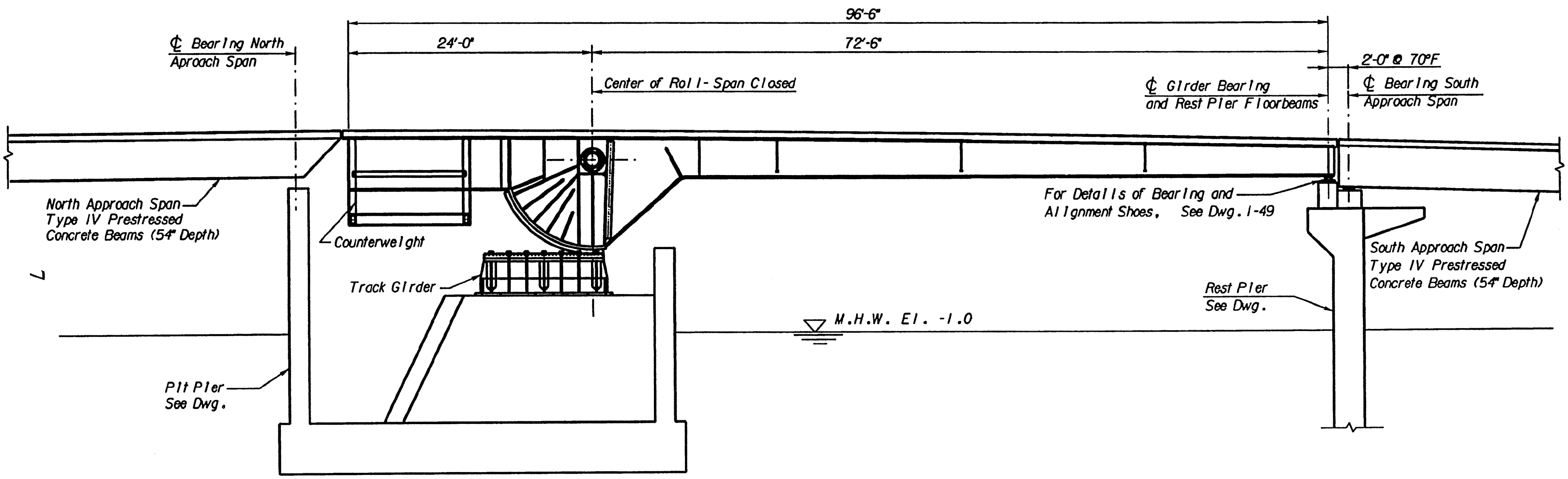
Construction on the existing alignment requires that the existing swing span be removed and piers demolished before work on the new piers can commence. Vehicular traffic on the existing structure must therefore be interrupted essentially for the duration of the project, which is expected to be 19 months. The principal shortcoming is the need to detour substantial traffic volumes, particularly during the summer months, during most of the construction period.

Marine traffic can generally be maintained, except that limited interruptions are necessary during some construction operations. Interruption will occur during the demolition of the exiting structure and the period during which the concrete deck and counterweight of the bascule span are placed. Since the latter must be done with the span in the closed position, deck and counterweight concrete placements must be coordinated with marine traffic interruptions.



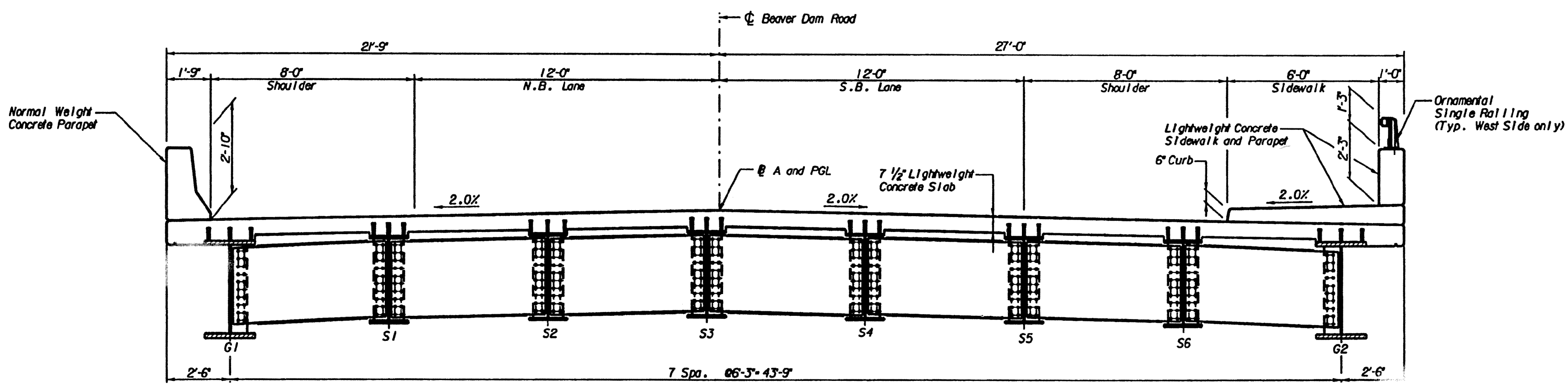
BASCULE SPAN FRAMING PLAN

1/8" = 1'-0"



