Research Project Highlight

New Seismically Resilient System for HSR, Ports and Vehicular Transportation Systems: Reducing Downtime, Construction Cost and Post-Earthquake Repair

TSRP Topic S3 - Studying ports, high-speed rail, & airports with PBEE or PBTE

Principal Investigators
Dawn Lehman, Civil & Environmental Engineering, University of Washington
Charles Roeder, Civil & Environmental Engineering, University of Washington

Research Team
Zhao Muzi, Ph.D. Candidate

Start-End Dates:
August 2019 - Aug 2021

Abstract
Transportation systems including elevated bridges for vehicles, high-speed rail and ports are moving towards modular systems that promote and facilitate accelerated construction. Accelerated construction (AC) of transportation systems is important and advantageous because it (1) reduces traffic interruption and downtime of the system, (2) reduces labor and (3) reduces on-site construction time, which in turn, reduces cost. However, most AC techniques use precast components as the piers, which is advantageous from the perspective of schedule but requires that heavy equipment which can increase the cost and thereby reduce the cost-effectiveness of AC. In addition, AC typically ignores the foundation construction cost and schedule which misses a critical point because foundations typically make up more than 50% of the cost of the structural system. A solution to reduce equipment cost and promote AC of transportation systems is to use concrete-filled steel tubes (CFSTs) An alternative system has been investigated for AC. This system uses CFSTs as piles and/or piers, shown below. By design, these connections promote AC and reduce damage through elongation of the steel without damage to the concrete, promoting ductile response without permanent damage, thereby meeting higher performance objectives. A missing piece of this new structural system is the foundation system including the direct pier-to-pile connection and the contribution of soil-structure interaction on the this is an economical solution that reduces the cost of the structural foundation system and Using this work as a basis, and understanding the performance objectives for post-event functionality required for HSR and ports, this project will investigate: (1) a new seismically resilient pile-to-pier connection, (2) system structural performance using the PEER Bridge PBEE tool as well and OpenSEES, and (3) developing new PBEE tools for HSR structural geometries to inform design and evaluation of post-earthquake functionality.

PEER Center – 325 Davis Hall, UC Berkeley, CA 94720 | peer_center@berkeley.edu

New Seismically Resilient System for HSR, Ports and Vehicular Transportation Systems: Reducing Downtime, Construction Cost and Post-Earthquake Repair

Deliverables

The project includes four tasks with the following objectives, milestones and deliverables.

1. Investigate new pile-to-CFST pier connections for seismic resilience and advancing AC for HSR and other transportation modalities. ***Deliverable***: new connection design expressions and specification language. ***Milestones***: completion of testing (Month 10) & completion of design expression (Month 12).
2. New nonlinear models for connections and CFST piles (and piers) for implementation in OpenSEES and the PEER Bridge PBEE. ***Deliverables***: new connection models implemented in OpenSEES and new PEER Bridge PBEE with capabilities to simulate HSR and other elevated structural systems with CFSTs. Milestones: new connection models (Month 14), implementation into PEER Bridge PBEE (Month 15).
3. System-level analysis of HSR systems including (1) all structural components, (2) connections and (soil-structure interaction). ***Milestones***: Model development (Month 8), simulation of systems (Month 13).
4. New, probabilistic based tools to inform design of high-speed rail (HSR) to meet post-earthquake functionality requirements. ***Milestones and deliverables***: New fragility curves for CFST transportation systems (Month 24)

Research Impact

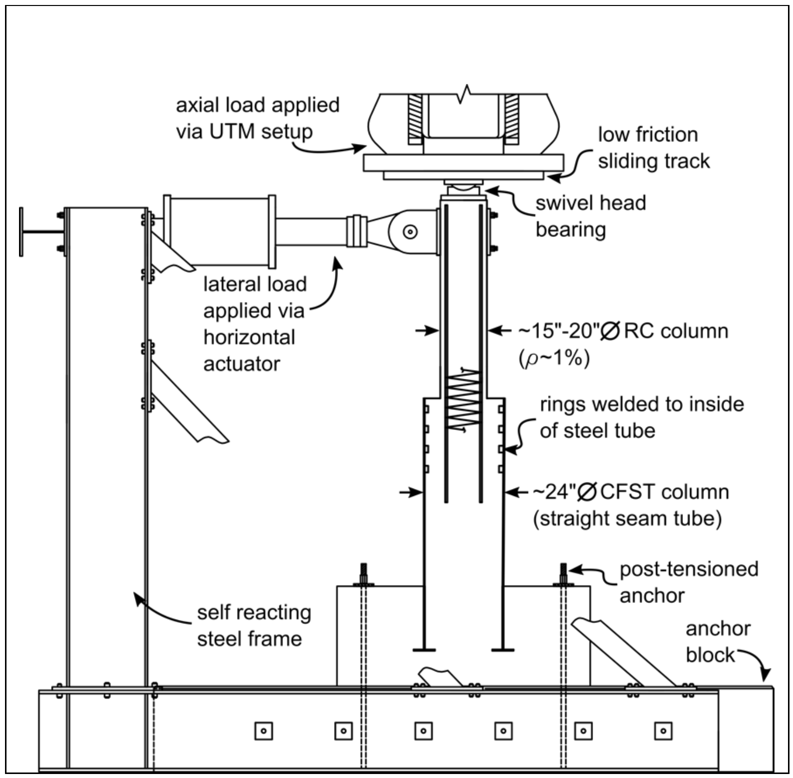
Although it is not possible to estimate the cost savings to future project, it is possible to illustrate the potential cost savings, both in terms of material and labor. Prior research shows that using CFST components in place of RC components can decrease the material required by 30-60%. Contractors indicate that the comparable cost savings is directly related to the material saved. An additional benefit that will result from this research project is eliminating the need for an internal reinforcing bar cage for CFST shafts. These cages are currently used to transfer the load from the bridge pier to the shaft. With the results from this project, this internal cage could be eliminated, which would be a substantial material and cost savings. As an illustration, consider a typical 60’ long, 8’-0” diameter shaft which would normally have roughly 50,000 lb. of rebar for the internal cage. The cost to fabricate, handle with large cranes, and set into the shaft would be on the order of $75,000 to $100,000 dollars. Eliminating the shaft and using the shaft casing for flexural and shear strength would not only eliminate the rebar but also the need for a large crane to pick the constructed rebar cage and set it in the hole. There are several bridge, HSR and port projects that will be constructing shafts that could take advantage of this technology.

PEER Center – 325 Davis Hall, UC Berkeley, CA 94720 | peer_center@berkeley.edu

Research Project Highlight

New Seismically Resilient System for HSR, Ports and Vehicular Transportation Systems: Reducing Downtime, Construction Cost and Post-Earthquake Repair

Project Image



PEER Center – 325 Davis Hall, UC Berkeley, CA 94720 | peer_center@berkeley.edu