Influence of Vertical Ground Motion on bridges isolated with Friction Pendulum Bearings

PEER Transportation Systems Research Program

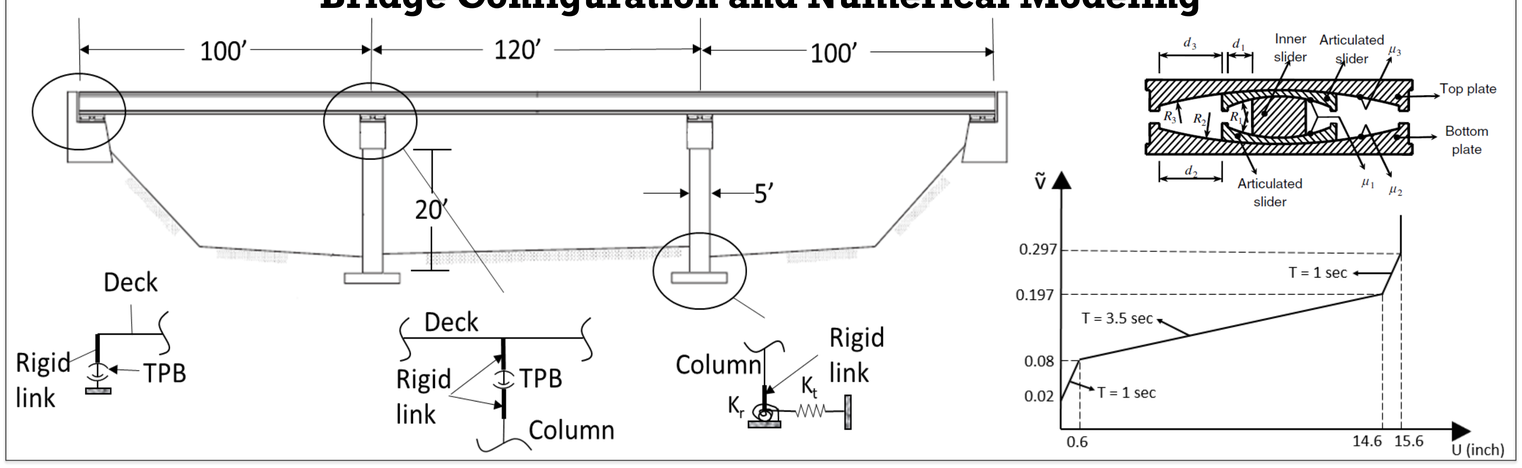
Principal Investigator: Keri Ryan, Associate Professor, University of Nevada Reno

Student Investigators: Rushil Mojidra, MS Candidate, University of Nevada Reno

Introduction and Objectives

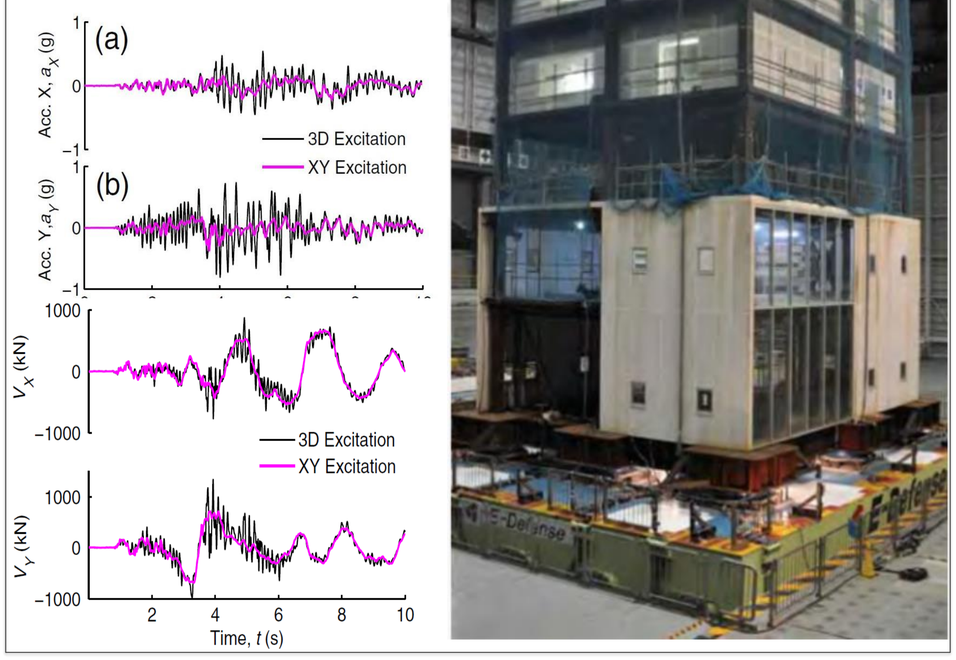
Seismic isolation is one of the most effective method to protect structures and its content during earthquakes. In this method, flexible layer is used between superstructure and substructure which lengthens time period of the system and hence reducing the demands on the structure. In the case of friction pendulum bearings, horizontal response is proportional to vertical force because the curvature of the spherical surfaces. Past several numerical and experimental studies have shown amplified base shear and floor accelerations because of the vertical shaking, specifically a full-scale shake table test of a 5 story steel moment frame building. The primary objective of this study is to answer the question: "Should vertical shaking be explicitly considered in the design of bridges with friction pendulum bearings?" This study also tries to achieve following objectives. Identify most suitable and common bridges types for seismic isolation. Develop detailed 3D bridge models isolated with Triple pendulum bearings. Compare and examine response of the bridges with and without vertical ground motions.

