HEAVY MOVABLE STRUCTURES, INC.
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Congress Parkway Bascule Bridge Rehabilitation over the South Branch of the Chicago River

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Abstract

The project is located in the City of Chicago, Cook County where the Congress Parkway (FAP 389) bascule bridge (SN #016-2445) crosses over the South Branch of the Chicago River. Congress Parkway is functionally classified as an Other Principal Arterial, is on the National Highway System (NHS) and a Class I Truck Route. The 2006 average daily traffic (ADT) count along Congress Parkway was 139,000 (2.0% trucks) and the forecasted 2021 ADT is 166,680. The existing cross section on the bascule bridge provides for four lanes in each direction with 10.75-foot-wide through lanes, a New Jersey aluminum barrier along the center of the bridge and a 1-foot, 5-inch high-steel curb along the outside edge of pavement adjacent to the 8-foot-wide sidewalk. The posted speed limit within the project limits is 45 mph westbound (WB) and 35 mph eastbound (EB).

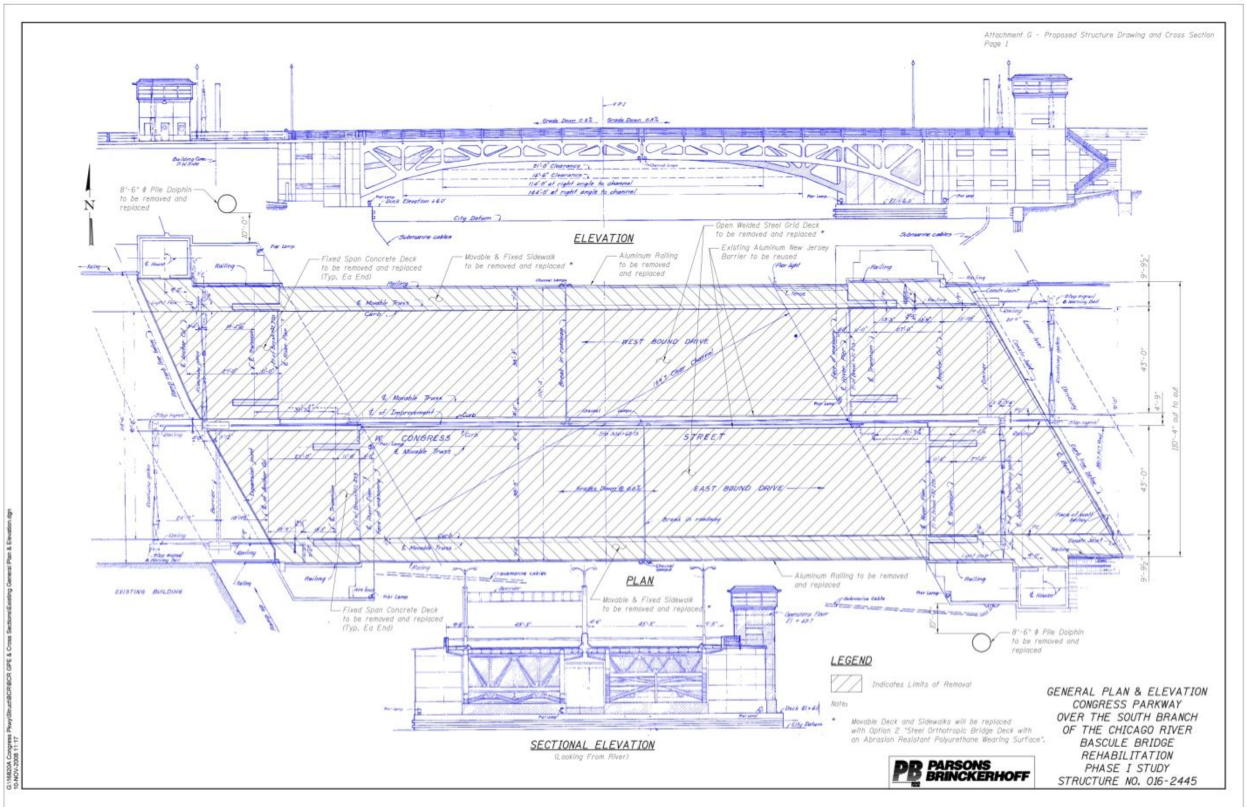
This bridge project was initiated due to structural, electrical and mechanical deficiencies, and associated bridge ratings. The bascule bridge is a fracture critical structure with a sufficiency rating of 2. The structure's poor condition rating is mainly due to the deterioration of structural components below the roadway level in the movable spans. This deteriorating condition may be attributed to the open-welded steel grid deck, which is not providing adequate protection to the superstructure elements.

The Illinois Department of Transportation (IDOT) contracted with Parsons Brinckerhoff to provide engineering services associated with the rehabilitation of the Congress Parkway over the South Branch of the Chicago River. The Phase I Engineering Services consisted of the studies and design needed to rehabilitate the existing bascule bridge over the Chicago River. Parsons Brinckerhoff provided the Phase I services accommodating the Project Report for Group II Categorical Exclusions and Design Approval. Other key work completed in conjunction with the Project Development Report included structural bridge inspections; architectural, electrical and mechanical inspections and other work tasks needed to prepare a complete Bridge Condition Report (BCR). The Phase II Engineering Services included the preparation of final contract plans, specifications and cost estimates (PS&E) and related documents. The Phase III Coordination Services included the review and approval of shop drawings, submittals and response to requests for information (RFIs). This paper will address the project development and the options for the rehabilitation of the structure, particularly the structural components including the use of an orthotropic deck.

