PEER-Bridge Program Request for Proposal (RFP) 23-02

Overview of the PEER-Bridge Program

PEER-Bridge Research Program is a streamlined framework of the long-standing Caltrans bridge research program.

Project topics are selected by Caltrans in consultation with PEER Headquarters. PEER administers a request-for-proposal (RFP) for each of these topics. Caltrans and PEER will review the proposals and decide on final selection(s). Selected proposals will be executed as Task Order agreements, and PEER will issue a subaward to the Principal Investigator's university.

In accordance with funding agency requirements, for this RFP, only public universities are eligible to submit proposals. That is, the Principal Investigator (PI) must be affiliated with one of the following universities: UC Berkeley, UC Davis, UC Irvine, UC Los Angeles, UC San Diego, Oregon State University, University of Nevada – Reno, and University of Washington. The Co-PI's or collaborators may be from any public or private institution. Cost for private institutions cannot exceed $50,000.

Problem Statement #1 for RFP 23-02

Objective

Establish guidelines for evaluating the remaining service life of existing bridge decks.

Background

Many of California's bridges have been in service for several decades and are approaching the end of their design life. Asset managers must decide when replacement of such bridges will be required. One of the objectives of the California Bridges and Structures Strategic Direction is to ensure reliability and structural integrity. Structures shall be constructed and maintained in a way that ensures safety, functionality, and durability, while optimizing service life. Optimizing service life needs a reasonable prediction of residual life of existing bridges. Such predictions are usually based on the fatigue resistance of the various bridge components. Bridge decks are the single component most vulnerable to fatigue.

Bridge engineers rely on AASHTO's Manual for Bridge Evaluation when performing strength and fatigue evaluation of existing bridges. The AASHTO Manual for Bridge Evaluation provides little guidance for the evaluation of bridge decks because of an underlying assumption that "there is significant reserve strength in concrete decks designed by AASHTO LRFD Bridge Design Specifications." Current AASHTO LRFD Design specifications state that "fatigue need not be investigated for deck slabs in multigirder applications, as stresses measured in concrete deck slabs of bridges in service are far below infinite fatigue life." While this may be true for new bridges, it is not necessarily true for older bridges, case-in-point the Vincent Thomas bridge in Los Angeles. This bridge, which was built in the mid 1960's, is currently programmed to undergo a complete deck replacement. It has already undergone a major deck rehabilitation about 17 years ago. It is clear that the stresses experienced by the bridge deck are not "far below infinite fatigue life." The decision to replace a bridge deck when the deck shows major signs of distress/fatigue is not a difficult one to make. For a bridge deck that does not show major signs of distress, the decision to replace the deck at the end of its design life is not an easy one to make. For major bridges deck replacement, which may sound like an easy task, can be quite expensive and may result in major disruptions to the local economy. It is necessary to get a good estimate of the remaining service life of the bridge deck in order to make informed decisions about the replacement vs. rehabilitatition alternatives.

Given the lack of guidance for evaluation of fatigue life of existing bridge decks, engineers rely on current bridge design code fatigue provisions. Code provisions are intended to produce conservative designs for new bridges. Using such provisions for the evaluation of existing bridge decks will likely overstate the fatigue vulnerability of existing bridge decks, which can lead to costly and perhaps unnecessary work. We should strive to get the most use out of existing bridges and do it in a safe and cost-effective manner. It is therefore necessary to develop deck fatigue evaluation guidelines that can do away with unnecessary conservatism that comes with design requirements of new bridges.

Fatigue life evaluation is commonly carried out using S-N relations for concrete and reinforcing steel. S-N relations relate the fatigue stress range S to the number cycles N that would cause fatigue. Codes, such as CEB-FIB model code, have proposed S-N relations for both steel and concrete, but these are more suited for design of new bridges. It is therefore necessary to

develop similar relations that would be more suited for the evaluation of existing bridges. While there is existing test data from deck fatigue tests, it may be necessary to conduct additional experimental tests to augment existing test data.
Structural analysis is required to establish the fatigue stress ranges for a given deck. Accurate stress computations require the use of finite element models. Such models can be simple linear elastic models using shell elements, or non-linear models with solid elements for the deck concrete and discrete elements for the deck rebar. Using linear elastic models is an easy task for most engineers, but the results will be highly dependent on the model geometry, i.e., selected mesh size, and material properties used. Translating the analysis results from linear elastic models into actual fatigue stress ranges is not a straightforward process. Using advanced models may solve some of the issues with linear elastic models but performing such analyses may require highly experienced/specialized engineers. Without the proper experience and the means to calibrate and verify such models, the results may not be any better than simpler models. It is desirable to develop guidelines that would permit the use of simpler models, e.g., linear-elastic, and still obtain a reasonable estimate of the fatigue demands.

