Heavy Movable Structures, Inc.

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"Movable Bridge Rehabilitation in Florida: Four Case Studies"

by

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BASCULE BRIDGE REHABILITATION IN FLORIDA: FOUR CASE STUDIES

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ABSTRACT

Four Florida Department of Transportation owned bascule bridge rehabilitation projects are presented in this paper. The bridges rehabilitated were originally built from 1959 to 1973, and are all in FDOT's District IV.

Rehabilitation work included replacement of drive machinery (racks, rack pinions, speed reducers, shafts, etc.), jacking of the bascule spans, in-place machining of trunnion shafts, replacement of span lock systems, widening for bicycle lanes, replacement of grid decks and stringers, improvements to the fatigue resistance of fracture critical structural components, and replacement of the control systems with PLC controls and relay-based logic.

The professional working relationships developed between the Engineer of Record, the Construction Inspectors, and the Contractors with the important benefits obtained from the "right" type of interaction are discussed.

INTRODUCTION

District Four of the Florida Department of Transportation has ownership and maintenance responsibility for 36 bascule bridges. Of these, 28 are over thirty years old. In order to preserve these bridges, District Four has managed a rehabilitation program to maintain and upgrade their bascule bridges.

Since 1993, A. G. Lichtenstein & Associates has participated in the rehabilitation of bascule bridges in District Four. Lichtenstein designed span lock replacements for seven bascule bridges, and the designed complete rehabilitation of the bascule bridge and approach spans at another four sites in District Four. Lichtenstein's involvement in the rehabilitation of these bascules included in-depth inspections, preparation of recommendation reports, plans preparation, and shop drawing review.

The bascule bridges discussed in this paper are parallel bridges carrying S.R. 802 (Lake Worth Road) over the Intracoastal Waterway, S.R, A1A over the Hillsboro Inlet, S.R. 810 (Hillsboro Boulevard) over the Intracoastal Waterway, and S.R. 870 (Commercial Boulevard) over the Intracoastal Waterway. The Contractor for all four bridge rehabilitations is PCL Civil Constructors, Inc. of Coral Springs, FL. The Construction Engineering and Inspection (CEI) consultants were Kisinger Campo & Associates, Corp., Fort Lauderdale for the Lake Worth bridges and Hillsboro Boulevard bridge, Constructioneer Corporation, Pembroke Pines, FL. for the Hillsboro Inlet bridge, and Lichtenstein is the CEI consultant for the Commercial Boulevard rehabilitation project.

During the construction phases of these bridges, it became apparent that the more Lichtenstein remained involved, the better the project progressed. This goes to say that the designer needs to remain committed to the project through all of its stages. This commitment to the project may be more important in bascule bridge rehabilitation than in new bridge design and construction. In bridge rehabilitation, there is greater potential for unforeseen conditions. This problem is multiplied by the presence of mechanical and electrical systems in bascule bridge rehabilitation.

S.R. 802 (LAKE WORTH ROAD) OVER THE INTRACOASTAL WATERWAY

These 1973 structures consist of two, parallel, single-leaf bascule bridges with prestressed concrete approach spans. Each bridge is 477.27 m (1565.83 ft.) long, consisting of 18 prestressed concrete AASHTO beam approach spans, a steel flanking span, and a 35 m (115 ft.) (centerline of trunnion to centerline of bearing at the rest pier) single leaf bascule span. Each of the parallel structures originally carried two lanes of traffic and a pedestrian sidewalk.

Before beginning the rehabilitation design, Lichtenstein completed in-depth structural, mechanical, and electrical inspections. These inspections, combined with the Department's previous inspections, provided the basis for the rehabilitation design. Complete load rating analyses were done for the bascule spans and the concrete approach spans. For the bascule spans, the analysis revealed that the stresses were close to the AASHTO allowable inventory stresses, but well below the operating rating allowables. The structure was re-rated taking into account the widening for bicycle lanes.

