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Strengthened Bascule Piers for the Newly Rehabilitated Bridge of Lions

Jian Huang, Ph.D., P.E. and R. Wayne McLennon, P.E.

TranSystems Corporation
2400 E. Commercial Blvd., Suite 1000
Fort Lauderdale, FL 33308

THE CARIBE ROYALE RESORT & HOTEL
ORLANDO, FLORIDA

Introduction

Strengthening of existing bridge foundations is always challenging work in design and construction due to the space constraint and the reverse order of construction in regard of load transfer. The Bridge of Lions was originally constructed in 1927, carrying SR A1A over the Matanzas River in St. Johns County, Florida. As a bridge on the National Register of Historic Places, the Bridge of Lions has been rehabilitated to meet the current structural and functional requirements. Considering the structural conditions and historic features, the bascule piers of the bridge have remained, but strengthened to meet the current design criteria including vessel impact and 100-yr scour requirements. The existing bascule piers consist of waterline footings supported by six 8' diameter caissons with independent mudline footers, which are supported by timber piles. A new waterline footing supported by five new 8-ft diameter drilled shafts at each bascule pier has been constructed to strengthen the existing bascule pier foundation. This paper will focus on the construction procedure for the bascule pier strengthening including the drilled shaft installation, half tub cofferdam, falsework for the new water line footing, reinforcing steel placement and concrete pours. Also presented in this paper are the added cantilever machinery platforms and other miscellaneous items.

Figure 1 General View of the Existing Bridge of Lions

A general view of the existing bascule span is shown in Figure 1. The newly rehabilitated bridge is exhibited in Figure 2.

Figure 2 Overview of the Newly Rehabilitated Bridge of Lions

Design Requirements For Bascule Piers

The existing bascule piers had been in place for approximately 75 years with no structural problems. The bascule piers have been strengthened based on the following design requirements:

VESSEL COLLISION: Based on the vessel impact analysis that considered the approach piers and bascule piers together, the lateral vessel collision force that must be resisted by each bascule pier is 2000 kips.

SCOUR: The elevation of the bottom of the channel is approximately -23.0 feet at the west bascule pier and -27.0 at the east bascule pier. The tip elevation of the existing timber piles is approximately -57 feet. Per the scour analysis and scale model test conducted for the project, the total scour for the 100-year storm at the bascule piers would be approximately 23.5 feet, which translates to an elevation of approximately -46.5 feet at the west bascule pier and -50.5 feet at the east bascule pier, respectively.

ADDED WEIGHTS: The new approach spans are 6'-5" wider than the existing spans. The new bascule leaves have the same width as the existing but have a solid roadway deck instead of the open grid deck. In addition, modifications on the bascule piers include closing of the openings in the existing waterline footing, new machinery platforms and new concrete floors at the machinery level.

Final Design Of The Foundation Strengthening

A new waterline footing supported by five new 8' diameter drilled shafts to be constructed below the existing waterline footing has been designed to strengthen the existing bascule pier foundations. Figures 3 and 4 illustrate the design scheme. Because the new drilled shafts extend above the mudline, the drilled shafts on the channel side of the piers were restricted to the footprint of the existing waterline footing so that they do not interfere with navigation. The new shafts at the rear of the existing piers could be placed as needed without restriction. The restriction on placement of the front drilled shafts also limited the size of

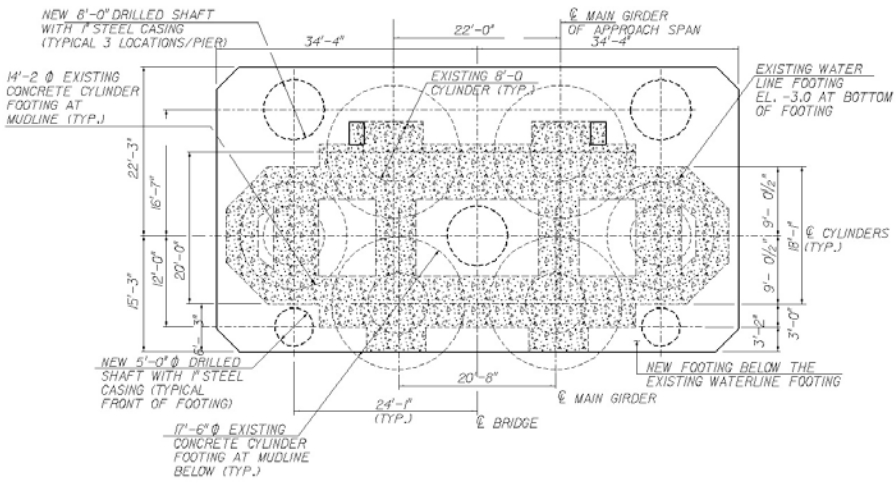

Figure 3 Plan View of New Waterline Footing

these shafts to 5'-0". The rear drilled shafts and the shaft placed at the center of the pier were 8'-0" diameter. Due to insufficient vertical bearing capacities, the 5' drilled shafts were replaced with 8' diameter drilled shafts below mudline, on which 5' columns were monolithically constructed. The new drilled shaft/footing consists of 5 - 8 foot diameter drilled shafts with 1" thick steel casing and 7 feet thick footing/shaft cap immediately below the existing waterline footing.