Introduction

The Congress Parkway Bridge is located in the City of Chicago, Illinois. The substructure was constructed in 1952; the superstructure was constructed in 1954. The electrical equipment was installed in 1954 and the bridge houses and enclosures were constructed in 1956. In 1981, the superstructure was rehabilitated, which involved removing the median curb and railing and replacing it with an Aluminum New Jersey Barrier, removing and replacing the open steel grid deck, rebalancing the bascule bridge, and performing various miscellaneous repairs throughout the bascule bridge. From 1998 through 2007, there have been repairs made to the stringers and floorbeams of the bascule bridge.

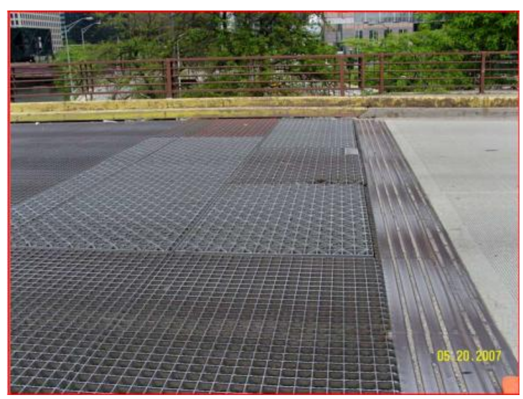
The existing structure is a dual double-leaf, trunnion type bascule bridge, carrying the EB and WB traffic of Congress Parkway over the South Branch of the Chicago River. There is a posted weight limit of 9 tons per axle and 37 tons gross. The movable structure has an overall length of approximately 298'-8 3/8" (centerline of anchor columns) and has an out-to-out deck width approximately 110'-4". The fixed spans vary in length (northwest = 52'-4", northeast = 78'-5", southwest = 63'-5", and the southeast = 75'-0"). The deck cross section consists of four 10'-9" traffic lanes with no shoulder, a 9'-9 .5" overall sidewalk on each side, and a 4'-9" median.



Field Inspection and Physical Evaluation

A field inspection and evaluation of the collected data assisted with determining the condition of the existing structure. . The field inspection included visual inspection and manual sounding of delaminated surfaces. The visual inspection was conducted with the aid of a manlift on a barge. The inspection was performed in accordance with the Federal Highway Administration (FHWA) Bridge Inspection Manual.

Deficiencies and deterioration, including collision damage, was located, photographed and recorded on previously prepared sketches. The condition of elements has been assigned descriptive ratings. Each descriptive rating corresponds to a general condition rating in accordance with the National Bridge Inspection Standards (NBIS).



In the movable span, the open- welded steel grid deck is in poor condition with loose sections and repair patches, particularly at the approach ends.

The superstructure was in serious overall condition, which corresponds to a National Bridge Inspection Standards NBIS and IDOT condition rating of 3.

The substructure is in satisfactory overall condition corresponding to an NBIS and IDOT condition rating of 6.

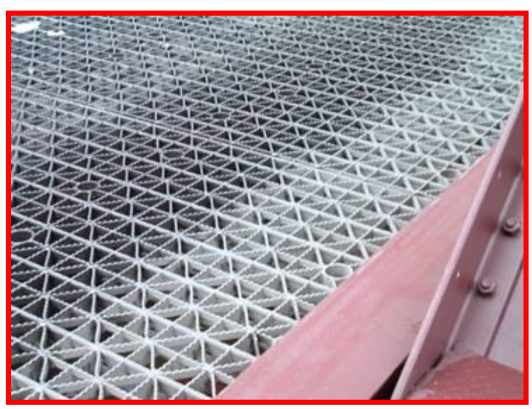
Potential Scope of Work Determination and Analysis

At the time of inspection, the bridge was generally in poor overall condition. To improve the deteriorating condition of the structural components and to provide an extended service life of 50 years, rehabilitation of the bridge is necessary. The recommendations outlined in this section for rehabilitation (replacement, repair, modify, or leave as is) of the structural members are based on several factors including cost effectiveness, useful service life, structural adequacy and efficiency in accordance with the current applicable standards. The adequacies of all existing members that are to be reused or deteriorated members that require repair or strengthening were further analyzed and load rated.

The structure's poor condition rating is mainly due to the deterioration of structural components below the roadway level in the movable spans. This deteriorating condition may be attributed to the open-welded steel grid deck, which is not providing adequate protection to the superstructure elements. Deicing chemicals, moisture, and debris accumulation may be the underlining cause of the current deterioration.