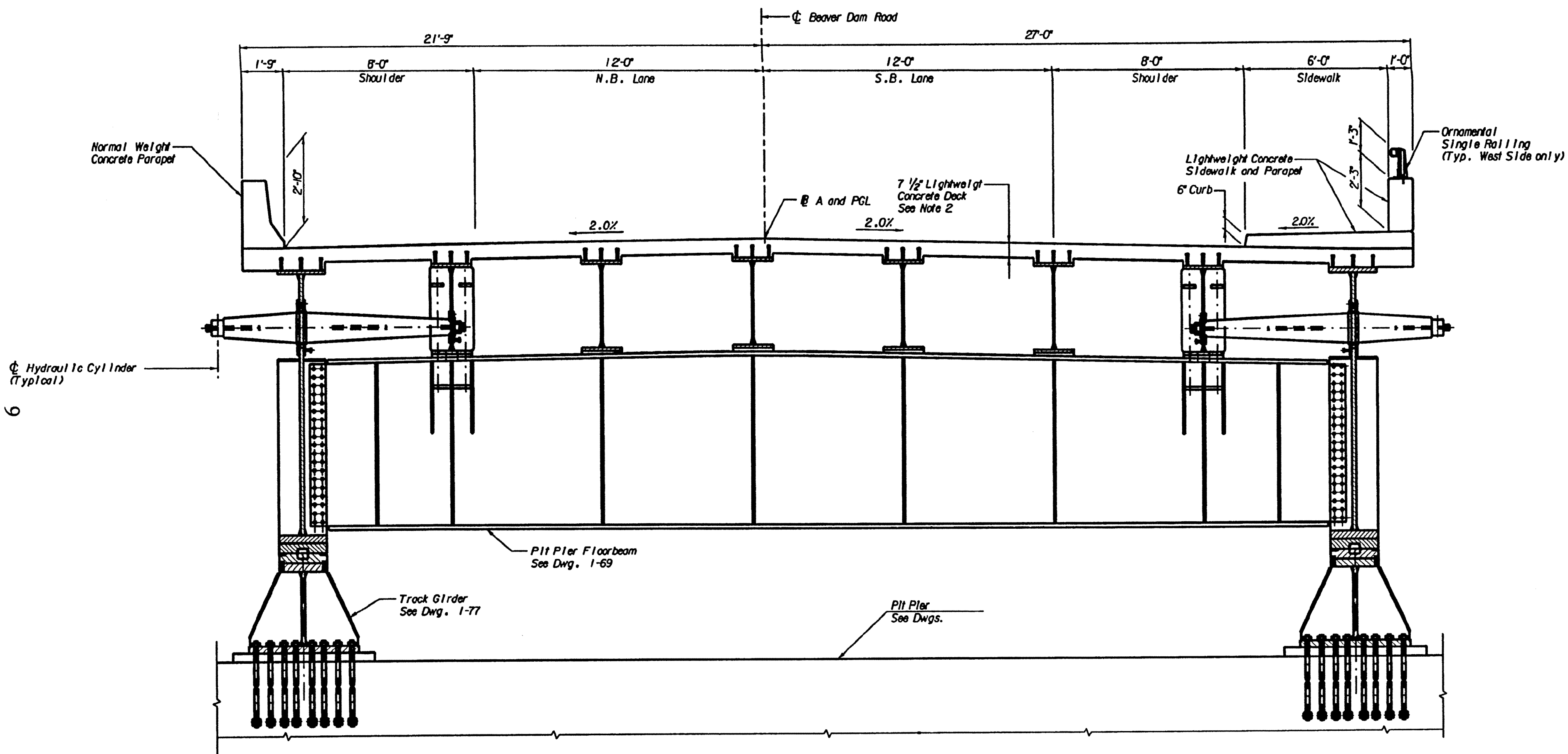
SECTION A-A

1/8" = 1'-0"



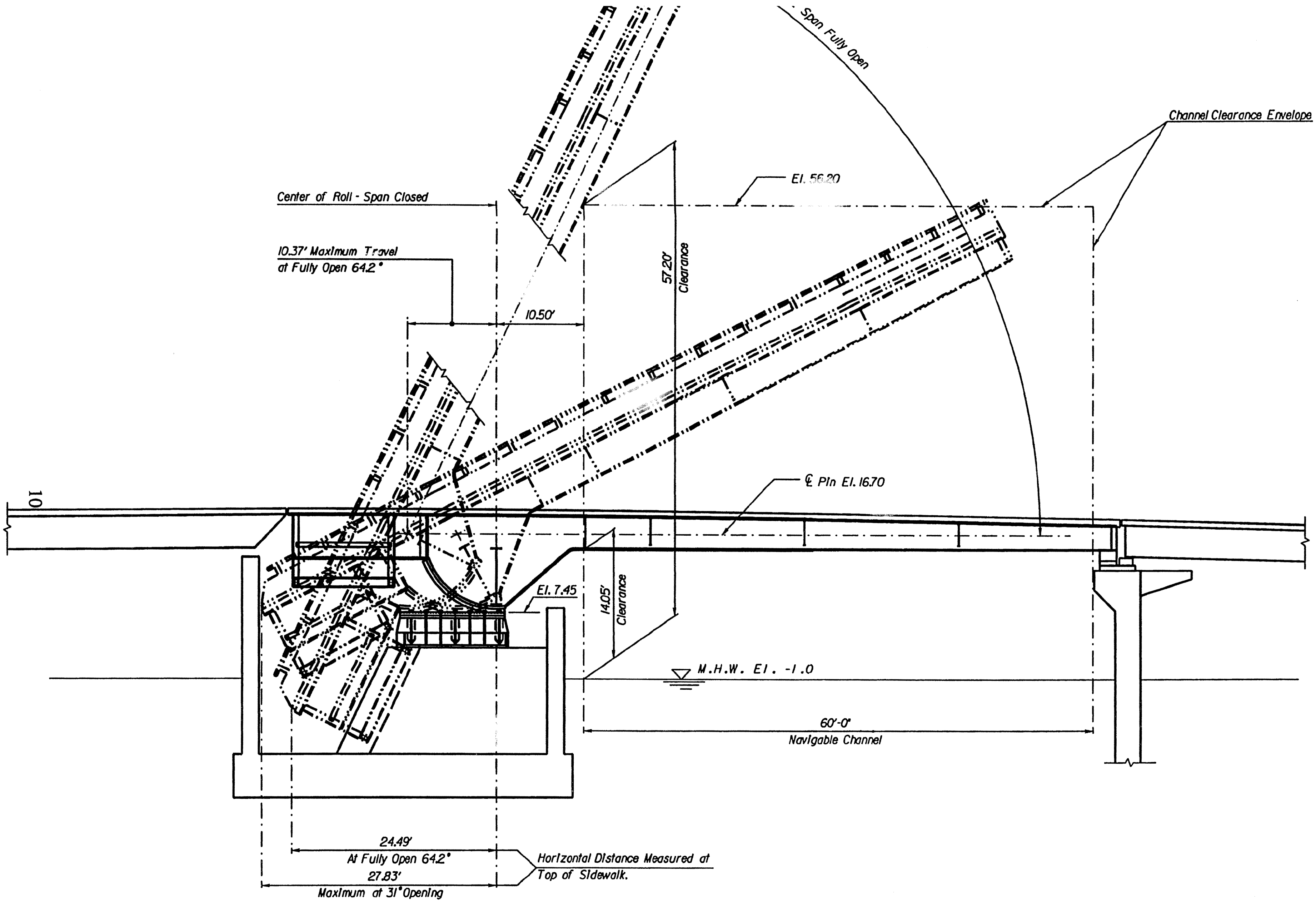
SECTION B-B (BETWEEN FLOORBEAMS)

⅜" = 1'-0"



SECTION C-C (AT CENTER OF ROLL)

3/8" = 1'-0"



SPAN OPENING DIAGRAM

1/8" = 1'-0"

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Aesthetic Engineering - A Unique Solution for a Signature Bascule Bridge

by

Richard J. Beaupre, P.E. and James M. Phillips III, P.E., E.C. Driver and Associates, Inc.

HEAVY MOVABLE STRUCTURES, INC.

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OCTOBER 30 - NOVEMBER 2, 1996

CLEARWATER BEACH, FLORIDA

AESTHETIC ENGINEERING - A UNIQUE SOLUTION FOR A SIGNATURE BASCULE BRIDGE

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Aesthetic Engineering - A Unique Solution for a Signature Bascule Bridge

Abstract: Although bridges are an integral part of many recognizable and picturesque landscapes, most modern movable bridges are considered more of an "eyesore." So when the residents of South Florida learned that the 17th Street Causeway Bridge would be replaced with a new draw bridge they stood up and demanded something different. They called for a "Signature Bascule Bridge" to provide an aesthetic gateway to the famous beaches of Fort Lauderdale. This paper presents the unique solution crafted by the design team to satisfy aesthetic objectives while maintaining economy and functionality. The solution was not achieved by ornamentation or minor alteration of the bascule pier, but through a study of function and load transfer which produced a strong unique pier element deserving of a "Signature Bascule Bridge". Special efforts were also made in the design of the bascule span superstructure to produce smooth lines and uncluttered beauty to complement the new pier.

Introduction

The design team led by E.C. Driver & Associates have designed a "one-of-a-kind" double-leaf bascule bridge which will replace an existing drawbridge at the 17th Street Causeway over the Intracoastal Waterway (Stranahan River) at Fort Lauderdale, Florida. District Four of the Florida Department of Transportation has directed the design team to give special attention to aesthetic issues on the project. This paper presents the aesthetic design solutions for the 17th Street Causeway Replacement Bridge.

Existing 17th Street Causeway Bridge

The site has an existing four lane bridge constructed in 1956 (see Figure 1) which must be replaced to provide a new roadway section meeting current standards. The existing vertical clearance is only 7.62 m (25 ft.), necessitating frequent openings and causing traffic jams for motorists. Horizontal clearance between fenders is 30.5 m (100 ft.). The bridge alignment crosses the channel at a skew angle of approximately 13 degrees. The existing approach structure consists of short steel I-beam spans with concrete bents supported on water-level foundations. The bascule span is a standard Florida design with an exposed couterweight. The utilitarian control tower is cantilevered off the south side of the west bascule pier. This structure has very little inherent beauty or historical significance.

