Heavy Movable Structures, Inc.

SEVENTH BIENNIAL SYMPOSIUM

November 4 - 6, 1998

Grosvenor Resort
Walt Disney World Village
Lake Buena Vista, Florida

"Replacement of the Ocean Avenue (SR 804) Bascule Bridge"

by

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Introduction

This Project was first presented at the Heavy Movable Structures Symposium in 1996 by the Project Manager. At the time this unique aesthetic and structural design solution for the Ocean Avenue Bridge crossing the Intracoastal Waterway between the City of Boynton Beach and Town of Ocean Ridge in Palm Beach County, Florida was presented, the project was in the preliminary design phase and several issues were still unresolved.

Identified as a priority replacement project over 25 years ago this project was a political "hot potato" due to the conflicting interests of the two municipalities, the local residents and commercial property owners and changing priorities with the local MPO and the Department of Transportation.

After an alternative alignment was denied a permit by Florida's Department of Environmental Protection, the only feasible alternate available was a replacement on the existing alignment. A fixed, high level (19.8 m (65') vertical clearance) and mid level (10.7 m (35') vertical clearance) bascule bridge were studied but both would have had very significant impacts upon the residential and commercial properties along Ocean Avenue. A low level (6.4 m (21') vertical clearance) double leaf bascule was chosen as the preferred alternate and the Department prepared a Project Development and Environmental report and obtained a Finding of No Significant Impact from the FWHA [1] based upon an Environmental Assessment performed by the Department.

In January, 1995 the Department advertised for a consultant to perform the final design of this project. In February, 1995 after a competitive technical proposal, A.G. Lichtenstein & Associates, Inc. was selected. Our design team included:

Roadway & Drainage Design	- Biscayne Engineering, Inc.
Landscape Architect	- Edward D. Stone Jr. & Associates
Architect	- Robert G. Currie Partnership
Geotechnical	- L J Nodarse & Associates, Inc.
Surveying	- Stoner & Associates, Inc.

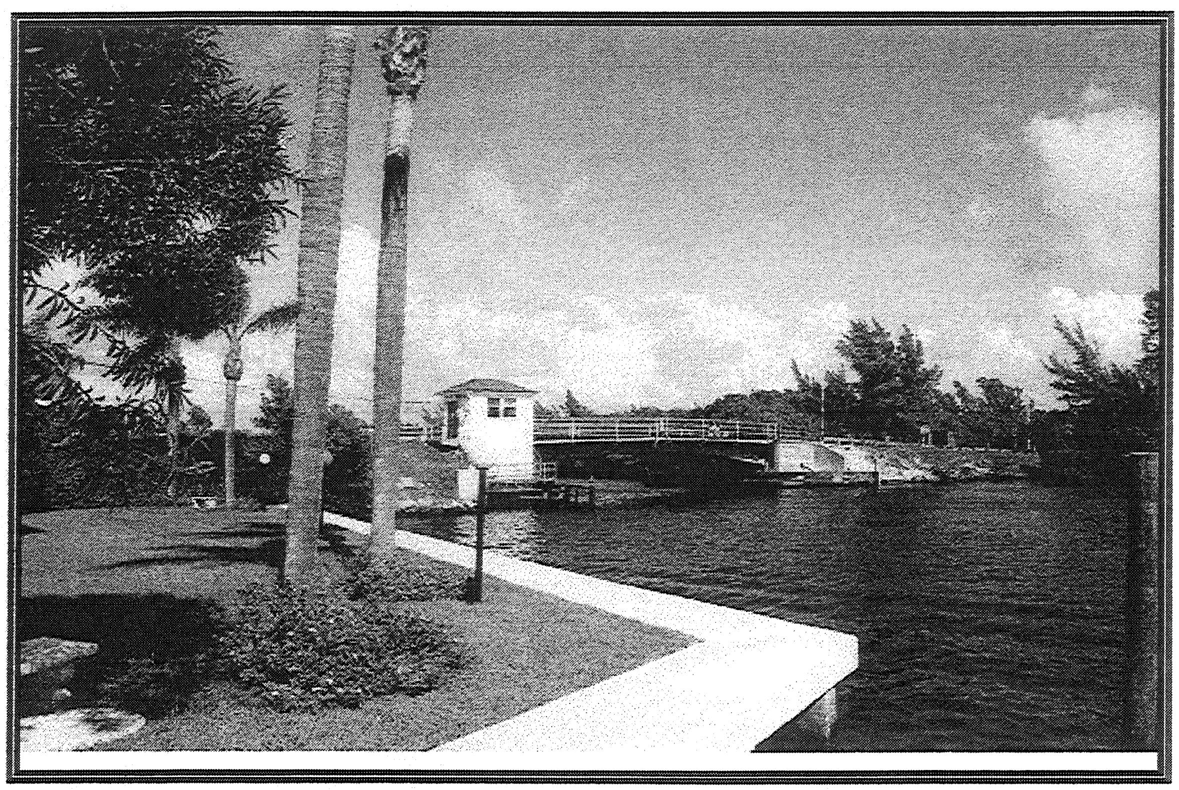
Lichtenstein performed the structural, mechanical and electrical engineering of the bascule spans, in-house.

[1] Ref: "Administrative Action- Finding of No Significant Impact" - FHWA Region 4, dated February 13, 1995.

The Final Design was completed in May 1998 and the bids for construction were due on July 29, 1998. The low bidder was The Walsh Group. The CEI will be performed by URS Consultants and Lichtenstein, along with their subconsultants will provide the necessary support services during construction.

The Site

The existing Ocean Avenue alignment is the result of a major widening project built by the State in 1968. From US 1 to the Intracoastal Waterway (ICWW) in Boynton Beach and from the ICWW to A1A in Ocean Ridge the existing approaches are 2 lanes in each direction with a center turn lane and parking lanes down both sides, flanked by sidewalks, all within an existing 27.4 m (90') right-of-way. The existing bridge and approach causeway within the limits of the ICWW consists of two narrow lanes with sidewalks, quite a contrast. The existing bridge was constructed in 1936 by Palm Beach County and is a double leaf rolling lift bridge fabricated by Scherzer Bridge Co.



Existing Bridge - South Elevation

The existing bridge provides 24.4 m (80') of horizontal clearance between fenders and 3 m (10') (max) vertical clearance with the bridge lowered. This requires frequent openings which have been tolerated due to relatively low (8400 ADT) traffic volumes. The construction of this bridge predates the dredging of the ICWW by the Army Corp of Engineers (ACOE). As such, the navigation opening is located approximately 9.1 m (30') west of the centerline of the ICWW. (Figure 1).

The bridge is severely deteriorated with a current NBIS Sufficiency Rating of less than 10. The bridge undergoes monthly inspections and requires continual maintenance and repair, a condition exacerbated by its frequent openings. (3 openings per hour on average).

The latest emergency repairs were performed in early February 1998 by a FDOT Maintenance Crew. The repairs required the bridge to be closed to vehicular traffic for more than a week. During this time, repairs were performed on the structural framing of the east leaf.

Due to the severe condition of the existing structure and the importance of the corridor to both communities, the City of Boynton Beach and the Town of Ocean Ridge requested FDOT advance the construction contract and try to replace the bridge as soon as possible.

The State revised the construction sequence to accommodate the communities' request. They will close the bridge to vehicular traffic from Day One of construction. Initially, the existing bridge would have remained opened for the first six (6) months of construction. This change should reduce construction time by three (3) months.