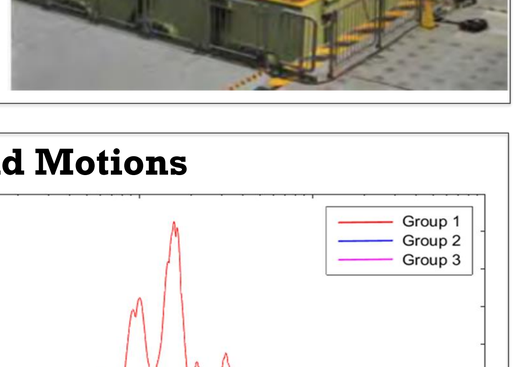
Bridge Configuration and Numerical Modeling



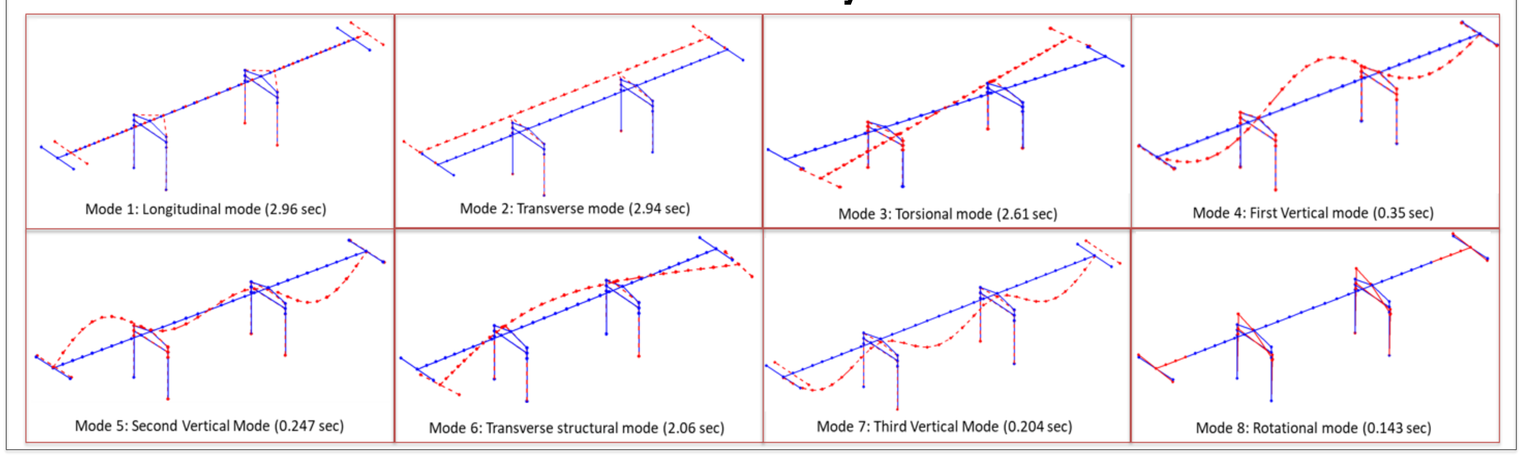
E-Defense Test

- Specimen: Full scale 2 x 2 bay 5-story steel moment resisting frame (10 x 12 m in plan and 16 m high) isolated with triple friction pendulum bearings.
- Ratio of response with and without vertical motion was 1.9 for base shear and 2.55 for horizontal acceleration.





