AMERICAN CONSULTING ENGINEERS COUNCIL'S

HEAVY MOVABLE STRUCTURES MOVABLE BRIDGES AFFILIATE

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SESSION WORKSHOP NOTES

Session (3-1)
"Major Rehab. of Jefferson and Jackson Street Movable Bridges",
I.J. Dvorak, Teng & Assoc.Inc.,Il.

MAJOR REHABILITATION OF JEFFERSON AND JACKSON STREET MOVABLE BRIDGES

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INTRODUCTION

The Illinois Department of Transportation selected Teng & Associates to inspect as well as to prepare a Bridge Condition Report and Contract Documents for the rehabilitation of the Jefferson and Jackson Street Movable Bridges over the Des Plaines River in Joliet, Illinois. (See Figure 1). Both bridges underwent similar major rehabilitation. For the purposes of this article, only the Jefferson Street Bridge will be discussed.

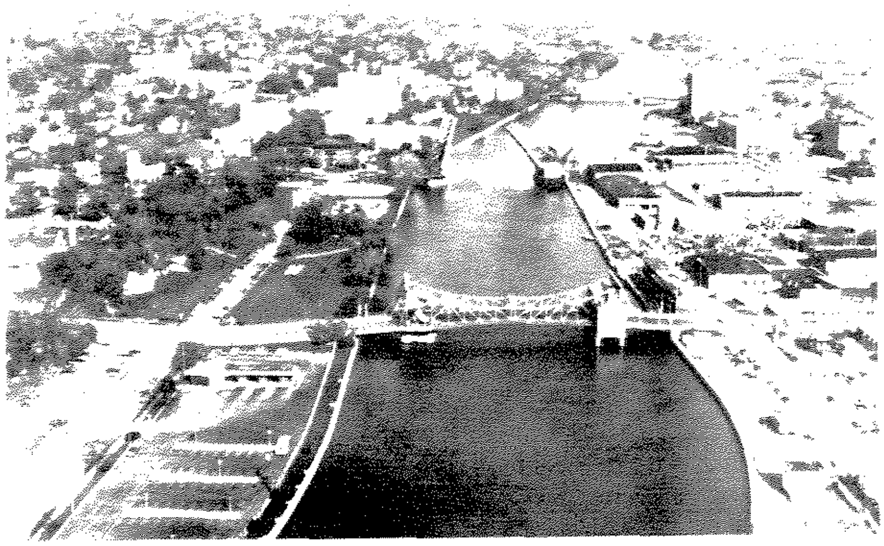

Figure 1 – Jefferson and Jackson Street Bridges

HISTORY OF STRUCTURES

Both bridges were designed as double leaf rolling lift bascule bridges and were built in 1932. The span between live load bearings is 168'. Clear channel width is 150 feet at an angle of 85 degrees with the centerline of the bridge.

The original track girder is a 24'–4" simple span rivited box girder. The box girder consists of two vertical webs and flange angles with cover plates. Four segments of track castings were attached by rivets to the top flange of the track girder. Prior to Teng's involvement, there were two major repairs made to track and segmental girders. One in 1958 and one in 1977. (See Figure 2).

The inspection in 1956 revealed that the 1/2" top flange cover plate had been "squeezed" down in thickness at the location of track casting joints. It was also found that many rivets connecting track casting to the top flange were loose, specifically those located close to the joints. The major portion of repairs to the track girders in 1956, were as follows:

1) The 1/2" top flange cover plate was replaced with a 1" thick plate
2) Existing stiffeners were thickened to 2 3/4"
3) New stiffener plates were welded to the bottom of outstanding leg of top flange angle.
4) A new 1" top flange cover plate was continuously welded to the outstanding leg of top flange angle.
5) Rivets connecting track casting to the track girder were replaced by high strength bolts.

Repairs to the track girders and castings were made again in 1977. This time, all four track girder castings were replaced. Top flange angles (8x6x7/8) and 1" cover plate were replaced in kind and existing stiffeners were rewelded to new top flange angles. (See Figure 2).

