HEAVY MOVABLE STRUCTURES, INC.
SIXTEENTH BIENNIAL SYMPOSIUM

September 19-22, 2016

Orthotropic steel deck: a proven solution for new uses

Éric Lévesque & Maxime Ampleman
Canam-Bridges

TAMPA MARRIOTT WATERSIDE HOTEL AND MARINA
TAMPA, FLORIDA

Abstract

The superstructure of the Hastings swing bridge, a small bridge in the Village of Hastings, Ontario, has been replaced recently. The replacement involved interesting challenges such as ensuring the weight of the new bridge superstructure and deck was low enough for the existing mechanical and electrical elements in the substructure to support its movement. The demolition and reconstruction of the bridge had to meet aggressive schedule requirements. This paper presents a solution to these movable bridge rehabilitation challenges by using orthotropic steel deck (OSD).

Introduction

The Hastings movable bridge, located in the Village of Hastings, Ontario, Canada, needed major repairs. The 2,200 square foot swing bridge - 83.8 feet (25.6 meters) long by 26.7 feet (8.2 meters) wide - superstructure needed replacement.

- 2013 - The owner decided to reconstruct the entire superstructure, and Canam-Bridges, through early involvement, proposed an OSD solution. Associated Engineering, was hired to design the superstructure that comprised an OSD, along with the mechanical, electrical and substructure.
- 2015 - The project was tendered for construction with two interested general contractors. For this tender, the general contractor was responsible of the final design of the OSD, and Canam-Bridges was awarded the final design of the OSD, the supply and fabrication of the OSD and the superstructure, the antiskid wearing surface Bimagrip LS, the transportation logistics, and the steel erection.
- 2016 – Canam-Bridges completed the erection of the new superstructure of the Hastings swing bridge.

The replacement involved interesting challenges like ensuring the weight of the new bridge superstructure and deck was low enough for the existing mechanical and electrical elements in the substructure to support its movement. The demolition and reconstruction of the bridge had to meet aggressive schedule requirements. This paper presents a solution to these movable bridge rehabilitation challenges by using orthotropic steel deck (OSD).

Orthotropic steel deck

Associated Engineering, along with Canam-Bridge's early involvement, chose an orthotropic steel deck (Figure 1) solution due to its light weight; a very competitive option for movable spans when compared to conventional deck systems. The Canadian Highway Bridge Design Code CAN/CSA S6-14 suggests that a solid deck of lightweight construction in movable spans be considered in order to improve traction, reduce noise and protect the infrastructure and superstructure of movable bridges.

Canam-Bridges' orthotropic steel deck is shop-fabricated under a rigorous quality-assurance and quality control program, offering a service life well beyond 75 years. With easily defined geometry, an orthotropic steel deck can offer increased moments of inertia, more effectively and efficiently controlling deflections.

OSD also allows the contractor to apply a thin antiskid (and asphalt if desired) wearing surface, allowing for an even quicker installation on the jobsite.

Figure 1: Typical orthotropic deck section

Particularities of the project

The design and optimization of the OSD was the contractor's responsibility, but the engineer designed the structure in accordance with the latest standards while also respecting the maximum weight imposed by the contract specifications.

The contract also specified that the OSD and the superstructure must be pre-assembled in the shop. Because Canam-Bridges secured both contracts for the OSD and superstructure, this continuity greatly simplified the process.

Finally, as the new bridge was erected on the existing substructure and rotating support, the weight of the new structure had to be adjusted accordingly.

Design/Fabrication

The new deck is non-composite; instead of using typical longitudinal T's connected to steel girders, loads are carried out by the floor beams to the twin-girder system superstructure (Figure 2).

