PEER-Bridge Program Request for Proposal (RFP) 21-03 & 21-04
Proposal Submission Deadline: Dec. 01, 2021

Overview of the PEER-Bridge Program

PEER-Bridge Research Program is a streamlined framework of long-standing Caltrans bridge research program. A single master contract was established between Caltrans and PEER, and different projects are executed as Task Orders under the master contract.

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.

Proposals are solicited for two topics, described below as RFP 21-03 and 21-04. **A researcher may be the PI on only one of these two solicitations**. There are no restrictions for co-PIs.

Problem Statement #1 for RFP 21-03

Objective

Evaluate 3 different design hazard level options for the construction of temporary bridges and compare their relative risk and cost benefits.

Background

Caltrans commonly constructs temporary structures that have an expected life of less than 5 years. Currently, seismic loading for temporary structures is based on a uniform hazard spectrum consistent with a 5% probability of exceedance in 5 years. This criterion was established to correspond to an approximate 0.2 PGA load level, the minimum design level before Caltrans adopted probabilistic-based specification of seismic demand. While the approximate 0.2g PGA target seems reasonable, it is rather arbitrary. Needed is a more complete evaluation of the relative risks and costs associated with alternative design hazard levels.

Guidance for seismic loading on temporary bridges design is currently under development at Caltrans. Bridges with expected lives less than 5 years are considered to be temporary. Bridges constructed in emergency circumstances and have an expected life on the order of several months to less than one year are exempt. In recent years the ability to quantitatively assess bridge performance risk has advanced. Reassessment of our current seismic loading policy for temporary bridges is needed to advance Caltrans reliability and cost efficiency goals.

Requirements

The work plan is envisioned as the following tasks:

Task 1A: Collect a representative set of as-builts for temporary and/or representative bridges constructed in the last 20 years. Caltrans engineers will assist in providing such as-builts.

Task 1B: Develop idealized bridge models using a reliable computational platform (e.g., OpenSees) for 3 representative locations: SF Bay area, San Luis Obispo, and Los Angeles. The SF Bay area model bridge is expected to have single column bents and the Los Angeles bridge model is expected to have multicolumn bents. At each location, the model bridge will consist of a baseline model based on a 5% in 5-year design hazard level (representing current design practice), and at least two variants: one based on a 10% in 5-year design hazard level and another based on a 5% in 10-year design hazard level. If preliminary analysis shows that the difference between the 5% in 5-year design and the 10% in 5-year design is insignificant, then a 5% in 20-year design should be evaluated instead of the 10% in 5-year hazard design.

Task 2: For each model bridge and variant, use nonlinear time-history analysis (NTHA) to estimate the annual probability of exceeding damage state 3 (serviceability) and damage state 5 (near collapse) corresponding to the seismic hazard at each bridge location. This analysis is suggested to be performed as follows (with deviations to the procedure subject to approval by Caltrans):

- Only column fragility will be considered in the performance analysis
- Column fragility will be based on Caltrans-PEER Workshop on Characterizing Uncertainty in Bridge-Component Capacity Limit-States (refer to: https://peer.berkeley.edu/news/peer-

research-project-highlight-caltrans-peer-workshop-characterizing-uncertainty-bridge) or similar studies.
- For each model bridge and variant, NTHA should be performed using 4 sets of 11 earthquake records. Each record set should be selected and scaled based on their fit to a conditional mean spectrum corresponding to one of four hazard levels with return periods of: 100-yr, 300-ys, 975-yr, and 2475-yr. These hazard levels may need to be adjusted to ensure a full range of performance is captured.
- Develop a performance model for all hazard levels by curve fitting between the 4 hazard levels.
- Convolve the hazard curve and performance model to estimate the annual probability of exceedance for damage states 3 and 5.

Task 3: Perform a cost analysis at the time of bridge construction to differentiate the costs of the baseline and variant bridge models.

Task 4: Create a Summary Table/Plot that effectively displays the cost difference (in percentage of total bridge cost) of each model and variant and seismic performance of each model and variant. Report on the relative merits of the three considered alternative hazard levels to be considered in future designs.

Additional project guidance and summary are listed as follows:
1. Temporary bridge performance criteria must be based on Caltrans Seismic Design Criteria (SDC)
2. Only sustained dead load and seismic load apply.
3. Secondary hazards triggered by earthquake do not apply.

Project Duration: 24 months

Maximum Budget: $200,000 (including any indirect costs at PI's institution and $7,500 overhead cost at UC Berkeley for an award to non-UC campus)

Problem Statement #2 for RFP 21-04

Objective

Develop regional highway network traffic models at various San Francisco Bay Area subregions to identify simple, yet accurate, design heuristics ("rule of thumb" guidelines) that can be used to determine whether a bridge should be designed to a *Recovery Bridge* performance standard or an *Ordinary Standard Bridge* performance standard.

Background

Recently adopted Seismic Design Criteria (SDC) 2.0 create an optional seismic performance target that exceeds what is applied to Ordinary Standard Bridges (OSB), deemed a "Recovery Bridge (RB)". Bridges designed to the more stringent criteria can be expected to remain undamaged in a modest earthquake (Functional Evaluation Earthquake, FEE) and incur only moderate damage in a severe design level event (Safety Evaluation Earthquake, SEE). See Table 1 for SDC the seismic hazard evaluation levels. From the perspective of Caltrans' Division of Engineering Services (DES), the choice of post-earthquake performance level is made at the District level since the benefits and costs of the project level design alternatives are evaluated at the District level. Feedback from District engineers is that they lack both the resources and the design tools necessary to assess the benefits of the higher performance standard in relation to the added expense.