The structural work resulting from the in-depth inspections included repair of heavily spalled concrete columns, replacement of concrete bulkhead caps, repair of cracks in concrete by epoxy injection, repair of deck spalls, strengthening of pier caps by external post-tensioning, replacement of pile fendering, repair of prestressed piles under water, upgrading the existing sidewalk railing to meet current safety standards, replacement of the deck joint system, replacement of broken bearing anchor bolts, replacement of deteriorated structural steel fasteners, widening and replacement of steel

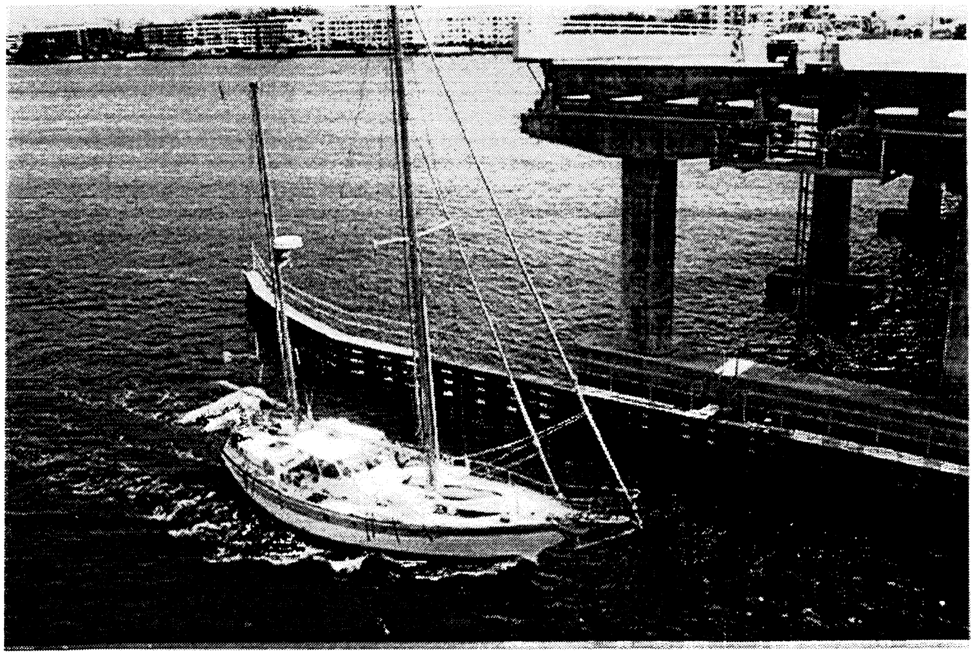

Photo 1: *View of new fendering. Also note pier encasement in the background.*

grid deck and stringers for addition of bicycle lanes, and installation of inspection catwalks and maintenance platforms. Electrical work included replacement of emergency generators, brake system, limit switches, navigation lighting, operating system with PLC control centers, and the electrical system in the bridge tender's house. Mechanical work included replacement of motor couplings, removal of buffer cylinders, replacement of the span lock system, and replacement of the rack pinion supports.

Of particular interest to the movable bridge community is the repair of approach piers by metallizing (passive cathodic protection), the replacement and widening of the bascule deck for bicycle lanes, and the replacement of the fendering system using recycled plastic lumber.

The lower 1.8 m (6 ft.) of the 18 approach piers were heavily deteriorated due to salt water splash and insufficient concrete cover over the reinforcing. In order to ensure a long term repair, the cover was completely removed from the reinforcing, the area cleaned, and new concrete was placed increasing the cover over the steel. This resulted in the columns being 100 mm (4 in.) thicker all around the bottom 1.8 m (6 ft.). Zinc metallizing was applied to the lower 1.8 m (6 ft.) of the columns. See Figure 1 and Photo 1. The zinc coating was electronically connected to the rebar cage by welding a stainless steel rod to the cage, and connecting this rod to an external galvanized steel plate. Uniform contact between the plate and the zinc coating was achieved by placing a lead plate under the steel plate.

It has been the District's policy to accommodate bicycle lanes in new construction, and major rehabilitation projects whenever feasible. Lichtenstein investigated the capacity of the existing bascule leaves, approach spans, and machinery, and determined that it was feasible to widen the deck

