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Fatigue Evaulation of the Increased Weight Limit on Transit Railway Bridges

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MNTRC Project 1143

September 2014

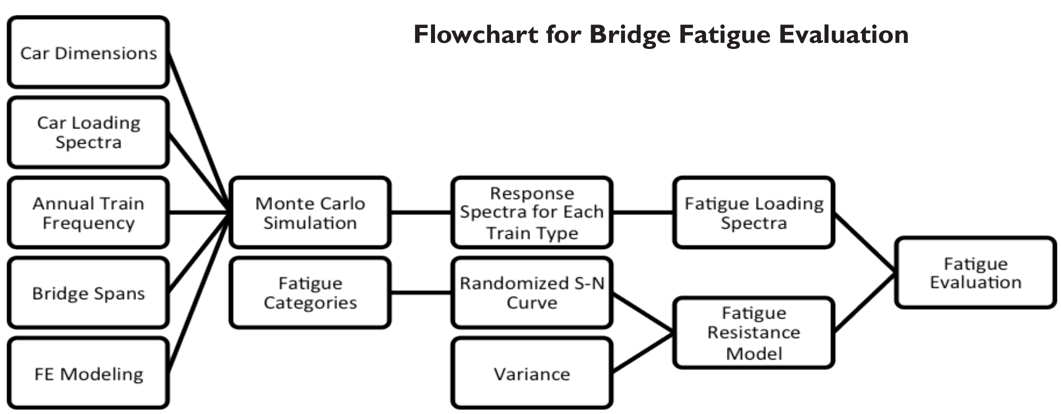
The cyclical bridge fatigue inspection should prioritize the short-span bridges and critical locations near the bridge support.

The recent increase of freight railcar weight limits from 263,000 lbs. to 286,000 lbs. raises concerns for bridges on transit passenger rail systems because they were not designed to support this additional weight. Thus, it is necessary to assess the impact of the weight increase on those bridges prior to using passenger lines for freight transportation. This study introduces an accurate approach to ascertaining the remaining fatigue life of steel railway bridges. The heavy freight car and its frequency were found to have a significant negative effect on the critical locations near the supports and on short span bridges.

Study Methods

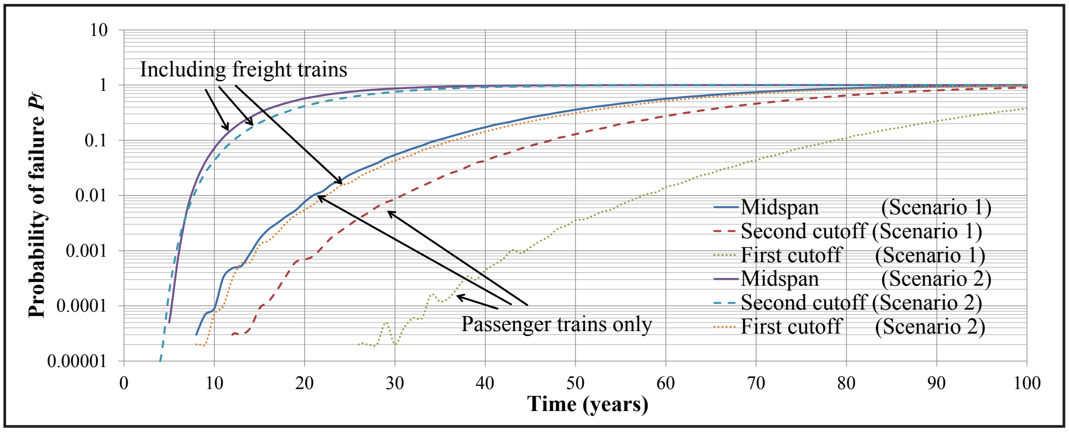
The research used an analytical approach that also included field testing. The first level of analysis involved review of the regional passenger and the freight train load data regarding weight, volume, and the number of railcars in each train. The next level of analysis involved simulation, in which stresses on bridge girders and/or other components were determined using finite element (FE) analysis methods. Results from field tests were used to verify and validate these FE models. Then a probabilistic model was developed for the load-induced fatigue evaluation of railway bridges. Various random variables related to loading were considered, including annual train frequencies, dynamic impact, passenger volume, and weight of the freight car. The probabilistic fatigue load spectra were derived using Monte Carlo simulation and Rainflow Counting method. In terms of resistance, the relevant S-N curves were randomized with constant variance in fatigue strength. Miner's Rule was used to estimate the cumulative damage over the years. Finally, the research team determined the probability of failure for each member. The procedure for fatigue evaluation of the bridge is shown in the figure below. Two scenarios were considered to investigate the effect of heavy railcars on the selected bridges, one with heavy railcars and one without heavy railcars.

Flowchart for Bridge Fatigue Evaluation



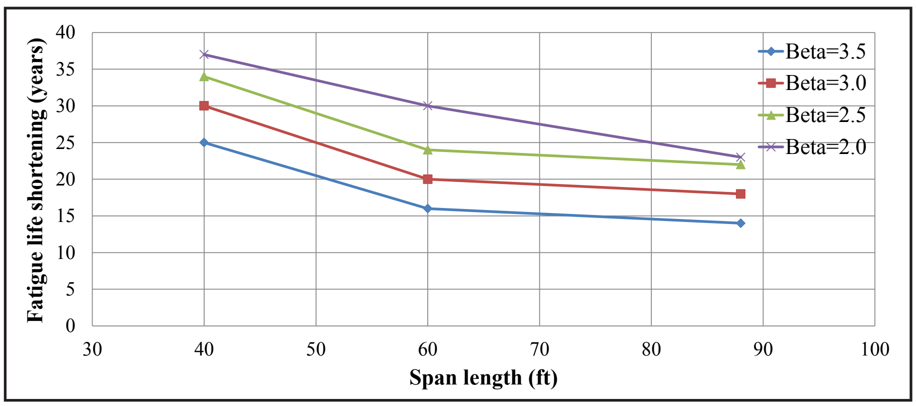
Findings

In fatigue analysis, the mid-span is not always the critical location. Heavy freight cars have a significant negative effect on critical locations near the support, which can be seen from the difference between two scenarios in the figure below.



Probability of Fatigue Failure for a Selected Bridge

An increase of 1000 freight trains in the annual trip frequency will shorten the remaining fatigue life by approximately two years. The selection of steel categories does not affect fatigue life significantly. The following figure shows that the introduction of heavier rail equipment will have a much more significant effect on short spans of less than 60 ft.



Policy Recommendations

Two primary recommendations are derived from this research. First, the cyclical bridge fatigue inspection should prioritize the short-span bridges and critical locations near the bridge support. This will allow transit operators or agencies to prioritize and schedule repairs and rehabilitation. Second, the relation between the annual freight train frequency and remaining fatigue life could help transit operators or agencies to balance the tradeoff between economic benefit and bridge rehabilitation cost.

About the Authors

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To Learn More

For more details about the study, download the full report at ***transweb.sjsu.edu/project/1143.html***

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