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"Emergency Pier Replacement At Choctawhatchee Bay Bridge",B.Martin, Modjeski & Masters, New Orleans, La.

EMERGENCY PIER REPLACEMENT AT

CHOCTAWHATCHEE BAY BRIDGE

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ABSTRACT

In December, 1989, a barge collision virtually destroyed the north bascule pier of the U.S. 331 bridge over Choctawhatchee Bay, Florida. This 50 year old structure crosses the Intracoastal Waterway, connecting beach resort areas with inland access routes. The bridge was immediately closed to traffic, and, because of its hazard to navigation, the bascule leaf was cut off near the trunnion. A ferry service was instituted to carry traffic until completion of a new high-level bridge already under construction at the site.

A marine contractor approached the state with a plan to replace the damaged pier and reopen the bridge. The contractor's consulting engineer designed a massive concrete pier on steel pipe piles straddling the underwater remains of the existing pier. Construction began a month after the accident with removal of the bascule counterweight and above-water portions of the old pier.

Complications encountered during construction included pile interference with pier debris, erratic soils conditions, splicing of the bascule leaf and coordination with the adjacent contractor. These problems were quickly resolved, and the bridge reopened to traffic in mid-March, 1990.

U.S. 331 crosses Choctawhatchee Bay near Freeport, Florida. The highway connects the beach resort areas along the Florida panhandle with an inland interstate, and is a main access route for summer tourists heading to the coast. The existing bridge was built around 1939, and consists of steel stringer span approaches supported on timber pile bents, and a double leaf, Hopkins drive, bascule span crossing the Intracoastal Waterway. A parallel high-level replacement bridge is currently under construction 50 feet to the west of the existing structure.

Due to its location across the Intracoastal Waterway, with high levels of barge traffic (almost 5000 tows per year) and variable cross winds, the bridge has suffered from marine impact damage throughout its life. In mid-December 1989, a coal barge struck the north bascule pier, severely damaging it. The top portion of the pier slid on top of its supporting columns, shearing along what appeared to be an old construction joint or pre-existing failure plane. Both of the columns apparently cracked at the top of their footings, causing them to lean. Total displacement of the bascule leaf was about 3.6 feet to the east. The impact shifted and damaged the adjacent timber bent supporting the approach stringer span. Surprisingly little damage was done to the barge.

State officials inspecting the damaged structure immediately closed it to traffic. Since the bridge was open at the time of impact, the leaf was in a near-vertical position. To prevent collapse of the north bascule pier and possible closure of the navigation channel, the bascule leaf was cut at a floorbeam near the trunnion and removed. The Florida Department of Transportation instituted a ferry service across the bay and began to consider remedies to the situation, including accelerating construction of the new bridge while abandoning the existing structure.

A marine contractor was informed of the accident, and after surveying the site and retaining a consulting engineer for design, approached the state with a plan to replace the damaged pier and restore the existing bridge to service. After review of his proposal and the replacement pier design, Florida agreed to the repair effort. The replacement design consisted of a massive concrete pier built on ten 24" diameter steel pipe piles. The piles straddled the underwater debris from the damaged pier. Concrete was selected to provide the mass necessary to reduce damage from any future, smaller, bridge impacts, and because it allowed more flexibility for adjustment due to field conditions than a rigid steel frame would have. In mid-January, 1990, the contract was signed and work began at the site.

The first hurdle to be cleared was the removal of the damaged bridge components. To prepare for this, bearings and machinery that were to be reused were match-marked to aid reassembly, and the submarine cables running across the channel to the operator's house were disconnected and moved clear of the work area. The contractor rented a 300 ton capacity crane from a shipyard, and used it to lift out the bascule span counterweight, the approach span, and the upper portion of the pier. The heaviest lifts on this project were approximately 245 tons, when the existing pier was removed and later when the repaired bascule span with counterweight was reinstalled. While some demolition work was needed, the removal generally went very smoothly. In five days the site was clear for the new construction. The bascule leaf and counterweight were barged to a shipyard near Slidell, Louisiana, to be repaired, and the pile driving crew moved in.

Debris from the damaged pier led to difficulties in pile driving. The concrete columns supporting the old pier proved to be tougher than expected, and plans to remove sections of them that interfered with planned pile locations were abandoned. To deal with this problem, the pile arrangement was redesigned to clear the remaining substructure, making maximum use of the flexibility of cast-in-place concrete. This flexibility gave the contractor freedom to drive piles where conditions allowed. The final pile locations led to a redesign of the pier and reinforcing (leading to an asymmetrical pier design), and required the addition of two piles and several structural steel members to frame the piles together.