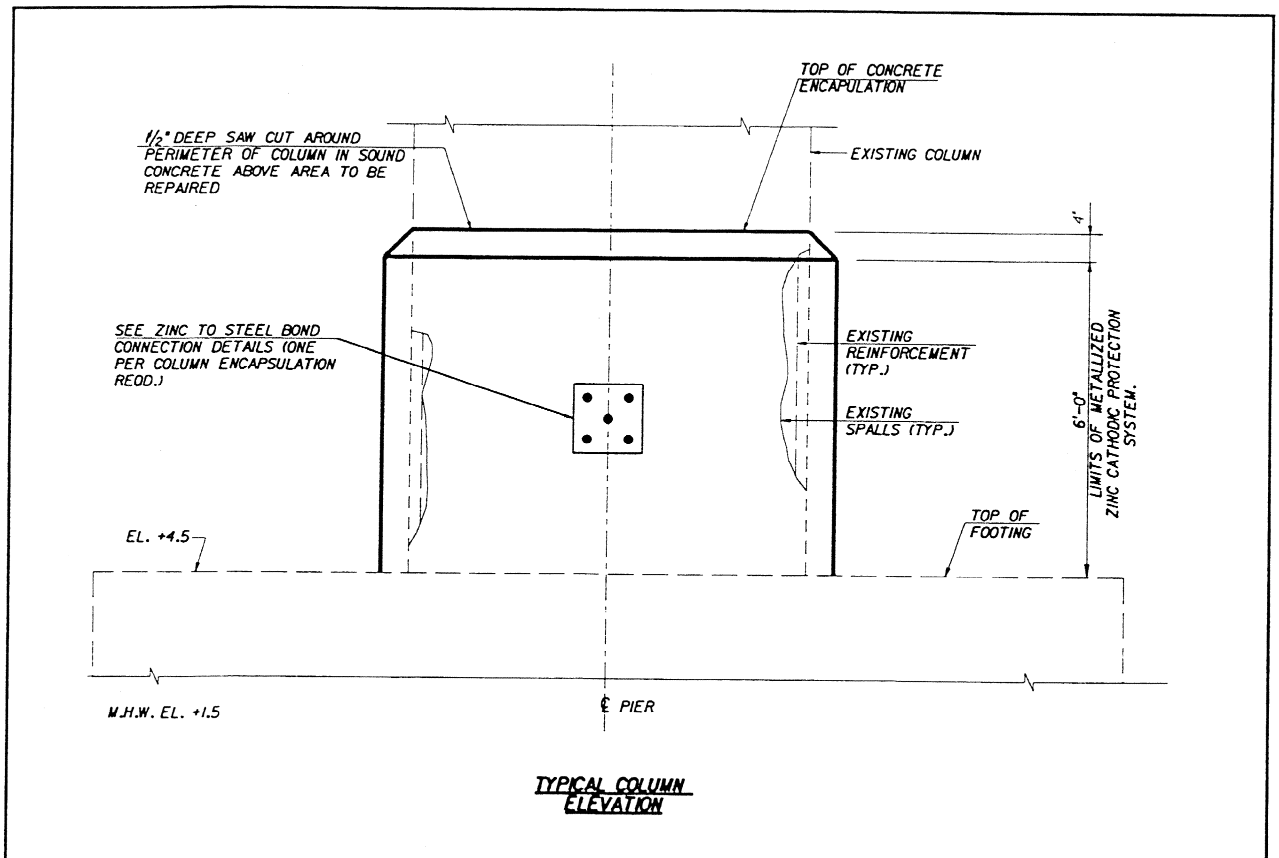

Figure 1: *Typical column repair with metallizing.*

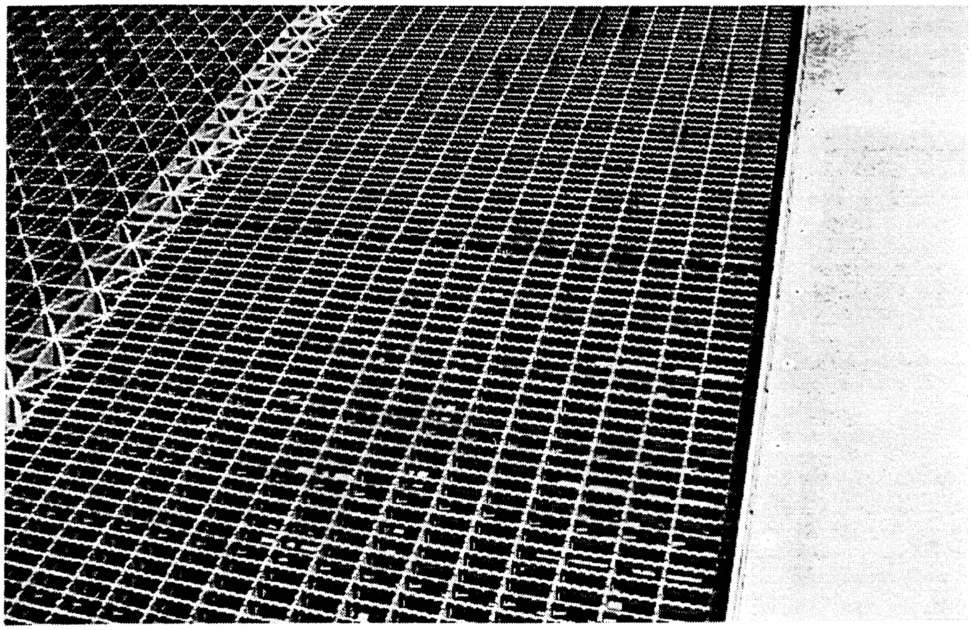

***Photo 2:** Rectangular deck designed for the bicycle lanes.*

into the existing median. Widening to the outside was not possible due to the location of the Operator's house. In order to provide bicycle lanes, the existing raised median was removed. A standard FDOT shaped barrier was designed, and installed. To save on weight, this barrier was designed using steel posts and rails to carry the AASHTO loads with an aluminum face. New stringers were installed utside of the main girder lines to carry the new deck. This detail was used to remove the fatigue sensitive detail created when the deck spacer bars are welded to the top flange of the main girders. See Figure 2.

There was concern regarding the difficultly of riding a bicycle over the new steel grating as this grating includes diagonal tertiary bars. To solve this problem, Lichtenstein worked with IKG Greulich to design a rectangular grid deck within the bicycle lane, with normal 4-way deck in the vehicular lanes. See photos 2 and 3.

The fendering consisted of treated timber piles, treated timber wales, and treated timber

Photo 3: *View of bascule deck. Note metal barrier and bicycle lane.*

catwalks. The piles and wales were in poor condition. Lichtenstein proposed using recycled plastic timber for the wales and spacers, with prestressed concrete piles. Lichtenstein also designed fiberglass hand rails for the catwalks on the fendering. Although recycled plastic timber is more expensive than timber, the recycled plastic has a fifty year design life. Also, using recycled plastic is more environmentally responsible for two major reasons. First, the timber is made of recycled plastic which reduces the amount of plastic going into landfills. Also, the plastic lumber has no chemicals that will leach into the environment as the product ages. The recycled plastic was easy to work with and should be maintenance free. See Photo 1.