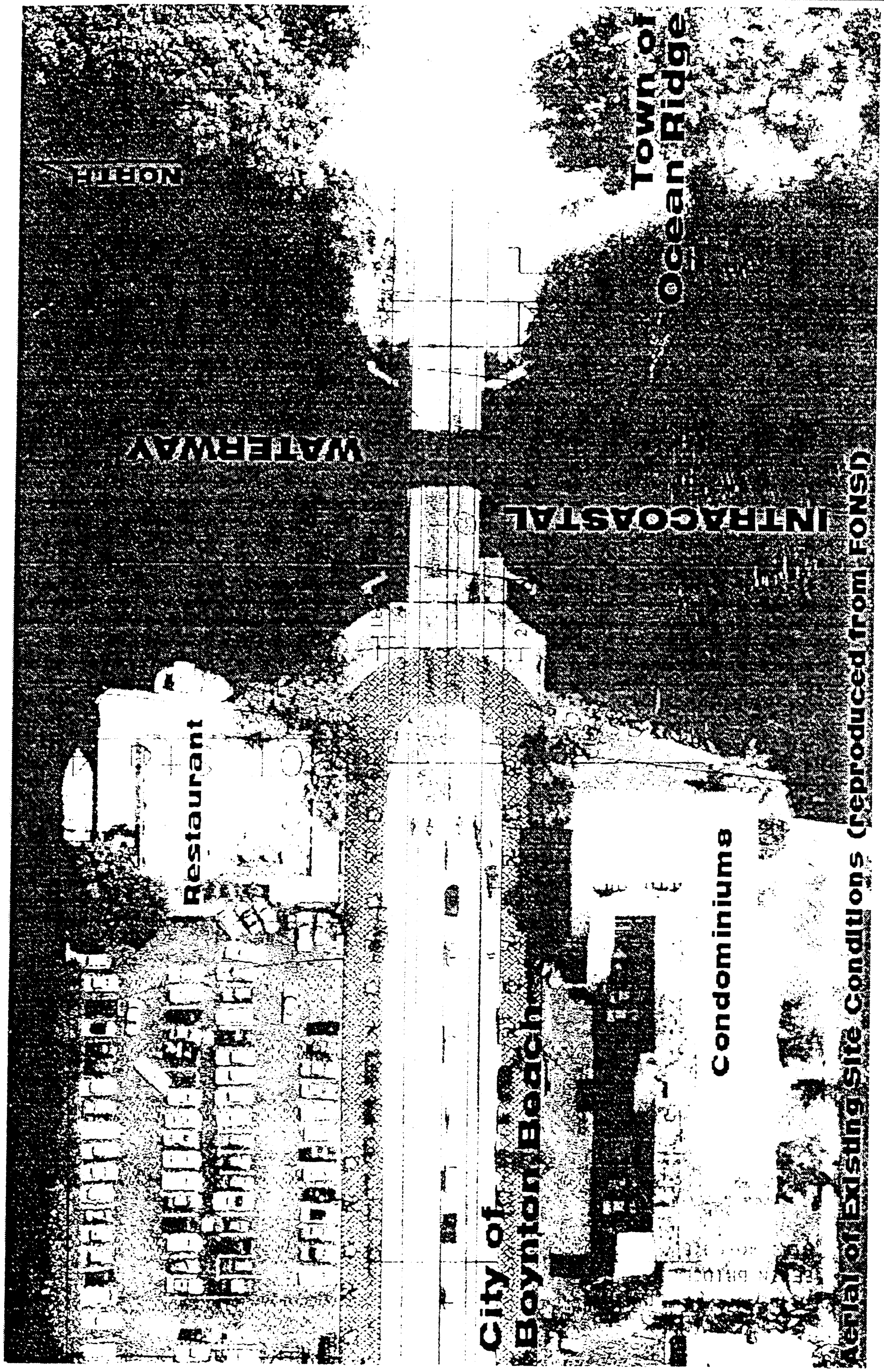

NORTH
Town of
Ocean Ridge
WATERWAY
INTRACOASTAL
Restaurant
Condominiums
City of
Boynton Beach
Aerial of Existing Site Conditions (reproduced from FONSI)

Figure 1

The bridge approaches are on fill, which has been exposed by the increase in width of the ICWW in the early 1960's. Severe erosion of the fill surrounding the bridge is evidenced by the extensive rubble rip-rap which has been placed over the years. Underlying the approaches on both sides of the ICWW is a variable depth layer of peat (muck) which is 3 m to 3.7 m (10 to 12 ft.) thick adjacent to the edge of the ICWW. (Figure 2).

On the Boynton Beach approach several properties abut the right-of-way from US 1 to the ICWW. These properties include a mid-rise condominium building and a popular restaurant both built on timber piling of unknown condition. The Ocean Ridge approach is flanked by single family housing on large lots, several of which are being demolished for slope easements.

<u>Community Opposition</u>

The history of community opposition to this bridge goes back over 25 years and is not the subject of this paper. However, after the Project Development and Environmental (PD&E) phase of the design was completed in-house by District 4, both the local governments agreed to the in-situ replacement. In compensation, the Department agreed to several areas of mitigation, including:

- A solid deck on the bascule span to reduce wheel "hum".
- A linear park "promenade" on the Boynton Beach end to encourage public access to the water's edge.
- A reduction in roadway width to one thru lane in each direction from US 1 to A1A with appropriate right-turn, left-turn and center turning lanes. In addition, a bike lane will be provided for both directions from end to end of the project.
- Extensive landscaping and aesthetic treatment of the bridge structure. This was of particular importance to Boynton Beach as they are looking to this project and an adjacent marina development to spur a downtown renaissance.

Despite the Department's commitment to considerable mitigation costs there remained community opposition to the proposed plan and profile. The opposition centered around the height of the new profile grade necessary to achieve 6.4 m (21') of vertical navigation clearance over the ICWW channel with the bridge lowered. Also, the size and scale of any new bridge was seen as being detrimental to both communities' residential qualities.

Reduction in Profile with Thru-Girder Design

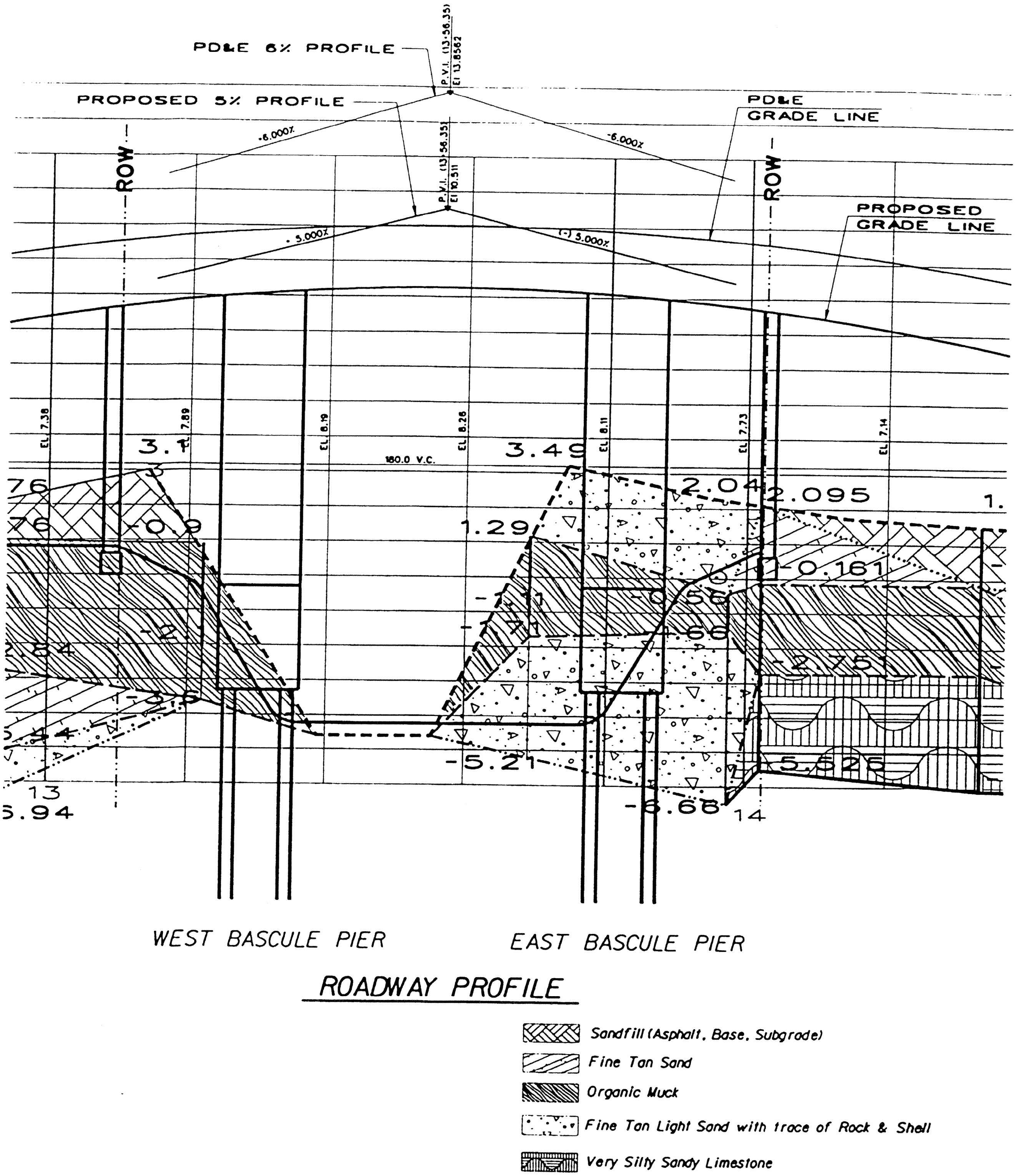


Figure 2

In order to maintain all sides engaged in the process and to achieve a consensus of opinion, the Department committed to working with a Task Force consisting of several members of both communities. These members were chosen by the local governments to represent the many divergent interests in their respective communities.

