# Research Project Highlight

# Performance-Based Economic Loss Assessment Due to a Hypothetical Large Southern California Earthquake Based on the Disruption and Recovery of Port of Los Angeles Freight Traffic

*TSRP Topic – Study of Ports, High-Speed Rail, & Airports – S3*

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**Start-End Dates:**
2/1/2020 – 1/31/2022

**Abstract**
This project develops a novel approach that couples an image-based structure-and-site-specific bridge fragility generation methodology with regional-scale travel demand and economic loss prediction models. The established framework is being applied to real-life bridge networks of crucial importance, including the highway network surrounding the Port of Los Angeles, to assess resilience and economic losses at a high resolution. Due to its data-intensive nature, the proposed approach will capture and incorporate many details that are usually omitted in traditional analyses (e.g., HAZUS). It, therefore, promises to yield significantly improved accuracy in estimating economic losses and recovery after a major scenario event and the discovery of finer metrics of seismic resilience for transportation networks.

**Deliverables**
Deliverables of this project comprise (*i*) archival peer-reviewed publications that disseminate the proposed methodology and its outcomes, (*ii*) a database of the metadata for the bridges within a 30-mile radius of the Ports of Los Angeles and Long Beach, (*iii*) OpenSees (Tcl) input files and system-level fragilities computed for each bridge, (*iv*) ArcGIS public-domain maps shared visualizing transportation network performance throughout the disaster timeline as well as economic impacts on the region.

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**Methodology**

Detailed representation of seismic damages to bridges requires an accurate depiction of the bridge inventory susceptible to earthquakes and consideration of the site conditions and seismicity in a site-specific manner. In this study, bridge inventory is generated using an image-based model generation algorithm. By collecting street-level imagery and from these images computing the deck, column, abutment, and in-span hinge dimensions of each structure, this method attains a comprehensive representation of the bridges'geometric attributes. These attributes are then paired with the class statistics existing in the literature to develop structure-specific models of every bridge within a study region. The models are nonlinear structural models capable of predicting the permanent deformations after a scenario earthquake, hence suitable for post-mainshock or -aftershock analyses. The ground motion records required to calculate the fragility functions of these bridges are also determined in a structure-specific way considering the potential directivity effect at each site. Site conditions are incorporated via topology-based average shear wave velocity values. The proposed framework can predict bridge damage due to scenario events in terms of damage probabilities for PBEE damage classes and bridge functionality as a percentage of the initial capacity. Recovery times for each time are also approximated through recovery functions.

Due to the large size of the study area, a semi-static traffic assignment model is used to compute the traffic volumes on the roads before and after bridge closures. Specifically, vehicles are assumed to choose the fastest path under the current road closure and traffic congestion status. The simulation is semi-static. The simulations are performed for a time step of 15 minutes, meaning a new route will be generated for vehicles still en-route. The most computational-intensive component of this method, i.e., vehicle routing, adopts Dijkstra's Algorithm and is carried out in parallel to improve the model efficiency. Spatial network analysis will be performed to explore the underlying network structure of the road network in addition to the traffic simulation.

**Progress after Project's First Year**

Nonlinear structural models for 1,000 bridges within the immediate periphery of the Ports of Los Angeles and Long Beach were established. The fragility functions for these bridges were computed for slight, moderate, extensive, and complete damage states. Using a GMPE-based approach, the expected 1-second spectral accelerations at each bridge site were determined for an $M_w$ 7.3 Palos Verdes Fault scenario event, 2 miles off the port islands. Based on these intensity measure levels, expected damage probabilities and functionality levels and the time required for recovery of these bridges were determined. Figure 1 shows one of the many damage map predictions obtained using the proposed approach. A physics-based simulation of the same scenario earthquake is currently underway.

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On the traffic side, the road network data for six counties in Southern California represented by the Southern California Association of Governments (SCAG) has been gathered from OpenStreetMap (OSM). The network is converted into a graph representation consisting of 1.4 million edges and 0.6 million nodes. In addition, the travel demand in normal situations (i.e., without earthquake damage) has been obtained from the SCAG and is being processed to the required format. A Python-based traffic assignment module is currently being used, which computes sub-hourly road-usage changes through an interactive assignment process with residual demand. A faster version of the traffic simulation that can better leverage High-Performance Computing (HPC) capabilities is currently being developed.

### Project Image

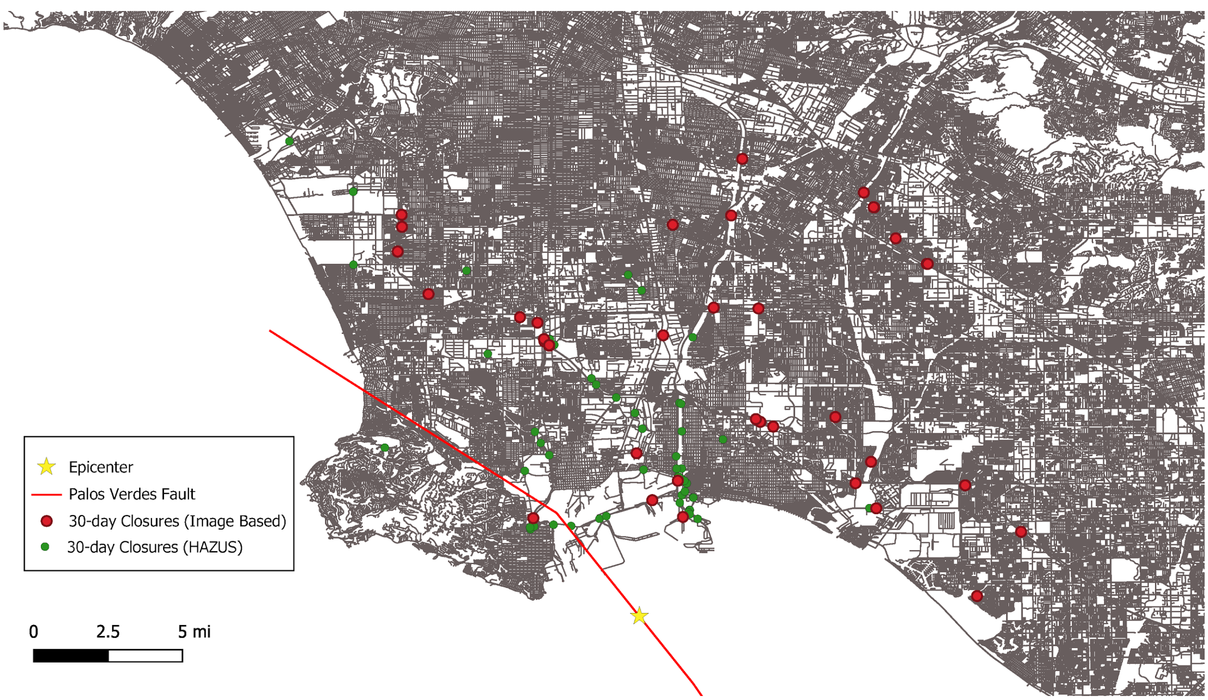


**Figure 1.** Preliminary results for 30-day bridge closures due to $M_w$ 7.3 Palos Verdes Fault scenario event. The closures were computed using the approach developed for this project (denoted in red) and HAZUS (denoted in green).



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