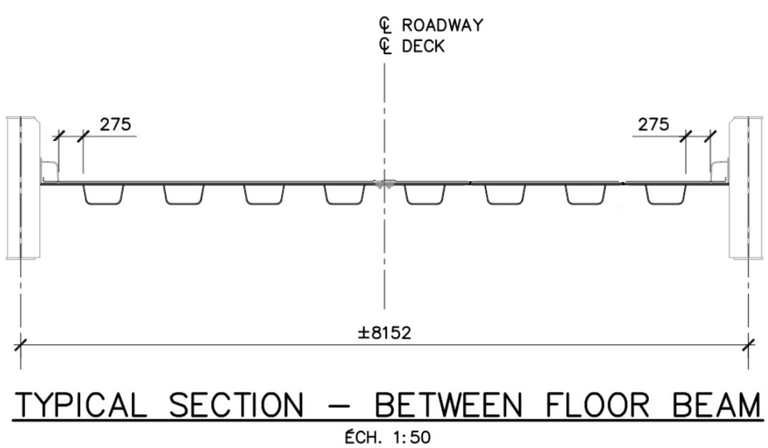

Figure 2: Typical cross section of the non-composite steel deck

The fabricated orthotropic steel deck weighs 53.8 lbs/ft^2 (263.3 kg/m^2). Two major criterias, self-weight and fabrication costs, were considered when optimizing the design of the deck. It is important to note that a lighter steel structure does not always equate to lower fabrication costs. In the case of an orthotropic steel deck, fabrication time is reduced by optimizing the number of ribs. Using a thicker deck plate increases the overall weight of the deck, but reduces the number of ribs, and in turn, reduces the cost of fabrication. When optimizing a design solution, it is critical to consider more than just weight. Reducing shop fabrication hours may have a greater impact on cost savings than trying to just reduce overall weight.

The contract documents specified an 80% partial joint penetration (PJP) with 70% minimum (Figure 3) for the rib-to-deck plate welds. The deck plate thickness was 18 mm, a thickness that reduces welding deformations.

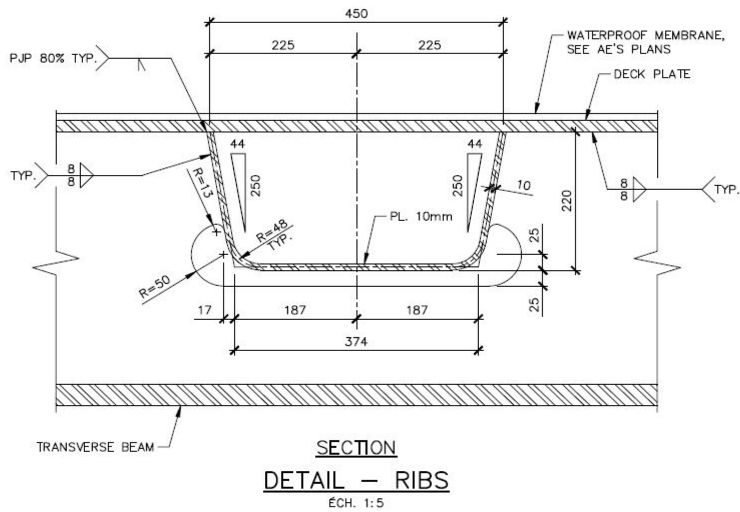

Figure 3: Detail of a rib-deck plate section

Another challenge of the design was that the client asked for an asphalt wearing surface. The engineer chose a longitudinal bolted joint with countersunk bolts to fasten the deck section (Figure 4).

