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REPLACEMENT OF SPHEROIDAL TRUNNION BUSHING ALFORD STREET (STATE ROUTE 99) OVER MYSTIC RIVER

Edward M. Long, P.E.
Hardesty & Hanover, LLP

CARIBE ROYALE HOTEL
ORLANDO, FL

Abstract

This paper details the replacement of a 28.58 in. diameter spheroidal trunnion bushing that had become seized onto the trunnion shaft, causing the bushing to rotate within the bearing, shearing the lock bolt. The navigation span is a twin double leaf Hopkins frame bascule spanning 160 feet, trunnion to trunnion, carrying four lanes of traffic.

The failure occurred at the start of the recreational boating season creating several concerns for the bridge owner. The first concern was maintaining operations for navigation during the time required to manufacture a new bushing without damaging the operating machinery. The second concern was addressing the impacts to the 50,000 automobiles and 10,000 trucks that use the bridge daily should the leaf be required to be left in the open position.

The paper will focus on the methods used to access the machinery level and counterweight pit to install the jacking equipment required to relieve the dead load from the bearing and lift the bushing sufficiently to precisely measure the outside diameter of the bushing and trunnion shaft and the inside diameter of the bearing casting. The existing bushing was replaced with a new 2-piece assembly machined to those dimensions.

The methods used for jacking of the bascule leaf will be discussed including systems used to maintain span alignment. Typically, spans will rotate slightly during jacking, and if not controlled, interference between the bushing, bearing and trunnion make removal and replacement of the bushing a time consuming affair. Additionally, overhead clearances above the trunnions and the clearance between the rear strike plate and the cross-girder limit operations.

Bridge operations for navigation were maintained for the eight weeks required for the fabrication of the new centrifugal cast C91300 bronze bushing. Upon arrival at the job sight, the old bushing was removed and the new one installed in 48 hours, including mobilization, set up, teardown and operational testing.

Alford Street Rehabilitation

This paper details the replacement of a 28.58 in. diameter spheroidal trunnion bushing that had become seized onto the trunnion shaft, causing the bushing to rotate within the bearing, shearing the lock bolt. The navigation span is a twin double leaf Hopkins frame bascule spanning 160 feet, trunnion to trunnion, carrying four lanes of traffic.

The failure occurred at the start of the recreational boating season creating several concerns for the bridge owner. The first was maintaining operations for navigation during the time required to manufacture a new bushing, without damaging the operating machinery, and second, addressing the impacts to the 50,000 automobiles and 10,000 trucks that use the bridge daily should the leaf be required to be left in the open position.

The root cause of the failure was incorrect lubrication, and corrosion of the trunnion shaft from storm water runoff, deicing salts and road debris. The original splash shield, attached to the top cap of the bearing had disintegrated allowing moisture to enter the annular space between the top of the trunnion and the bushing. The relief plugs, on the far side of the grease journals, adjacent to the bascule girders, had not previously been removed to permit lubrication to travel across the journals, through the bearing. The trunnions had never been lubricated while the navigation span was in operation, and finally, the bridge is only operated seasonally, reducing the benefits of periodic maintenance.

The first order of construction was to place the jacking equipment and cribbing into the counterweight pit. This was done with the leaf in the fully open position. A small truck mounted crane was used to lower the jacking drums, cribbing and other equipment through the opening at the heel crack. The installation and the erection of the cribbing and jacking tower was completed in about twelve (12) hours.

The first step in the replacement operation is to remove the trunnion cap, to expose the spheroidal bushing, and jack the bridge sufficiently to expose the full outside diameter of the bushing for measurement (a minimum of 3/8 inch is required to clear the outside diameter of the micrometer and mandrel). The jacking point for lifting the bridge is the timber bumper block located on the bottom flange of the main girder. A 200-ton jack was used to elevate the 650-ton leaf.