The deck is in overall poor condition. The existing open-welded steel grid deck was replaced during the 1981 deck rehabilitation. Based on the deterioration and the age of the existing deck (26 years), bridge deck replacement is most appropriate. Various deck replacement options have been investigated including:

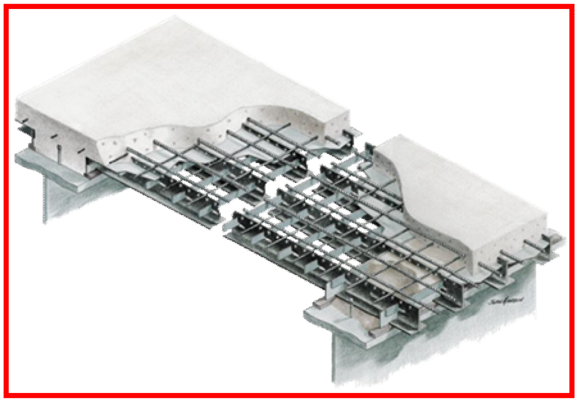
- Option 1: Solid deck using exodermic deck with lightweight concrete
- Option 2: Solid deck using orthotropic deck
- Option 3. Solid deck using half-depth filled steel grid deck with lightweight concrete
- Option 4: Partially filled deck using half-depth filled grid deck with lightweight concrete at the breaks and 8'-0" sections over the floorbeams
- Option 5: Open steel grid deck (similar to existing)



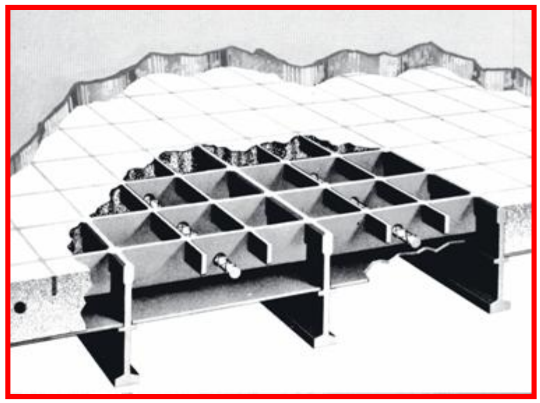
Replacement in-kind (Option 5) was immediately ruled out. In redecking scenarios, it is common practice in bascule bridge rehabilitations to utilize closed decking systems aiding in the dramatic reduction of costly maintenance repairs to the structural components below the roadway level.

The use of a solid deck (Options 1-3), offers the following advantages:

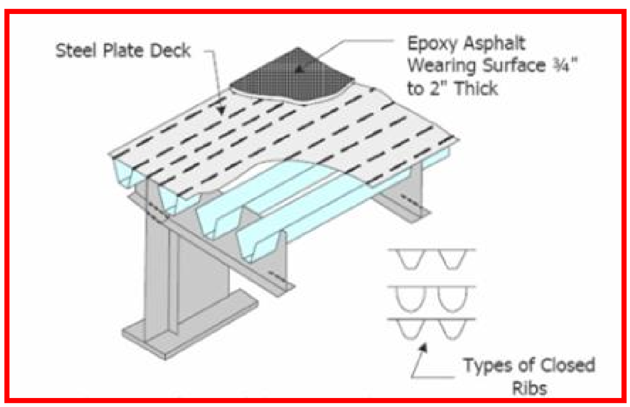
- Drastically improves the overall riding quality – decreasing road noise and providing better skid resistance
- Protects the floor system below the roadway surface from water runoff, chloride contaminates, and debris accumulation
- These modular deck systems are prefabricated offsite and constructed rapidly often erected during short construction windows



Exodermic bridge decks (Option 1) have been around since the early 1980s. However, the system is recommended for spans up to 15 feet between supports. After conducting a preliminary analysis of an exodermic deck spanning between to the floorbeams at approximately 16 foot on center and utilizing lightweight concrete, the decking would have to be simply supported between floorbeams complicating the required floor system framing details and ultimately increaseing the deck thickness to 9.6 inches with an overall weight to 71.5 psf. The maximum available distance above the inside truss and at the Floorbeam 12-12 is only 6 inches. In addition, Option 1 would require replacing the main drive motors, adding counterweight beyond what the counterweight pockets will accommodate, and would load the trunnion shafts and bearings beyond American Association of State Highway and Transportation Officials (AASHTO) allowable limits. This option is not recommended.



Half-depth filled grid bridge decks (Option 3) have been around since the early 1930s. The longevity of these grid deck systems can be attributed to their fundamental design combining the tensile strength of the steel with the compressive strength of the concrete utilizing the capacities of both materials. A majority of the movable bascule bridges in Chicago utilize the open, half-depth, and full-depth filled grid decks with satisfactory performance. Utilizing the half-depth filled 5” grid deck with lightweight concrete will weigh approximately 45 psf and can be implemented on the Congress Parkway Bridge since it was originally designed for an open 5” grid deck. However, Option 3 would require replacing the main drive motors, adding counterweight beyond what the counterweight pockets will accommodate, and would load the trunnion shafts and bearings beyond AASHTO allowable limits. This option is not recommended.