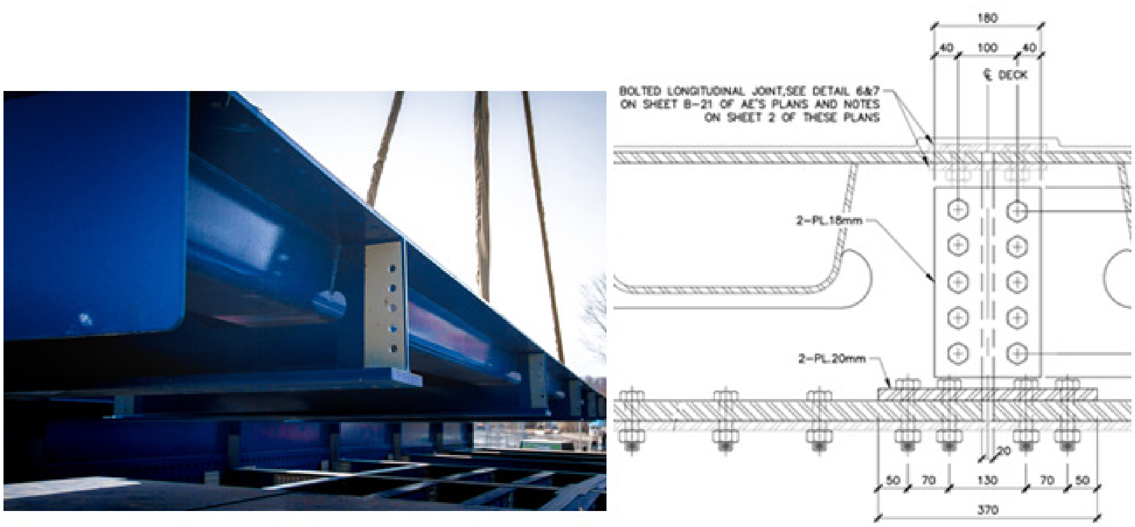

Figure 4: Bolted longitudinal joint

Canam-Bridges fabricated both the superstructure and OSD which ensured a proper fit up when pre-assembled in the shop (Figure 5). More specifically, the OSD was fabricated to fit on the "as built" superstructure, reducing any chance of error. On site, the structure was re-assembled at the same elevations that were tested in the shop.

Figure 5: Pre-assembly in shop

Balance testing

To balance the weight of the bridge, counterweights were used to position the center of gravity in alignment with the center of the rotating support located at 1/3 the length of the span. These counterweights were made up of steel plates in boxes on the short side of the bridge (Figure 6).

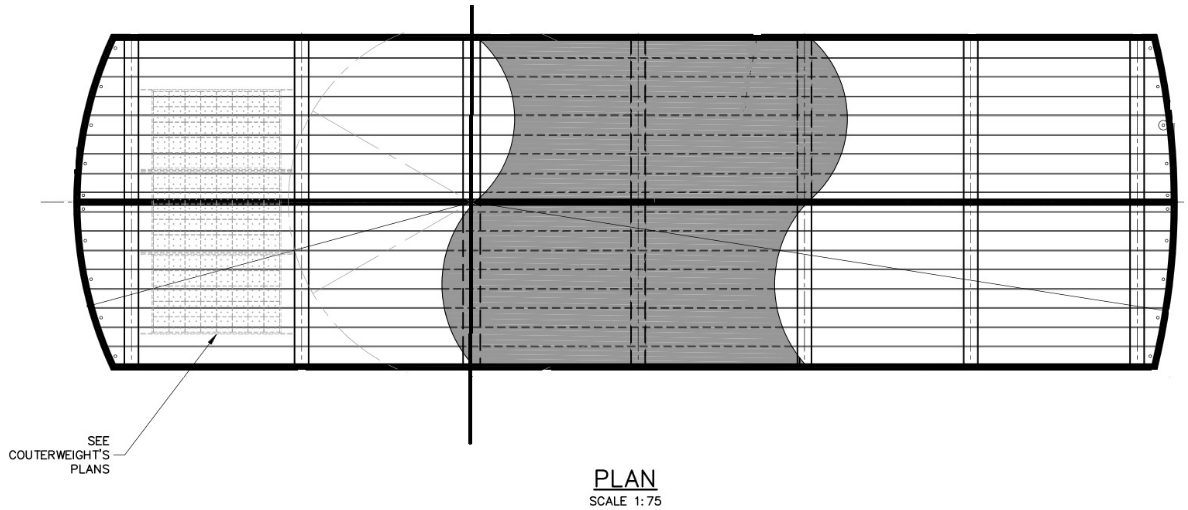

Figure 6: Counterweights on the short side of the bridge

In order to ensure balance, the weight of every piece of the bridge was scrutinized. The theoretical weight of each steel piece was indicated on the shop drawings. However, counterweights and the majority of the "as built" bridge assemblies had to be weighed in the shop (Figure 7) to properly locate the counterweights and ensure a favorable center of gravity. The final balance was carried out on site.

Figure 7: Measuring the weight of one assembly

Conclusions

This paper presented a successful orthotropic steel deck solution for a movable bridge rehabilitation (Figure 8). Key points to this project's success can be summarized as follow:

A. Final design and optimization of the OSD was performed by the contractor;
B. Fabrication of the OSD and superstructure have been done in the same plant in order to facilitate the pre-assembly in shop and to have an OSD that fit in the superstructure "as built";
C. Steel fabricator had experience with OSD in order to avoid fabrication difficulties.

Figure 8: Bridge installation on site