HEAVY MOVABLE STRUCTURES, INC.

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"Stone Harbor Bridge - Emergency Mechanical Repairs"

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STONE HARBOR BRIDGE-EMERGENCY MECHANICAL REPAIRS

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Abstract

In July 1999, the County of Cape May, New Jersey retained Parsons Brinckerhoff (PB) to perform an emergency inspection and to prepare contract documents for emergency mechanical repairs on the Stone Harbor Bridge. At that time, the bridge operators were hearing abnormal noises emanating from the west bascule span whenever the bridge was operated at normal speed. Additionally, bridge maintenance staff had reported that one of the drive motors was drawing more power than the rated motor current. It was found that one of the double bascule spans was not properly aligned in the closed position. Soon after a contract was awarded to make the emergency repairs and before this work started the lower pin holding one of the control struts broke, closing the bridge to marine traffic. During emergency repairs over a weekend, the pin was temporary replaced. All of the work was completed this past spring.

Bridge Description

The Stone Harbor Bridge, also known as the 96th Street Bridge, carries County Route 657 over the Great Channel (Figure 1). It is located in the Borough of Stone Harbor and the Township of Middle in Cape May County, New Jersey. The bridge has a 19-meter-long (63-foot) Rall-type double-leaf bascule span, linking US 9 and the Garden State Parkway to the beach town of Stone Harbor. The Great Channel is a vital link carrying marine traffic into and out of Stone Harbor—a very busy area for marine and vehicular traffic. In the summer, the bascule span has more than 1,000 openings a month.

The entire bridge, a 14-span structure, was originally built in the 1930s. Over the years, the bridge has undergone several rehabilitation/reconstruction projects. The approach spans, all completely replaced in 1984, are composed of five pre-stressed concrete, multi-cell box beams. There are five spans on the east approach with lengths varying from 67 feet to 72 feet,-5 inches.. A short flanking span with a length of 15 feet, -9 inches lead to the bascule spans on the east approach. The west approach also consists of six spans with lengths varying from 67 feet,-1 inch to- 72 feet,-5 inches, as well as a similar short flanking span. All the approach span beams are topped with fully reinforced concrete overlay. The main span double leaf bascule leaves are comprised of through cantilevered steel plate girders. There are three steel floorbeams in each half of the span supporting ten rolled steel stringers on which the open grid deck rests. At the middle of the bascule spans, the two through girders are connected by means of a shear lock mechanism. The machinery for the main operating drive is located inside wooden, box-shaped enclosures at the four corners of the bascule span. Each independent drive consists of a 7 ½ HP motor, a set of open gearing and a rack and pinion arrangement (Figure 2). The trunnion roller wheels and track girders are located inside the bascule piers.

Background: Rall-Type Bascule

The Rall bascule, a type of rolling lift bascule, is much less common than the Scherzer bascule. Seven years after the first Scherzer-type bascule bridge was built in 1894 (the same time the Tower Bridge in London was built), Theodore Rall was issued his first patent, which was then re-issued in 1906. By the time the Stone Harbor Bridge was built , the Rall patent was owned by the Strobel Steel Construction Company of Chicago, Illinois. Only six Rall-type bascule bridges were built—Stone Harbor Bridge; Hannover Street Bridge in Baltimore, Maryland; Broadway Bridge in Portland, Oregon and three railroad bridges over the Indiana Harbor Canal, Indiana—all six are believed to still be in operation.

The basis of the Rall patent and the chief characteristic of this bridge type is that the trunnion of the span is installed in a large steel roller or wheel that recedes from the channel opening as the span is rotated upward. The rotation of the span is driven by an operating strut, similar to that on a Strauss heel trunnion bascule (the arc of the swing was cleverly conceived to lift the roller/trunnion wheel off the track girder in the fully closed position). Thus, the roller and trunnion are not subject to live load, so wear on the bushings within the trunnions is reduced and the wheel bearings can be removed for repair without jacking the bridge or taking it out of service. Separate adjustable bearing shoes are provided to support the bascule span in the fully closed position by carrying both the dead load of the moving span and the live load.

Hovey[3], Waddell, and Hool[2] and Kinne[2] described the advantages of this type of bridge as providing a maximum clear channel opening for minimum span length. Hool[2] and Kinne[2] further describe the ability to remove the trunnion wheel for maintenance as an advantage over the fixed trunnion. However, they note a disadvantage specifically, the shifting load on the foundation, a common feature of all rolling lift bridges.