Orthotropic bridge decks (Option 2) have not been widely used in the past due to fatigue concerns and have been plagued for years since the technology was first implemented in the U.S. because of the wearing surfaces prematurely delaminating from the steel plates. In the past 10 years, new wearing surfaces like the epoxy asphalt type have been developed which are said to eliminate this problem. Unfortunately, this wearing surface has not been utilized on any bascule bridges and it is unsure how the wearing surface will perform in the movable bridge application. However, an abrasion resistant polyurethane wearing surface is a selection of high-grade abrasion resistant aggregates held together with a blend of specially formulated polyurethane resins, designed to give strength, flexibility, and long life durability. The resin system is fully impervious and encapsulates the steel surfaces to give it added corrosion protection, thereby extending the service life of the steel itself. This is new technology and has been tested here in the U.S. and in Canada. This wearing surface is said to decrease stopping distance by 30 percent when compared to conventional asphalt wearing surfaces and can last for 10 years before reapplication. After conducting a preliminary design, the orthotropic deck can be continuously supported between the floorbeams and will have an overall weight of approximately 42 psf including the wearing surface. The 42 psf includes the main longitudinal stringers that account for approximately 15 psf in the existing condition. Therefore, the added net weight is approximately 7 psf over existing condition.

Similarly, a lighter partially half-depth filled 5" grid deck (Option 4) with lightweight concrete filled only at the breaks and in approximately 8 foot sections over the floorbeams will weigh approximately 33 psf (average half-filled and open steel grid deck). Although, the flooring system is not completely closed, the structural element including the floorbeams, stringer ends, and bottom bracing connections will be protected from water runoff, chloride contaminates, and debris accumulation which are the major causes for structural deterioration.

Therefore, after conducting an analysis including the necessary rebalancing of the bridge and considering the weight of each deck (Options 1 thru 4) when evaluating the increased stresses on the existing machinery elements, either the orthotropic deck (Option 2) or the partially half-depth filled 5" welded steel grid deck utilizing lightweight concrete (Option 4) are recommended as viable options.

The partially half-depth filled 5" welded steel grid deck utilizing lightweight concrete or the orthotropic deck can be utilized by rebalancing of the bascule bridge by adding additional counterweight blocks in the counterweight boxes. The orthotropic deck has a construction cost of $3,858,862 excluding the approximately $600,000 that will be required for the replacement of the four motors due to the added stress resulting from wind loads on closed deck. The partially half-depth filled 5" welded steel grid deck has a construction cost of $4,212,296. Since the orthotropic deck will fully protect the structural elements, it is the recommended deck option for the rehabilitation.

The orthotropic deck system recommended (Option 2) has been specifically designed to keep the actual stresses low, by introducing closely spaced built-in transverse floorbeams and in this case also closely spaced longitudinal stringers. Thus, the design stress range for the deck and its components can be kept less than 50 percent of the constant-amplitude fatigue threshold. This means that the fatigue resistance of the deck will theoretically provide an infinite life. (See clause 6.6.1.2.5 and commentary of AASHTO LRFD Bridge Design Specifications). Therefore, if the stress range is below a certain value, fatigue no longer controls the design life of the deck.

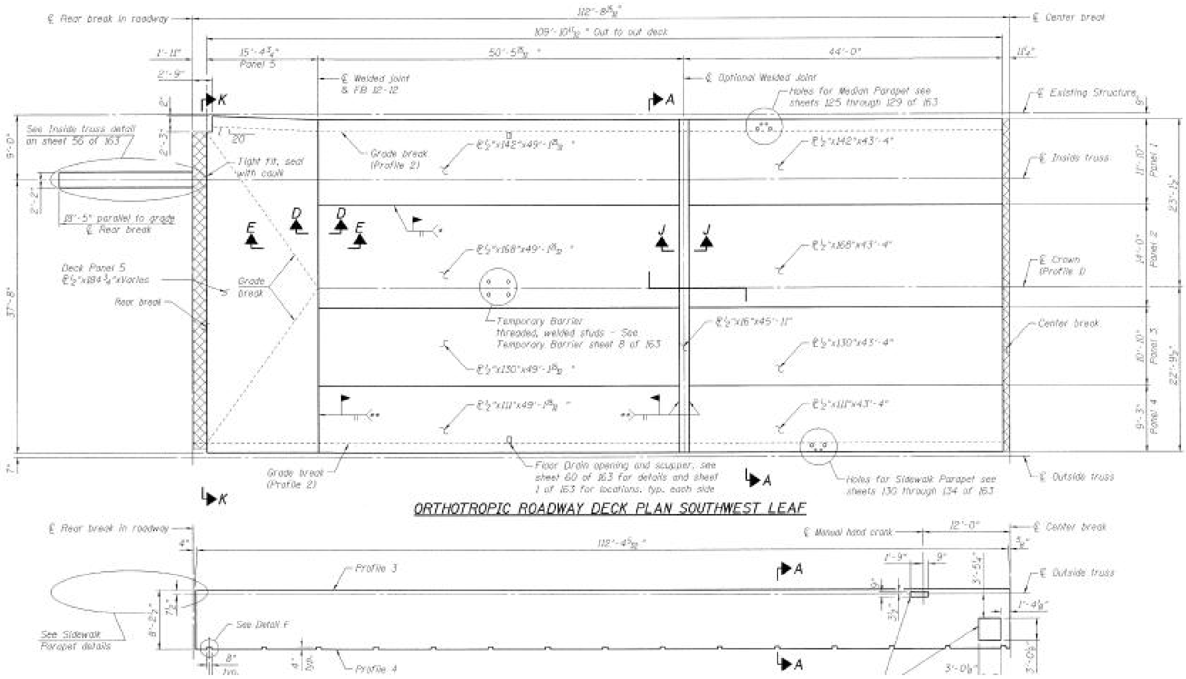
To alleviate a common misconception, the deck is not considered to be fracture critical. In order to be fracture critical, a member failure would have to result in the collapse of the bridge. Each deck section is proposed to have 16 continuous ribs, as well as eight continuous longitudinal stringers plus transverse floor beams spaced approximately every eight feet. There is a lot of redundancy in this type of deck and thus it is not fracture critical.