Based on the design pile load of 100 tons, and using soil properties from borings done for the adjacent structure, it was estimated that the piles should be approximately 80' long with 70' penetration. Unfortunately, though, both designer and contractor were unaware that the normal rules of soil mechanics are apparently suspended in Choctawhatchee Bay. Extremely variable pile driving was encountered, with piles only five feet apart having vastly different blow counts. By the time all piles were satisfactorily driven, the shortest was 98 feet long and the longest 161 feet long. (For the short life span required for the replacement pier, it was felt that differential settlement due to different pile tip elevations would not be a problem.) Three different hammers were used to drive the piles. All three were Kobe diesel hammers. The K35 hammer had too much energy and damaged the pile butts. A K15 hammer did not have enough energy to provide the required blow count without risking damage to the hammer. Finally, the K25 model did the job. (It was later discovered that the contractor on the adjacent project had encountered similar pile driving problems.)

Pile capacities were determined using the Florida DOT steel pile bearing capacity formula. This formula was verified by two pile load tests. The first test was a standard jack test with a 300 ton jack, and the second was a modified quick test. Neither test showed that the pile had the necessary capacity, but the results did correlate well with the capacity calculated from the formula using the final blow counts. This correlation allowed confident use of the formulas to continue driving and determine the pile capacity. The frame used for the jack test was designed to be reused to tie piles together in the final pier construction. The existing pier columns were used as reaction blocks for the pile test.

Precise pile location was critical in several spots, since the high-level bridge under construction alongside had a large footing next to the north bascule pier. At one point, construction was temporarily suspended to allow the neighboring contractor to drive piles for this footing before concrete was poured for the replacement pier. Interference between piles, especially battered piles, was a constant concern. Tight survey control and coordination with the Florida DOT and the contractors involved kept this concern from becoming a problem. Minimum clearance between the bascule pier and the footing for the high-level bridge was eleven feet, and the envelopes of batter pile tip locations actually overlapped. At times, the formwork for the bascule pier butted up against the pile driving template for the adjacent bridge.

Pile driving was the most troublesome part of the entire project. Driving took three and one-half weeks, about twice as long as anticipated. Only rapid progress on other areas of the work allowed the original completion date to be met. After pile driving was completed, a steel frame was fabricated to support the formwork for the pier concrete pour. This frame was welded to the piles and helped brace them laterally during the pour.

While pile driving and forming for concrete work was underway, repairs were made to the bridge superstructure and machinery. This work was done at the same shipyard that supplied the crane for bridge removal. The bascule leaf, which had been burned into two pieces, was spliced together using 7/8" and 1" diameter A325 bolts. Splices were also required for floor system stringers and the roadway grid deck. Measurements taken using a system of stretched wires at the shipyard ensured that the leaf was spliced square and that no racking of the span had occurred. Supports for the span machinery had been damaged in the collision and were replaced.

High early strength concrete was used to speed the pier construction. The pier was poured in two lifts, the second five days after the first. Anchor bolts for machinery and girder live load shoes were cast into the first pour of about 100 cubic yards. Trunnion and approach span anchor bolts were cast in the second pour, also of about 100 cubic yards. Provisions were made to allow adjustment of the trunnion locations and bearing elevations to align the bridge. Anchor bolt and base plate locations were based on a survey of the existing south pier. Concrete tests showed two-day strengths of 3,150 psi minimum, higher than the 3000 psi value used for design. A water reducer and retarder were included in the mix for high strength and workability after the 50 minute trip from the batch plant.

The potential for another barge collision was a constant concern during construction. Two barge collisions with fendering and equipment on the adjacent job occurred during this project period.

On March 10, 1990, the barge carrying the spliced bascule span arrived with the shipyard crane at the site. After the machinery was placed, the bascule span was lifted back into place on the replacement pier. The span bearing locations were adjusted to obtain proper clearance between the counterweight and pier and at the channel joint between spans. Using the match-marks made at removal, the operating machinery and rack were reset at the correct point. The machinery controls were reconnected, and testing done to ensure correct operation of the structure. Some adjustments and shimming of bearings were necessary to seat the span properly. The trunnions were cleaned and lubricated before span installation. A crew from Florida DOT tested the bridge balance and determined that no adjustments were needed. Navigation lights and traffic gates were reconnected.

With the approach span and its timber bent repaired and in place, and guardrails fabricated and installed, the old bridge was ready to resume service. Some of the first vehicles across were trucks carrying concrete for footings on the adjacent project. At midday on March 14, the bridge was reopened to traffic.

While the official opening ceremonies were held on the following day, March 15, 1990, repair work on fenders and other cleanup items continued until March 20.

Residents were happy that the bridge was repaired in time for spring break and the summer tourist season, and that the disruption to their lives caused by the barge collision was ended. State officials were pleased to save the money that would have been required to continue the ferry service.

The pier replacement at Choctawhatchee Bay was a fast-track design-construct project. The contractor usually worked seven days a week, from dawn to dark. The designer's field engineer was on site to perform construction layout, provide interpretation and direction as necessary, and to ensure that the work was done according to the plans and the Florida DOT specifications. Office engineers were available to modify or totally redesign portions of the project as required. Florida DOT staff provided quick decisions and directives, and DOT personnel were always available for coordination, technical assistance and material testing. The successful reconstruction of this bridge in only nine weeks (January 15-March 14, 1990) displays the importance of teamwork, especially when projects are challenging and deadlines are short.