Inspection Findings

Upon inspecting the bridge, the primary problems identified included:

Control Strut: The southwest strut had broken several times and had been welded together. The welding of the strut had shortened the strut length, overstressing the strut and misaligned the entire leaf. A critical requirement of the Rall-type design is to maintain the exact geometry and relative position of the bascule leaf, control and operating struts as the bridge moves. The original center to center distance of the lower and upper pins was designed to be exactly 30 inches. The existing struts on the bascule span measured 33 and 32 inches. The struts have broken several times over and had been welded together. Also, the bushings in the upper strut were noisy and appeared to be seized inside the upper end of the strut sleeve. The set screws holding the strut sleeve to the bushings were missing. It was recommended that the struts be replaced. The following improvements to the original details were also made (Figure 3):

1. The new struts were 2 inches wider than the existing struts. The existing strut were fabricated out of 6-inch steel tubing and plates. The wall thickness of the tubing did not allow for a solid connection between the tubing and the bushings.
2. Struts were machined out of a single piece of forged steel instead of steel weldments. The existing struts had been repaired several times by field welding the broken pieces. The single forged steel minimized the high stress concentrated location on the struts.
3. The new bushings were flanged and bolted to the strut sleeves instead of being locked in place with set screws. The set screws connecting the bushings to the existing strut sleeves had failed. The flanged bushings provided a bolted connection between the strut sleeves and the bushings.

The wider struts provided enough surface area to directly bolt the flanged bushings to the struts.

The lower and the upper strut pins appeared to be in good condition and no modifications were required.

Roller Wheels: The bascule span and associated components have undergone several rehabilitations. None of these known rehabilitation efforts included work on the roller wheels. The trunnion cap was moving away from the trunnion journal, indicating that the roller wheel was not functioning properly. Additionally, in accordance with the Rall patent, the wheel is supposed to lift off the track as the span reaches the closed position. Unfortunately, this was not the case in this instance, so it was concluded that the bushings in the wheels might have been damaged over time due to live load.

Although the existing wheel castings exhibited some surface corrosion, they appeared to be in good condition. It was recommended that the wheels be rehabilitated as follows:

1. Clean and inspect the wheels for any cracks.
2. Re-machine the wheel surfaces.
3. Replace the wheel bushings with new flanged type bushings (Figure 8).

Carriage Frame Assembly: The carriage frame, that holds the rack and pinion together, appeared to be loose. The bearings that assist the movement of the roller on the rack were skidding on the rack. It was recommended that the bearings be replaced and the entire carriage frame removed, cleaned and inspected in the shop as part of the bearing replacement.

Emergency Arises Prior to the Repair Work

Months after the contract for the repair work was awarded, the lower pin that connects the control strut to the wheel support casting broke off during an opening. PB responded to this emergency and assisted the county and the repair contractor with a temporary replacement of the broken pin.

Examination of the broken piece led us to conclude that the pins were being subjected to live load and that failure is classic fatigue failure. . After a site meeting with the county engineers and the contractor's crew, a decision was made to fabricate a new pin.

The broken pin was shrunk fit into the anchor casting (Figure 5). The initial challenge was to remove the broken half from the lower anchor casting without damaging the bore in the housing. After various discussions to find ways to shrink the broken piece or to expand the bore in the anchor casting, an iron-worker decided to burn off the broken half.

The pin dimensions on all existing drawings did not indicate the correct size of the pin, therefore, the new pin had to be re-machined and additional site work was postponed until the following morning. On Sunday, the new pin was fitted into the anchor casting bore.

A contract modification was subsequently made to replace all the control strut pins and to re-shim the live load bearings. The contractor completed the rehabilitation this spring with the exception of minor punch list items. The bridge is now well aligned and working well. A subsequent contract modification has been prepared to re-shim the bascule span and support castings, stabilize the bascule leaves on the support bearings, and minimize or eliminate live load impacts and resulting damage on the Rall wheels, control struts and pins.

This work has now been completed and the bridge is working satisfactory.

Summary

Several lessons were learned on this rehabilitation.

- The concept of the rollers being lifted off the track when the bridge is down and carrying traffic was not necessary implemented on Rall type bascules constructed.

- The struts are sensitive to maintenance and when worn can result in improper bridge seating and operation.

- The struts and pins are not designed to carry live load. Proper shimming of the live load shoes are critical in ensuring that the pins and struts are not subjected to live load.

- The rollers are normally heavy and cannot be easily removed for maintenance.
- It's quite important to maintain the original dimension design dimensions of the control struts.

References:

1. *David Nyarko,* Mechanical Repairs on Stone Harbor Bridge, *PB Network, July 2000*
2. *George A. Hool and W.S. Kinne,* Movable and Long-Span Steel Bridges, *McGraw Hill, 1923*
3. *Otis E. Hovey,* Movable Bridges, *John Widey & Sons, 1926*

Acknowledgements

My sincere gratitude is extended to Dale Forester, P.E., Cape May County Engineer, and the entire WT Welding crew that worked on the bridge.