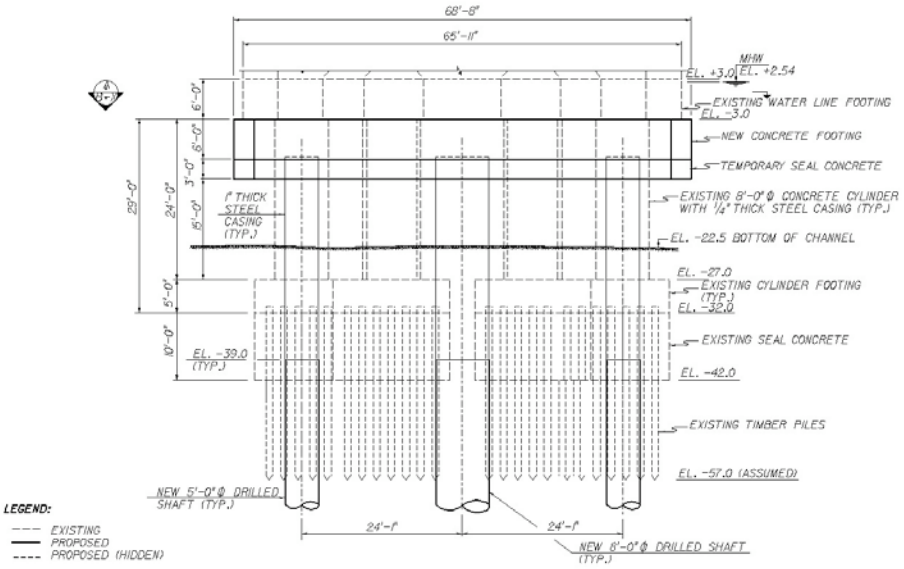

Figure 4 Elevation of New Waterline

A computer rendering of the existing bascule pier and the new waterline footing is shown in Figures 5 through 7. The darker solid (red color) shapes show the new structure.

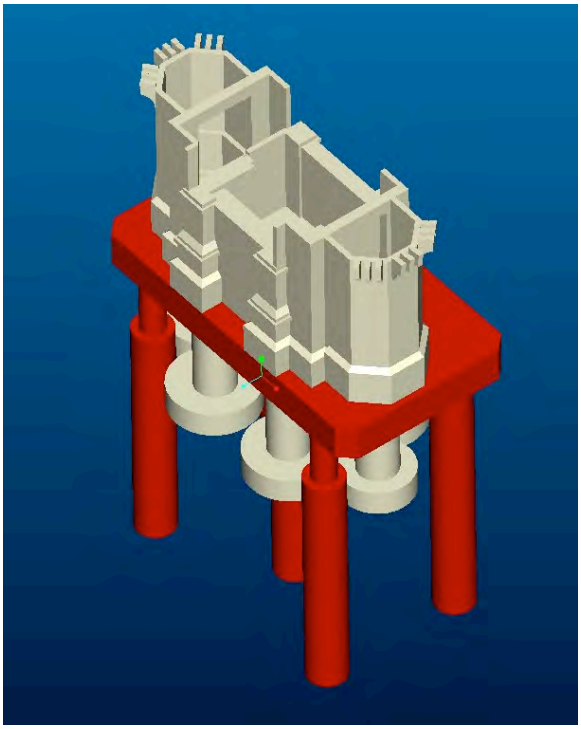

Figure 5 Computer Rendering Showing the Existing Pier and the New Waterline Footing

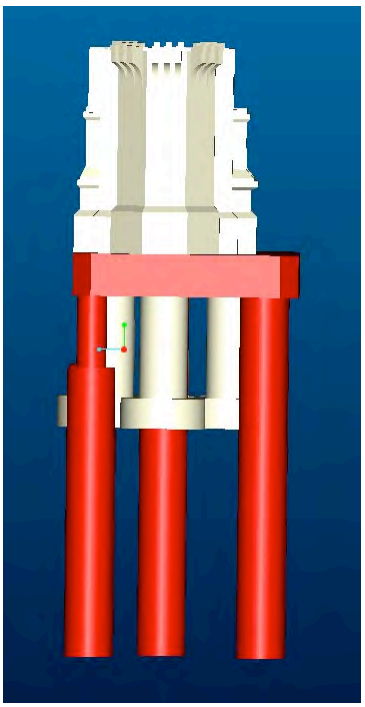

Figure 6 Computer Rendering Showing Side View of the Pier with New Drilled Shafts and Footing

