MPC-397
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Project Title:
Evaluation and Mitigation of Vehicle Impact Hazard for Overpass Bridges in South Dakota

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Research Needs:
With the increase in heavy truck traffic resulting from the oil industry in the northern plains, the probability of a significant impact load on a bridge pier resulting from a truck collision will increase. Collision loads, intentional or accidental, could potentially cause partial or total collapse of highway bridges. Catastrophic failure of bridges may result in significant loss of life and adverse socio-economic impact. Bridges in the northern plains are especially vulnerable to impact loads since they were and are not designed for any significant lateral load levels such as earthquake or blast loads. Studies are needed to develop risk assessment and management strategies to reduce the risk of collision loads in Region 8 states to a level that is economically feasible.

Although not commonly occurring, collision of heavy vehicles on to highway overpass bridge piers had happened in the past and paralyzed traffic on both the overpass and the highway below. The 2003 Nebraska bridge collapse accident on I-80 was caused by a truck collision and halted the traffic in that section for 3 days. This type of hazard can be categorized as an extreme event that has a low probability of happening, but carries very significant consequences, which justifies certain preventive measures if proven to be cost effective. The robustness of the overpass pier and the preventive measures to slow down the vehicle before collision are the keys to mitigate the impact of the accident. The cost for increasing the robustness of pier structure to the level

compatible to impact loading may not be justifiable especially for existing structures. Thus it is assumed in this study that the most cost effective mitigation measure for this type of hazard is to effectively reduce the speed of the accident vehicle before the collision or to retrofit deficient bridge column to increase. This study will evaluate the impact resistance for typical bridge columns on South Dakota Interstate system and provide practical recommendations to reduce vehicle speed under the collapse threshold and to retrofit deficient bridge columns.

Research Objectives:

1. Evaluate the risk of bridge collapse caused by vehicle collision impact for South Dakota highway system.
2. Based on impact resistance of existing bridge columns, propose practical mitigation measures to reduce the accident vehicle speed approaching the column in order to reduce the risk of bridge collapse due to vehicle impact.
3. Provide recommendations for the design of bridge columns in future bridges.

Research Methods:

The SDDOT PONTIS data bank will be used to obtain information on all overpass bridges on the South Dakota Interstate system. Risk factors for vehicle collision with bridge columns will be identified. The bridge sites will be inspected to note the risk factors that exist and the severity of each risk factor. A probabilistic analysis will be performed to assess the risk of vehicle collision. The ability of existing columns to withstand the impact loads will be assessed analytically and experimentally in the lab. The economic and societal impact of a bridge failure will be performed for the bridges are found to be susceptible to failure. An acceptable threshold risk will be set in order to identify bridges that are in need of enhanced protection against collision loads. Strategies to mitigate collision loads and bridge failure will be recommended.

Expected Outcomes:

A risk assessment and management strategy will be developed to reduce the risk of catastrophic bridge failure under collision loads to an acceptable risk level.

Relevance to Strategic Goals:

1. State of good repair
2. Safety
3. Economic competitiveness

Educational Benefits:

Two graduate students will be recruited for this study. The students will be trained on conducting risk assessment and experimental work on large-scale bridge columns.

Work Plan:

The proposed research can be accomplished through following tasks:

Task 1: Survey the inventory of all overpass column configurations in South Dakota highway system and identify representative configurations as the focus of the study. These typical configurations should be ones that are on the interstate highway system and may be vulnerable under impact loading.

Task 2: Evaluate impact resistance of typical design configurations identified in Task 1 through numerical and experimental investigation. Step-wise nonlinear analysis for columns under lateral impact load and vertical gravity load will be conducted for different configurations. The lateral impact load that may cause instability of the column will be calculated. The numerical analysis will be calibrated with limited number of scaled column tests. The impact resistance of typical columns will be obtained from this task.

Task 3: Based on the ultimate lateral load levels for each column configuration, level of acceptable impact speed for each column and vehicle type combination can be calculated. Based on the speed limit near the site (with certain level of assumed variation), the needed speed reduction before vehicle hitting the column will be determined, which serves as the basis for designing mitigation measures.

Task 4: Review the existing techniques used in traffic safety control for reducing vehicle speed. Recommend practical measures based on the site condition and needed speed reduction. It is envisioned that in most cases, needed speed reduction can be achieved through fortified roadside barrier or additional obstacles placed near the column.

Project Cost:
Total Project Costs: $170,000
MPC Funds Requested: $80,000
Matching Funds: $90,000. Source of Matching Funds: SDDOT ($80,000) and SDSU ($10,000)

TRB Keywords:
Impact loading, Vehicle collision, Overpass, Bridge column design, Roadside barrier

References:

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