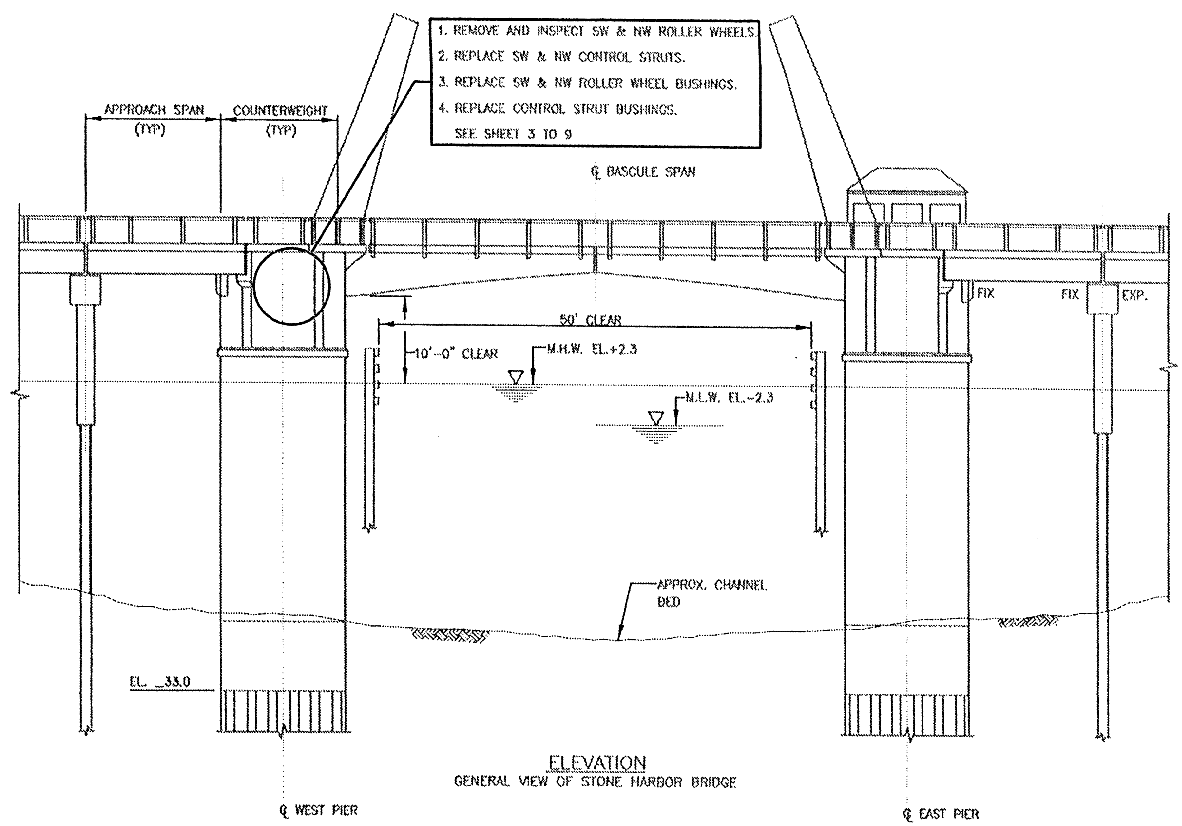
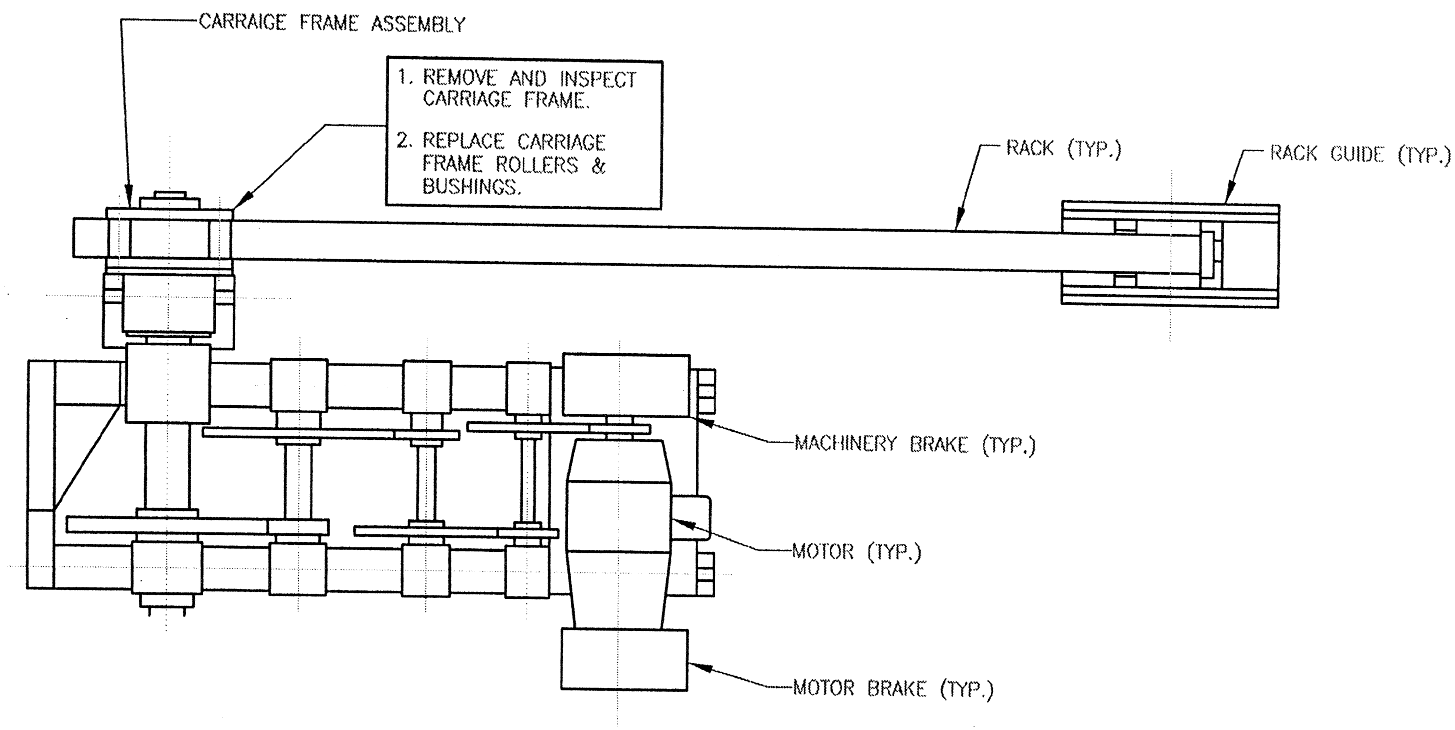
