Strengthening of a Single Track Railroad Steel Truss Bridge with Addition of a Two Lane Highway Deck

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Summary

The need for a highway link was highlighted after 12 people died in a ferry accident in 2002 on the Karakaya Dam reservoir near Malatya, Turkey. The closest link to the ferry route is a thirty year old, 2030 meter long single track steel truss railroad bridge. The existing bridge, with 29 identical spans, is supported on massive piers. The existing steel truss superstructure has design-originated seismic deficiencies. This is because the current seismic requirements of the bridge specifications have increased since recent regional analysis has shown demands to increase as compared to past assessments. The main focus of this paper is to demonstrate that the additional highway deck placed on top of the truss not only provides a needed highway link but also helps the bridge structurally to mitigate the seismic deficiencies. As part of this effort, the seismic and structural reliability of the bridge, review of existing design, modifications, material tests and structural monitoring test results are evaluated. The provided solution of the upper highway deck system not only adds mass but also rigidity to the truss bridge, helping to solve some of the inherent design problems associated with the existing structural system.

Keywords: bridge, concrete, steel, railroad, highway

1. Introduction

Double deck bridges are used to combine railway and highway transportation in many countries. Most of these two-level bridges were originally designed to be double deck. Very few of them have a later addition of an additional deck such as was done at the George Washington Bridge in New York. In engineering practice, these bridges are generally heavier and stiffer in vertical direction compared to single deck bridges having the same span length. It is known that the additional stiffness and mass helps the double deck bridges to have better control of vibrations induced by external effects such as lateral wind or vertical live load.

Fig. 1. General View of Karakaya Bridge

The preliminary investigations indicated that an excess vertical load carrying capacity may be available in the bridge. The original design train load, S1950, is heavier than the currently used

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design train load of UIC LM-71 in the new bridge designs in Turkey. S1950 has basically one more 250 kN axle load than UIC LM-71 train.

It has been known that many old railroad truss bridges can not meet the new seismic requirements of the bridge specifications especially when regional seismic demands are increased over the years [5]. For those bridges, seismic retrofit is usually considered as a component of a major bridge rehabilitation project. In the case of Karakaya Bridge, it has been observed during the visual inspections that the original design has a seismically vulnerable load carrying system at the upper chord of the bridge as shown in Fig. 2. The upper bracing is designed to transfer the bracing seismic forces to the mid length of an upper edge I-beam at its weak axis instead of corners. Furthermore, the original peak ground acceleration selected in the first design was determined to be increased from 0.2g to 0.41g. Analytical results indicate that some other members such as portal diagonals, end floor beams and lower bracings also require seismic retrofit under this new level of design earthquake.

The main focus of study is to describe the methods involved in improving the load carrying mechanism of the seismically deficient bridge by adding stiffness, by means of a new upper highway deck. The addition of the new highway deck not only allows highway transportation but also provides a rigid diaphragm over the existing bridge allowing a better distribution of vertical live loads and lateral seismic loads among members. The trucks and trains are considered to use the bridge at the same time for the proposed rehabilitation case.

2. Conclusions

The following conclusions can be drawn from this study.

- The additional deck not only stiffened the bridge but also improved the seismic behavior of the existing seismically deficient bridge.
- The existing bridge is determined to not to satisfy the reliability index limits of the current European standards. The additional deck and strengthening plates significantly improve the structural response, and minimum limits of reliability index of the European standards are satisfied.
- The bridge is strengthened in such a way that rail or highway traffic can use the bridge at the same time.