Moving Target

Between the dates when the final design contract was advertised and the Notice to Proceed was given the level of difficulty for the design increased. The PD&E document assumed a 27.4 m (90') horizontal navigation channel width; however, the USCG and Florida's Inland Navigation District (FIND) have determined that all new bridges over the ICWW on the east coast of Florida should provide 38.1 m (125') of horizontal navigation clearance with 6.4 m (21') of vertical clearance in the lowered position. An exception will be made only when achieving those dimensions is not feasible.

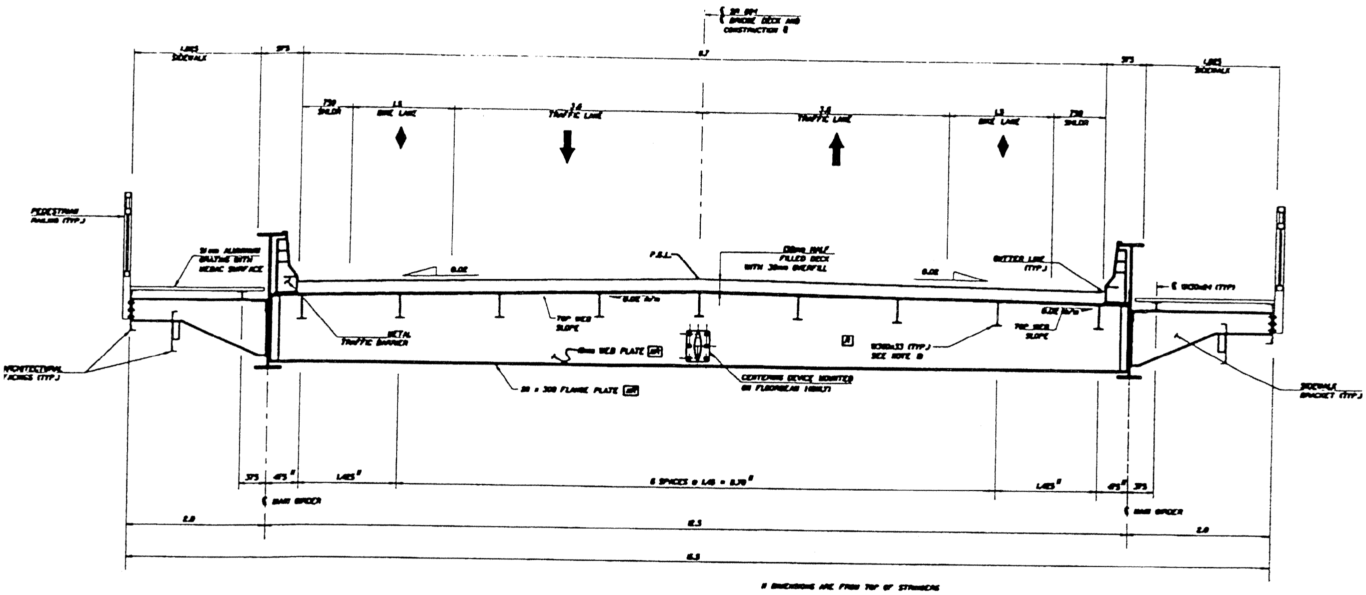
Our design team was instructed to study both span lengths and compare the costs and benefits of the two alternates.

Design Concept

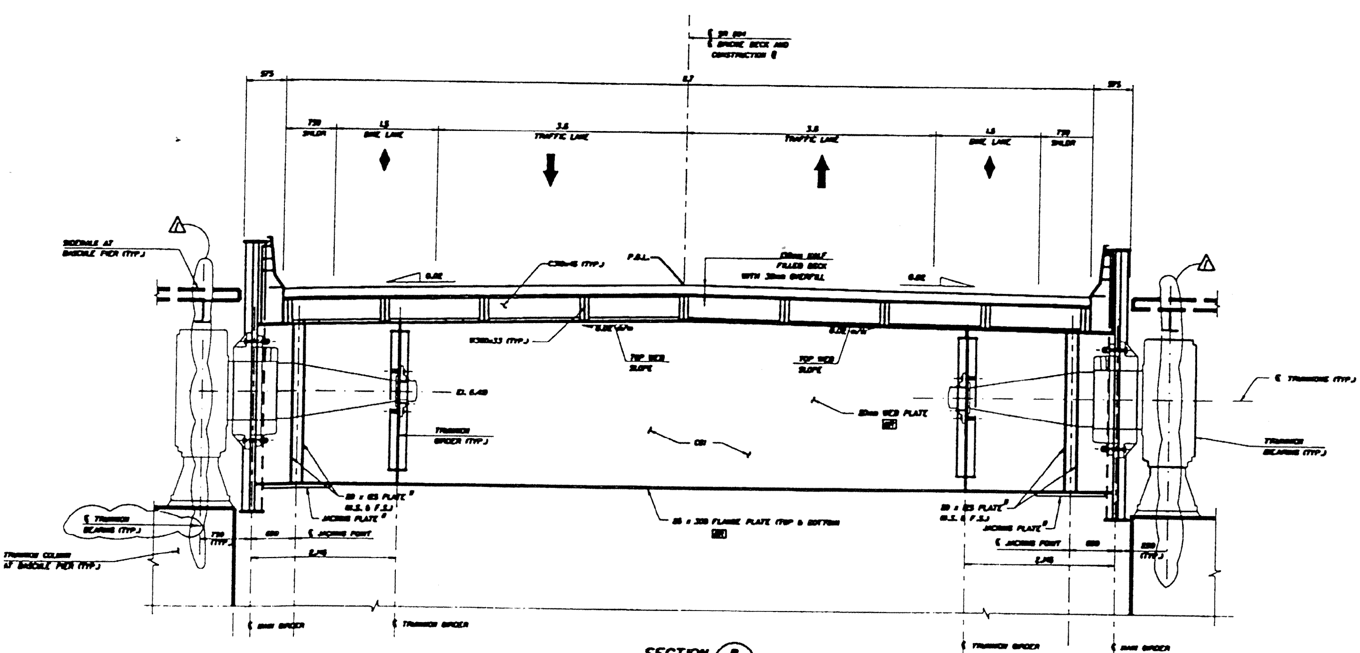
The method of selection for this contract involved a competitive written technical and oral proposal. From the beginning it was clear to us that the key to obtaining the design contract and to reducing public opposition was to provide a bridge at a lower profile grade than that shown in the Department's PD&E document.

We performed a preliminary design of the bascule span to determine that our concept would work and we prepared preliminary design layouts and a photographic rendering of the bridge, all prior to presenting our proposal.

The innovation which won us the design and which continued to be the basis for both the 27.4 m (90') and 38.1 m (125') channel alternates is the use of a thru-girder design for the bascule spans (see Figure 3).



SECTION A



SECTION B

Figure 3

In a thru-girder span the effective span depth from top of roadway to underside of the framing (clearance point) is set by the depth of the floor framing, not by the depth of the main load carrying girders. We determined that a 1.0 m (3.3') depth from the P.G. line was sufficient to span between the two girders, which would be located at the edge of roadway with the sidewalks bracketed off the outside face. By setting the vertical grade 1.0 m (3.3') higher than the vertical clearance tight points at the face of the fenders we were able to lower the profile grade 1.8 m (6') from the preliminary design (see Figure 2). This represented more than a 20% reduction of overall height. An additional benefit was that we were able to use 5% max slopes on the approaches which kept the sidewalks within the confines of the ADA without the need for design exceptions or "rest" areas.

The depth of the two thru girders was set by the depth of the floor framing and the height of the standard "F"- shape traffic barrier 0.815 m (2'-8") which separates the girder from the roadway. Using this overall depth of 1.90 m (6'-3") we have optimized the girder web and flange plates for economy of material. (Figure 4).

