DRISI

CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Geotechnical /Structures

May 2025

Project Title: Refined Bridge Deck Design and Analysis

Task Number: 3668

Start Date: November 1, 2020

Completion Date: October 31, 2024

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DRISI provides solutions and knowledge that improves California's transportation system.

Refined Bridge Deck Design and Analysis

Bridge research to improve bridge deck design procedure and reduce construction and maintenance costs.

WHAT IS THE NEED?

The current bridge deck design procedure is based on the American Association of State Highway and Transportation Officials Load and Resistance Factor Design (AASHTO LRFD) Bridge Design Specification approximate analysis method that was initially developed in the 1930's then improved in the 1940's and 1950's. The accuracy of the approximate analysis method is of concern due to simplifications and approximations in the procedure. Additionally, truck loads and wheel configurations used for current design do not reflect modern vehicle loadings. New vehicle configurations mandated or allowed by federal programs such as Special Hauling Vehicles (SHV) and Emergency Vehicles (EV) need to be considered in our design process. Finally, current design procedures do not directly address high cyclic fatigue despite it being a common mode of deck failure.

WHAT ARE WE DOING?

Through the PEER-Bridge Program, the California Department of Transportation (Caltrans) is contracting with UC Davis to develop an updated LRFD bridge deck design procedure based on a refined analysis method using finite element computer modeling. The updated method will consider modern vehicle load configurations and more accurate load demands. Both simplified and advanced procedures will be developed for bridge designer use. The study will also include recommendations on incorporation of concrete fatigue into deck design practice based on a comprehensive literature survey and impact assessment.

WHAT IS OUR GOAL?

The primary goal of the Refined Bridge Deck Design and Analysis is to develop a more accurate and reliable bridge deck design procedure for production design.

WHAT IS THE BENEFIT?

Bridges play a critical role in our transportation system in enhancing California mobility and economy. In the current bridge deck design of approximate method of analysis, simplified assumptions and rough load demands estimates can lead to unnecessary additional cost in the bridge deck system. The current design method does not consider realistic modern vehicle loads that an actual bridge will see during daily operation. These unaccounted-for loadings can accelerate the degradation of deck performance and result in increased bridge maintenance costs, and in turn, increased life-cycle cost of the bridge. By refining and improving our current deck design methodology, with better estimates of load demands and load-carrying capacity of the bridge deck, a more efficient and cost-effective deck design can be achieved to meet the growing traffic demand of our users.

WHAT IS THE PROGRESS TO DATE?

Refined Bridge Deck Design and Analysis project started on November 1, 2020 and operate for 36 months.

To investigate finite element (FE) modeling strategy in the adoption of commercial software ATENA for deck demand evaluation, representative prototype bridges are selected for modeling from the bridge inventory. Bridge geometries, materials, boundary conditions, and loadings are defined in the model studies. Numerous case studies on load magnitudes (HL-93 and P15), axle placements, truck in-span locations, etc. are conducted. Deck responses (i.e. positive moment, negative, shear) are captured for each study case. Critical positions on load demands are identified. Future work includes parametric studies of different girder spacing, number of cells, deck width in terms of number of traffic lanes, and vehicle types.

Existing fatigue models and deck shear models on reinforced concrete from literature are being collected. Existing large scale deck fatigue experimental testing results are being reviewed. A fatigue study summary report was prepared based on literature survey and investigation.

Bridge deck rigid support model assumption was validated with refined finite element model and produced conservative results. Therefore, the ridge support model is deemed as a practical alternative to refined FE modeling. The adoption of rigid support model analysis to verify ASSHTO Appendix A4 deck demands is underway. The goal is to quantitatively assess AASHTO LRFD approximate analysis method on deck design.

IMAGES

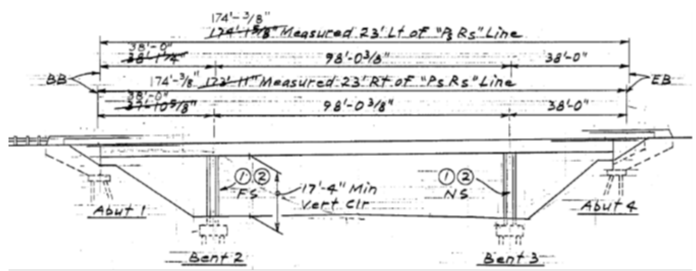

Image 1: Elevation; General plan of prototype bridge (49-0165L).