Additionally, repairs were made to the segmental girder. Two rows of 1" diameter high strength bolts were installed on each side of the break in all segmental castings. Also, cracked welds in segmental girders were repaired.

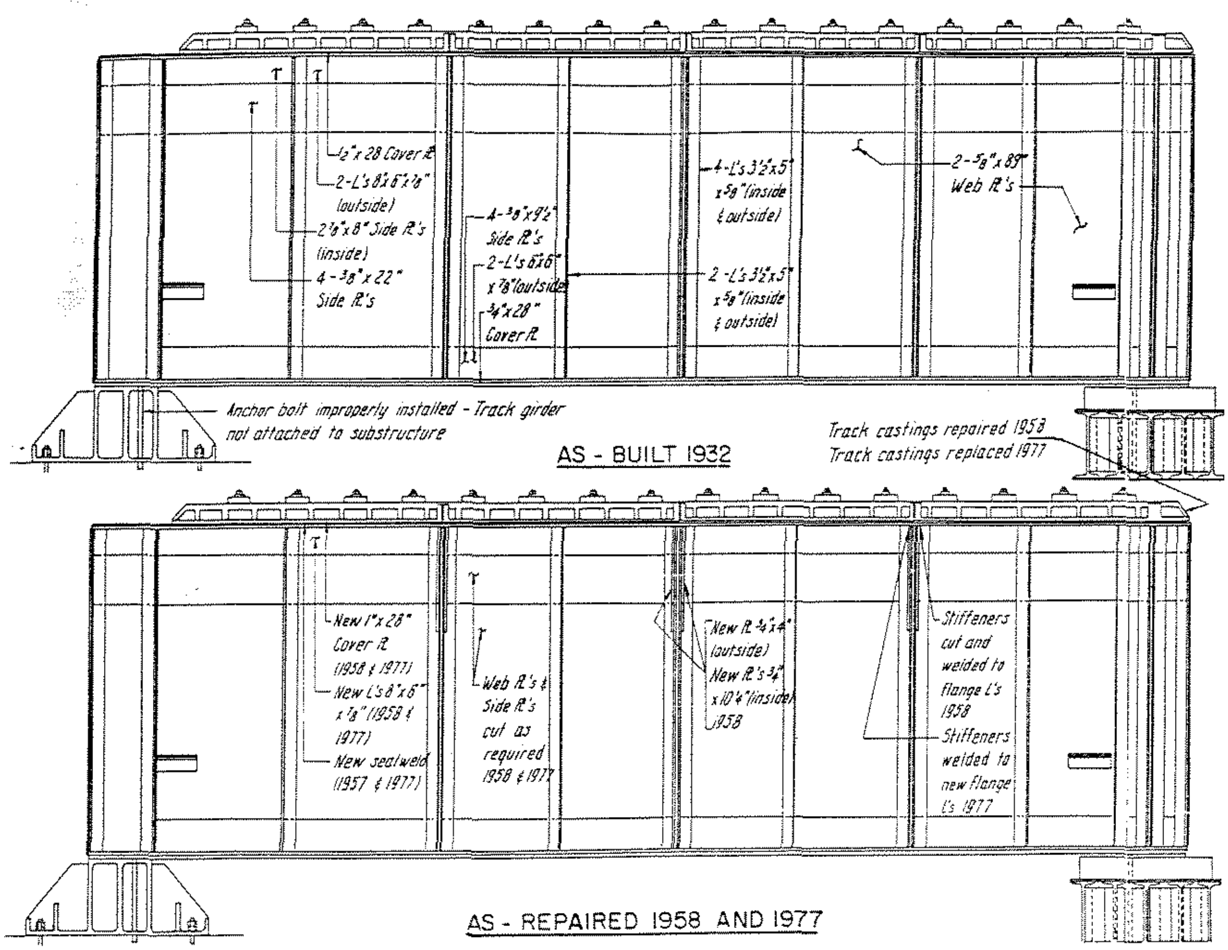

Figure 2 – Track Box Girder

FIELD INSPECTION

During field inspections conducted by Teng & Associates in 1983, the following significant deficiencies were discovered:

a) **Track and segmental girders.** Welds between flange angles and stiffeners were found cracked. In some cases cracks propagated into the outstanding legs of the flange angles. (See Figure 3 and 4). Slight permanent deflection of top flanges was observed over some of the intermediate stiffeners. Several intermediate stiffeners were buckled. Many H.S. bolts connecting track and segmental castings had been replaced, specifically in the vicinity of the joints. According to maintenance personnel, the breakage of these bolts was a common occurrence.

Interference of track and segmental casting lugs due to movable span misalignment was observed as well as the deflection of castings at their joints while movable span was in motion. It was also found that although track girders were attached to channel side bearings, they were not positively attached to approach side bearings. This was due to misalignments of bearings. Although the track girders had never been positively attached to the concrete substructure, there was no evidence of any movement of track girders from their original, as erected, position.

Figure 3 – Cracked Track Girder Flange

Figure 4 – Cracked Segmental Girder Flange

b) **Center break and center locks.** Center break teeth were not aligned and some had to be cut to allow operation of the bridge. This was due to movable spans misalignments. Center locks had an excessive clearance between "jaws" and diaphragms, causing the leaves to bounce under live load.

c) **Live load anchorages.** There was a gap instead of firm contact between anchor column bearing and anchor arm of the movable span. This caused the movable span to be supported by live load bearing and track teeth through the main pinion and machinery. The pinion and machinery were not designed for such loading. (See Figure 5).

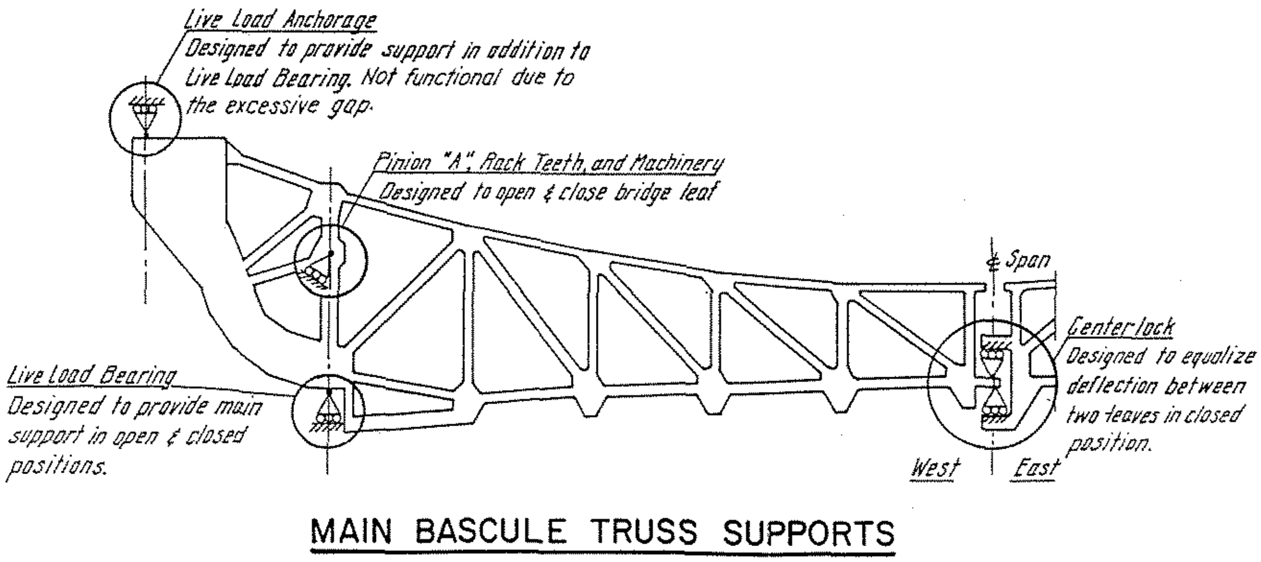

Figure 5 – Boundary Conditions without Support at Anchor Column

d) **Racks, pinions and pinion bearings.** The pinions bottomed out at approximately the location along the tracks at which the center of roll is above the joints in the horizontal tracks. This was caused by the downward movement of the leaf while moving across these joints. Bolts connecting main pinion bearings had been replaced but still were not preventing bearing from the up and down movement during the passage of live load over the bridge. This was due to boundary conditions described above in "c" for which this bearing and connection were not designed.