Another wrinkle in the design was the 7° 15' skew between the centerline of Ocean Avenue and the centerline of ICWW. We decided that for aesthetics and to keep the design as simple as possible, the two leaves would be square to the centerline of Ocean Avenue, but for reasons of hydraulic opening and scour that the bascule piers would parallel the ICWW.

As can be seen from the longitudinal section (Figure 4), adopting the thru girder configuration dictated several other design features:

- The counterweight length was originally set to keep the tail dry. This was feasible for the 27.4 m (90') alternate, but would have resulted in an extremely dense (300 pcf) counterweight for the 38.1 m (125') alternate. The Department required that we keep the counterweight in a normal density range to facilitate future balancing. A longer counterweight meant that a counterweight pit would be required.

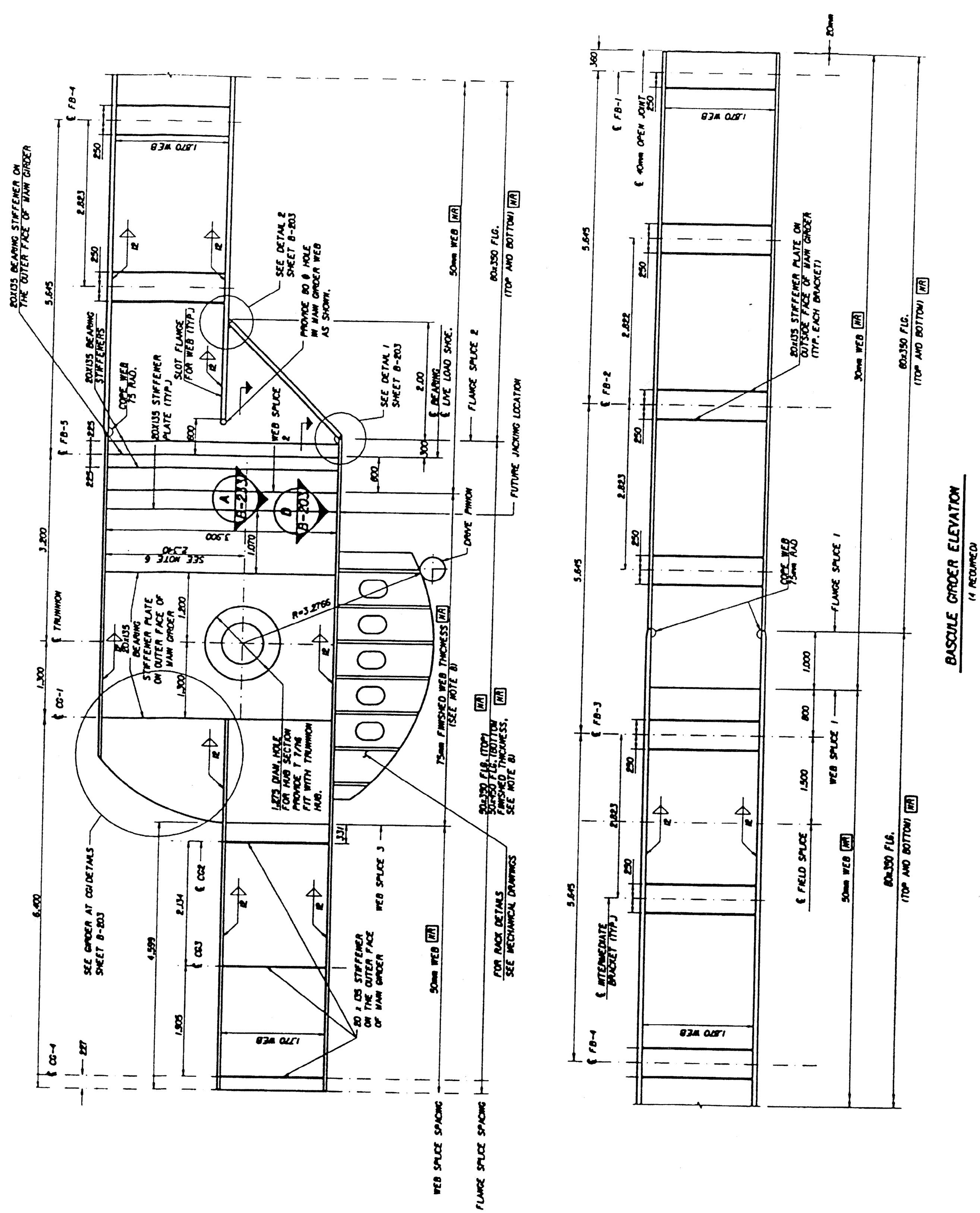


Figure 4

- This, in turn, imposed another set of design considerations. To keep the pit dry, the backwall had to extend high enough to keep out normal high tides and overwash (waves and wakes). The clearance line of the swinging counterweight dictated where the wall must be located to achieve a height of 0.96 m above MHW, which is the 10 year flood elevation. No increase in pier size beyond this minimum could be tolerated due to aesthetics, stream hydraulics and scour around the large piers. This wall height will subject the counterweight pits to periodic inundation. The interior pit wall elevation adjacent to the machinery floor was set at elevation 2.75 m. This elevation is higher than the greatest flood record for this location. This will ensure that the machinery floor and machinery will remain dry even if the pit floods. The pits will be provided with normal sump pumps for seepage, rainwater and overwash, but for the greater than 10 year storm event a large operator-controlled pump will be provided to allow the pit to be emptied quickly after the storm water level subsides. They will be wired so that the emergency generator can be used if shore power is lost. If, however the storm tide condition should persist, it will still be possible to open the spans approximately 37° without dipping, which should provide sufficient navigation opening for anticipated marine traffic. (Figure 5 & 6).