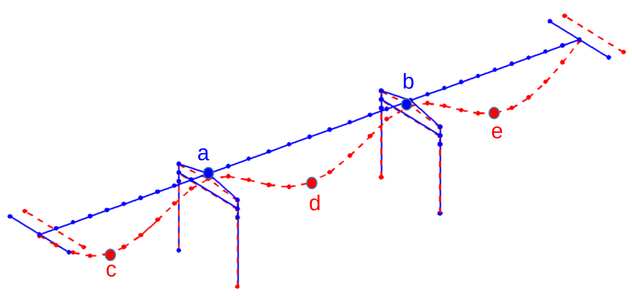
Modal Analysis



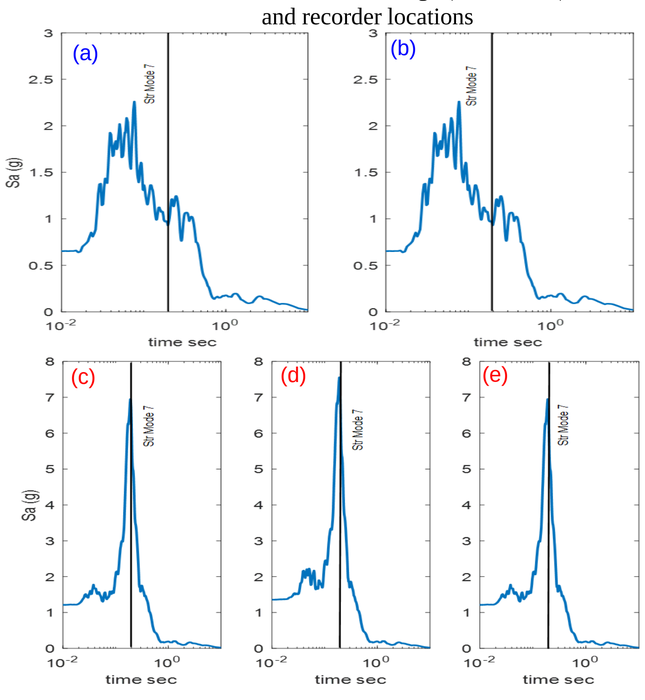
Ground Motions

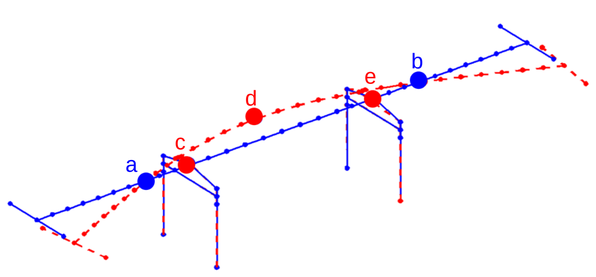
- 11 near field Ground motions from Carlton (2014) dissertation also present in Shahi and Baker database for PEER transportation research program.
- Motions have wide range of scaled vPGA from 0.26g to 1.68g.

