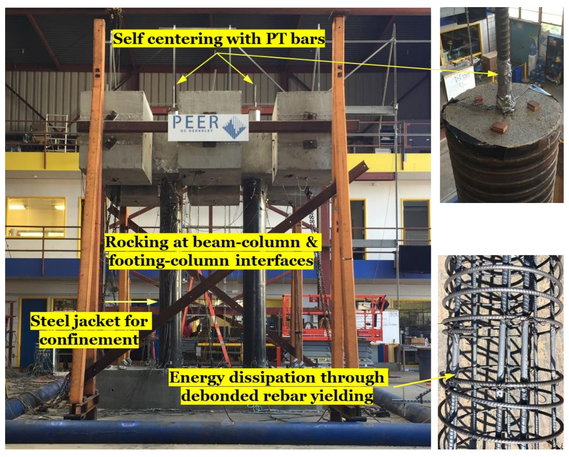
SYSTEM LEVEL PERFORMANCE EVALUATION OF AN INNOVATIVE BRIDGE BENT DESIGN USING HYBRID SIMULATION

PEER Transportation Systems Research Program

Principal Investigator: Khalid M. Mosalam, UC Berkeley
Other Investigators: Yingjie Wu and Selim Günay, UC Berkeley
Pacific Earthquake Engineering Research (PEER) Center, University of California Berkeley

INTRODUCTION

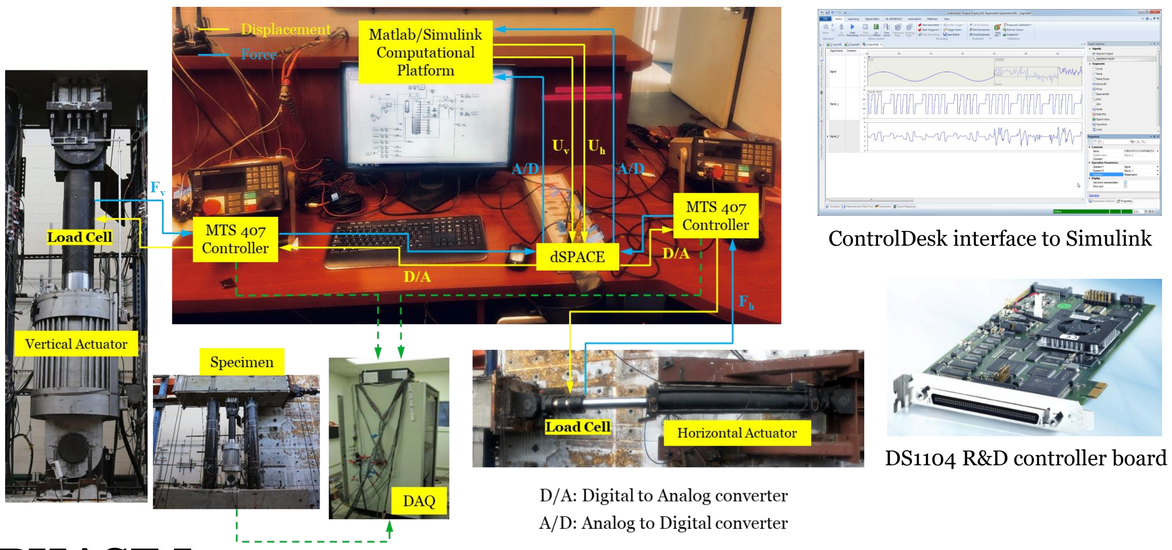


A new and innovative bridge bent, with **self-centering, rocking and energy dissipation** features, was designed and tested on the PEER **shaking table** (Nema, 2019)

Objectives of this project are:

- Conduct a **hybrid simulation** version of the shaking table test and **validate** the conducted **hybrid simulation**; and
- Explore the **system level response** of a complete bridge **involving the innovative bridge bent.**

HYBRID SIMULATION SYSTEM (HSS)



ControlDesk interface to Simulink

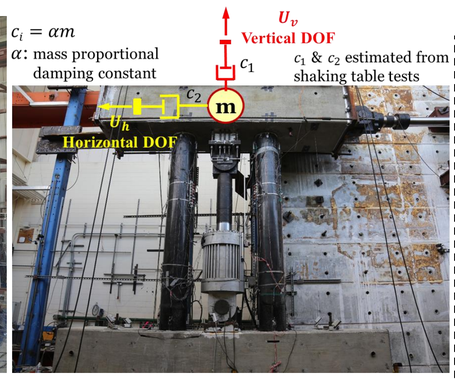
DS1104 R&D controller board

D/A: Digital to Analog converter
A/D: Analog to Digital converter

PHASE I

Goal: compare the hybrid simulation (HS) results to the shaking table test.