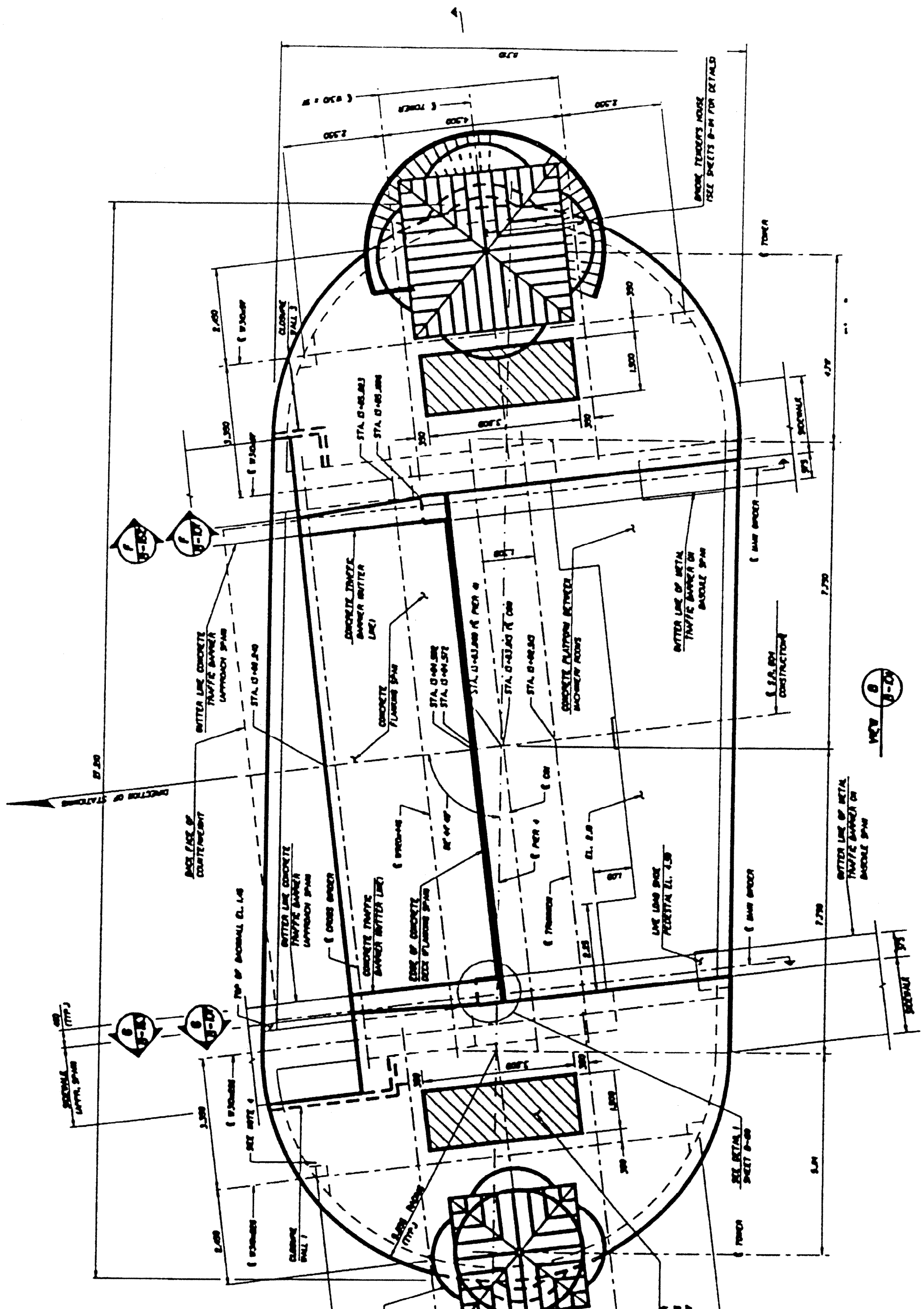


Figure 5

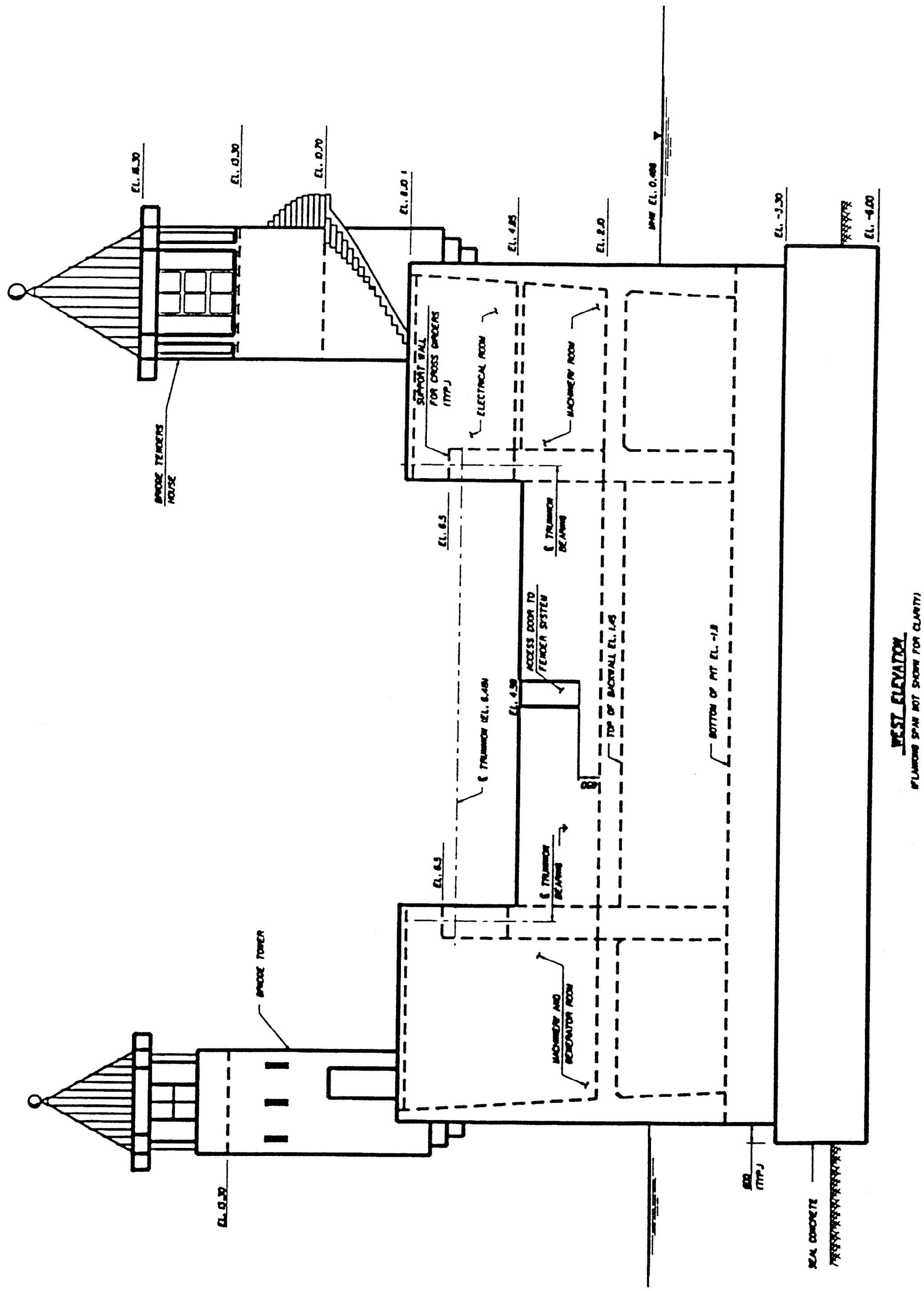

BRIDGE TENDERS HOUSE
BRIDGE TOWER
ELECTRICAL ROOM
MACHINERY ROOM
WEST ELEVATION
SEAL CONCRETE

Figure 6

- Another design issue which results from the thru-girder arrangement is the type of trunnion and trunnion supports. The counterweight girders will swing below the centerline of the trunnions when the bridge is fully raised. This precludes a simply supported trunnion arrangement so that an overhanging (or "Hopkins") trunnion with a trunnion girder will be used. Both conventional sleeve bushings and a spherical bushing were studied. A spherical journal/bushing was selected because the spherical journal/bushing gives a better alignment.

- The fourth major design issue which results from the thru girder arrangement is the configuration and location of the operating machinery and gearing:

  The rack gear was determined to have an optimal radius of 3.276 m (10.75') for the size and weight of leaf. The only feasible location(s) for the rack to be mounted was the bottom flange of the bascule girder or the bottom flange of the trunnion girder. This provided very limited choices as to location of the pinion and main drive shaft due to pier configuration and storm tide elevation. After studying several combinations, the rack/pinion arrangement shown in Figure 7 was determined to be the optimum layout. From this point, three options were studied for driving the pinion gear:

  1) Centrally mounted, twin 75HP motors thru a single primary reducer/differential and two secondary reducers.

  2) Centrally mounted twin 75 HP motors, individual primary reducers and secondary reducers interconnected electronically.

  3) Outboard mounted, separate 75 HP motors, primary and secondary reducers, interconnected electronically.

  Option 3 was chosen for the following reasons:

  1) All equipment would be interior to the piers, placing it out of the weather and away from roadway debris.

  2) Maintenance access was much better than either centrally located option.

  3) Clearance problems for Options 1 or 2 would require the secondary reducer box to be non-standard.

During the final design, the 75 HP motors were reduced to 60 HP motors because of the Spherical Roller Bearings chosen for the trunnion bearings. These bearings provide less friction thereby reducing the power requirements.

The machinery layout will be as shown in Figure 7 and 8. One of the benefits of the aesthetic bridge design was the ample space provided in the piers which was put to use for machinery rooms.

The machinery was sized for this project to provide redundancy in the mechanical systems. The Department wanted the ability to work on the machinery for maintenance or repairs without affecting the normal operation of the bascule span. Therefore, the motors selected have the ability to raise the leaf completely with only one motor in operation. The only detrimental effect will be a minor increase in opening time (10 seconds). Single motor operation can be achieved by simply disengaging the coupling between the rack pinion and the secondary reducer on one side.