Deck Spectra

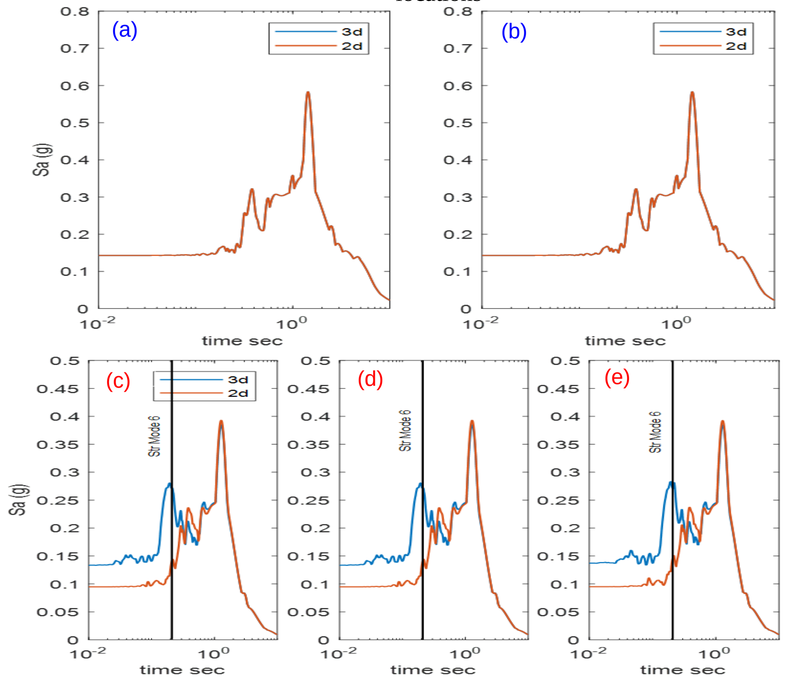


7th structural mode of bridge (T = 0.2 sec) and recorder locations

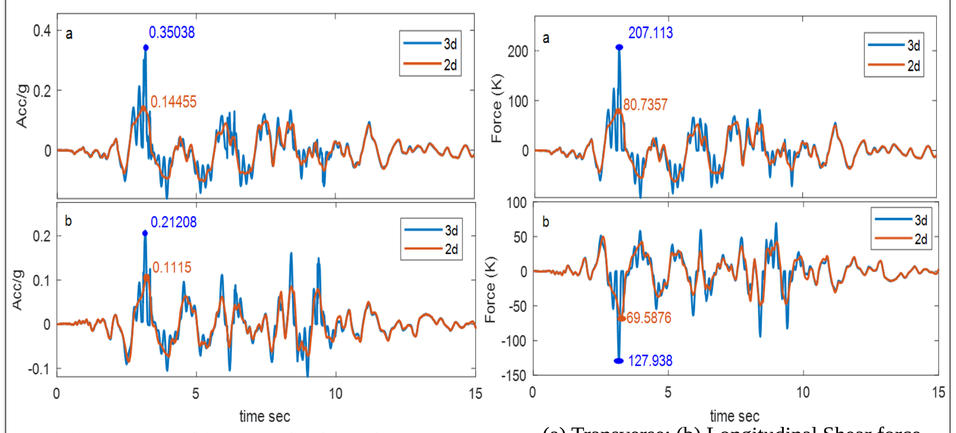




6th structural mode of bridge (T = 0.21 sec) and recorder locations

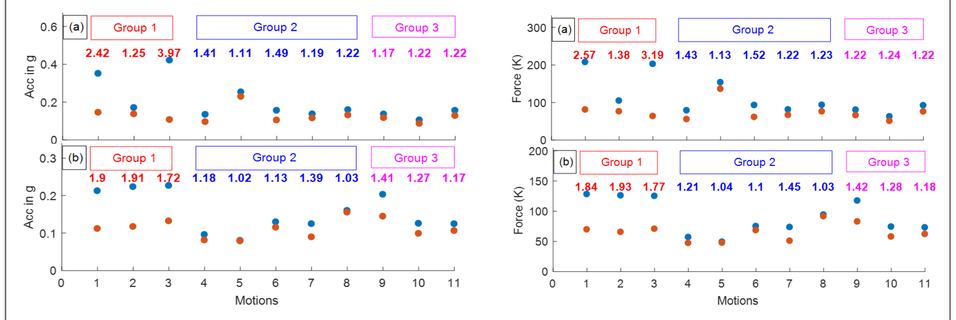


Results



(a) Transverse; (b) Longitudinal Acceleration History SFPU motion at bent1

(a) Transverse; (b) Longitudinal Shear force History SFPU motion at bent1



(a) Transverse; (b) Longitudinal Acceleration Amplification factors

(a) Transverse; (b) Longitudinal Base shear Amplification factors

Future Work

- Future work involves parametric variations like span length, pier height, deck width, single/multiple column bent, no of spans, and isolator properties to investigate effect of each variable on the response.

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