During the research and preparation of this report, data was gathered through correspondence with two well known wearing surface manufacturers, RS Clare and Stirling Lloyd.

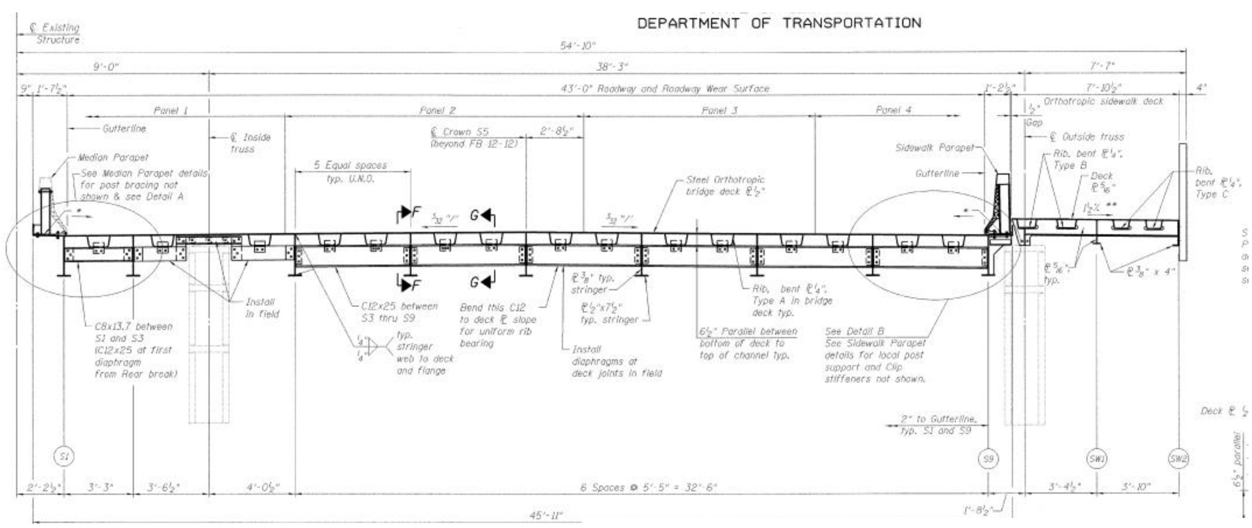
Scope of Work

Some of the selective scope of work included:

1. Remove the open steel grid deck and replace with an orthotropic deck system to protect the structural elements below the roadway.