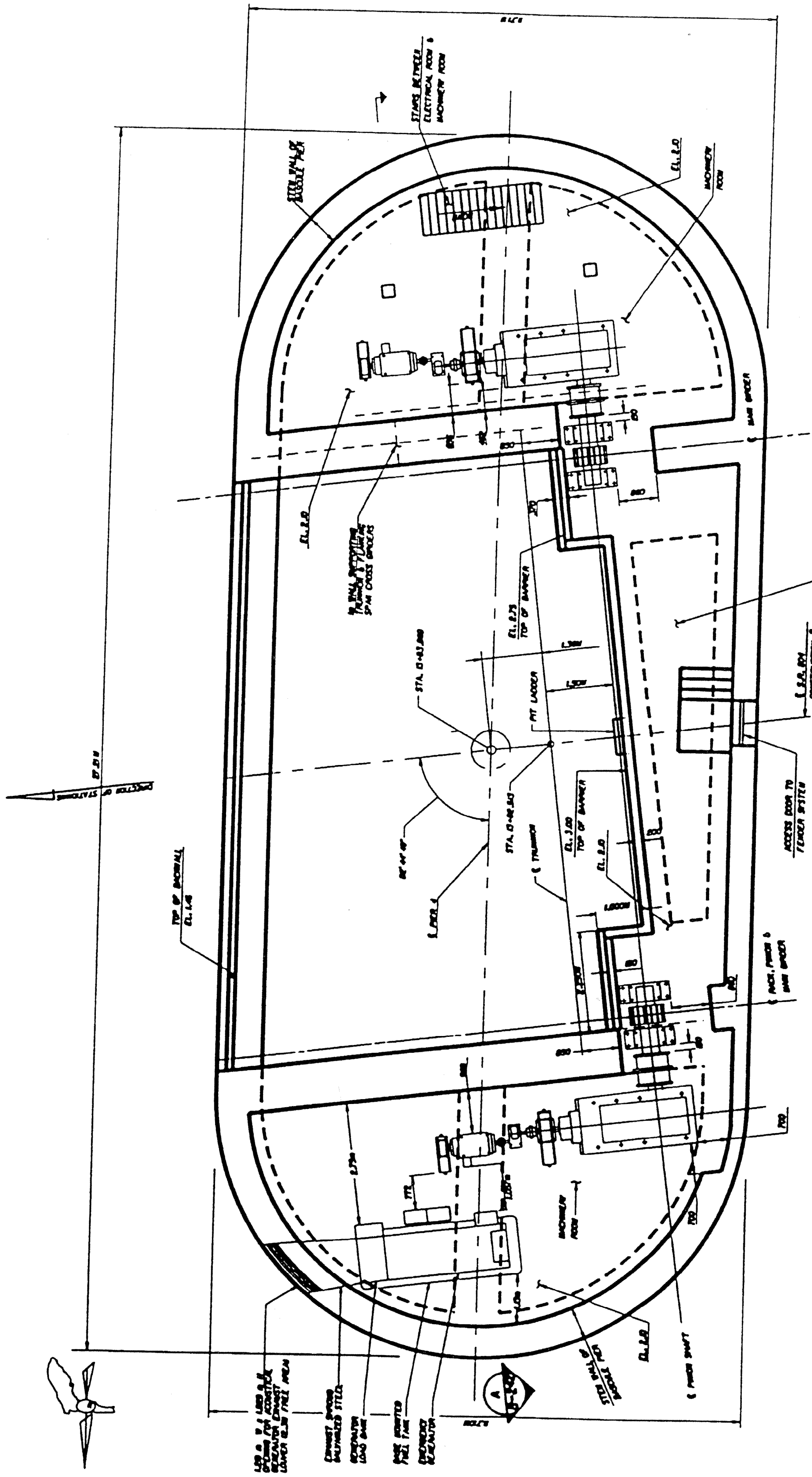


Figure 7

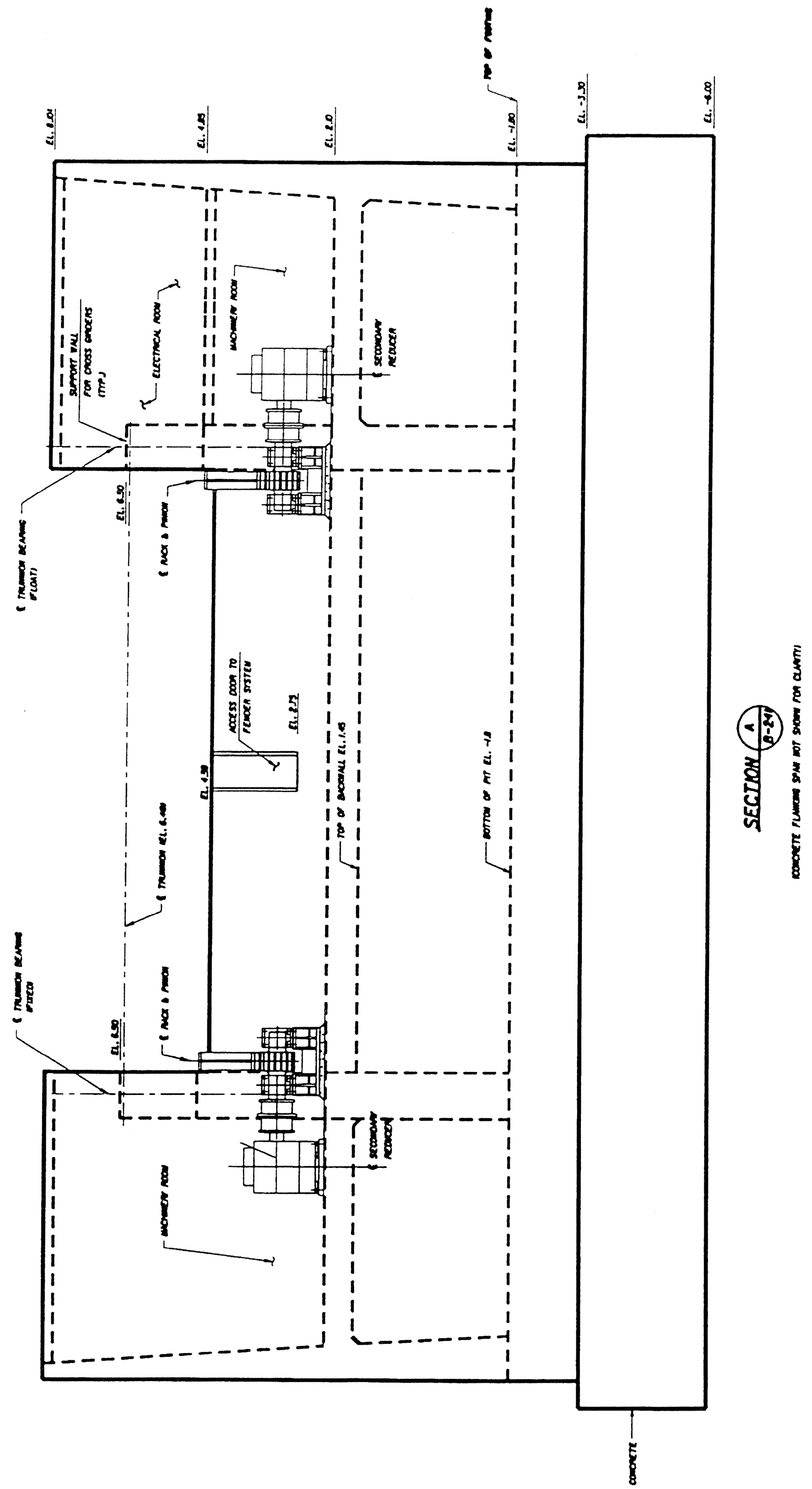


Figure 8

Bascule Piers and Towers

The width of the bascule piers was determined by the skew and the need for an enclosed counterweight pit. The circular ends were originally chosen for aesthetics and scour, but the space provided has become both the machinery room and the electrical room. The towers are the defining "signature" of this bridge. They are intended to be a gateway between the City of Boynton Beach and the Town of Ocean Ridge. The community Task Force liked the towers but wanted them kept "light" and unimposing. The Department, on the other hand, wanted the operator's house to be a large structure with a regular staircase (as opposed to a ship's ladder) running to all floors. These goals seemed to be mutually exclusive until the concept of the external spiral staircase was proposed. Although it does require maintenance personnel to step outside to change floors it does meet the other goals and is even considered to enhance the aesthetics. (Figure 9).

Deck Alternates

Three alternates for the solid deck of the bascule span and the floor framing were considered:

1) 127 mm (5") - 4 way grid deck, half filled with lightweight aggregate concrete with a 38 mm (1½") wearing surface, composite with steel stringers and floorbeams. (See Figure 10)

2) An "Exodermic" deck, utilizing lightweight aggregate concrete supported on stringers and floorbeams. (See Figure 10)

3) An "Exodermic" deck, as above, but eliminating the stringers and spanning from floorbeam to floorbeam, and considering composite action with the floorbeams.

Based on the weight of the leaf and the cost estimate performed during the Phase I submission, Alternate 1 was the optimum design.