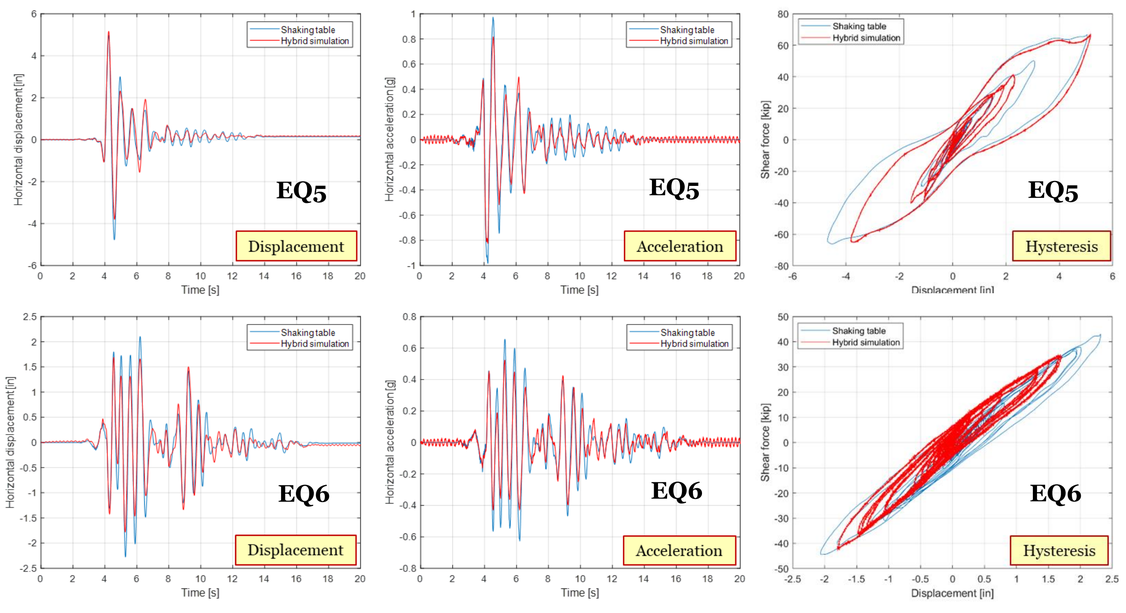
Shaking table test



Hybrid simulation test

EQ #	Event Name	Station Name	Unscaled PGA [g]	Scale Factor	Expected Drift [%]
01	For checking shaking table tests and not used in HS				
02	Landers, 1992	Lucerne	0.72	0.9	0.6
03	`, 1978	Tabas	0.85	-0.9	1.8
04	Kocaeli, 1999	Yarimca	0.30	1.0	0.6
05	Northridge, 1994	RRS	0.85	0.8	4.0
06	Duzce, 1999	Duzce	0.51	1.0	1.8
07	Northridge, 1994	NFS	0.72	-1.2	4.0