The existing bridge is located adjacent to Port Everglades, a major east coast port facility and various other marina facilities. The Fort Lauderdale area is a major yachting destination which contributes to a high density of vessels in the bridge area. Included in the vessels which frequent the site are many high mast sail boats, some with masts exceeding 40 m (130 ft.).

Project Requirements

Preliminary studies had concluded that the replacement structure would require a double leaf bascule span with a length of 70 m (229.66 ft.) between centerline of foundations with a 16.76 m (55 ft.) vertical clearance (to reduce the number of openings). The 70 m (229.66 ft.) span was required for construction phasing. The horizontal clearance between the fenders will be 38.1 m (125 ft.). A single leaf bascule was not considered viable because of the span length. A vertical lift span was not practical since the towers would need to be excessively tall to accommodate the high mast sail boats which pass under the bridge. A swing bridge was not viable since the swing span would reduce the already limited vessel queuing area that is available. The site could not practically accommodate a fixed span that was high enough for the boats that currently pass through the bridge. The required approaches for a fixed bridge would dominate the landscape and adversely impact adjacent intersections. The tunnel options were dismissed due to excessive cost. Preliminary engineering activity done previously on the project established the aesthetics of the structure as extremely important.

Aesthetic Bridge Design in Florida

The Florida Department of Transportation has three general levels of aesthetic consideration and effort which are designated as levels one to three with level three requiring the greatest attention to aesthetics. The FDOT District Office usually determines the level of aesthetic effort warranted on a project. This project was given a level three Aesthetic grading. Level three aesthetics includes structural shapes, systems and span arrangements that are inherently pleasing, such as oval or polygonal shaped columns, integral pier caps, piers in lieu of pile bents, smooth lines and transitions. In addition, level three aesthetics apply to the project surroundings and consider landscaping and unique architectural features of the community.

Design Charettes

This project has incorporated a "Design Charette" process to assure that the aesthetic concerns of both the FDOT and the Fort Lauderdale community at large are met. Two Design Charettes were held. The purpose of the first Design Charette was to review the existing site conditions, to evaluate the various design and architectural options, and to develop aesthetic criteria for design. Participants included representatives of the FDOT, the City of Fort Lauderdale, Broward County, local officials, concerned citizens, and the members of the E.C. Driver/Figg Engineers design team. Members of the project team presented views of the proposed bridge, ideas for structural shapes, shadow effects, vistas, architectural features, lighting and landscaping concepts. Topics discussed during the first Design Charette included:

- Architectural Themes
- Architectural Features
- Lighting Design
- Underdeck Area Usage
- Landscape Architecture

The following terms and phrases were identified as desirable attributes of the replacement bridge by the Design Charette members:

- Clean Lines
- Concrete
- White or Gray
- Contemporary
- Structural Simplicity
- Free of Adornment
- Thin and Elegant
- Understated Elegance
- Compatible with the Environment
- Each Element Important to the Whole

- Graceful and Simple

The second Design Charette was held to present the design team's concepts to the public and finalize the bridge aesthetic features.

For the second Design Charette, two bridge shapes with open and narrow bascule pier configurations were specifically developed to promote the openness of view for not only the traveling public but pedestrians and boat traffic as well. At the conclusion of the second Design Charette the design team was directed to go forth and develop a final design for their bridge that incorporates the following features:

- Carina Pier Bascule Design (defined in later section)
- Variable Depth Concrete Approach Span with Flared Piers
- Mudline Footings
- Pedestrian Overlooks
- Landscaping on the Retaining Walls
- Illinois Traffic Barrier & Architectural Pedestrian Rail

Aesthetic Bridge Design

It is well documented that aesthetic bridge design is not the result of simply using ornamentation, but achieved through design excellence (ref. 1). The two recommendations for achieving design excellence are that the bridge should be appropriate for its site and it should be structurally expressive. Several famous bridge engineers have summarized their comments on the first of these recommendations as follows:

> "We must respect the natural balance and form of our structures in a manner which leads to the least possible disturbance of the landscape. This is especially important if bridges are built near outstanding natural scenery," Werner von Olnhausen, Sweden

> "...We recognize the need to integrate a structure into its environment, landscape, or city scape, particularly where the dimensional relationships and scale are concerned...," Fritz Leonhardt, Germany

> "Structures should never be considered independent of their surroundings. Consequently, with few exceptions, they must be designed to compliment and exist in harmony with their settings," Christian Menn, Switzerland

> "Because a bridge is built in a certain environment, it should not only preserve the existing landscape, but should also complement its setting and even enhance it," Jean M. Muller, France

The following famous bridge engineer's have summarized their thoughts on the second recommendation for achieving an aesthetic design:

> "The structure also needs to reveal itself as a pure, clear form and thus impart a feeling of confidence and stability. Here, we must seek simplicity. The form of the basic structure must also correspond to the materials used. Brick masonry and timber each dictate different forms from those for steel or reinforced concrete," Fritz Leonhardt, Germany

> "An analysis of this kind would show the indivisible relationship that binds aesthetic expression to structural validity so tightly together that it becomes difficult to decide whether the creative impulse behind certain works of architecture, works that touch us for pure beauty, was an abstract aesthetic inspiration or a static-constructural idea," Fabrizio de Miranda, Italy

> "In this connection, however, it must be emphasized that the approach of designing a structure in accordance with engineering requirements, and then attempting to improve the appearance by minor alterations or by ornamentation, is to be decried in the strongest of terms. A beautiful design can only be achieved if the aesthetic design is developed as an essential part of the total concept. There must, therefore, be a full involvement of the architect, or whoever is consulted, from the very beginning, when the basic form is being conceived," A.C. Liebenberg, South Africa

We have attempted to meet the high level aesthetics required on this project by meeting these two criteria.

Typical Bascule Bridges and Aesthetics

Books on bridge aesthetic show very few movable bridges. Why is this? Typically, bascule piers are relatively wide elements in comparison to other types of bridge substructure elements (in the longitudinal direction of the bridge). As movable bridge designers are aware, standard bascule piers are typically wide because the counterweight of the bascule span is enclosed within the interior of the bascule pier along with the bascule span machinery and electrical equipment. As a result, the wide piers are blocky structures with poor aesthetic characteristics. The wide pier detracts from the proportions of the bridge which are governed by the pier height to span ratio, the pier width to span ratio, and the superstructure depth to span ratio. The wide pier width appears heavy leading to suggestions of structural imbalance.

Additional factors which limit the aesthetic appeal of bascule bridges are the discontinuity of the bridge superstructure at the interface between the bascule piers and the approaches and the bascule span superstructures which typically have less desirable aesthetic characteristics because of the busy network of floor beams, stringers and cross-bracing required. For the

17th Street Causeway Replacement Bridge, the designers have attempted to focus on these areas which limit the aesthetic appeal of bascule bridges in addition to prescribing to the criteria stated above.

Aesthetic Design for the 17th Street Causeway Replacement Bridge

A significant design study was performed for this project to develop a design which would be more aesthetically pleasing than a typical bascule bridge. A special effort was made in the design of the following elements:

- Bascule Piers
- Bascule Span Superstructure
- Approach Structure
- Bridge Coatings
- Traffic Barriers & Hand Rails
- Landscape Architecture

These elements were designed also to work together as a whole, so the total structure will be aesthetically pleasing.