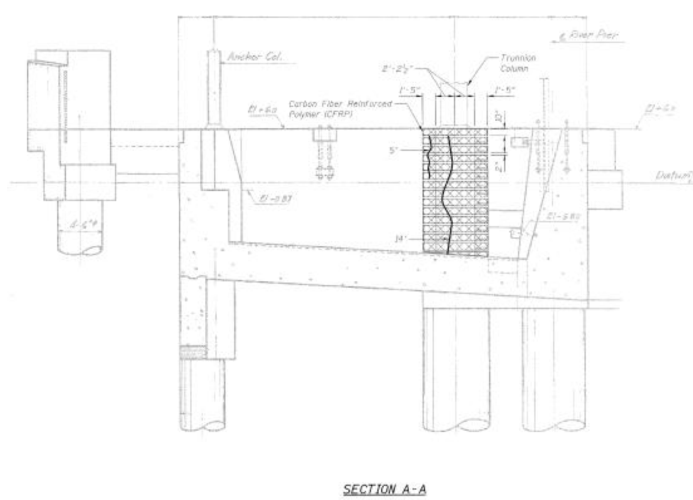


Typical orthotropic deck and sidewalk plan

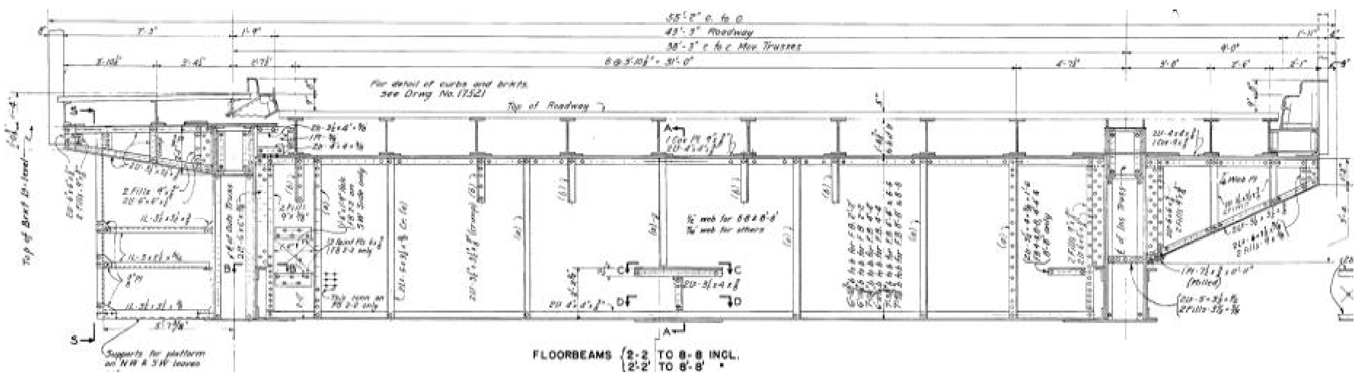


Typical orthotropic deck section

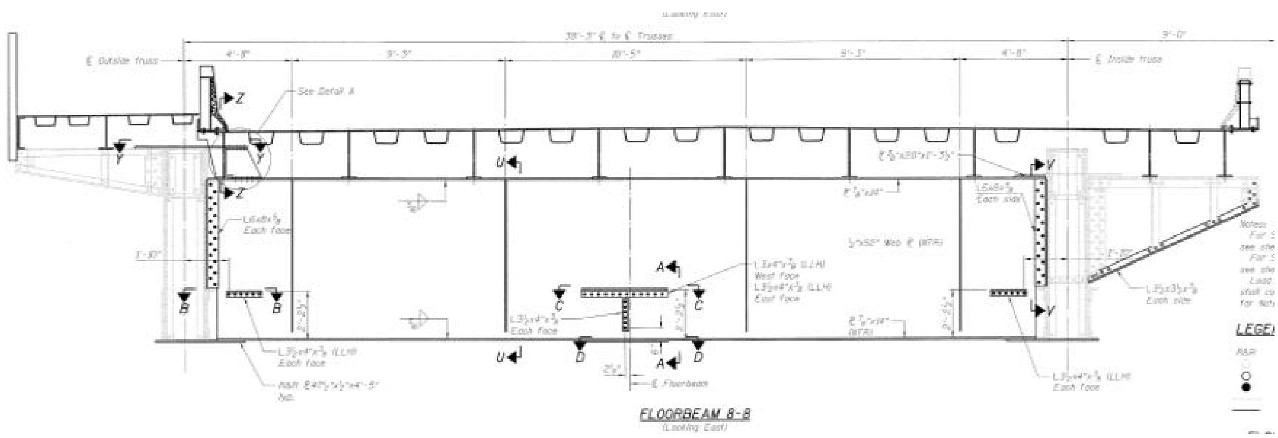
2. Perform structural concrete repairs and epoxy injecting cracks of the substructure elements. Reinforce concrete pedestals (sidewall corbel piers) at the trunnion bearings with carbon fiber reinforced polymer (CFRP) repair system.