Requirements

- Establish a fatigue model for reinforcing steel suitable for the evaluation of existing bridge decks.
- Develop finite element modeling guidelines and procedure for linear elastic analysis of existing bridge decks. This task may require instrumentation of existing bridge deck reinforcement and testing the desk under actual live load trucks in order to correlate linear analysis stresses with actual bar stresses.

Additional project guidance and summary are listed as follows:

1. Previous Caltrans funded project conducted literature survey on fatigue behavior of reinforced concrete bridge decks. Various fatigue life deterministic, probabilistic, and energy models were identified. Various experimental studies and test observations were reviewed. Due to limited number of fatigue testing on desk slabs and the complexity of deck failure mechanism, the applicability of available fatigue models for prediction of bridge deck service life is lacking. The report from this previous project is available upon request.
2. Deck service life is a function of age of deck, load magnitude, and usage frequency. From past experience and maintenance records, deck service life goes down as maintenance activities increases. The solution to service life prediction might consist of correlation between theoretical and/or testing formulation with deck maintenance activities data. Such maintenance activity data is available for a large number of bridges in the FHWA Bridge database.
3. Proposal of practical methodologies or framework for predicting deck remaining service life are welcome.

Project Duration: 30 months

Maximum Budget: $450,000 (including 35% overhead and indirect costs)

Proposal Submission Instructions

1. According to the Master Agreement between the funding agency and the University of California, Berkeley, **for this RFP**, only public universities are eligible to submit proposals. That is, the Principal Investigator (PI) must be affiliated with one of the following universities: UC Berkeley, UC Davis, UC Irvine, UC Los Angeles, UC San Diego, Oregon State University, University of Nevada – Reno, and University of Washington. The Co-PI's or collaborators may be from any public or private institution.
2. Description of the PEER-Bridge Research Program and other PEER-related programs including active projects are available at https://peer.berkeley.edu/research/PEER-Bridge.
3. Proposals should be prepared using the form in the above site and should include five-page project description, two-page biographical sketch of each key personnel and a one-page budget (linked to an Excel Spreadsheet). A one-page budget justification can be included. At this stage, the proposal need not be submitted via the institution's official sponsored project office.
4. Proposals should be uploaded at the above site before the submission deadline indicated in the title of this document. A single PDF document may be uploaded with the filename in this format: <PI's last name>_<PB2023-2>_<optional title less than 20 characters>.pdf.

Other Requirements

Investigators must commit to the following:

1. Working as part of the overall PEER-Bridge team, and sharing information, data, models, outcomes and ideas needed for other projects,
2. Attending at least three meetings per each year of funding: the PEER Annual Meeting (usually held in January), the PEER Researchers' Workshop (usually held in August), and a PEER-Bridge specific meeting in April or May,
3. Submitting a research highlight at the beginning of the project for distribution to the PEER and Caltrans community,
4. Writing a PEER report at the end of the project (no later than 3 months after the completion of the project),
5. Along with the PEER report, submitting a two-page high-level summary of the project ("research nuggets"), that summarizes 'Why', 'How' and 'What' of the project along with 'Who benefits' (please refer to the research nuggets template),
6. In the case of two-year projects, submitting a detailed progress report at the end of the first year, along with a plan for the second year, for review by PEER and Caltrans,
7. Making data available to Caltrans and PEER community in an open-source format at the end of the project (allowing for reasonable journal publication requirements by the research team), and
8. Acknowledging PEER and Caltrans in all oral presentations and written papers/articles/reports on the project.

It is expected that proposing institutions will waive indirect costs, as is the practice for University of California institutions. Final budgets with campus sponsored projects office approval can be prepared after the initial selection of successful proposals and any negotiated agreement on the scope and preliminary one-page budget.