e) **Counterweight and bridge balance.** The concrete counterweight showed significant spalling and cracking. Bridge leaves were unbalanced. The leaves were counterweight heavy when closed and span heavy when open.

f) **Miscellaneous**. Steel deck grating had experienced significant loss of webs due to corrosion. Sidewalk brackets and fascia stringers were damaged by river traffic.

One interesting defect was found in the connection between approach sidewalk stringers and track girder. All angles which connected these stringers to track girder were fully cracked. This was due to the fact that the angle leg connected to the track girder was moved upward and inward by rotation and deflection of the track girder supporting a rolling bridge leaf, while the leg connected to the sidewalk stringer was restrained by concrete sidewalk slab. At one location, the angle was completely sheared off and stringer had dropped approximately 6". (See Figure 6).

Figure 6 – Sheared Off Stringer Connection

DESIGN OF REPAIRS

The main criteria for design of repairs for these bridges was to extend the service life of these bridges another 50 years. The design of main repairs were as follows:

a) **Track and segmental girders.** In the past, major and expensive rehabilitation had been performed on both these girders. These repairs had not significantly prolonged service life of the girders. Therefore, it was important first to find the cause of failure before the design of new retrofit.

Analysis of the track girder found that although the main bending stresses were well within allowable, the local bending stresses in the top flange cover plate and flange angle were well above the allowable. This was due to the geometry of the segmental and track casting details as well as the support details of the track girder's top flange. The geometry causes the total rolling concentrated load to be spread almost uniformly across the full width of the top flange of the track girders. The loading causes excessively high bending and shear stresses in the horizontal leg of the top flange angle.

It was important that the new design will keep local stresses of top flange within allowables. This was achieved in conjunction with the redesign of track and segmental plates. The new geometry facilitates a more direct transfer of the rolling concentrated load to the track box girders webs. (See Figure 7 for new detail.) By using A588 steel, the length of line bearing required was minimized. The existing top flange plates, angles and stiffener to flange connections were removed. The new flange plates were sized to keep the local tension bending stresses below the AASHTO allowable. The existing webs and side plates were cut in the field to accommodate the height of new flange and track plate. In order to attach the new top flange to the existing webs of track or segmental box girders, a weldment of a flange and two web plates was designed. (See Figure 8). This weldment was then connected by high strength bolts to the webs of existing track or segmental girder. (See Figure 9 and 10).

Conventional design for track and segmental girders requires that the enormous loads of rolling leaf are transferred directly through the bearing between flanges and webs. Since webs had to be cut to accommodate the deeper new detail, it would be necessary to prepare by field milling the web edges to provide bearing surface for new flanges. It was decided that such a procedure would be very time consuming and expensive. Furthermore, the detail would not allow for any field adjustment. Therefore, it was decided to cut the webs short and rely one hundred percent on friction rather than bearing connections, utilizing high strength bolts. (See Figure 7). To assure serviceability of this connection for the design life of this rehabilitation, it was decided to lower AASHTO allowable design load per one bolt by fifty percent.

One of the major deficiencies in the old design was the presence of numerous joints between track castings. In the new design of track and segmental casting, a milled plate was used instead with only one joint to avoid uneven deflection and breakage of connection bolts. This joint would not be required in the case of new construction, but in this retrofit it was required due to the construction staging. Design of repairs to segmental girder was similar to those designed for the track girders.