Bascule Piers

Initially, the approach to developing an aesthetically pleasing bascule bridge was to attempt to narrow the pier in the longitudinal direction so that the pier width to span ratio would be smaller (Figures 2 and 3). In addition to narrowing the pier, placing transverse openings in pier was attempted. The reason for this was to give a lighter impression of the pier since such a large pier width was required to accommodate the wide roadway section. The narrow pier first proposed was a modified closed bascule pier. The counterweight extended beyond the pier (dual counterweights required outboard of the approach span); however, the interior of the pier enclosed the machinery and electrical equipment as in a conventional closed type pier. By removing the counterweight from the interior of the pier, it was possible to reduce the pier width. The disadvantages of the narrow pier option were that the bearing support for the approach span was more complex, a more complicated dual counterweight was required, the machinery and equipment areas were reduced, and the distance from the centerline of the trunnion to the live load shoe was minimized. Although this narrow pier option would have been an improvement aesthetically over the typical wide pier, the designers were not satisfied that they had achieved a bridge design that would qualify as a "Signature Bascule Bridge." The final solution was developed based on further study of the narrow and wide pier options.

This final pier configuration selected by the design team was the product of a search for an alternative design solution that would provide structural and visual continuity between the approach span and the bascule span structure. This pier element is V-shaped in the longitudinal direction (see Figures 4 through 6). This pier has since been named the Carina pier after the Latin word "carina" for the delta-shaped keel of a boat. As previously stated, bascule piers are typically wide elements in comparison to other types of bridge substructure elements for the reasons explained above. The major advantages of the wide pier are the simplified connection with the approach span and increased area for machinery and electrical equipment. The major advantage for the narrow pier is the more desirable proportions of the pier width as compared to the bascule span length. The pier innovation that was developed combines the structural and aesthetic advantages of both the wide and the narrow pier option. Structurally, this pier configuration incorporates an integral connection with the approach span concrete box superstructure to permit the base of the pier to be reduced to only 2.3 m (7.55 ft.) (approximately 1/3 the width of the narrow pier alternative). This gives the structure a lighter impression. Another major advantage of this option is the decreased bascule span superstructure length which is revised from 70 m (229.66 ft.) (based on a narrow pier configuration) to 64 m (196.85 ft.). This will result in savings for the machinery/electrical elements and a reduced counterweight. Also, the connection of the approach span at the Carina Pier will no longer require a maintenance prone expansion joint. The disadvantage for this pier configuration is the more complex pier erection. This pier type also accommodates large transverse openings in the pier. These openings are much larger than those for the narrow pier since an intermediate support was required for each approach span in that option. The openings in the Carina pier correspond to the width of the counterweight which will be exposed when the bridge is opened. As requested by the participants of the Design Charettes, pedestrian overlooks were incorporated into the bascule pier design. The outside faces of the Carina pier were flared out to accommodate the overlooks. This pier configuration will provide a strong unique element which will hopefully make the replacement structure a "Signature Bascule Bridge".

The inspiration for the pier shape selected for this project is developed from a V-shaped pier which was utilized for a railroad bridge in Germany (Main River Bridge Gemunden designed by Leonhardt, Andra und Partner of Stuttgart) (ref. 2). This railway bridge utilizes concrete box girder supported on integral V-shaped piers. It crosses the Main River Valley with a total length of 793.5 m (2603.3 ft.). The main span of 135 m (442.9 ft.) is the current world record holder for prestressed concrete beam for railways. The frame bridge with V-piers on concrete hinges was chosen because it permits the smallest beam depth of $\ell/30$ or 4.6 m (15.10 ft.) in the center for the given site conditions. This structure was much lighter than all other options investigated, thus disturbing the surroundings less. The chosen solution was the only option which was approved by the public living in the vicinity of the bridge. This bridge has received the prestigious German Structural Award (Ingenieur-Pries) in 1988. The awarding jury summarized their remarks as follows:

> “Taking into account the large loads from the high-speed railway trains an unobtrusive but unique structure was created which fits the surrounding landscape harmonically.”

Bascule Span Superstructure

A steel box girder system was chosen for its chief advantages which include high torsional rigidity, uncluttered beauty, and low profile. In addition, the box girder requires less maintenance because of its protected interior and uncluttered exterior. The box girder section was also chosen to complement the approach span box sections. This option provides significant aesthetic appeal over a plate girder system. The box girder also provides a location for the span lock mechanism which can be accessed for maintenance through the girder eliminating the need for exterior catwalks and platforms. Simple trunnions are chosen for this option to provide greater rigidity at the support when the span is open and under lateral loads. A closed deck was proposed to reduce traffic noise, and to provide a skid resistant riding surface. The closed deck also provides an improved riding surface for bicycles. The combination of steel box girders and exodermic deck also enabled the elimination of unsightly lateral bracing. The bascule span was designed such that with the leaf fully open, there is unrestricted vertical clearance at the fender system with the bridge raised. Typical of most bascule spans in Florida, the leaf for this bridge will utilize a forward load shoe.

Approach Structure

A large portion of the proposed 17th Street Causeway Bridge will be over land potentially with parking and pedestrian areas directly underneath. Multiple I-beam alternatives, both steel and concrete, were eliminated because they present an unsightly cluttered look below. The absence of a smooth solid under surface coupled with the overall width of the full depth superstructure required by this project would have detracted from the final aesthetics by eliminating the openness of structure necessary to enhance the pedestrian areas. Concrete box girders, on the other hand with their long cantilever overhangs and simple, uncomplicated, smooth lines provide very pleasing, open, elegant aesthetics even from directly below. Substructure components also figure into the aesthetic equation. Footings will be submerged or below mud line in order minimize the visual impact of the support structures. The piers will consist of rectangular sections that flare at the top to match the sloping walls of the superstructure box section. The flaring portion of the pier will incorporate triangular protrusions that, by casting sloping shadows across the pier face, will visually tie the element with the Carina Pier (see Figure 7).

Bridge Coatings

Overall, in keeping with the sleek and uncluttered appearance sought in the design, the structure will receive a light-grey textured coating to eliminate the form joints and color gradients inherent to formed concrete structures. The horizontal elements of the traffic barriers and handrails, the lighting fixtures, and the glazing of the tender's house windows present opportunities for introducing color into the architectural design scheme.

Control Tower

Currently, the design of the control tower is underway. Efforts are being made to integrate this element with the whole bridge.

Traffic Barriers & Pedestrian Railing

In an effort to provide more aesthetically pleasing traffic barriers and pedestrian railings, design studies were carried out. In the first Design Charette, it was requested by the participants that the barrier not be solid, but open, to provide improved outward views from the bridge. It was concluded, that based on the level of crash worthiness required on this project, that there were very few approved barriers with openings. With few barriers to choose from, the design team has chosen the steel Illinois barrier which consists of two horizontal rectangular tubes bolted to I-shaped posts which are mounted to a continuous concrete parapet. A special open pedestrian rail also has been designed by the Design Team and approved by the participants at the second Design Charette. This railing consists of round aluminum vertical posts which are curved inward at the top and connected by small diameter horizontal steel tubing providing openness and also a sense of security for the pedestrians

Landscape Architecture

Special attention is being given to the landscaping and land use in the project area. Plazas and additional parking are planned for the area below the east and west ends of the bridge. Palm trees and small shrubbery will be used to line the walking and driving avenues. A stairway will be provided on the west end of the project to lead pedestrians from the bridge sidewalk to the Convention Center. It is anticipated that the retaining walls will be covered with vines to de-emphasize the structure.