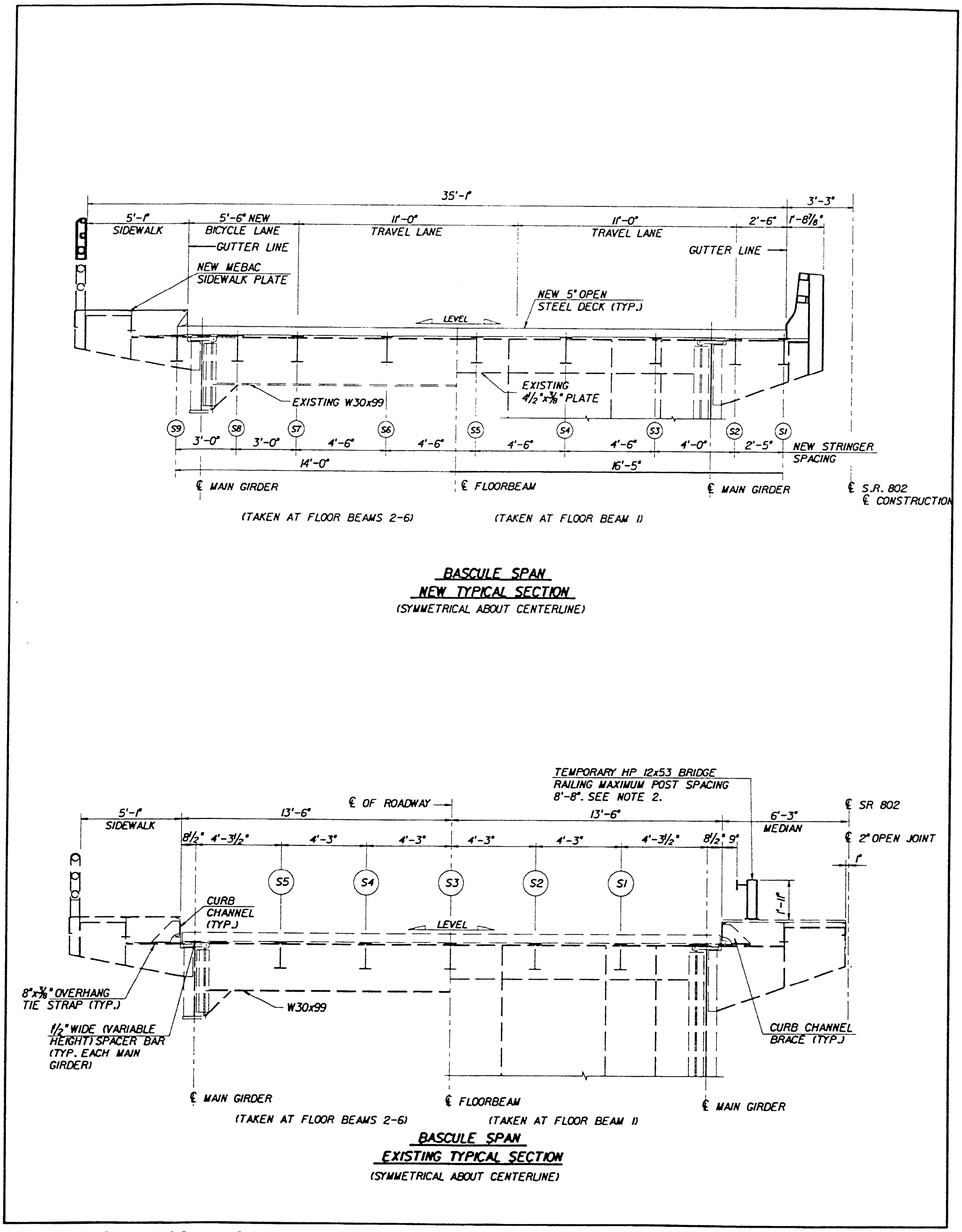

Figure 2: Typical bascule span cross sections before and after rehabilitation.

S.R, A1A OVER THE HILLSBORO INLET

The bridge carrying S.R. A1A over the Hillsboro Inlet is 107 m (351.33 ft.) long, and consists of four prestressed concrete approach spans, a steel flanking span, and a 25.4 m (83.33 ft.)long single leaf bascule span. The single leaf bascule carries one lane of S.R. A1A in each direction with a single sidewalk.

Lichtenstein performed in-depth structural, mechanical, and electrical inspections, completed load rating calculations, and prepared rehabilitation plans and specifications. The result of the inspections was that this was primarily a mechanical and electrical project. The structural work was mostly for repairing spalls and cracks in the concrete approach spans.

The structural work included replacement of concrete bulkhead caps, repair of cracks in concrete by epoxy injection, replacement of fendering, upgrading the existing sidewalk railing to meet current safety standards, replacement of the deck joint system, replacement of neoprene bearing pads, replacement of broken bearing anchor bolts, replacement of deteriorated structural steel fasteners, and installation of inspection catwalks and maintenance platforms. Electrical work included replacement of emergency generator, brake system, limit switches, navigation lighting, operating system with PLC control centers, and the electrical system in the bridge tender's house.

Mechanical work included replacement of all open gearing, shafts, and motor couplings, removal of buffer cylinders, and field machining of trunnions in place. The open gearing was replaced with enclosed speed reducer boxes. It was determined that because the racks were in good condition, and because of the expense related to their replacement, the new machinery should be sized to the capacity of the existing racks to remain. The existing rack pinions had some uneven wear, and it was decided to machine the teeth to remove the uneven areas. This was to be done in

Photo 4: *Tubular steel struts used to secure the bascule span in the open position.*

the shop with the bridge out of service, and the reconditioned racks mounted on new shafts.

In order to accommodate marine traffic, the bridge needed to be secured in the open position for the duration of any work requiring that the bridge be inoperable. This work included machining of the trunnions, replacement of the open gearing and speed reducers, replacement of the motors, and replacement of the control system. Lichtenstein estimated that the bridge would be closed to vehicular traffic for 56 days.

