FY 16-17 Research Initial Scope of Work Guidelines

I. Project Title:

Deck Design Loads and Analysis

II. Project Problem Statement:

Caltrans weigh-in-motion (WIM) data needs to be studied to validate current deck design loads or propose a more modern design load configuration. An appropriate load factor and dynamic load allowance must also be assigned. Current deck design methods should also be validated for potential concrete fatigue effects, rolling, and various relative stiffness ratios between the deck and girder support detail.

III. Problem Statement Background/Context:

The current AASHTO *LRFD Bridge Design Specifications* require that a 32 kip single axle load be used for deck design, a requirement that stems from the 1944 design truck. Most heavy trucks now have tandem axles. The California Vehicle Code (CVC) requires that trucks with axle loads up to 60k distribute load via tandem a tandem axle in trunnion (8 tires) configuration. Other states permit tridem axles. Weigh-in-motion (WIM) technology has since come into practice to detect and measure axle and gross vehicle weights.

The current AASHTO *LRFD Bridge Design Specifications* require that fatigue in bar reinforcing be checked; fatigue checks of the concrete do not commonly exist despite the rubbing of crack faces. Furthermore, the load is applied statically with a dynamic load allowance. The rolling effects are ignored. The relative stiffness of the deck and support connection is also ignored. Caltrans requires that deck design be done using strip or refined methods, but serviceability tends to control in typical bridge deck designs.

FHWA requires that all bridges be given a deck sufficiency rating. Caltrans has many decks in fair to poor condition and spends many resources on repair, overlays, and replacements. Other Caltrans research is studying methods of replacing bridge decks on cast-in-place post-tensioned box girder bridges. Such projects require lane closures if not bridge closures, cause traffic congestion, and hinder the economic benefits of goods movement.

IV. Research Objectives:

- To develop a calibrated WIM-based load configuration for bridge deck design in California. Alternatively, an argument could be made for using this load configuration at the service level for shear and bending design.
- To develop a method of assessing and designing for fatigue in typical concrete bridge decks.

- To incorporate rolling phenomenon and the relative stiffness of bridge decks and support connections into typical concrete bridge deck design

V. Support California Bridges & Structure Strategic Direction:

This research will optimize the design service life of bridge decks and maximize the public's return on investment. Fewer bridge deck repairs, overlays, and replacements mean fewer traffic delays.

VI. Description of Work:

1. Literature review of WIM studies including axle load analysis.
2. Literature review of concrete fatigue, effect of rolling deck loads, and effect of relative stiffness.
3. Propose a WIM dataset to be representative of both highway and local road systems, sample size needed from each station, sorting process, etc.
4. Explain how the load factor and dynamic load allowance will be calibrated.
5. Develop interim report on WIM, deck analysis, and calibration.
6. After approval of research panel, carry out WIM collection and data analysis
7. After approval of research panel, develop recommended revisions to deck design methods.
8. Carry out the calibration.
9. Develop recommended California Amendments to the AASHTO *LRFD Bridge Design Specifications*
10. Final Report

VII. Related Research:

Elfayoumy, Adel, Uddin, Nasim, *The Effect of Increasing Heavy Vehicle Loads on a Steel Bridge with RC Deck Lifespan*, Transportation Research Board, TRB 94th Annual Meeting Compendium of Papers, 2015.

Frosch, Robert J, Bice, Jacob B, Erickson, Jared B, *Field Investigation of a Concrete Deck Designed by the AASHTO Empirical Method: The Control of Deck Cracking*, FHWA/IN-JTRP-2006/32, 2006.

Kulicki, J. M., et. al., *Updating the Calibration Report for AASHTO LRFD Code*, Final Report, Project No. NCHRP 20-7/186, National Cooperative Highway Research Program, Transportation Research Board, 2007.

Kulicki, J. M., et. al., *Bridges for Service Life Beyond 100 Years: Service Limit State Design*, Prepublication Draft. SHRP2, Transportation Research Board of the National Academies, Washington, DC, 2014.

Okada, Kiyoshi et. al., *Fatigue Failure Mechanism of Reinforced Concrete Bridge Deck Slabs*, Transportation Research Record No. 664, Bridge Engineering Volume 1, pp 136-144. Transportation Research Board, 1978.

Perdikaris, Philip C., Beim, Sergio, *RC Bridge Decks Under Pulsating and Moving Load*, American Society of Civil Engineers, 1988.

Schmeckpeper, Edwin R, et. al., *Effect of Bridge Deck Design Methodology on Crack Control*, National Institute for Advanced Transportation Technology, N09-08, 2010.

Strocko, Ed, FHWA; Sprung, Michael, Nguyen, Long BTS; Rick, Christopher, Sedor, Joanne, SAIC *Freight Facts and Figures 2013*, FHWA-HOP-14-004, January 2014.

Seible, F, Priestley, MJN, Krishnan, K, Nagy, G, Sharabi, N, *Simulation Of Rolling Loads On The Gepford Overhead Bridge Section. Interim Report*, UCSD/SSRP-90/05, 1990.

Senate Report No. 107-38, *Study & Report to Congress: Applicability of Maximum Axle Weight Limitations to Over-the- Road and Public Transit Buses*, 2003.

Sivakumar, B., Ghosn, M. and Moses, F. "*Protocols for Collecting and Using Traffic Data in Bridge Design*", NCHRP Report 683, 2011.

Zhibin Lin, Jian Zhao, Habib Tabatabai, *Impact of Overweight Vehicles (with Heavy Axle Loads) on Bridge Deck Deterioration*, CFIRE 04-06, National Center for Freight & Infrastructure Research & Education, University of Wisconsin–Madison, 2012.

VIII. Deliverables/Deployment Potential:

The deployable product will be California Amendments to the AASHTO *LRFD Bridge Design Specifications*. A Memo to Designer may also be needed to explain implementation of the research.

This is a large project that calls for multiple specialties and could be broken into two simultaneous contracts: one for WIM, and one for analysis and design. At the conclusion of these studies, a contract for the calibration can commence.

IX. Sponsor: Loads Committee, Concrete Committee
Date: 01/07/2016