VShaker Project: Visualization of Steel Building Response to Ground Motion Time Histories

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Project Overview

SCEC researchers perform earthquake wave propagation simulations for both historical and scenario earthquakes that produce ground motion time-histories (seismograms). These synthetic seismograms can be used to model building response to strong ground motions. To support the exchange of ground motion time histories between SCEC ground motion modeling groups and building engineering groups, we have developed new tools for combining simulation-based synthetic seismograms with engineering-based building models.

On our VShaker Project, we have developed an interface between SCEC ground motion seismograms (Websims) and the scientific gateway, Caltech Virtual Shaker, in order to visualize building response to ground motion time-histories.

SCEC Websims

SCEC Websims developed by Geoffrey Ely is a web application for cataloging, exploring, comparing and disseminating four-dimensional results of large numerical simulations.

Websims was used to obtain the M8 synthetic seismograms used in this study.

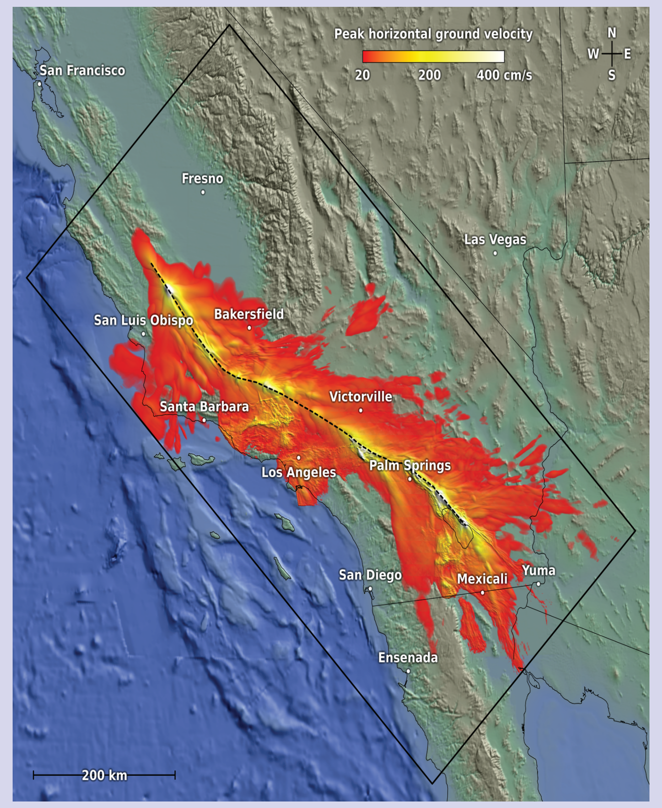

Figure 1: M8 Peak horizontal ground velocity.

Websims can be use to explore ground motion data for each of the grid points in the cataloged simulation region. In this example a ground motion plot was obtained for Northridge site (34.2187 N, 118.5313 W) by specifying the simulation region offsets for the site coordinates.

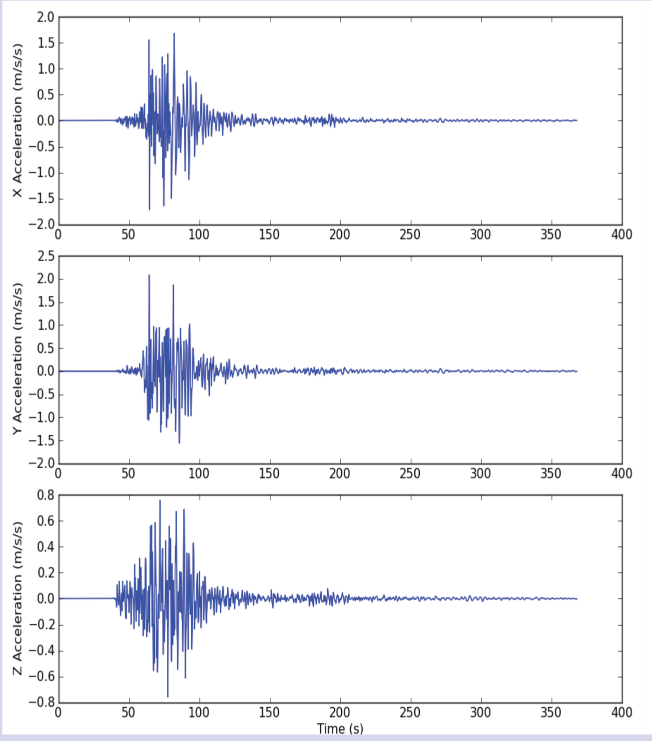

Figure 2: Plot M8 Ground Motion - Acceleration for Northridge site.

