Assessing and Rehabilitating the Anthony Wayne Suspension Bridge

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Summary

The Anthony Wayne Suspension Bridge Assessment & Rehabilitation project is located on U.S. Route 2 in Toledo, Ohio. Built in 1931, the bridge is in need of rehabilitation and repair to extend its life. An inspection and analysis of the suspension spans, deck truss and girder approach were performed prior to rehabilitation design to determine appropriate repair measures. The rehabilitation and repair measures include: concrete deck replacement; cable opening and inspection, structural steel repairs; deck truss span replacement; and deck joint elimination.

Keywords: suspension bridge, deck truss, cable assessment, rehabilitation, load rating

1. Introduction

This project is the rehabilitation of the Anthony Wayne Bridge, a major high-level bridge on U.S. Route 2 that spans the Maumee River in Toledo, Ohio.

Fig. 1: Anthony Wayne Suspension Bridge

The bridge is comprised of 28 spans, extending a total length of 980 m and includes: nine multi-beam spans; 14 two girder spans; 2 deck truss spans; and the suspension spans. The roadway has two lanes in each direction with a width of 7,9 m measured from sidewalk curb-to-toe of 685 mm median barrier for an overall curb-to-curb dimension of approximately 16,45 m. Each sidewalk extends 2,0 m from toe of curb to outside edge. Previous significant rehabilitations have been performed to the bridge in 1961 and 1996.

The suspension spans are comprised of two steel stiffening girders, floorbeams, and stringers supporting a reinforced-concrete deck. Side span lengths are 71 m spans, with a main span of 239 m. The steel deck trusses, floorbeams, and stringers support a reinforced concrete deck at the ends of the suspension spans and are 58,5 m in length. The two girder spans are made up of riveted plate girders with floorbeams and stringers that support the reinforced-concrete deck at each end of the bridge. Span lengths vary from 21 m to 50,3 m. The multi-beam spans consist of steel rolled beams that support the reinforced concrete deck. Span lengths vary from 6,1 m to 13,8 m.

1.1. Project Objectives

The bridge is in poor condition and rated 4 out of 9. To extend the life of the bridge, repairs and rehabilitation are necessary. The rehabilitation elements include the replacement of the deck for the entire structure; sidewalk (except suspension span); railing/fence; expansion joints; and entire truss span. Repairs include: superstructure steel; steel tower; substructure patching and sealing of concrete surfaces; suspension cable and hold-down repairs; and painting of selected steel members. One of the primary reasons for the needed repairs is the leaking of joints. The design focused on the elimination of as many joints as possible on the bridge. An analysis of the bridge was completed to ensure the bridge can carry current loadings.

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2. Analysis

The bridge was load rated for the AASHTO HS20 truck and state of Ohio legal truck loads. Since all members were repaired to original condition, existing member properties were used in the analysis. The original member sections without section loss were found to have successful ratings for HS20 and all Ohio legal loads.

A fatigue and rating analysis was performed on the bridge. The remaining fatigue life of the approach spans exceeded the expected rehabilitation life of the bridge. The truss spans were not evaluated for fatigue because they are to be replaced. The fatigue evaluation of the suspension span indicated that all components were acceptable for fatigue except for the cable hold-down. Some fatigue cracks were found at the coped stringer ends where they frame into the floorbeams, and at end of floorbeams. Although the remaining fatigue life was acceptable, it was decided to repair the deteriorated stringers and floorbeams.

3. Rehabilitation

3.1. Joint Elimination

The primary cause of deterioration of this bridge is due to leaking joints. Joints exist at every pier. Joints also occur over floor beams in the two girder spans and the suspension spans. A structural evaluation of the each portion of the bridge was conducted to determine if joints could be eliminated. It was determined that half of the multi beam joints could be eliminated by making the spans continuous over the piers. The two girder spans were analyzed and it was determined that all interior joints over the floorbeams could be eliminated. To eliminate the joints in the suspension spans without overstressing the steel framing, a positive connection between the concrete deck and the stiffening girder would be required to constrain the differential displacement between the two elements. After evaluating several concepts to connect the concrete deck to the stiffening girder, it was decided to extend the deck over to the stiffening girder and connect the deck to the stiffening girder with shear studs protruding from side of the stiffening girder web into the deck.

3.2. Rehabilitation

Notable repairs made to the two girder and suspension span floor system members included full length replacement of the floorbeam top flange. Another significant repair involved adding cover plates to the heavily deteriorated lateral bracing gusset plates. Many other minor areas of repair were noted and included: replacement of angles that make up the cantilevered floorbeam brackets; replacement of portions of the built-up sidewalk beam; and the replacement of other miscellaneous steel members. Repairs included replacement of existing rivets with high-strength bolts.

The concrete deck was replaced with standard strength and weight concrete in the approach spans. The suspension span deck utilized lightweight concrete to improve the load rating. The existing railing and fencing was also replaced and/or rehabilitated. The historically significant original railing was cleaned, painted and reused. Any posts that would require replacement duplicated the original design and supported the new fence.

The single span truss spans were replaced with two span welded steel plate girders. The primary components of the two-span replacement structure included the new concrete pier as well as piers B & E steel modification, and the superstructure configuration. The new concrete pier consisted of two columns with a concrete cap to support the steel girders to match the shape of the approach columns. A steel frame was designed to minimize the loads on piers B & E and make up the difference in height from the truss to the plate girders. To match the look of the original truss span, the steel girders were spaced evenly across the deck but do not extend under the sidewalk. Since a guardrail is located at the face of the curb, a shallow rolled steel beam is supported off of the exterior plate girder to support the sidewalk.

4. Conclusion

The inspection and analysis of the Anthony Wayne Suspension Bridge revealed that the bridge can be rehabilitated to extend its useful service life while carrying current truck loads. The elimination of joints in the suspension spans and approach spans will reduce future maintenance. The engineers cost estimate is for $34Million US dollars. This will be a prudent investment to keep this important transportation link in service.