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Research Results

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The Effect of End Eccentricity in Steel Truss Bridge for Load Rating Analysis

Procedures of modeling steel truss bridge with member connection eccentricity and capacity calculations for steel pin and pin plate.

WHAT WAS THE NEED?

The member end connection eccentricity in truss bridge is inconsistently applied by different agencies in load rating analysis. Some state agencies, such as Caltrans, include the eccentricity in the analysis, while many do not. Although the magnitude of the eccentricity is small comparing to the size of truss member, capacity for truss member can be reduced significantly if eccentricity is considered. However, Caltrans uses approximate approaches when considering the eccentricity in the rating analysis. The first objective of this research is to evaluate the accuracy of truss load using Caltrans approaches, and to propose different analysis procedures if necessary.

The current American Associate of State Highway and Transportation Officials (AASHTO) specification stands apart from other specifications and uses very conservative approach in its evaluation of the bearing capacity of pin plates. The capacity of plate from AASHTO is much lower than those using other design specifications. The capacity of pin from AASHTO specifications is also very conservative. Using these conservative approaches, some bridges were required to be retrofitted, although there was no distress on the pins and pin plates under the same traffic loads for more than 40 years. Therefore, the second objective of this research is to evaluate the approaches from AASHTO specifications and to provide more accurate calculation methods to prevent the high costs associated with the unnecessary bridge retrofit.

WHAT WAS OUR GOAL?

The goal of this research is to provide some practical guidelines to Caltrans for load rating steel truss bridges with the member end connection eccentricity and steel bridges with pinned connection.

WHAT DID WE DO?

For the study of steel truss with end connection eccentricity, two existing bridges in California were studied. A pin-connected truss bridge, Bridge Road over Santa Paula Creek, was evaluated by finite element analysis and field testing. The finite element analysis was only conducted for Bridge Road over Klamath River, which uses riveted gusset plates connecting truss members. Two software (ABAQUS and SAP2000) were used for the finite element analysis to cross check the modeling accuracy with different elements. The live load demands from the field test, from the analyses using ABAQUS and SAP2000, and using Caltrans rating analysis procedures have been compared with each other.

To evaluate the pin capacity of combined flexure and shear based on AASHTO specifications, twelve 2- inch diameter steel pins were tested. Finite element analysis using ABAQUES was also conducted to generalize the test results for pins with different diameters. The capacities from the test measurements, the finites element analysis, and the calculation using AASHTO specifications were compared.

To evaluate the bearing capacity of pin plate, eight pin plate specimens and five pin specimens were tested with different plate thickness, steel grade, and pin diameter. The finite element analysis to simulate the testing were also performed using ABAQUS. Testing results were compared with the those from finite element analysis and calculation based on AASHTO specifications.

WHAT WAS THE OUTCOME?

For steel trusses with eccentrical member connection, using steel pins and riveted or bolted gusset plates, the member eccentricity needs to be included. The double-curvature bending moment distribution in most of top chord members observed in the field test and from the finite element analysis could not be predicted using Caltrans current load rating analysis procedures. The magnitude of the bending moment in truss members could also not be predicted correctly using Caltrans current procedures. However, these bending moments can be predicted accurately from finite element analysis using beam elements and rigid links simulating eccentrical member connections. Procedures with such modeling approaches have been proposed.

The approach assuming pin as a beam and considering flexure and shear interaction in the AASHTO specifications cannot be confirmed by either testing or finite element analyses. Both testing and finite element analyses showed that the actual capacity is significantly higher than that predicted by the AASHTO Specifications. A new equation to calculate the pin capacity was developed.

For the bearing capacity of pin plate, it was found the current AASHTO specifications underestimate the bearing strength of pin plate by a large margin. The testing data support the inclusion of the 1.5 factor, or the same bearing capacity equation for pin, when calculating the bearing capacity of pin plate. An alternate bearing capacity equation which archives a better correlation with the test results has been proposed. Additional equation for the pin plate serviceability has also been proposed.

WHAT IS THE BENEFIT?

The proposed analysis methods considering the member eccentricity in steel truss will provide more accurate load for truss bridge. By using the proposed procedures, bridge safety will be improved by capturing real bridge conditions. It can also save bridge owners money for some bridges by preventing unnecessary retrofit work.

The proposed equations for pin capacity and pin plate bearing capacity provide higher capacities than those from AASHTO specifications. Using these proposed methods, the load rating will be improved significantly for many steel bridges, which will save taxpayer's money by preventing unnecessary retrofit due to lower structural capacities from the existing AASHTO specifications.

The proposed analysis methods and capacity equations can also be used to design new bridge more economically and to improve the safety of the bridge.