Research Project Highlight

Bridge Functionality Instead of Component Damage as PBEE Metric

TSRP Topic S1 - Bridge & other transportation systems: Development of fundamental knowledge

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Abstract
The project will develop functionality fragilities that will relate bridge-level limit states to existing component-level limit states. The states of art and practice for bridge functionality focus on component-level limit states; however, there is a lack of information on system functionality, which includes its relationship to component limit states and economic consequences of loss of functionality. There are no formal demand parameters or damage measures that describe bridge-level response, damage, or functionality. All current methods, HAZUS or otherwise, utilize a component-to-system map that is not based on bridge-level functionality, and that is not invertible.

This project will also engage stakeholders to establish risk-based thresholds for operation decisions based on functionality. It is anticipated that risk-based thresholds could change the way PEER conducts future PBEE studies. Currently, for every new protective system or innovative material/component tested, it is necessary to independently identify and quantify limit states, generate component damage fragilities, then perform cost estimation and scheduling to understand the system impacts. From this project, researchers calibrating analytical and numerical models based on their tests will be able to extend their results to system and network level quantities of resilience and life cycle costs using functionality as the conduit rather than component damage.

Collapse simulation and collapse probabilities are common terms in the seismic risk assessment of buildings. The methods of collapse prediction are often extended to bridges using moment-rotation degradation models calibrated for building response, but ignore collapse potential in other components of a bridge system. In this project, we propose to extend OpenSees models generated for previous and ongoing Caltrans projects to capture column degradation mechanisms, as wells as support settlement and abutment or internal hinge unseating. Column model calibration will be based on recent experimental testing that considered variable axial load.

Deliverables
A PEER report and conference and journal papers that describe the methodology, along with OpenSees input files for collapse analysis of bridges.

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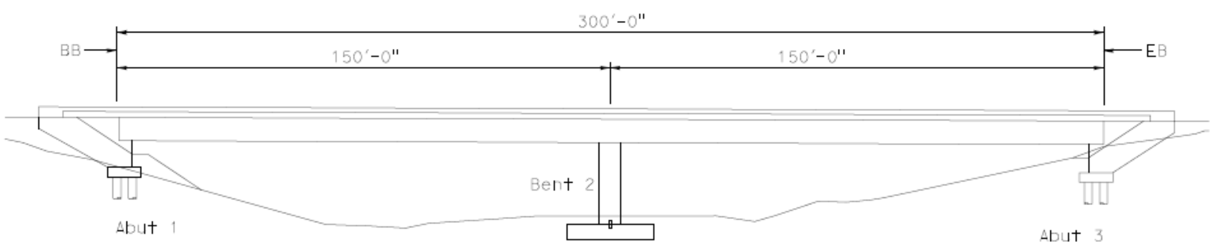
Research Impact

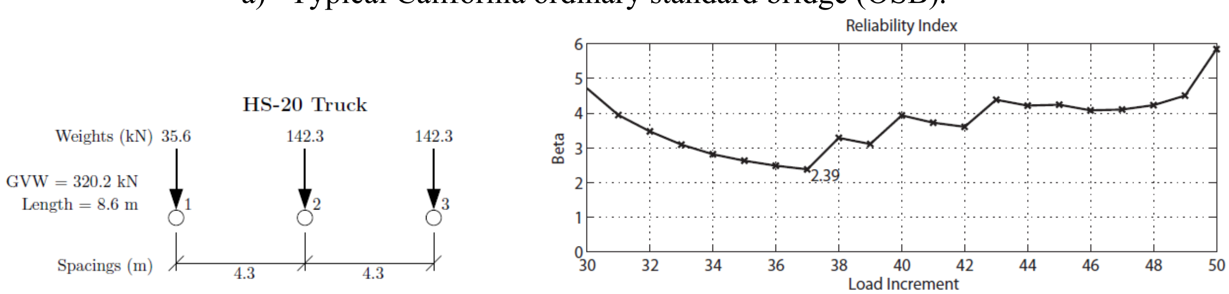
A considerable body of knowledge has been generated in the last 15 years on bridge component-level limit states and their corresponding fragilities. Focus on component damage limit states, particularly those for columns, has enabled a better relationship between experimental testing on traditional cast-in-place and new column systems, numerical modeling and tools for predicting observed behaviors, and bridge- and network-level modeling to produce bridge-specific fragilities and network risk assessment. However, a major disconnect remains in that bridge and network decisions are ideally based on functionality, and there is little and often unknown correlation between column damage limit states and bridge functionality.

In addition, work performed on extending decision variables (DVs) to economic losses has not always been applied to new materials and structural systems due to the difficulties in obtaining repair schematics and cost estimations. At the transportation network level, the resulting direct costs associated with bridge repair do not drive a substantial portion of the total economic losses due to loss of function. Transitioning industry and research beyond the 3 Ds (death, dollars, and downtime) towards resilience requires a quantifiable measure of functionality. In addition, it should be recognized that existing network risk assessment software already utilize functionality versus time curves to simulate costs for a region. Therefore, the proposed work will give a more direct representation of this functionality loss, potentially eliminating the DM variable introduced in the early years of PEER.

Project Image



a) Typical California ordinary standard bridge (OSB).



b) Collapse probability under vertical loading on damaged OSB model.

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