3. Repair/replace floorbeams and floorbeam brackets in the movable spans.

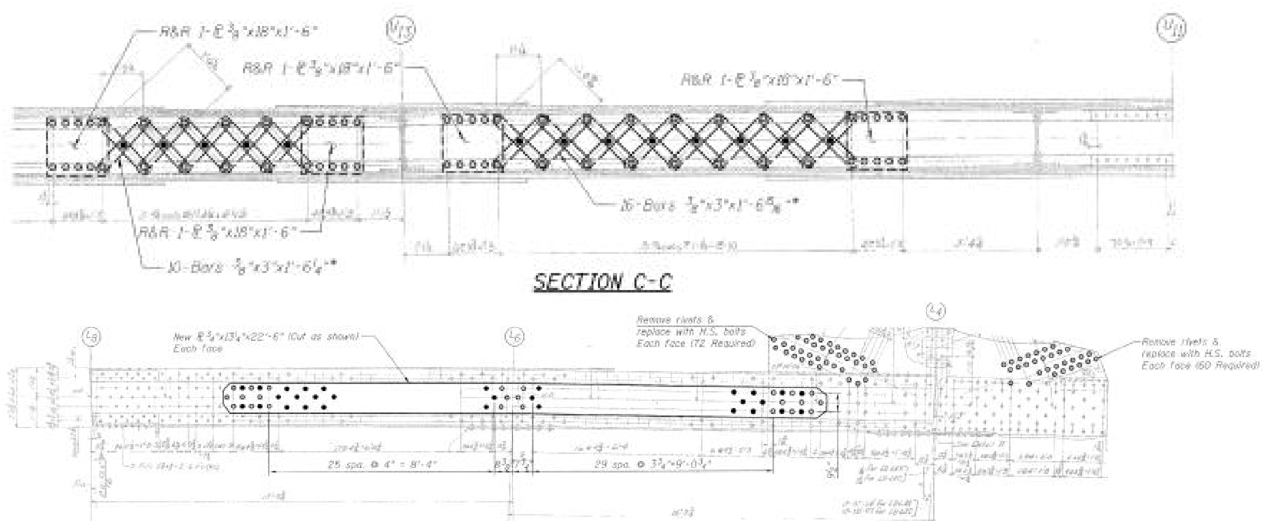


Existing floorbeam in the movable span

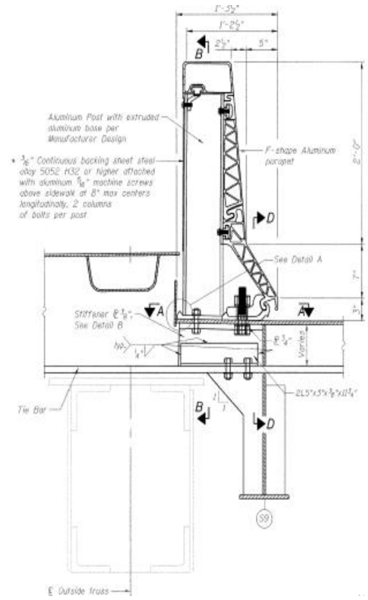


Proposed floorbeam in the movable span

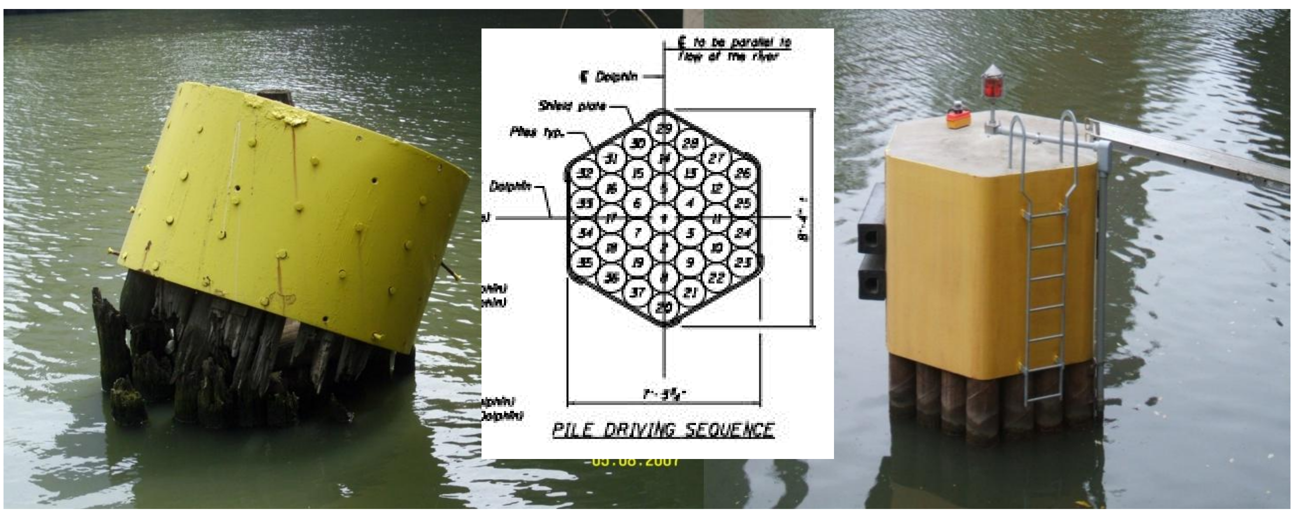
4. Truss Steel Repairs – replace selected elements or plate the areas of documented section loss and strengthen members as required by the load rating.



5. Remove and replace the steel curb in the movable spans with F-shape aluminum barrier. Note that the F-shape aluminum barrier is proposed to extend into the fixed approach spans and the adjacent structure to the west.