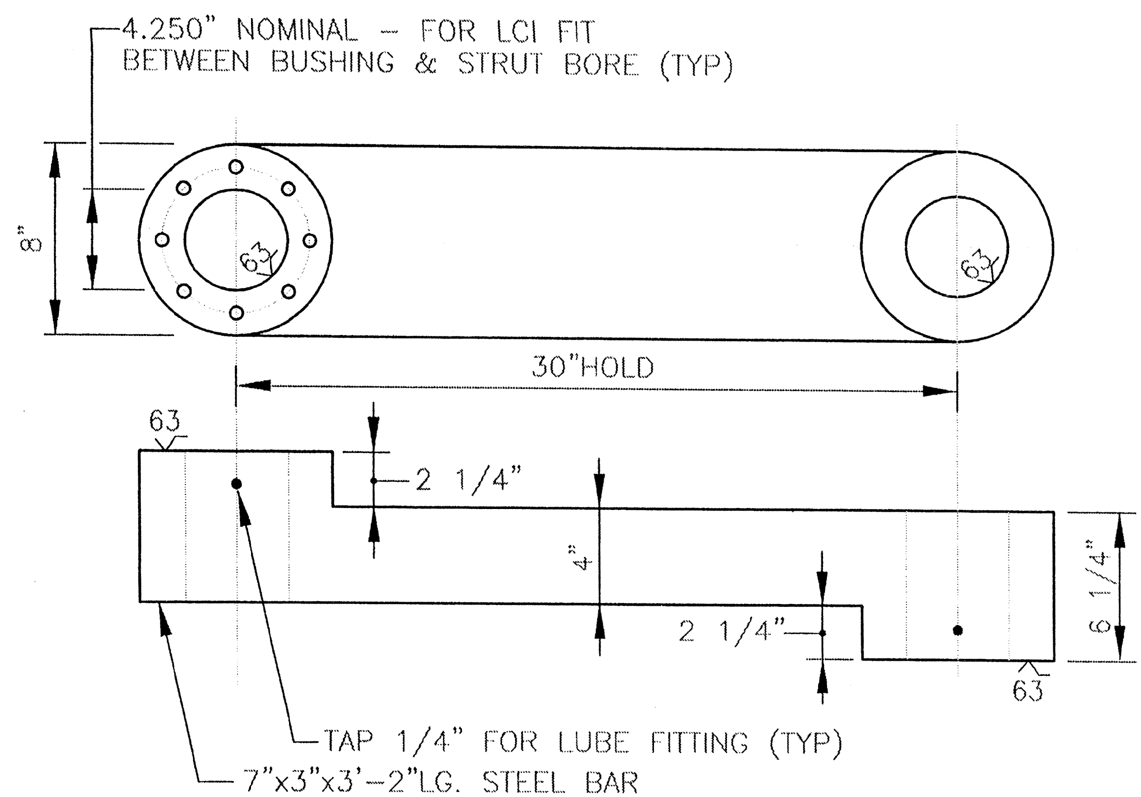