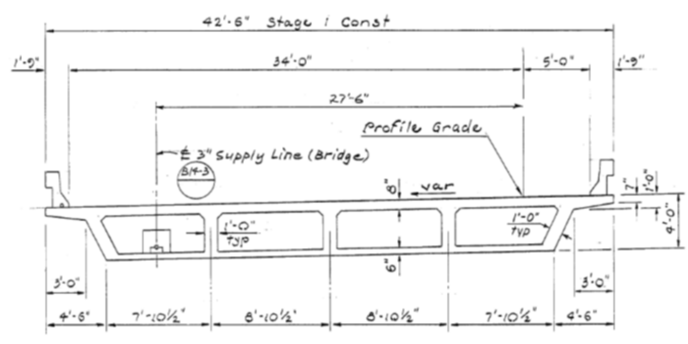

Image 2: Cross-section; General plan of prototype bridge (49-0165L).

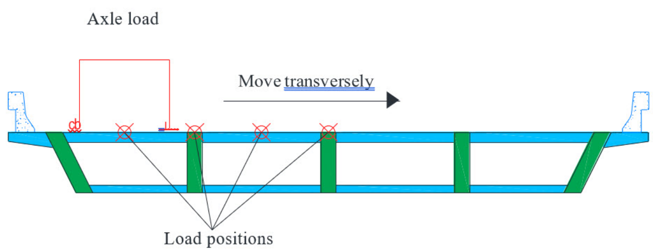

Image 3: Transverse positions of axle loads under study.

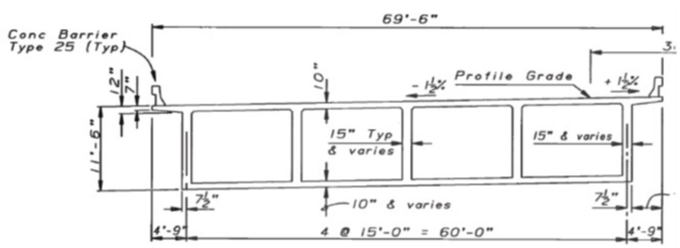

Image 4: General plan of prototype bridge cross-section (53-2790L).

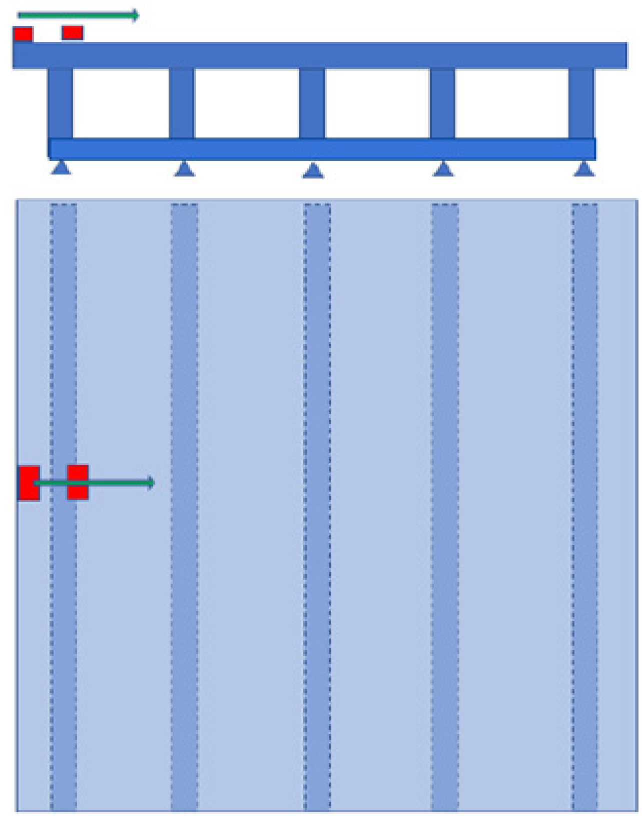

Image 5: Illustrated concept of rigid support analysis.