Conclusion

It is the opinion of the design team, that the 17th Street Causeway replacement bridge will be a “Signature Bascule Bridge”. The proposed bridge is appropriate for the site and is structurally expressive. The Carina bascule pier was the product of a search for an alternative design solution that would provide structural and visual continuity between the approach span and the bascule span structure. The shape of the Carina Pier allows the relocation of the trunnion point inward towards the channel centerline, shortening and lightening the bascule span in the process. Additionally, the Carina Pier will provide a strong unique element worthy of a "Signature Bascule Bridge". Other elements of the bridge have been designed to complement the Carina pier and provide an aesthetically pleasing whole.

References

1. Burke, Martin P., "Achieving Excellence in Concrete Bridge Design," Concrete International, August 1995, pp. 34-38.

2. Leonhardt, Andra und Partner, Incrementally Launched Bridges, unpublished text, Stuttgart, Germany.

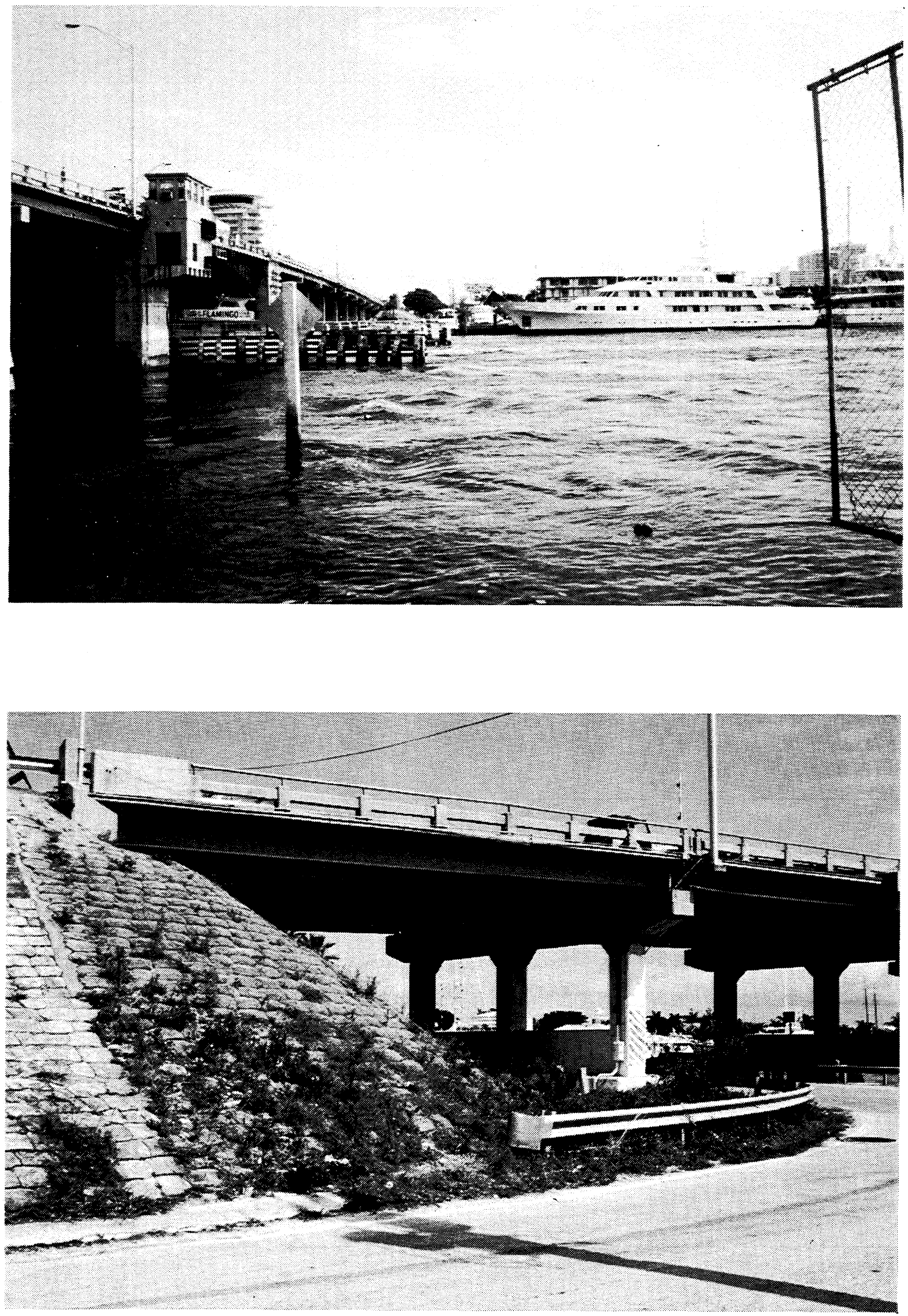


Figure 1
Photographs of Existing 17th Street Causeway Bridge

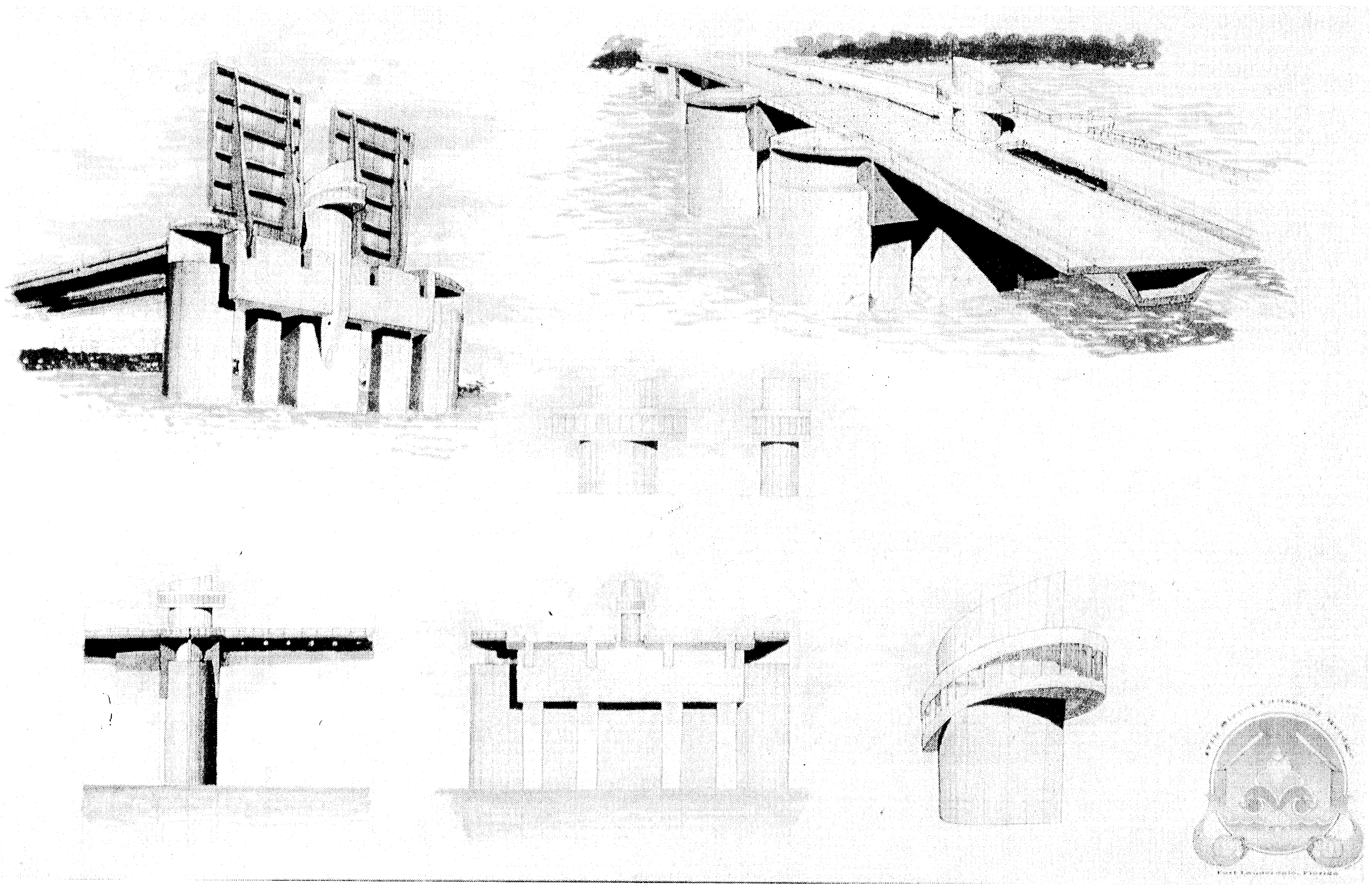


Figure 2

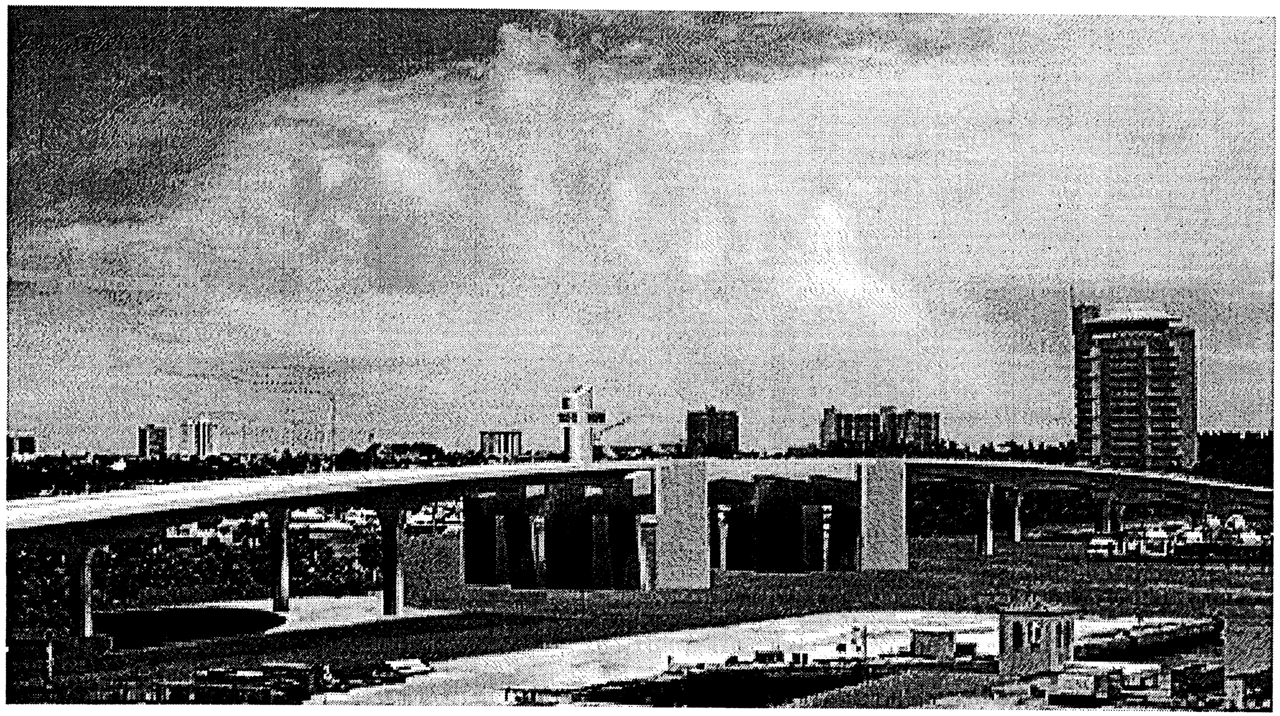


Figure 3
Computer Generated Rendering of Narrow Bascule Pier Bridge

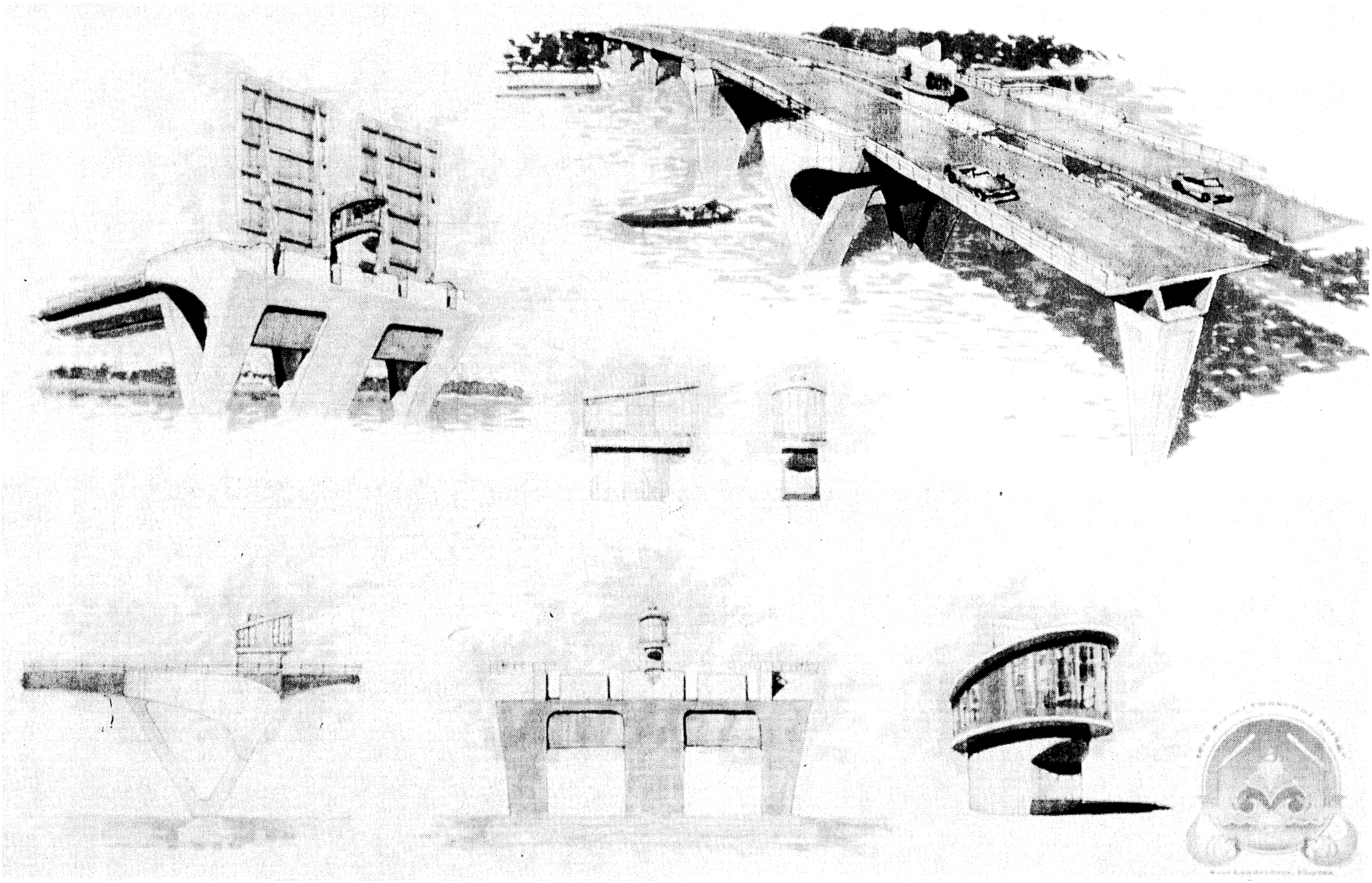


Figure 4

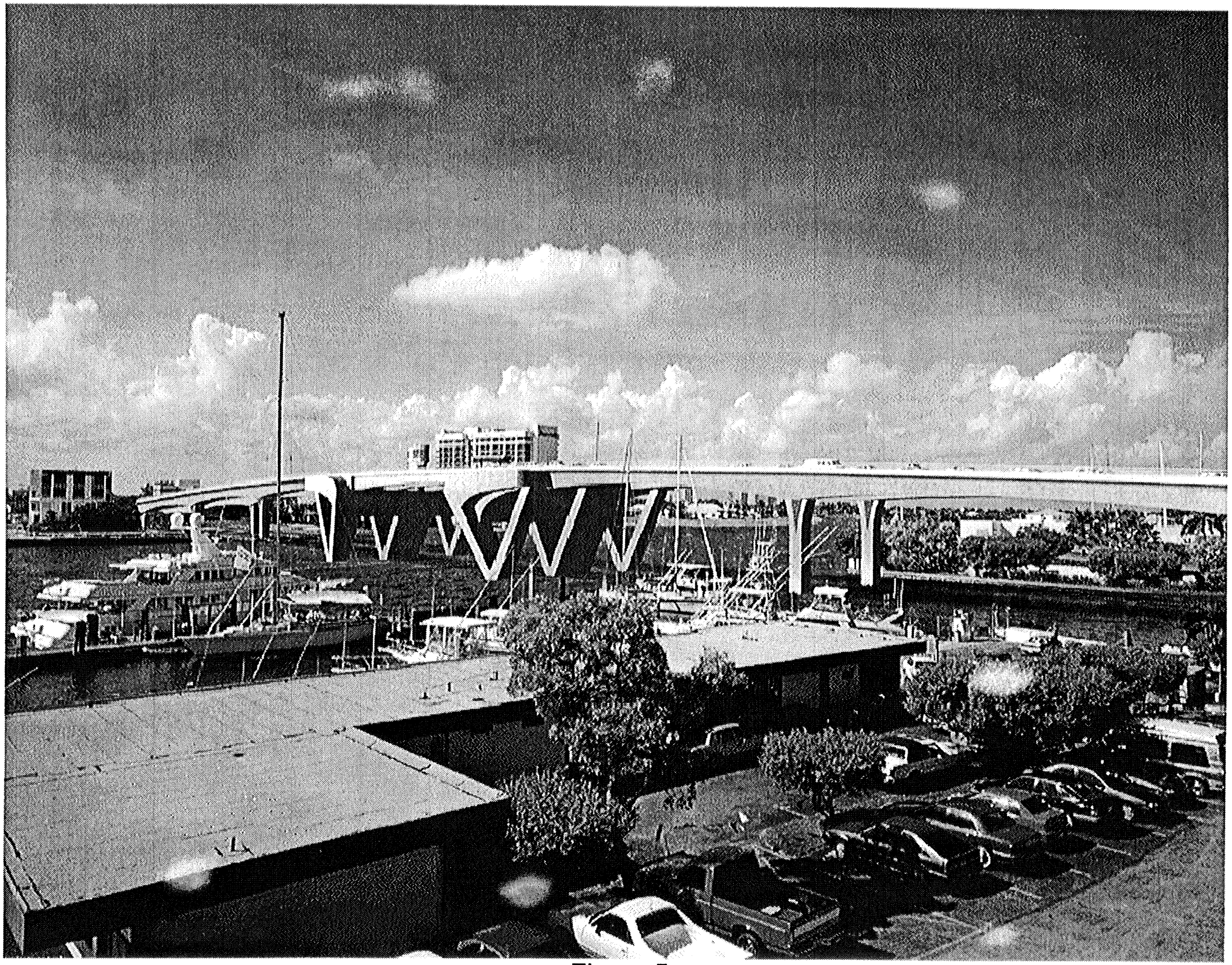


Figure 5

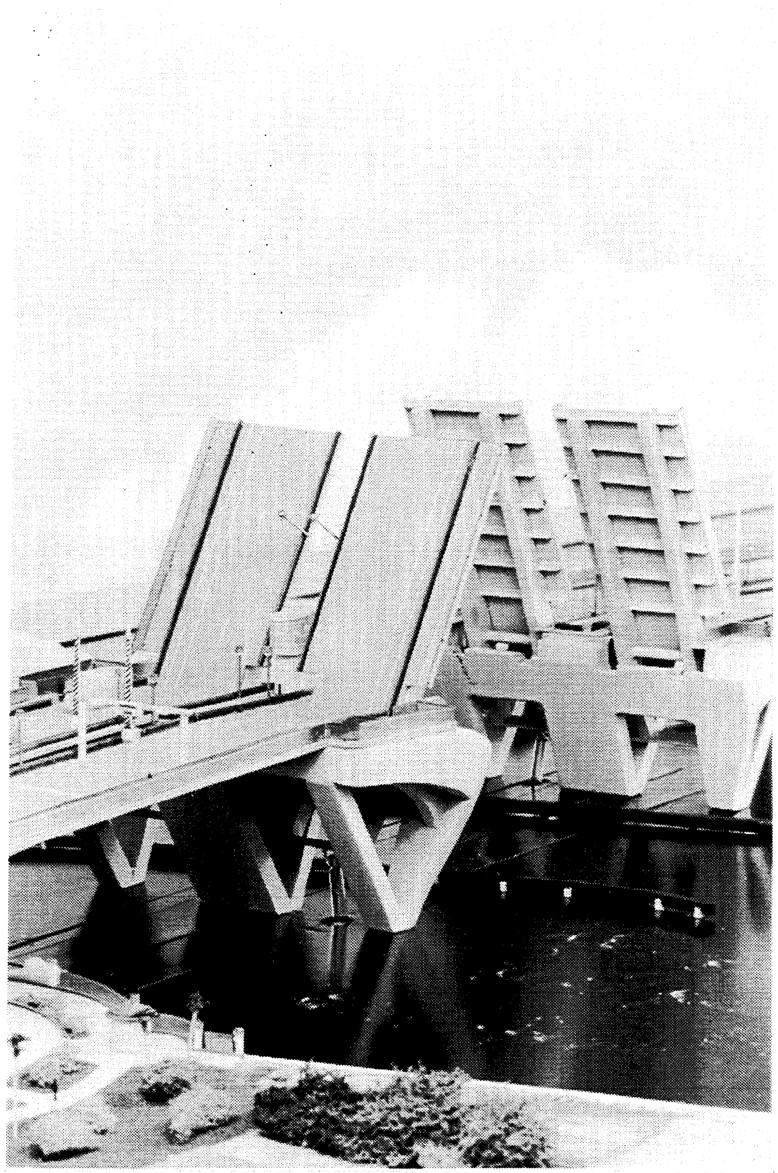
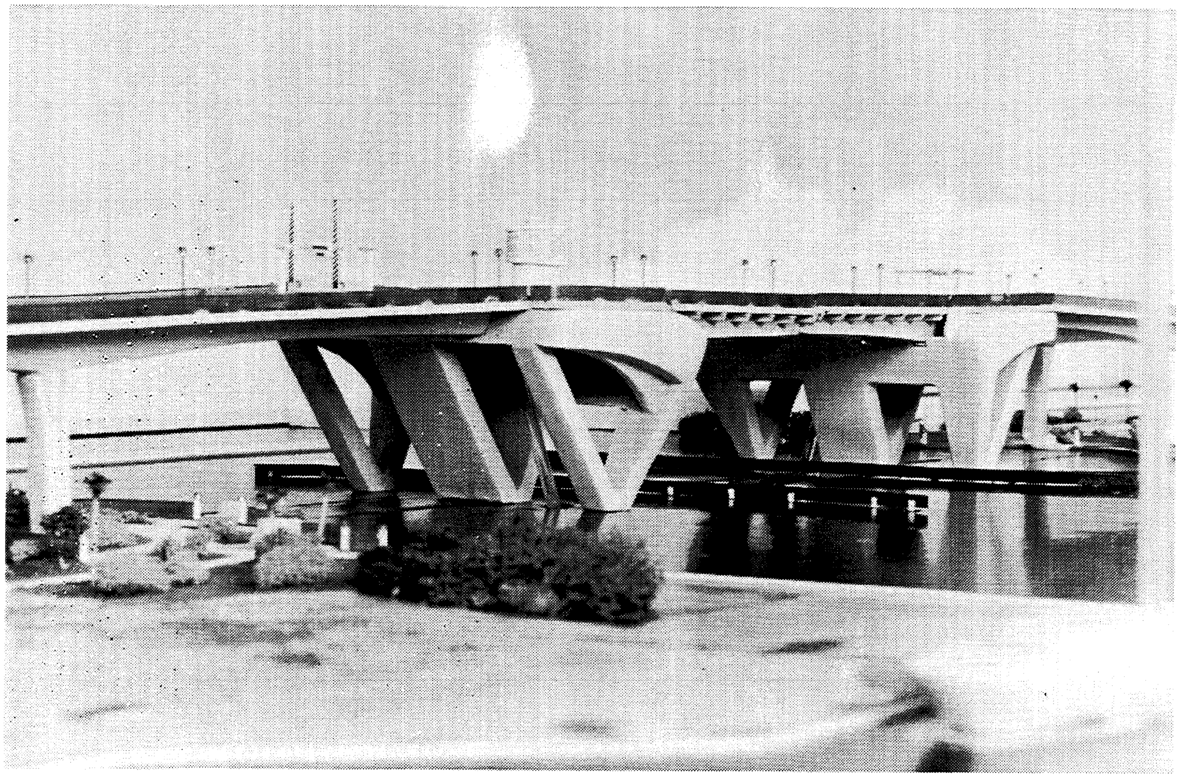