1. REMOVE AND INSPECT SW & NW ROLLER WHEELS.
2. REPLACE SW & NW CONTROL STRUTS.
3. REPLACE SW & NW ROLLER WHEEL BUSHINGS.
4. REPLACE CONTROL STRUT BUSHINGS.
SEE SHEET 3 TO 9
APPROACH SPAN (TYP)
COUNTERWEIGHT (TYP)
℄ BASCULE SPAN
FIX
FIX
EXP.
50' CLEAR
10'-0" CLEAR
M.H.W. EL.+2.3
M.L.W. EL.-2.3
APPROX. CHANNEL BED
EL. _33.0
ELEVATION
GENERAL VIEW OF STONE HARBOR BRIDGE
℄ WEST PIER
℄ EAST PIER

FIGURE 1



DRIVE MACHINERY



NEW CONTROL STRUT (2-REQ'D)

MATERIAL ASTM A668 GRADE D

FIGURE 3

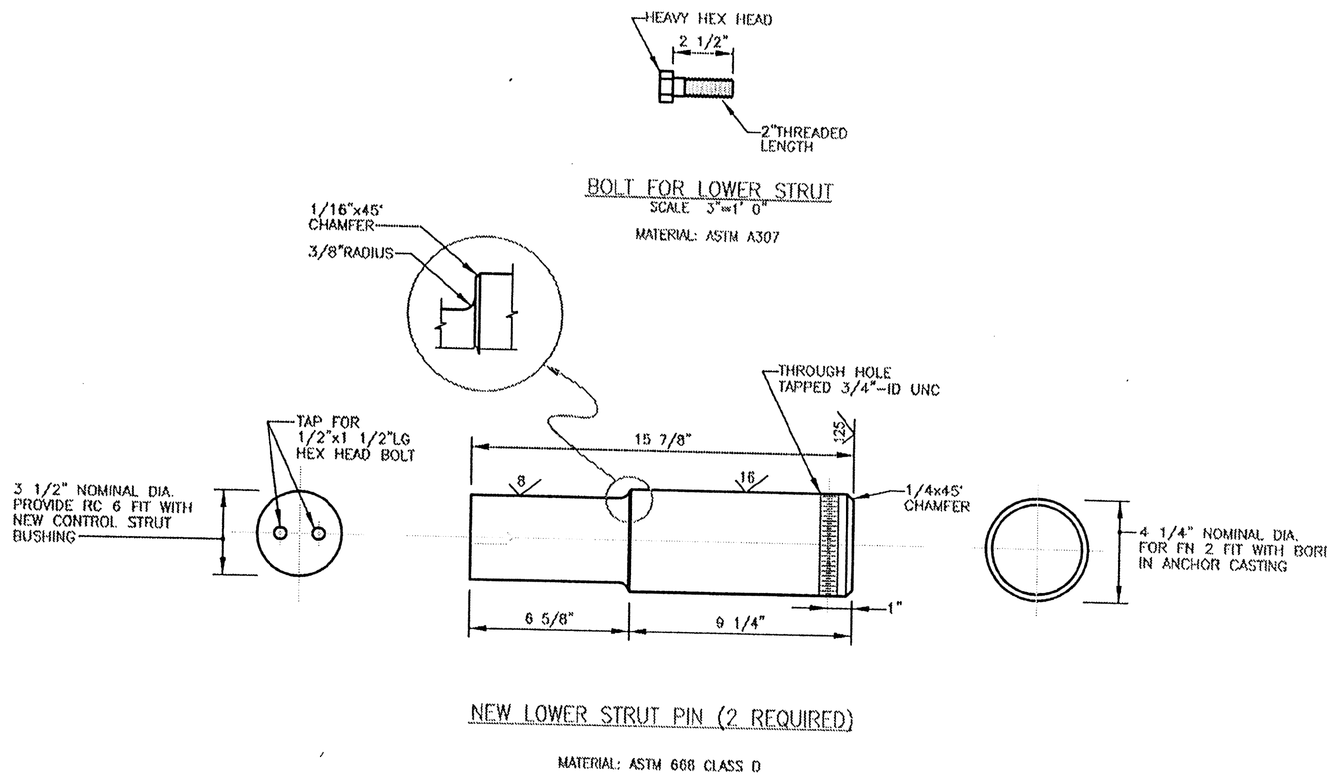
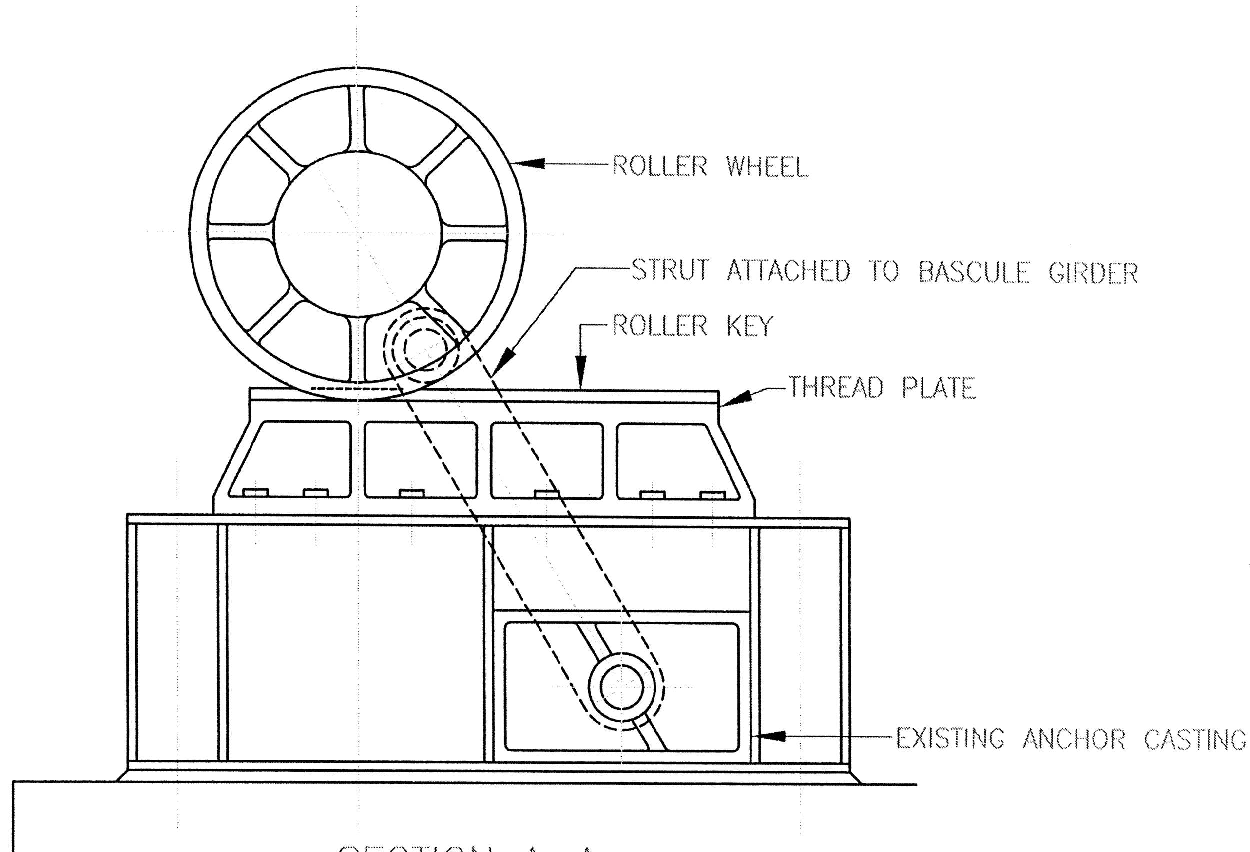
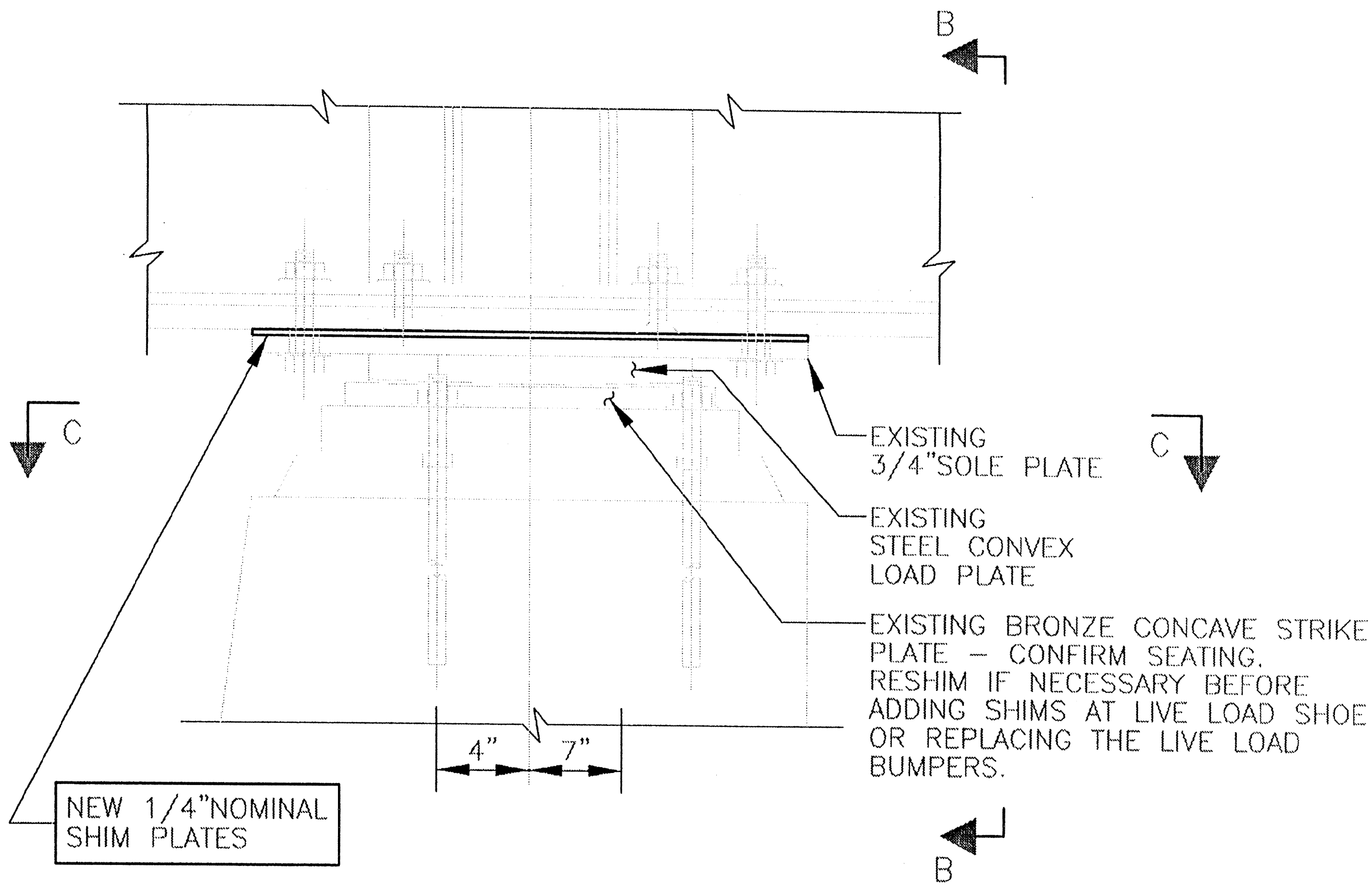