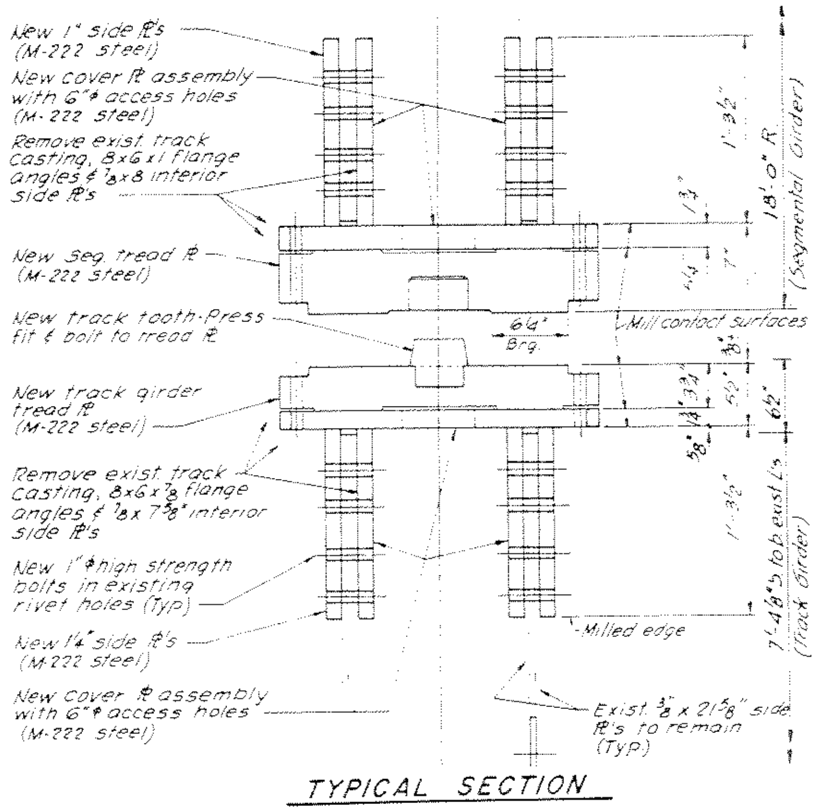

Figure 7 – New Segmental and Track Girder Stringer

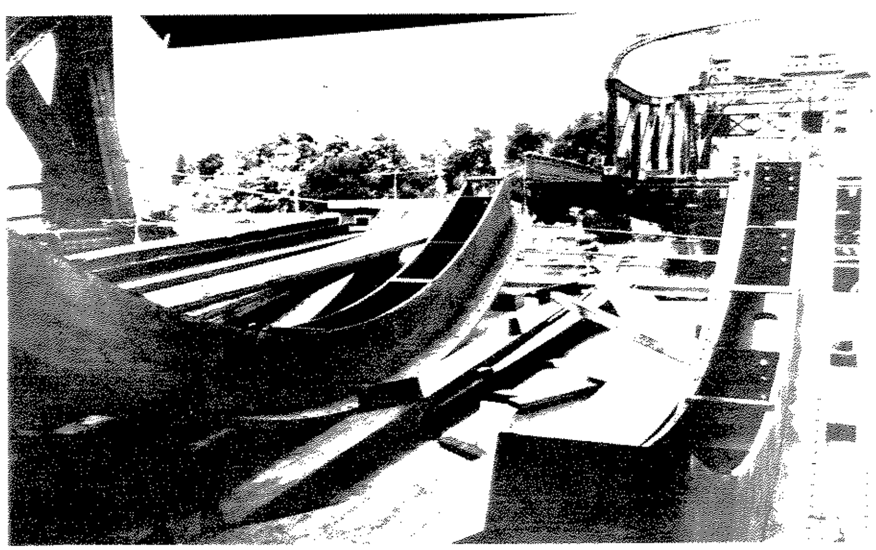

Figure 8 – Continuous Curved Segmental Girder Weldment Prior to Installation

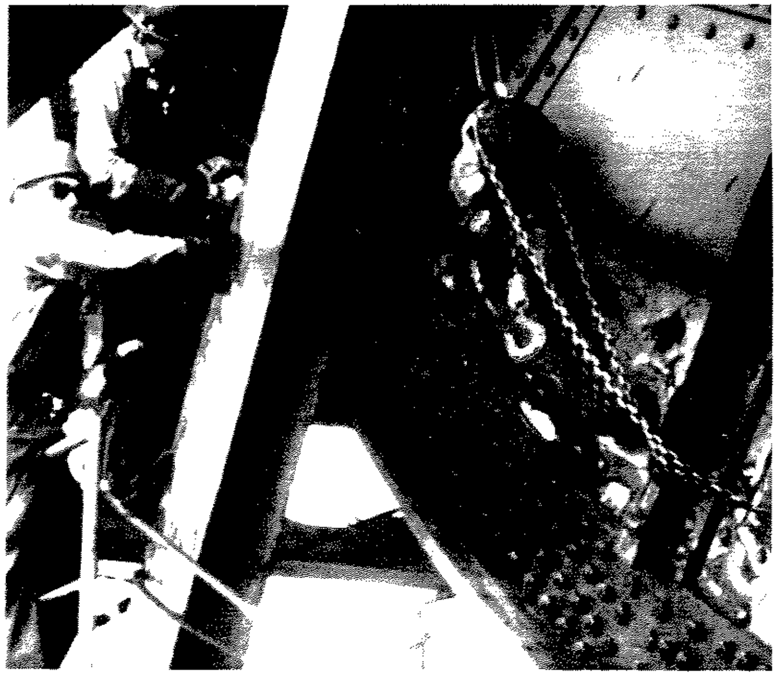

Figure 9 – Installation of New Segmental Girder Weldment

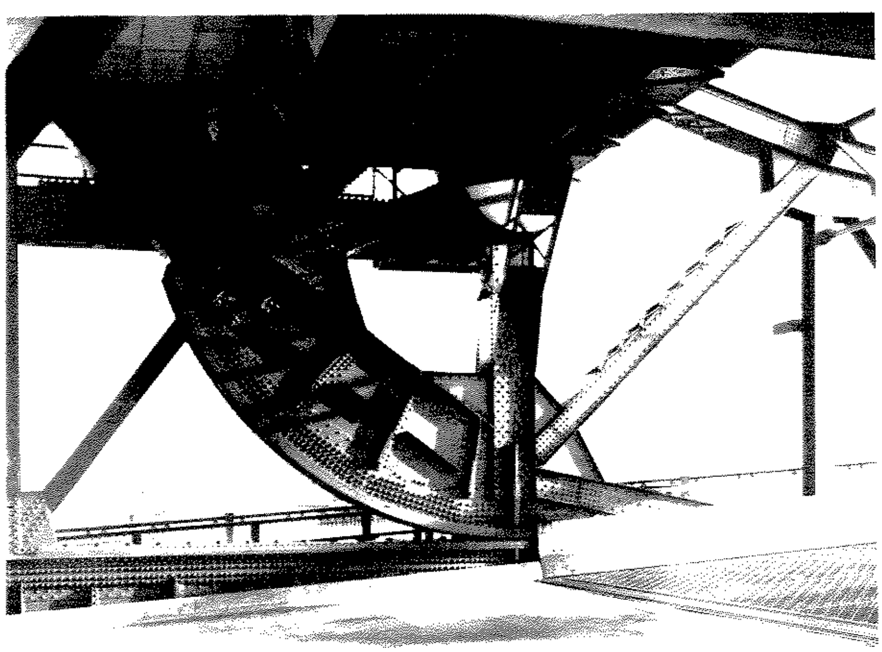

Figure 10 – Completed Installation

b) **Center break and center locks.** To avoid lateral and longitudinal interference of the existing center break finger plates, new spring loaded center break plates were used. This center break provides a smooth transition between the bridge leaves. (See Figure 11). This detail was used in the 1960's in Germany. The author adapted this detail for design of the new Columbus Drive Bascule Bridge in Chicago where it proved to be performing satisfactorily. Worn center locks were replaced to bring clearances down to 1/16".