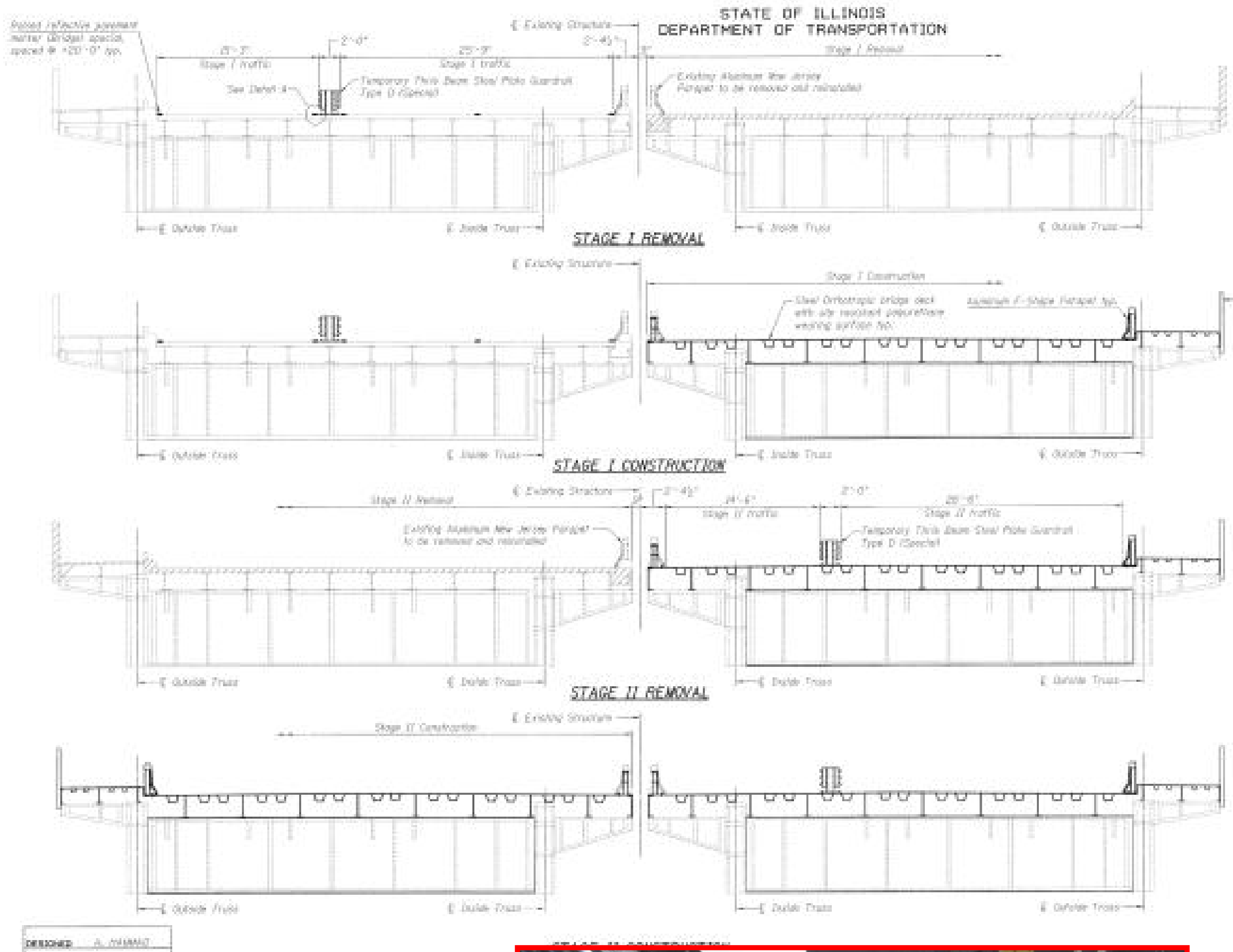


6. Remove and replace the pile dolphins at the southeast and northwest ends.
7. Remove and replace the fender system and counterweight pit bumpers with a self-restoring rubber type that would not be severely damaged upon impact.



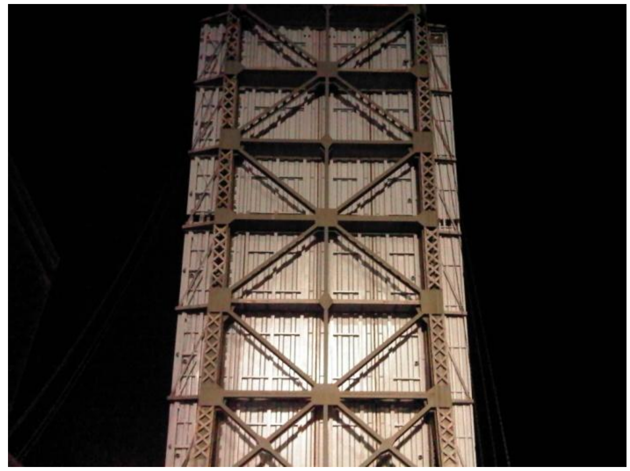
Maintenance of Traffic

Congress Parkway Bridge (016-2445) consists of adjacent structures (EB and WB). Each structure will

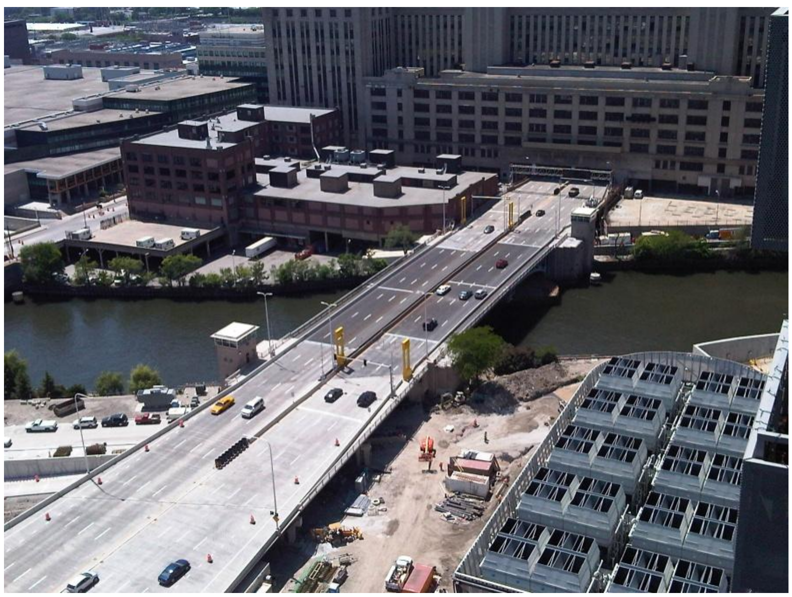


be closed to vehicular traffic during construction and traffic will be detoured. To allow for river traffic requiring opening of the leafs, rehabilitation may be done on both leafs while in the open position, or rehabilitation may be done on one closed leaf while allowing the other to be opened for river traffic.

Orthotropic deck during erection



Underside of orthotropic deck in the open position



All lanes are open to traffic after two years of construction

Acknowledgement

We are grateful to IDOT District 1 and Bureau of Bridges and Structures. In particular, we thank the IDOT Project Manager Brian Kuttab for his support and contribution.