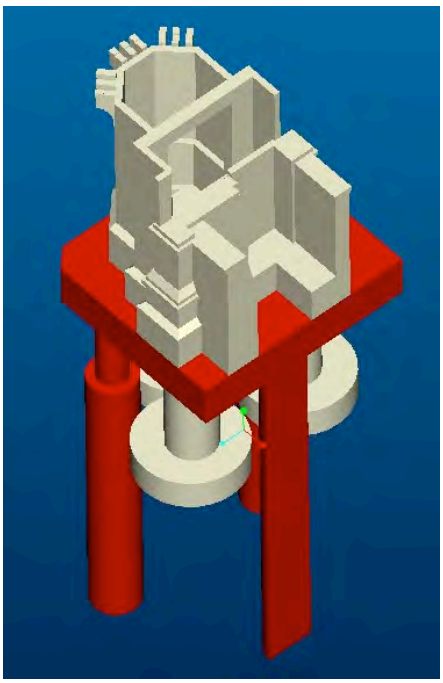

Figure 7 Computer Rendering Showing a Half Pier View with New Drilled Shafts and Footing

Construction Of The Foundation Strengthening

1) Cofferdams

Cofferdams were built to create a dry environment for the new waterline footing construction. As seen in Figure 8, the water level inside the cofferdam only maintain below the falsework for the new waterline footing. There is no seal concrete required for the cofferdam, which eliminates potential environmental issues and saves the construction costs. Also as seen in the figure, the horizontal struts for the cofferdam utilized the existing waterline footing as the support/load transfer members.

Figure 8 Partial View of Cofferdam

2) New Drilled Shafts

The construction of the 8’ diameter drilled shafts is relatively straightforward except for the channel side shafts comprised of 8’ diameter drilled shafts with 5’ diameter columns on the top.

3) Falsework for the New Waterline Footing

The falsework for the new waterline footing is supported by the new drilled shafts at their heads, temporary steel pipe piles, and some hangers tied to the existing waterline footing as supplemental supports. Figures 9 to 13 show the concept of this unique falsework.

Figure 9 Steel Frame on the Drilled Shaft Head to Support Falsework (Permanently embedded in the new concrete footing)

Figure 10 Steel Pipe Pile Supporting the Falsework

Figure 11 Partial View of Falsework under the Existing Waterline Footing

Figure 12 Another View of Falsework under the Existing Waterline Footing

Figure 13 Hangers and Cross Steel Beam for the Falsework at the Opening of the Existing Waterline Footing

Figure 14 Showing the Falsework Platform at the Middle Opening of the Existing Waterline Footing and the New Drilled Shaft

4) New Waterline Footing

The new water line footing was constructed under the existing waterline footing. In addition, the existing 8' diameter concrete caissons go through the new footing. As seen in Figures 15 to 18, the space is tight for the placement of the reinforcing steel and concrete for the new footing. Both high slump normal concrete and self-consolidated concrete (SCC) were considered for the footing concrete pour. Considering testing results of the SCC concrete and the construction schedule, high slump normal concrete has been used for the new waterline footings at both bascule piers.

Figure 15 Showing the Top Layer of the Reinforcing Steel in the New Waterline Footing (Back Side of the Pier)

Figure 16 Showing the Top Layer of the Reinforcing Steel in the New Waterline Footing (at a Front/Side Corner of the Pier)

Figure 17 Showing the Top Layer of the Reinforcing Steel in the New Waterline Footing (At the Middle Opening of the Existing Waterline Footing

Figure 18 Showing the Newly Poured Waterline Footing and Preparation for Restoring the Existing Bascule Pier Surface

Figure 19 Another View of the Newly Poured Waterline Footing and Preparation for Restoring the Existing Bascule Pier

Construction Of Miscellaneous Components

1) New Machinery Platform

The existing machinery was on the moving bascule leaves. Due to increased size of the new machinery meeting the current design requirements, the new machinery is required to be placed off the moving leaves. New machinery platform have been built above the existing 18" wide backwalls of the piers. The new machinery platforms are also supported at the ends by the expanded columns, which at the meantime support the approach span girders. It should be noted that the actual reinforcing steel in the back wall was significantly less than that assumed during design. Additional reinforcing steel has been added, see Figure 20.

Figure 20 New Machinery Platform Cantilevered from the Existing 18" Wide Backwall

Figure 21 Additonal Reinforcing Steel Added by Removing the Back Face of the Backwall

2) Replacement Of the Cantilevered Roadway/Sidewalk Deck

Due to added concrete traffic barrier and carrying portion of the roadway, the existing cantilevered pier deck has been replaced. It should be mentioned that the actual reinforcing steel is also significantly less than that assumed during design. There was only one layer of reinforcing steel and a much larger than expected spacing of the reinforcing steel in the existing deck, see Figures 22 and 23. Additional reinforcing steel has been added.

Figure 22 Much Less Than Expected Reinforcing Steel in the Existing Deck

Figure 23 Another View of the Existing Reinforcing Steel in the Deck

Re-Opening Of The Bridge of Lions

The rehabilitated Bridge of Lions has been opened to traffic on March 16, 2010. Figures 24 and 25 show the opening day of the bridge.

Figure 24 Re-Opened Bridge of Lions (on the Re-Opening Ceremony Day)

Figure 25 Re-Opened Bridge of Lions (Vehicles Travelling on the Bridge)