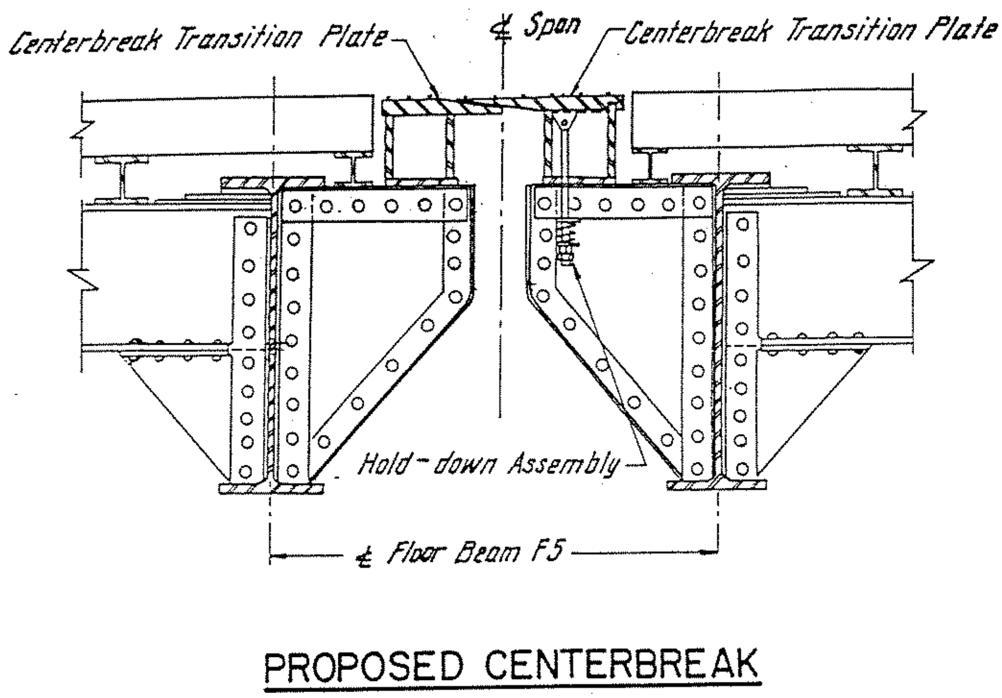

Figure 11 – New Spring Loaded Center Break Plate

c) **Live load anchorages.** Live load anchorage bearing plates were shimmed to assure firm contact between the counterweight and bearing plates, when the bridge is in closed position. Fully closed limit switches were adjusted to allow such contact.

d) **Racks and pinions.** Racks and pinions were replaced. Original track consisted of several segments. The new track design is a one piece configuration. Shims were added under the tracks, which could be removed as the tracks wear to prevent bottoming of pinions.

e) **Counterweight and balancing.** Approximately 9" to 12" of unsound concrete counterweight was removed around its perimeter and replaced with new reinforced concrete and sealed. Electronic balancing using strain gauges attached to the pinions shaft was designed to assist in the rebalancing of the bridge.

f) **Miscellaneous.** New steel grading was installed. A new 28' diameter dolphin was placed on the upstream side of the bridge to protect the bridge from the river traffic. The sidewalk stringer connection to the track was redesigned to use elastomeric pad which accommodates the rotation and movement of this connection.

SUMMARY AND CONCLUSION

Rehabilitations were completed 3 years ago. Based on on our discussion with maintenance personnel and our own cursory inspection of the bridges, all of the details appear to be functioning as designed. This rehabilitation design used several innovative details. Most significantly, the rehabilitation used several innovative details. Most significantly the design included a bolted connection of the track and segmental girder flange to webs connection and the use of a spring loaded center break. The flange to web connection of the girders has essentially eliminated fatigue sensitive details that had caused past maintenance problems. The new center break details allows more clearance for closing the spans and provides a smoother ride for vehicles crossing the bridge.

Both details have performed well and would be recommended for use in future designs.