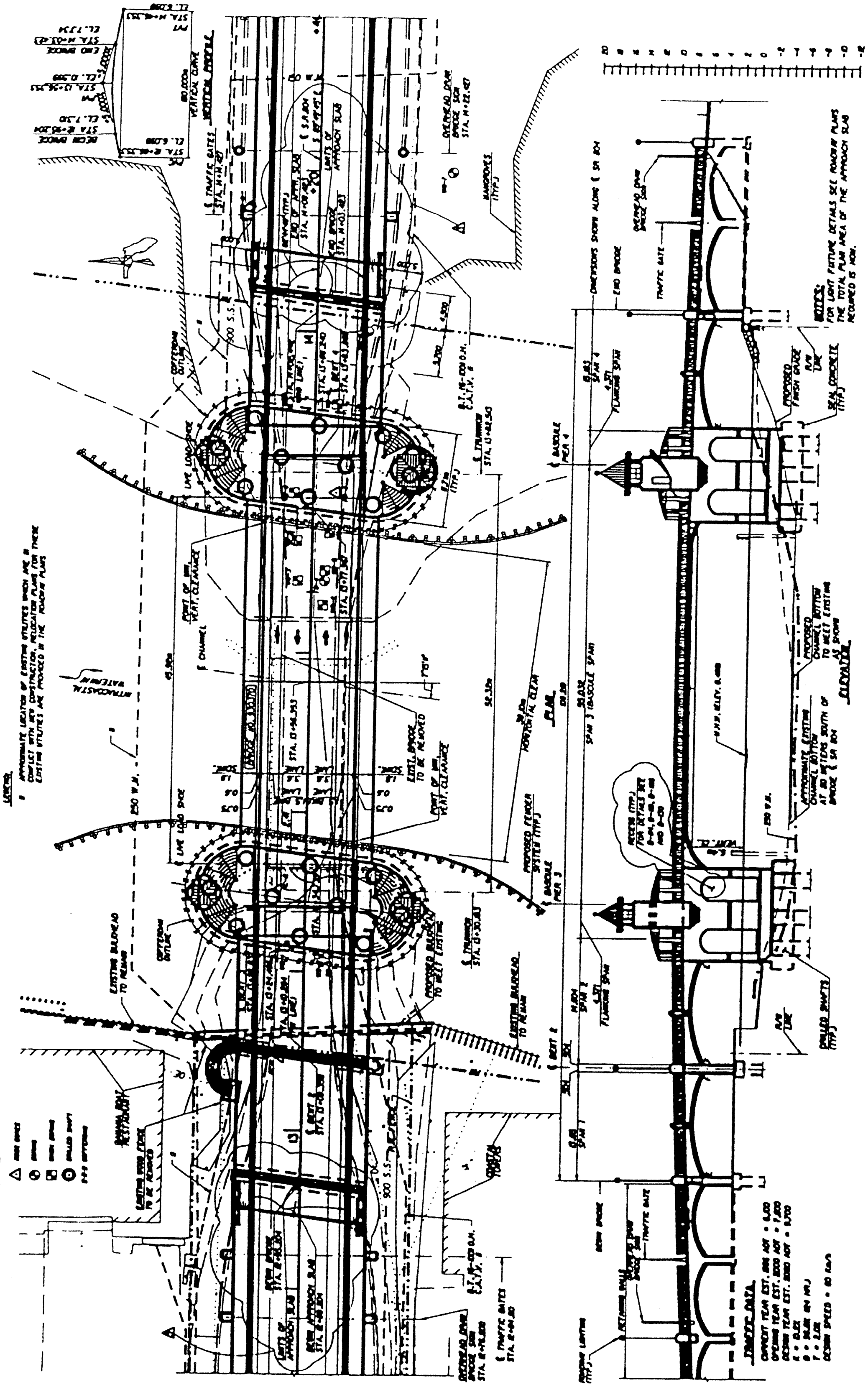


Figure 9

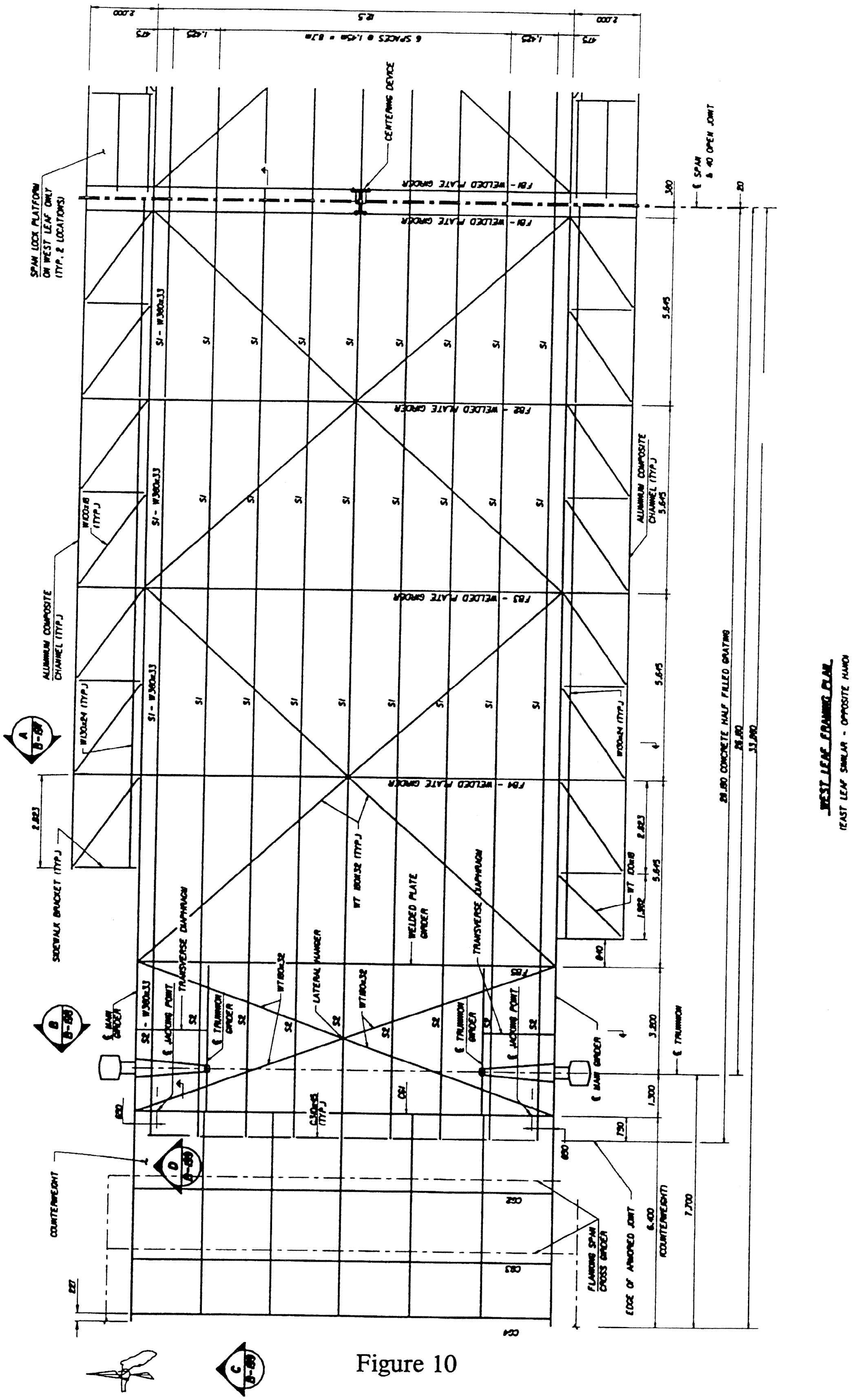

WEST LEAF FRAMING PLAN
(EAST LEAF SIMILAR - OPPOSITE HAND)
CENTERING DEVICE

Figure 10

Foundation

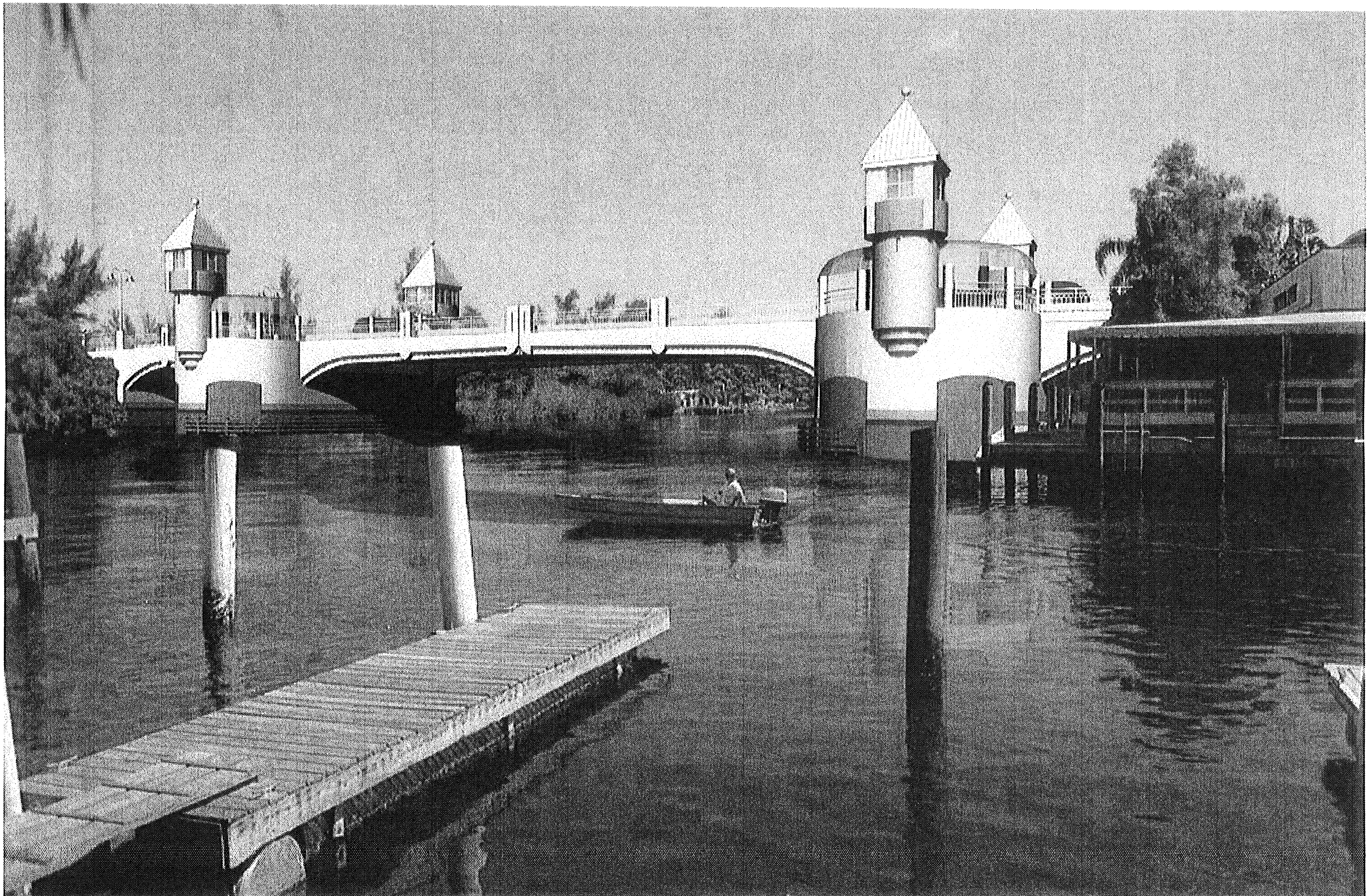
In choosing a solid deck structure with a clear channel width of 38.1 m (125'), the Department realized that this would be a very heavy span. In fact, it was estimated that these leaves would be the second heaviest in the DOT's inventory. As mentioned in the opening to this paper, the site is underlaid by a layer of peat over layers of sand, capstone and finally limestone bedrock at an elevation of approximately -22 meters (-75'). To support these loads, as well as ship impact, a total of 10, 1.8 m (6') diameter drilled shafts will be drilled down to the bedrock layer and socketed approximately 2.5 m (8.20') into the rock at each bascule pier.

Project Schedule

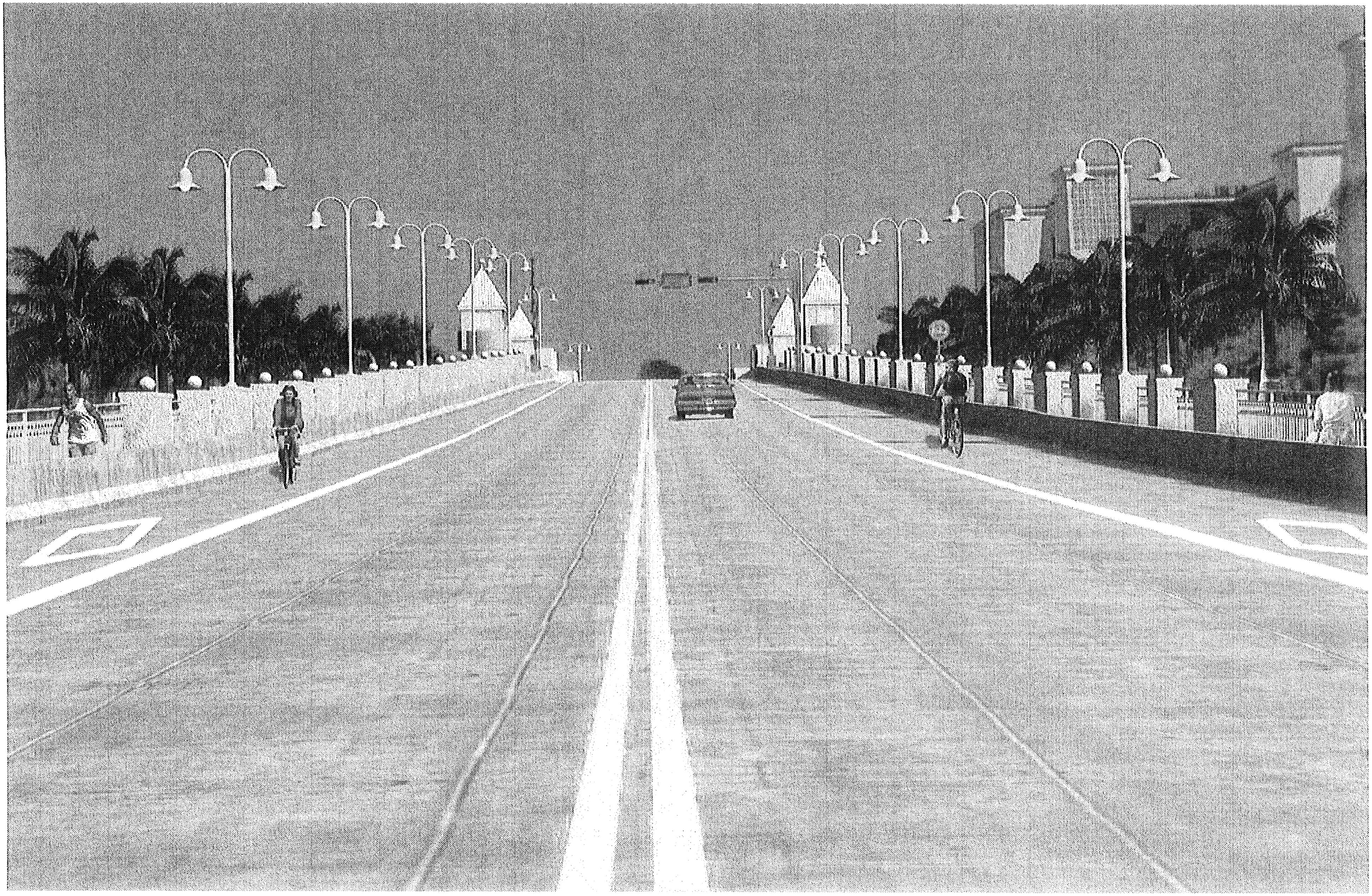
The photographic renderings shown today were developed for the August 6, 1996 Public Meeting which was held at the City of Boynton Beach. As of the writing of this paper, the Contractor, The Walsh Group was low bidder. Construction will begin in October 1998. The CEI will be performed by URS Consultants. Lichtenstein, along with their subconsultants will provide the necessary support services during construction. The construction should take approximately 1 3/4 years for completion. The low bid for construction was $23.4 million with an overall cost of $29.2 million because of the A & B Alternative Bidding Technique.

Additional Information

A copy of the FONSI and the 100% plans submission will be available for viewing at the presentation.



Proposed North Elevation **Ocean Avenue over Intracoastal Waterway**



Proposed West Approach **Ocean Avenue over Intracoastal Waterway**

Proposed West Approach Wall - North Elevation **Ocean Avenue over Intracoastal Waterway**