Figure 6
Photograph of Carina Bascule Pier Bridge Model



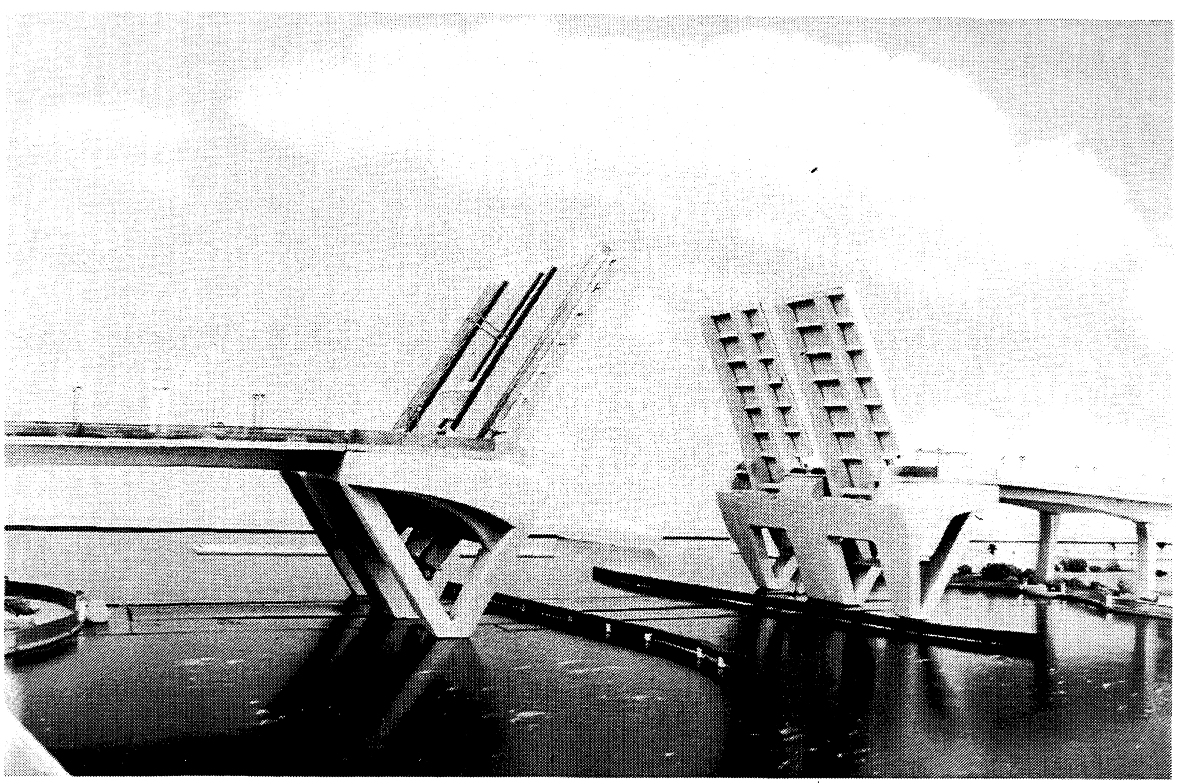


Figure 6 cont.
Photographs of Carina Bascule Pier Bridge Model

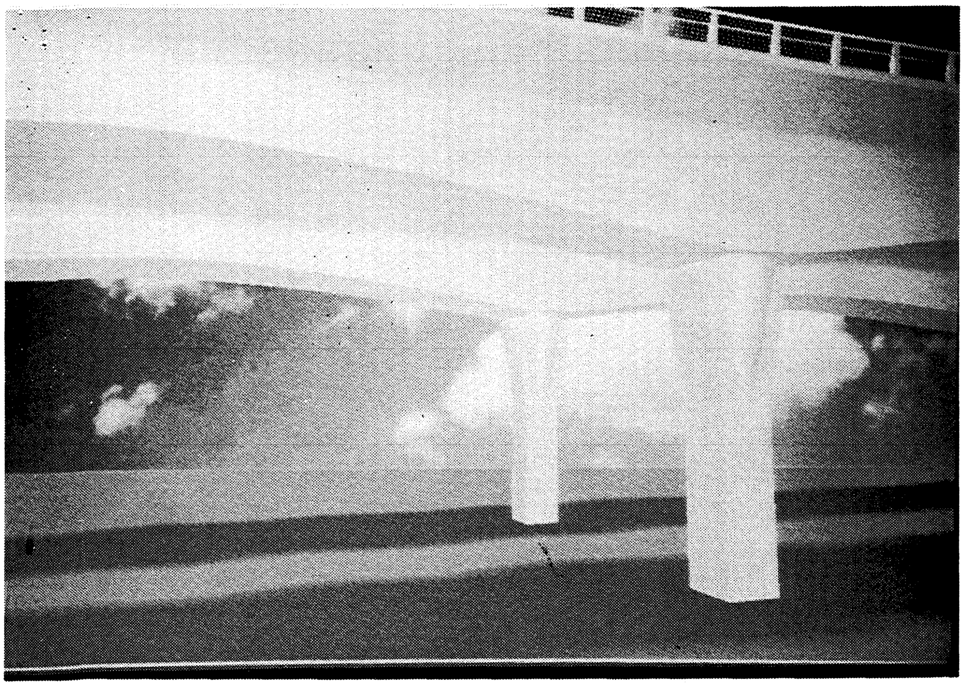


Figure 7
Computer Generated Rendering of Approach Structure