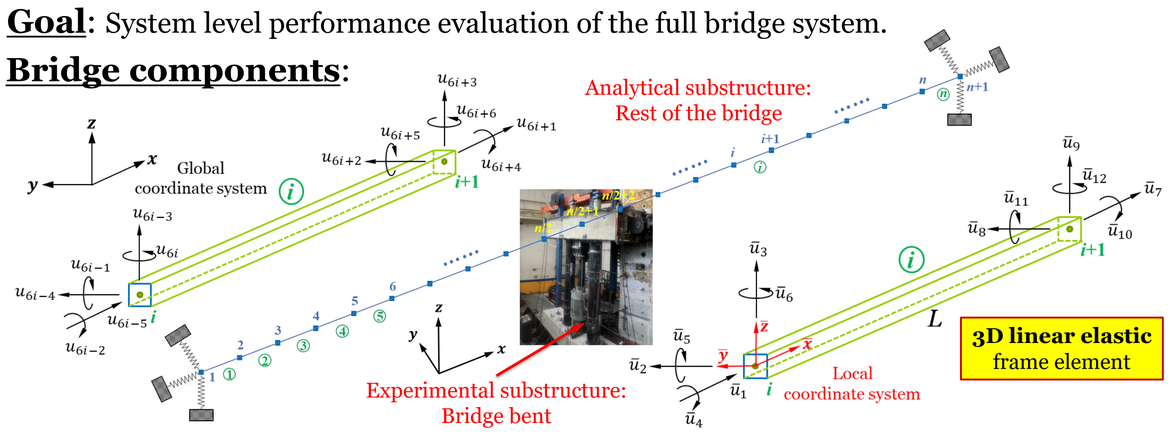
- ➢ Responses from two directions represented by two **independent** & **uncoupled** differential equations of motion (horizontal & vertical DOFs) are formulated separately;
- ➢ A horizontal actuator applies calculated **lateral displacement** (negligible top moment from the shaking table tests); and
- ➢ A vertical actuator applies **gravity** & **vertical forces** for the vertical component of the ground motion.

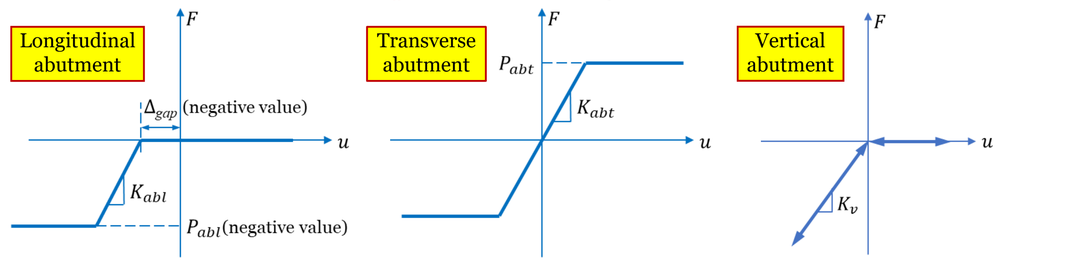


PHASE II

Goal: System level performance evaluation of the full bridge system.

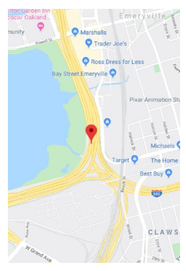
Bridge components:

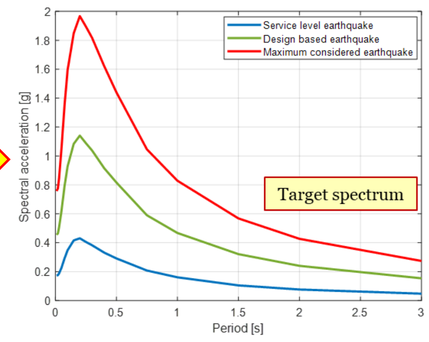


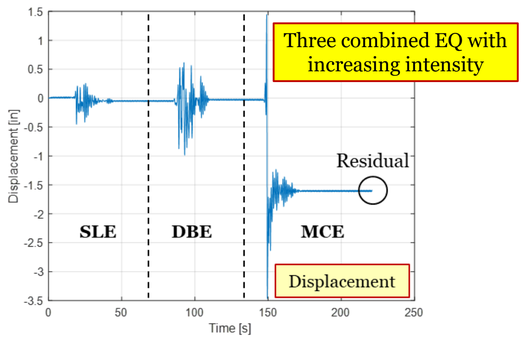


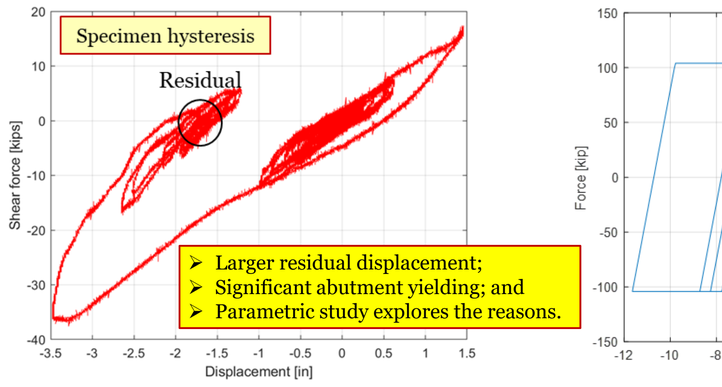
- **Longitudinal**: compression-only spring with elastic perfectly-plastic gap material;
- **Transverse**: spring with elastic perfectly-plastic material; and
- **Vertical**: compression-only elastic spring.

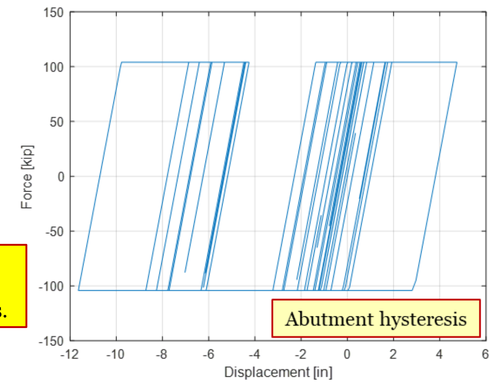
Results:



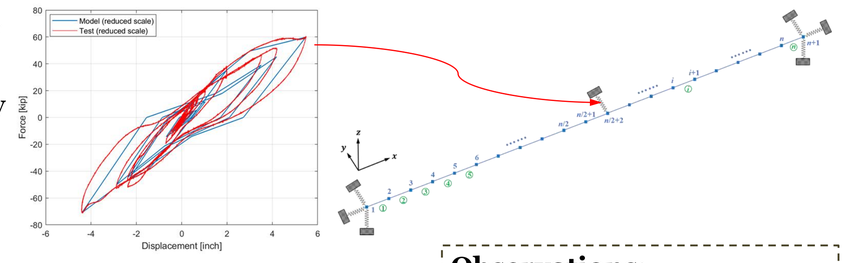


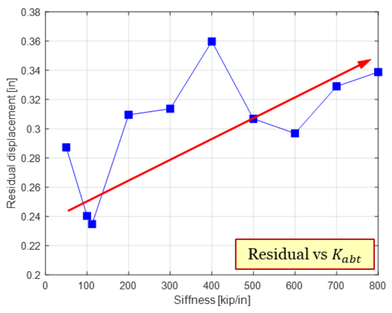


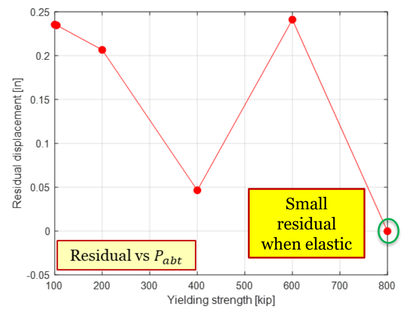




Parametric study:
It demonstrates the effect of transverse abutment on the bridge response, particularly residual displacement, referred to as "residual" herein.







Observations:

- Residual is close to zero when the abutment remains elastic;
- Residual tends to increase as K_{abt} increases;
- Large residual is due to abutment yielding; and
- No clear relationship between residual and P_{abt}.

CONCLUSIONS

- ✓ A **new Hybrid Simulation System** was developed for single and multi-DOF analytical substructures;
- ✓ **Good matching** of the test results was achieved between phase I Hybrid Simulation (HS) and the shaking table tests;
- ✓ **Larger residua**l displacement of the bridge bent was observed in phase II HS testing;
- ✓ Further attention is needed not only for key bridge components, but also in other components like the abutment in order to **completely benefit from innovative holistic designs**; and
- ✓ System level HS is a practical approach towards more future **damage-free** bridge designs.

This project was made possible with support from:

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER
UC Berkeley • Caltech • OSU • Stanford • UC Davis • UC Irvine • UC Los Angeles • UC San Diego • UNR • USC • U Washington
peer.berkeley.edu