There were incentives in place for the Contractor to reduce the duration of the bridge closure, and there was also great pressure from the community to open the bridge early. PCL made several proposals to enable them to reduce the total duration of the closure. Close cooperation was needed between the designer (Lichtenstein), the contractor (PCL), and the CEI (Constructioneer). First of all, it was requested that critical shop drawings be reviewed and returned within seven days. Secondly, PCL proposed dividing the closure into two smaller duration closures. These closure periods were ten days and 21 days. During the first closure, PCL jacked the bascule span, secured it in the open position, machined the trunnions, and installed new bushings. During the second closure, the machinery and control system were replaced. Third, to reduce the duration of the second

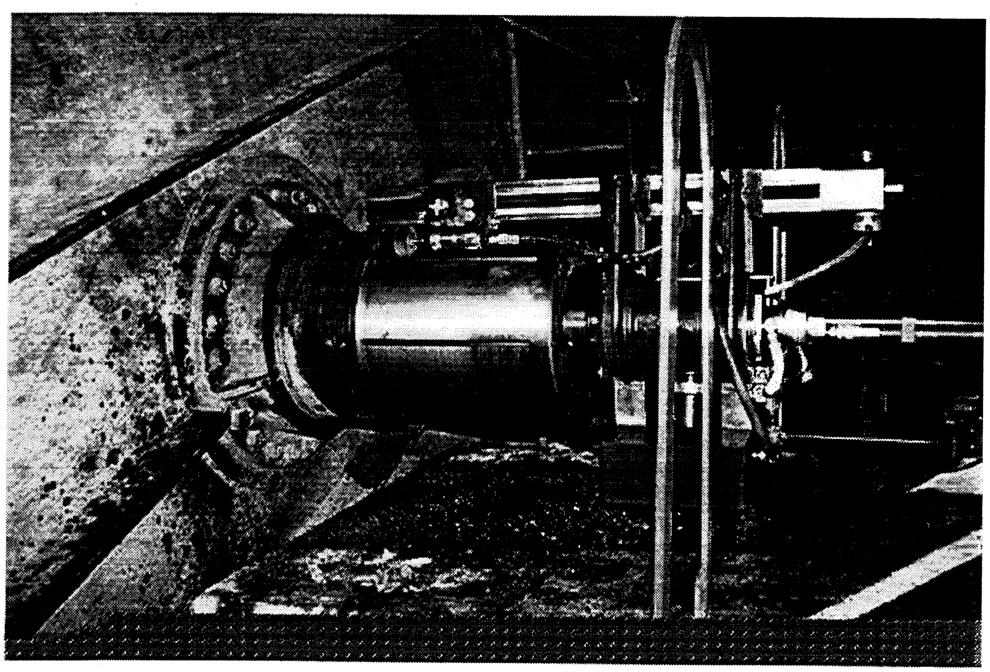

Photo 5: *Machining of the trunnion journal in place. Note that the bearings and anchor bolts were removed.*

closure, PCL proposed replacing the existing rack pinion with a new rack pinion which was fabricated and delivered to the site before taking the bridge out of service.

A complete bascule span jacking scheme was designed and shown on the plans, along with jacking loads. This was necessary to prove that the jacking plan was feasible and to provide a uniform basis for bidding. As expected, PCL proposed a different jacking setup and design. As specified in the plans, PCL submitted calculations for the proposed scheme. Lichtenstein reviewed the calculations and returned comments in a reduced time frame to allow the short bridge closure schedule. PCL needed to be able to reuse the span tie-downs during the second closure. They used a strut system of structural steel tubing. See photo 4.

Once the span was jacked and secured, the trunnion bearings were removed, and the trunnion journals machined in place. See photo 5. Minimum and maximum amounts of machining were specified. After machining and finishing, the journals were measured to finalize the bushing fabrication. These were installed in the bearing housing at the shop, and brought to the site. See photo 6.

The major difficulty of this project was improving the bridge closure schedule and maintaining the revised schedule. The contractor did an excellent job of improving on the construction schedule and satisfying the public's needs, but great cooperation between all parties was required to make this happen.

