Ambassador Bridge Redecking Fosters Growth between Nations

By Michael Borzok, P.E.

As the single busiest land border crossing in North America, the Ambassador Bridge is critical to trade and tourism between the United States and Canada. It is estimated that 150,000 jobs in the region and $13 billion in annual production are reliant on the crossing. As bridge traffic is expected to increase in the coming years, it is important for the region's economy that the bridge continue to provide for safe and unobstructed traffic flow between the two countries.

Motorists traveling on I-75, a major highway that carries traffic through Detroit, could not easily access the bridge from the interstate. The Detroit International Bridge Company (DIBC), the owner of the Ambassador Bridge, and the Michigan Department of Transportation (MDOT) wanted to improve access from I-75 to enable traffic to flow more freely between Detroit and Windsor, Ontario. To do so, they would need to add new ramps to provide direct access from I-75 to the bridge.

In order to receive federal funding for the new ramps project and to ensure the safety of motorists crossing the bridge, the MDOT required a complete structural assessment of the existing structure. The effects of decades of heavy use, complicated by the fact that a comprehensive load rating had not been done in a number of years, would need to be assessed. Thus, the Ambassador Bridge Gateway Project was created. The $230 million project is the largest single construction project ever undertaken by MDOT and was created to ensure that the iconic structure will be able to bear the load of future bridge traffic, and serve both the United States and Canada for years to come.

Deck replacement of the suspended spans included installation of new steel stringers.

The DIBC turned to bridge engineering firm Modjeski and Masters, which had served as design consultant when the Ambassador Bridge was originally constructed in 1929, to lead both the assessment and design phases. Modjeski and Masters began by developing a detailed asset management plan that provided a well-defined strategy for addressing critical needs first and prioritizing others. The plan would ultimately involve an in-depth inspection, and the assessment and instrumentation of numerous members on the bridge. Next, they completed a comprehensive load rating, which identified the need for structural repairs to ensure the safety of the traveling public. Along with the repairs, an internal inspection of the main cables was performed, which included a determination of their strength.

Major repairs, as outlined in the comprehensive assessment, were underway in 2007 and included the replacement of 30% of the suspender ropes, the rehabilitation of various structural members and, ultimately, a redecking of the main span. Bridge lanes on the main span also needed to be widened to accommodate 12-foot lanes – today's industry standard.

During the redecking design phase, the engineering team faced a series of challenges that had to be addressed early in the process. Featuring a main span of 1,850 feet, the Ambassador Bridge was once the longest suspension bridge in the world. A suspension bridge of this magnitude, located 150 feet above water level, is a dynamic structure that requires specialized structural expertise during the design phase. Maintaining weight distribution and preventing instability during and after construction were critical to preserving structural integrity and, in turn, motorist safety.

A solid Jersey-type barrier presented the first major challenge for the design team. Another consultant, engaged before Modjeski and Masters, had already created deck replacement plans that were ultimately put on hold. As part of their work, however, a solid concrete barrier was specified from end to end. The design team knew a solid barrier could potentially cause a suspension bridge to become unstable during certain wind events. The team engaged an aerodynamic consultant who created a scale model of the bridge that was tested in a wind tunnel, and confirmed that the solid concrete barrier was creating instabilities during strong winds. Working together with the DIBC, it was determined that the concrete barrier would need to be substituted with an open barrier in order to improve aerodynamics.

Further complicating bridge behavior was the widening of travel lanes, and the removal of a sidewalk located on only the western side of the bridge. The original bridge had four 11-foot travel lanes – one foot per lane too narrow for today's safety criteria. Pedestrian and bicycle traffic

were previously allowed to cross between the United States and Canada, but following the September 11, 2001 terrorist attacks, the U.S. Department of Homeland Security prohibited all pedestrian traffic at international crossings. To accommodate today's 12-foot lane standard, the design included removing the sidewalk to create more space.

However, removing the sidewalk, and replacing it with heavier roadway, presented a new challenge in maintaining bridge balance. To account for the weight imbalance, the design called for the replaced deck to be made up of a combination of lightweight and normal weight concrete. In addition, concrete ballast was added to the westernmost side of the bridge, along with a curb consisting of heavyweight concrete.

The rehabilitation of the suspended spans was performed in stages.

Another challenge involved traffic flow during the construction stages. Since so much commerce relies on this crossing, it was essential that traffic continue moving throughout the entirety of the redecking contact. The project was broken into four stages, which would allow for three of the four traffic lanes to remain open at all times, as required by the DIBC.

Final contract plans were completed in early 2010, and the construction phase began in June 2010. The construction phase commenced with the installation of Safespan® decking underneath the bridge. Once the Safespan® was installed, construction teams began the redecking process. Active work zones required a temporary concrete safety barrier to protect construction teams from bridge traffic. However, at 1,850 feet in length, a temporary concrete barrier spanning the entire bridge would once again impact bridge behavior. Redecking would need to take place incrementally; to determine the appropriate segment length, a 3D finite element analysis model was created to assist with construction staging analysis. Results of the evaluation determined that 145 feet was a safe maximum length for each section without impacting the weight distribution of the bridge. Additional weight corrections were needed as segments of decking and stringers were removed – steel ballast was used on top of the temporary concrete barrier and was repositioned as new roadway was constructed.

The deck was removed in 145-foot sections using a gantry crane to lift and remove each piece. Once the deck was lifted away, construction teams could remove old stringers and perform repairs to floorbeams, a majority of which could not be accessed with stringers still in place. New stringers were then installed, followed by the placement of new steel grid panels, which were then filled with concrete. As noted previously, a combination of lightweight, normal weight and heavyweight concrete was used across the four phases to maintain balance and prevent any alterations to the bridge's geometry. This process was repeated for each phase of the construction process, with stages one and four requiring the additional step of installing open railings on either side of the bridge. The fourth phase of redecking was finalized in May 2012, and construction teams are expected to remain on site until the end of the summer to perform clean-up work.

Not only is the structural health of the Ambassador Bridge critical to shared commerce between the United State and Canada, but so is using North American products and labor to complete the redecking. The Ambassador Bridge Gateway Project and the redecking of the main span of the Ambassador Bridge are important to growth and rebuilding for the Detroit-Windsor region. With more than 4.6 million passenger cars and 2.6 million truck crossings every year, the rehabilitated 83 year old main span of the Ambassador Bridge can now safely accommodate current traffic and forecasted traffic increases in coming years.▪

Staged construction was used to help maintain traffic.

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Sources

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