Typical of Hopkins Trunnion Bascules, the bridge is equipped with sliding lock bars at the draw crack, forward live load shoes and rear main girder shoes. The rear main girder shoes are located directly below the crossbeam that supports the deck over counterweight. The original design clearance for the rear main girder shoe and strike plate, located on the bottom flange of the crossbeam is 1/32 of an inch. This minimal clearance requires a steel shim plate be installed between the forward live load shoe and strike plate, rotating the span around the trunnion, and increasing the clearance at the rear main girder shoe. A shim plate of ½ inch thickness

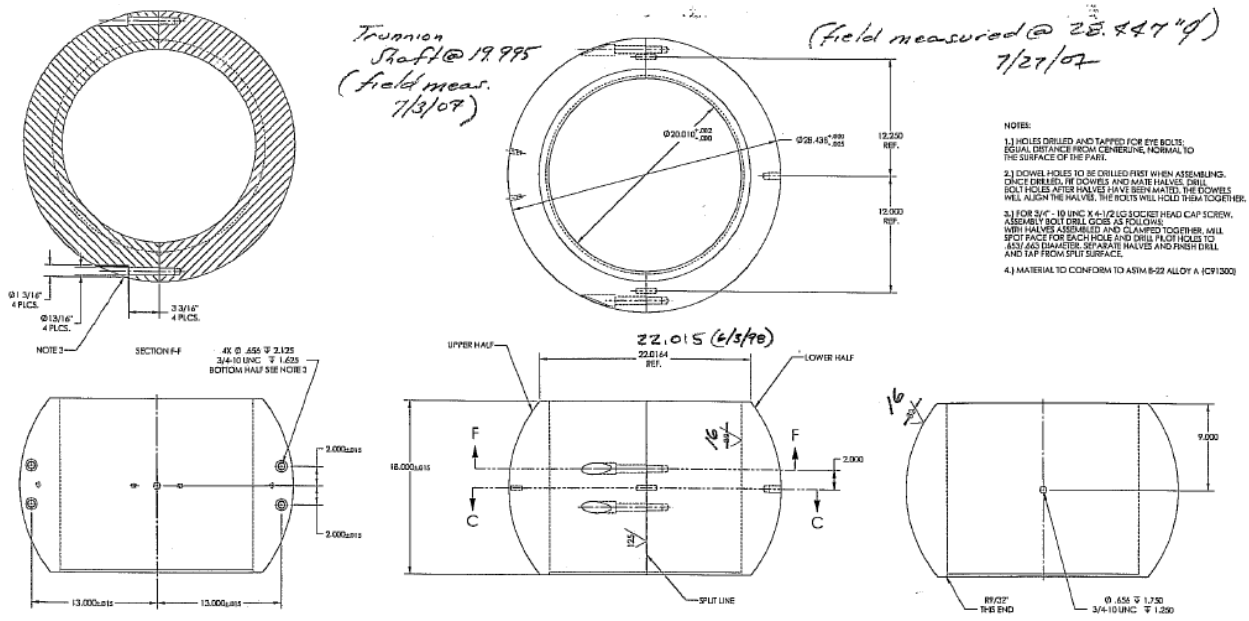
increases the clearance to approximately 3/8 inch. The shim plate also raises the toe of the leaf at the draw crack approximately 3-1/2 inches.

Jacking the leaf from the bumper block rotates the span around the live load shoe, lifting the bushing from the bearing and returning the elevation of the toe to the same elevation as the opposing leaf. Jacking the leaf in this way also causes the span to rotate slightly, which must be accounted for, or the bronze bushing could be damaged during reseating. Inserting wedges in the draw crack, prior to jacking, prevented span rotation.

Following the jacking of the span, to permit field measurements, shop drawings for fabrication of a 2-piece replacement bushing could be completed. Fabrication of the bushing required a minimum of eight weeks and it was this delivery time that created a major problem for the bridge owner. The navigation season was in high season and the opposing leaf did not operate. [*See Shop Drawing Below*]

Operation of this leaf, with the bushing rotating in the bearing, was a requirement of the bridge owner, due to of maintenance of vehicular traffic considerations. Lubricating the spheroidal contact surfaces of the bushing and the bearing would be required.

Tribology Tech Lube T-1000 was placed in the bottom half of the trunnion bearing while the bushing was elevated for measuring. After reassembly, lubricant was poured through the boss in the top cap and into the drill hole in the bushing formerly occupied by the lock screw. It was anticipated that some of this oil lubricant would disperse along the interface of the bushing and the casting, and spill out and reach the lower half of the trunnion assembly during operations



for navigation. The on-call maintenance contractor was directed to refill the makeshift oil reservoir every other day.

Photo – Existing Bearing

The new bushing was fabricated by Johnson Centrifugal Technology of Saukville, Wisconsin and delivered to the bridge approximately 6 weeks from date of order. The millwright work, including span jacking, was performed by Lydon Millwright Services of Brockton, Massachusetts.