A Recovery Bridge would incur damage during a design level earthquake, but the level of damage would be moderate. The bridge would be available for emergency vehicles and some reduced level of service for general traffic. While there are guidelines and experience related to how to build Recovery Bridges, there is a knowledge gap related to deciding on *when* to build them. It is generally agreed upon that Recovery Bridges should be used when the consequences of being down for an extended period is severe. However, determining an objective measure of severity is challenging. First, having a high performing bridge that is surrounded by bridges with standard performance might not result in improved network performance for rapid recovery. Thus, consideration of corridors for future upgrades and improvement is required. Another challenge is that the losses of some bridges affect the network performance more than others. Some routes have alternatives that can be used if the bridge is closed while others have no practical alternatives. Finally, local factors must be considered such as access to critical facilities and evacuation routes during the bridge performance evaluation process.

Table 1: SDC Seismic Hazard Evaluation Level

SDC Seismic Hazard Evaluation Levels and Expected Performance			
BRIDGE CATEGORY	SEISMIC HAZARD EVALUATION LEVEL	EXPECTED POST EARTHQUAKE DAMAGE STATE	EXPECTED POST EARTHQUAKE SERVICE LEVEL
Ordinary	SEE: 5% probability of exceedance in 50 years (or 975-year return period)	Major	No Service
Recovery	SEE: 5% probability of exceedance in 50 years (or 975-year return period)	Moderate	Limited Service-weeks
	FEE: 20% probability of exceedance in 50 years (or 225-year return period)	Minimal	Full Service

The project must emphasize on these main requirements as follows:

1) Highway transportation network modeling will be developed for large portions of the San Francisco Bay Area. The model will include highways and major arterials.
2) Identify critical corridors and network systems serving as the vital link for emergency and public access within the **first 72 hours** of an earthquake event.
3) Develop a set of **practical** methodologies that can be used to determine whether a recovery bridge performance goal is justified for a given bridge. These practical methodologies would utilize currently available information such as Average Daily Traffic (ADT) data and do not require traffic modeling and/or lengthy calculations or analyses. Example of a practical method can be in the form of items checklist with a straightforward scoring/impact scale system for the bridge in question. Other proposed methods are also welcome.

If need arises, additional secondary requirements should be included as follows:

1) Fragility models will be assigned to each bridge in the network for bridge vulnerability and performance capability assessment. No model development is required. This scope is limited to utilizing already developed models available in the literature.
2) Several earthquake scenarios/simulations will be used to generate ground motion intensity that will be applied to the network model to evaluate the impact on the network capacity. For each considered earthquake scenario, optimization techniques will be developed and employed to assess the benefits of different design options (i.e., some bridges designed as RB, others as OSB.)

Additional project guidance and requirements are listed as follows:

1. RB is designated as a bridge on the main (or only) route for emergency access to Critical Facility (assuming all critical facilities and other infrastructures met their desired seismic performance and functional levels) as follow:
    a. Hospitals
    b. Fire stations
    c. Disaster recovery centers
    d. Emergency service centers; main police/911 dispatch centers
    e. Main power/fuel stations
    f. Airport/landing zones for emergency search and rescue aircrafts
    g. Port facilities
2. RB is designated as a bridge on the main (or only) route for community evacuation.
3. Consideration of bridge impact interdependency within the network is required.
4. All benefit-cost analyses will not need to be examined.
5. Assume all other transportation systems (local street, mass transit, railway, aviation, and maritime) maintain normal operations and have no interdependence relationship to the highway network.
6. Identify corridor/highway network access redundancies.
7. Identify corridor/highway network access impact priorities. Related potential studies include: 1) bridge vulnerability assessment, and 2) secondary hazards impact to network infrastructure/segments using existing mapping/data available by USGS or other resources.

8. Investigate correlation between network performance capacity and operability to estimate the travel time.
9. Investigate areas of congestion for critical facilities in terms of impact to access and evacuation route.
10. ADT data should be based on pre-pandemic (COVID-19) event.

Related Research
Several projects funded by the Transportation Systems Research Program (TSRP) of the Pacific Earthquake Engineering Research (PEER) Center (refer to https://peer.berkeley.edu/research/transportation-systems/projects) have focused on work related to post-earthquake traffic network modeling making use of existing Bay Area network models that could be leveraged for this planned PEER-Bridge project. Moreover, The Institute of Transportation Studies (ITS) at Berkeley has models of the Bay Area transportation network and there are studies at the University of Nevada, Reno and University of California, Berkeley, in coordination with Lawrence Berkeley National Laboratory (LBNL), that conduct physics-based simulations of scenario earthquakes in the Bay Area. These models and simulations also include the idealization of the structural systems, e.g., bridges, which can be directly used to quantify the consequences of specific earthquakes on the recovery bridge performance in a direct manner. This can be an alternative reference approach to the one that uses ShakeMap and generic fragility functions for the bridges.

Project Duration: 24 months

Maximum Budget: $200,000 (including any indirect costs at PI's institution and $7,500 overhead cost at UC Berkeley for an award to non-UC campus)

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 person 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 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>_<PB2021-3 or 4>_<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 in the above website),
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.