S.R. 810 (HILLSBORO BOULEVARD) AND S.R. 870 (COMMERCIAL BOULEVARD) OVER THE INTRACOASTAL WATERWAY

Lichtenstein performed the in-depth inspection and rehabilitation design of two double leaf bascule Hopkins drive bridges over the Intracoastal Waterway. The Hillsboro Boulevard bridge approach spans consist of five steel stringer spans. Total bridge length is 135m (444 ft.) including the 33m (109 ft.) bascule span. The Commercial Boulevard approach spans consist of four

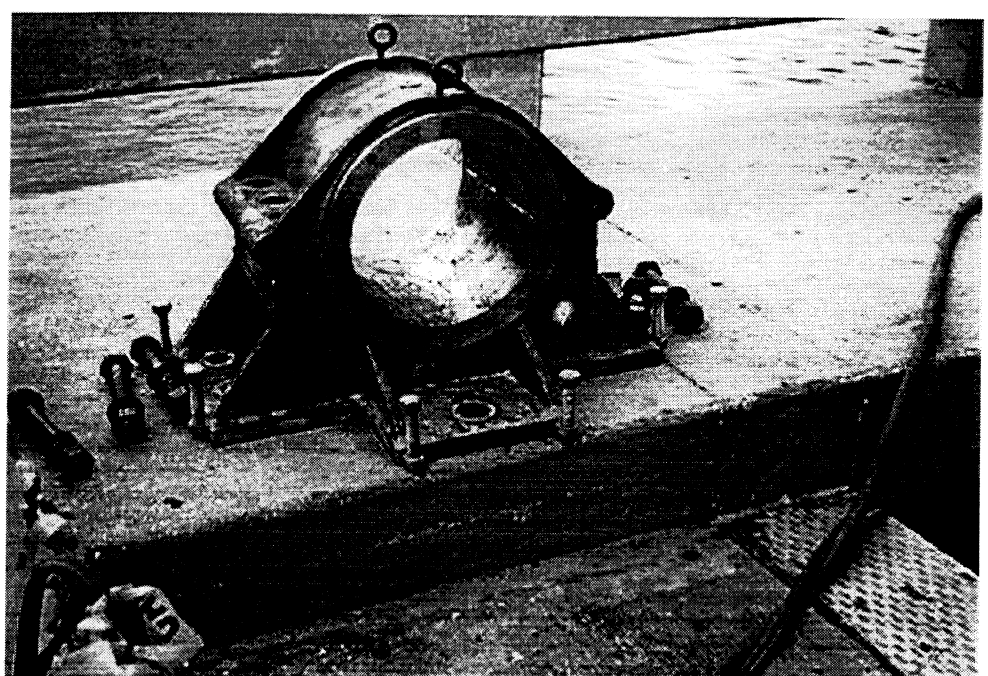

Photo 6: *Finished trunnion bushing and bearing, ready for installation.*

prestressed AASHTO beam spans. Total bridge length is 107 m (350 ft.) including the 33 m (109 ft.) bascule span. Each bridge carries four lanes of traffic and two, heavily used sidewalks leading to the beach area.

Work included replacement of the bascule span open steel grid deck and stringers, slope repairs, bulkhead repairs, crack injection, spall repairs, approach span deck joint replacement, replacement of bearings, fendering repairs, and architectural enhancements to the control houses. The new bascule span stringer arrangement was designed to omit the fatigue sensitive details created by welding of the steel grating to the fracture critical main girders. The fendering repairs included the use of recycled plastic lumber for the replacement of the bottom wales at Hillsboro Boulevard, and replacement of treated timber piles with concrete piles and new recycled plastic wales at Commercial Boulevard.

Electrical repairs included the complete upgrading of the control system, replacement of the navigation lights, and the installation of architectural lighting.

Architectural improvements at Hillsboro Boulevard include the installation of decorative hand rail, which was designed to meet the requirements of the AASHTO Specifications, and the construction of an additional story to the control house, required for housing of control system cabinets. At Commercial Boulevard, architectural improvements to the control house include the addition of a new bathroom, and remodeling of the interior to use the space previously occupied by the bathroom for electrical equipment. Both control houses will get new central air conditioning systems. Both houses will receive new roofs.

At Hillsboro Boulevard, a new access road is being added under the westernmost approach span, along with extensive landscaping requested by the City.

Mechanical repairs at both bridges include the replacement of the Hopkins frame pins with spherical bearings, field machining of the trunnions, and replacement of the span lock systems. Additionally, at Commercial Boulevard, cracked racks are being replaced along with the mating rack pinions.