Photo – New Milled Bearing

The steel grillage and timber cribbing was left in the counterweight pit during the fabrication period to reduce remobilization time. The hydraulic jacks were removed from the site.

The two-piece, 1400-pound bronze bushing (ASTM B-22 Alloy A) was delivered to the site and replaced over a 48-hour closure to navigation.

Jacking the span, to relieve dead load from the bushing, was the first step. A ½ inch steel shim was again placed between the live load shoe and the strike plate, and two small 20-ton jacks placed in a temporary jacking frame located at the draw crack. These jacks would permit making small adjustments to span alignment, simplifying removal of the old bushing, and

installation of the new bushing, without damage to the bushing or the bearing assembly.

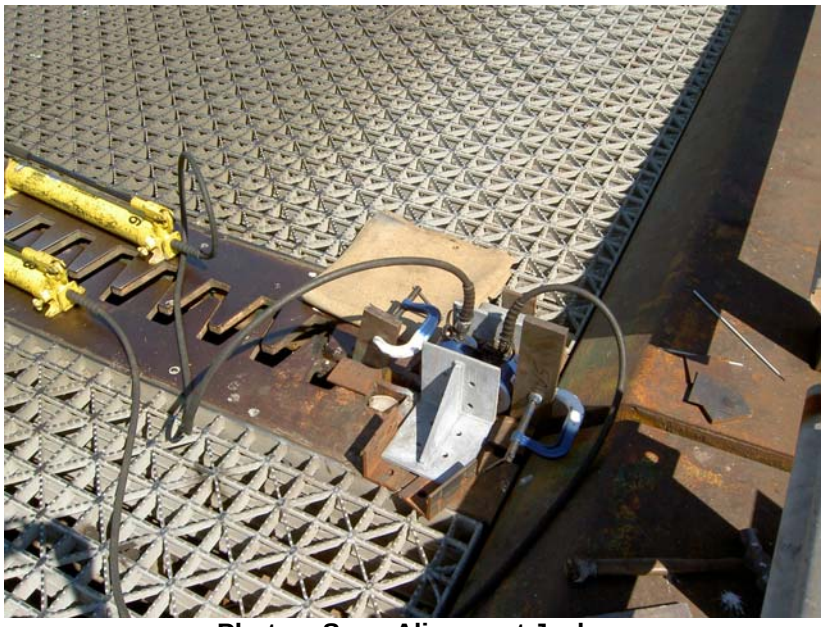


Photo – Span Alignment Jacks

Mineral spirits was injected through the lock screw boss, to reduce hydraulic suction from the oil lubricant, and to simplify removal of the trunnion bearing top cap. [*See Photo – Existing Bearing*] With the top cap removed, mineral spirits was injected into the lower bearing half, between the bushing and the bearing casting.

The bridge leaf was elevated about 3/8 of an inch before removal work on the bushing was started. Span alignment was maintained by the small jacking system located at the draw crack. The top part of the existing bushing was removed in small sections using abrasive wheels to cut the material and steel wedges to separate and break apart the sections.

Photo – Trimmed Bushing

Removal of the bottom half of the bushing was done by jacking the section down and rotating it into a position where a screw eye could be inserted for lifting the section.

Photo – Jacking

Photo – Old Bearing Removal

The 20-inch diameter trunnion shaft was thoroughly cleaned of rust, scale and old lubricant using wire brushed and solvents, and flame brushed with a torch to remove non-visible scale. The lubricant removed from the grease journals had the consistency of black rubber "bungee" chords. The surface of the trunnion shaft was primed with an AGMA EP 2 lubricant prior to installation of the new bushing assembly.

Photo – New Bushing Assembly

Photo – New Bushing Installation

Prior to replacing the bearing top cap, a frame was fabricated to support a "mag drill" to drill a hole in the new bushing for a replacement lock screw.

Photo – Mag Drill Frame

Installation of the new spheroidal trunnion bushing, reassembly of the bearing cap and installation of a

new lock bolt was completed. The trunnion was lubricated and the span tested for proper operation. The trunnion was also lubricated with the span in motion.

Photo – Span Operation

The new bushing has been in service for fifteen months without problems. Other bronze bushing replaced on this bridge and using this protocol have been in service for over ten years.