PEER-Bridge Program Request for Proposal
Proposal Submission Deadline: 12/08/2020 at 11:59 PM PST

Objective

Develop guidelines for using the approximate method (moment magnification) and the refined method (second-order analysis) for efficient design of slender bridge columns. The research should consider a variety of common bridge types and configurations to satisfy the following objectives: 1) evaluate the performance of the moment magnification method (per AASHTO) relative to refined second-order analysis, 2) develop modifications on effective length factors and effective column stiffness to improve the accuracy of the moment magnification method, 3) identify any shortcomings and/or modifications needed to the moment magnification formulation that improve the accuracy of the method, 4) identify bridge configurations and foundation types that would be better served using the refined method, and 5) develop bridge modeling guidelines for using the refined method.

Background

AASHTO approximate method for the design of slender columns was adopted from the building industry, i.e. ACI, and has not been readily studied for applicability to bridges. Bridge frames are vastly different from building frames, so assumptions and parameters that may be appropriate for use in buildings are not necessarily appropriate for bridges. Due to a lack of bridge focused guidance, designers often make very conservative assumptions when dealing with slender bridge columns. Bridge configuration, superstructure rigidity relative to that of the columns, foundation type, and abutment type are likely to have a significant impact on the allowable column slenderness, yet these factors are typically not taken into consideration. Refined analysis using finite element models have consistently resulted in lower second-order effects than would be predicted using the approximate method, yet the refined method is rarely used in design because it requires significantly more effort when compared to the approximate method. The difference in demand when comparing the approximate and refined method grows larger with higher column slenderness ratios. When the slenderness ratio approaches the limit of 100, column demands using the approximate method deviate substantially from the refined method demands. There is a clear need for improved guidance in parameter selection for use in the approximate method and potentially a need to update the method formulation. Moreover, if the refined method is to become more widely used, it will require better guidance to reduce the amount of computational effort, time required and the risk of incorrect modeling assumptions.

Therefore, the main emphasis of the submitted proposals should be to evaluate AASHTO with CA amendment approximate moment magnification method using second-order analysis including P-Δ effects for deflections on axial loads and moments. Parametric studies should be conducted on common Caltrans bridge types with varying configurations and controlling parameters should be

identified on results of both methods of analyses. When results of the approximate method significantly deviate from the refined method, formulations and/or modifications to the approximate method should be derived to reduce the difference between the two methods. The proposals should also include descriptions of how to address the below research components, in addition to other aspects not listed here, as deemed necessary by the proposers.

Research Components to be Addressed

I. Establish appropriate member effective stiffness (*EI*) for both the approximate moment magnification method and the second-order analysis method. For *EI* formulation, investigate sustained load factor, β_d used by Code and its appropriate application to bridge columns.

II. Establish appropriate effective length factor (*K*) for AASHTO approximate moment magnification method based on realistic bridge system stiffness and boundary conditions. Validate Code requirements of lower limit (22) and upper limit (100) on the slenderness ration (*KL*/*r*) for the approximate method.

III. Establish column axial load carrying capacity, deformation limits (buckling), and lateral displacement limits (structural instability) as a function of the slenderness ratio (*KL*/*r*).

IV. Develop modeling guidelines and/or simplified design procedures for design of slender bridge columns based on second-order analysis in conjunction with AASHTO and ACI specifications.

V. Identify bridge configuration criteria and controlling limits for the application of second-order analysis. Parameters include, but are not limited to, column slenderness ratio, boundary conditions, cap beam/box girder to column stiffness ratio, loading conditions, bridge geometry, foundation type, and lateral displacement restraint. Currently, Code requirement for the use of second-order analysis is when $KL/r > 100$. Is this limit appropriate? And if not, what are the new guidelines should be?

VI. Perform literature search in support of decision made for both the approximate method and the refined method results. Identify issues on divergence and/or potential disagreement from Code specifications, experimental results, and literature reference. It is expected that the proposed research will make use of this literature to validate the proposed modifications.

Additional project guidance is summarized as follows:

a. Analysis should be carried out for AASHTO with CA amendment for limit states: Service I, Strength I, and Strength II according to Table 3.4.1-1, Section 3 Page 3-15B of the Load Resistance Factor Design CA Amendments - 8th Edition, https://dot.ca.gov/programs/engineering-services/manuals/lrfd-ca-amendments-8th-edition.
b. Analysis should consider the influence of axial loads, member stiffness (*EI*), and element boundary conditions.
c. Second-order analysis can be performed using any analysis tools, e.g., OpenSees, MIDAS, or ABAQUS. However, final recommendations should also be validated by CSiBridge.
d. Second-order analysis should be based on realistic material stress-strain relationships and section moment-curvature relationships, obtained in conjunction with Caltrans Seismic Design Criteria (SDC) specifications.
e. Superstructure and bent cap bending stiffness contribution shall be investigated.
f. Abutment type contribution to bridge lateral stability shall be investigated.
g. Influence on effective *EI* due to sustained load factor, β_d, shall be investigated.
h. Varying bridge configurations should include:
    a. CIP Box Girder with integrated bent cap; CIP P/S "I" Girder with drop cap.
    b. Single frame bridge (2 spans, 3 spans, and 4 spans) and multi-frame bridge.
    c. Straight, skewed, and curved bridge.
    d. Single column bent and multi-column bent.
    e. "Pinned" and "fixed" end column conditions.
    f. A range of foundation stiffnesses should be considered to account for possible foundation types and soil conditions.
    g. Seat type abutment and diaphragm abutment.

Project Duration: 24 months

Maximum Budget: $300,000 including the required 30% max. overhead by the UC system. For example, if the project direct costs are $230,769, and indirect cost (UC overhead) rate of 30% is applied on this full base cost, then the total budget is under $300,000.

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, Seattle. 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 and https://peer.berkeley.edu/research/transportation-systems/projects.
3. Proposals should be prepared using the form in this link: https://peer.berkeley.edu/research/peer-bridge-program/request-proposals 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 link 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>_<PB2020-2>_<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 in this link: https://peer.berkeley.edu/tools-funded-peer-researchers),
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 the research team to complete all their publications), 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.