Traditionally, Hopkins frames experience large amounts of movement at the base of the frame. These two bridges open very frequently all year for marine traffic, and the movement at the bottom pin of the Hopkins frame has become excessive due to wear at the pin. The anchor bolts have been replaced in the past, and cracking in the frames has also been repaired in the past. The traditional Hopkins frame bottom pin connection has been designed as a structural element, similar to a pinned truss joint, with steel rotating on steel. Steel truss joints typically do not undergo as much rotation as the Hopkins frame. Lichtenstein are replacing the steel-on-steel pin connection with a spherical bearing, designed using machinery allowable stresses rather than structural steel allowable stresses. See Figure 3.

Cracks in the racks at Commercial Boulevard have been found over the last few inspection cycles, and or in-depth inspection revealed additional cracks in the roots between rack teeth. Our analysis showed that the racks were severely under-designed by today's AASHTO Specifications. It was decided to replace the four racks. Because of the wear patterns the mating rack pinions have developed over the years of operation, it was also decided to replace the rack pinions.

There are incentives in place for the contractor to reduce the duration of the total bridge closures at Hillsboro and Commercial Boulevards. Lichtenstein will continue to work in close cooperation with the contractor, the CEI consultant, and the Department to facilitate the reduction in the closure period to reduce the inconvenience to the public.

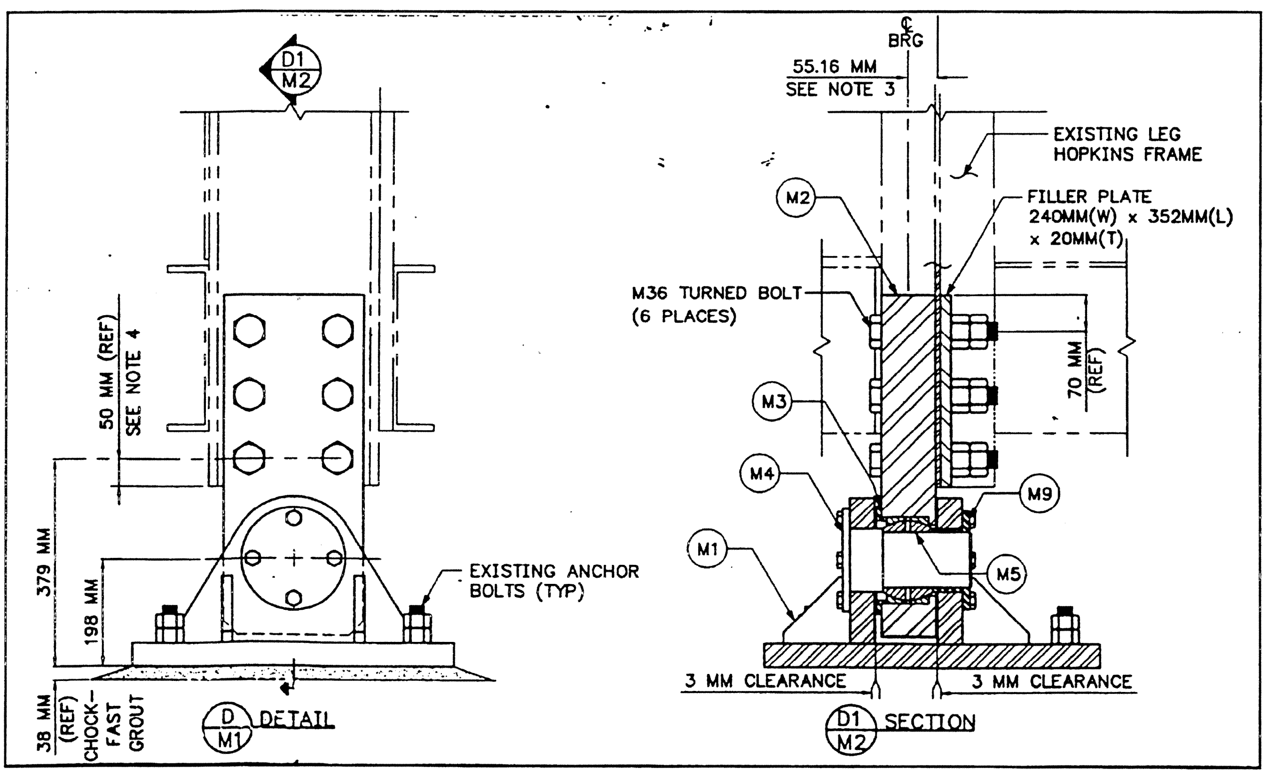

Figure 3: *Spherical bearing at the base of the Hopkins frames.*