HEAVY HEX HEAD
2 1/2"
2"THREADED LENGTH
BOLT FOR LOWER STRUT
SCALE 3"=1' 0"
MATERIAL: ASTM A307
1/16"x45' CHAMFER
3/8"RADIUS
THROUGH HOLE TAPPED 3/4"-ID UNC
TAP FOR 1/2"x1 1/2"LG HEX HEAD BOLT
15 7/8"
125
8
16
3 1/2" NOMINAL DIA. PROVIDE RC 6 FIT WITH NEW CONTROL STRUT BUSHING
1/4x45' CHAMFER
4 1/4" NOMINAL DIA. FOR FN 2 FIT WITH BORE IN ANCHOR CASTING
1"
6 5/8"
9 1/4"
NEW LOWER STRUT PIN (2 REQUIRED)
MATERIAL: ASTM 668 CLASS D

FIGURE 4

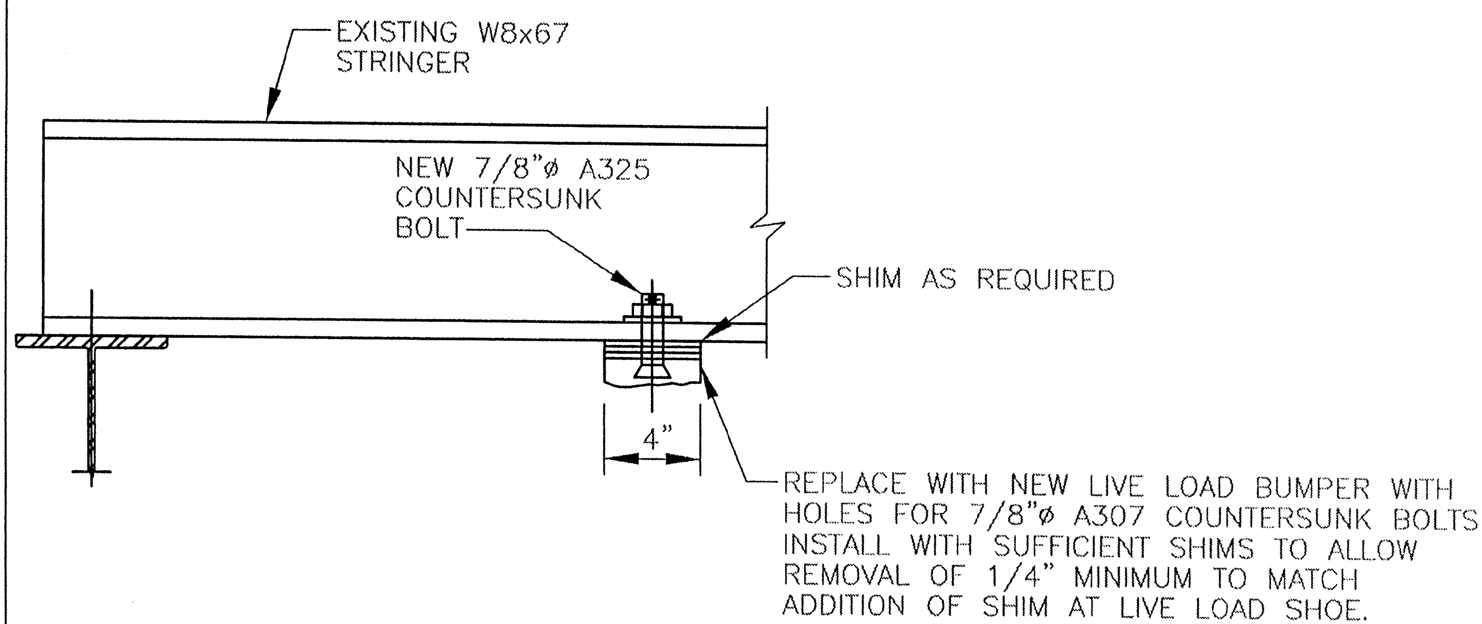


SECTION A–A
RALL WHEEL & TRACK

FIGURE 5

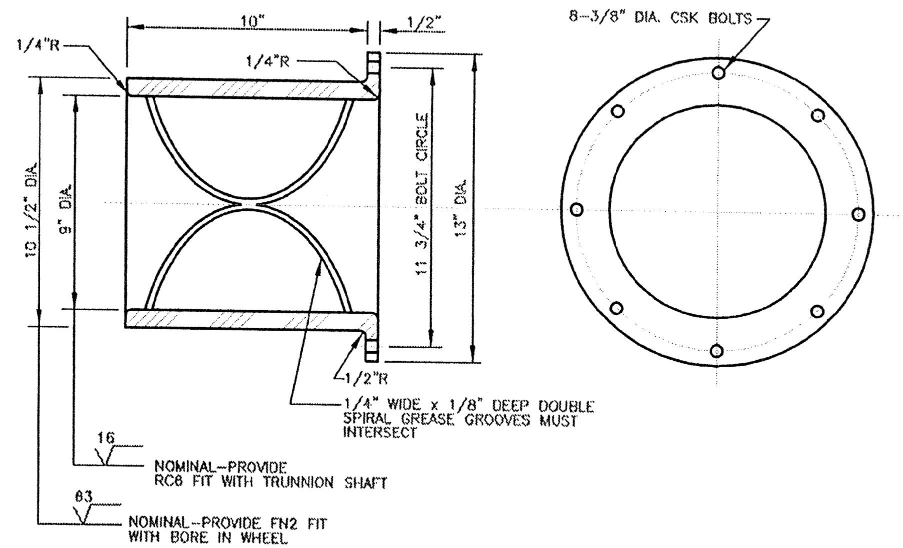


LOWER LIVE LOAD SHOE



UPPER LIVE LOAD BUMPER ASSEMBLY

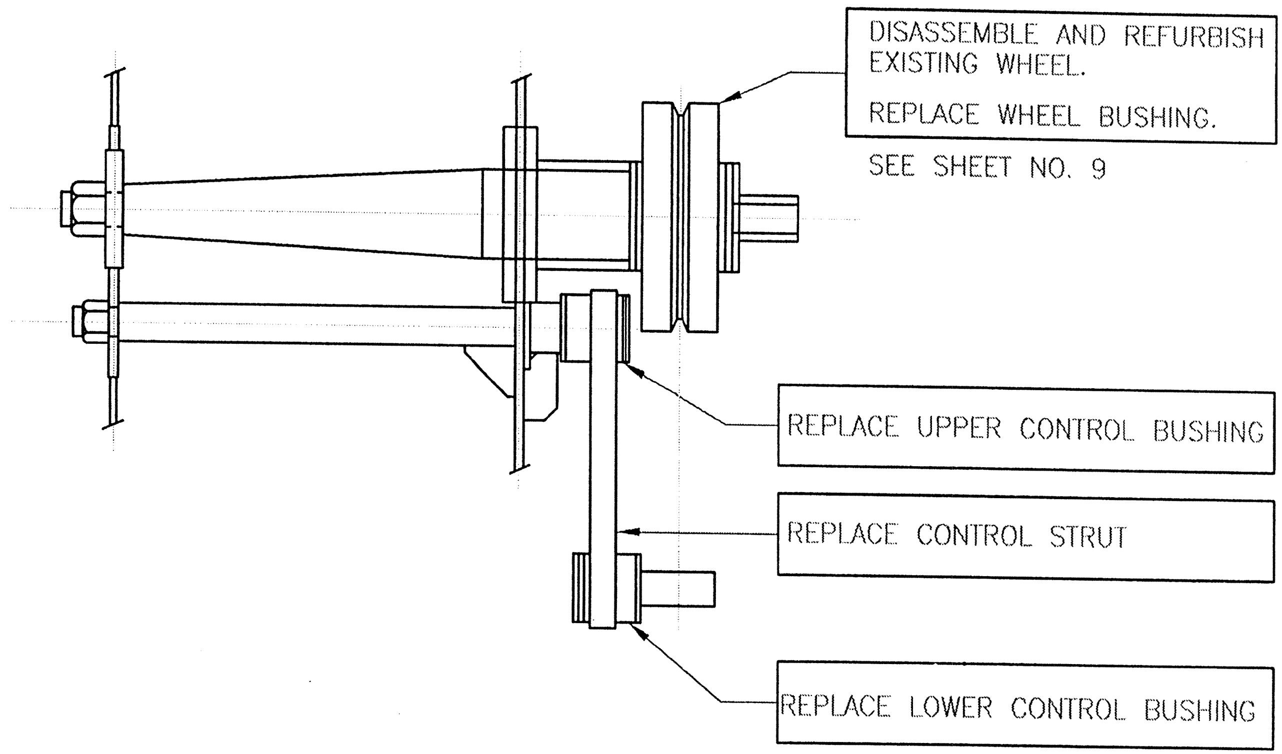
FIGURE 7



NEW ROLLER WHEEL BUSHING

MATERIAL: ASTM B22 ALLOY 937

FIGURE 8



SECTION B–B

TREAD PLATE NOT SHOWN
FOR CLARITY

FIGURE 9