Web site: ***http://scec.usc.edu/websims/***

Caltech Virtual Shaker

Caltech Virtual Shaker is an e-analysis facility created by the Earthquake Engineering research Laboratory for the remote nonlinear time history analysis of structural models, subjected to earthquake shaking. FRAME3D, the analysis engine for the Virtual Shaker, allows us to perform efficient three-dimensional nonlinear analysis of steel buildings subject to ground acceleration records.

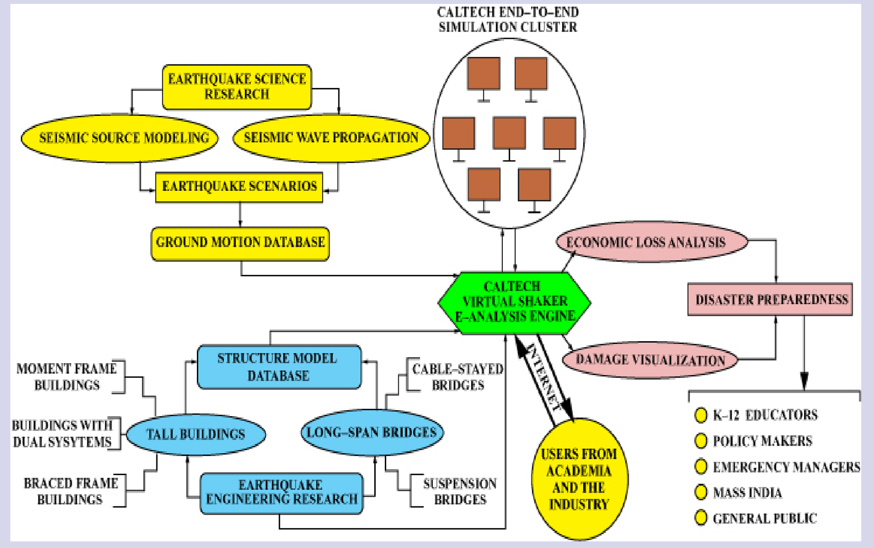

Figure 3: Caltech Virtual Shaker Scientific Gateway

The 18 story building model shown below was selected for this study from Virtual Shaker's searchable structural model database. This is a model of an actual building located in Northridge.

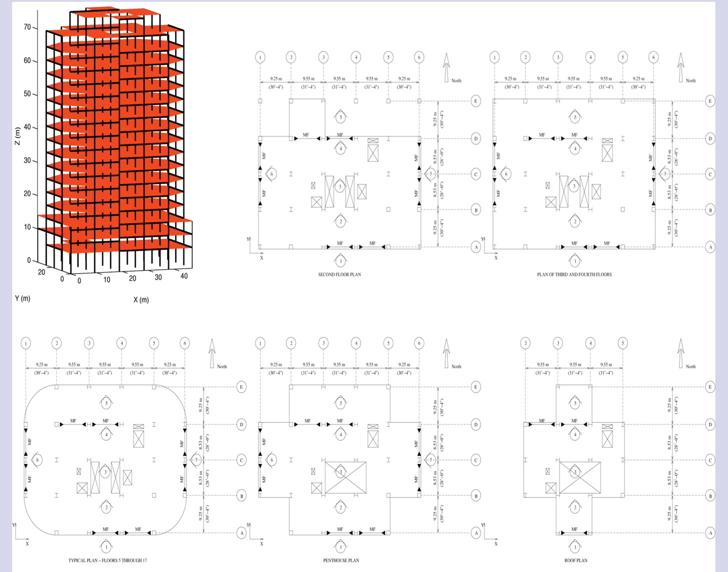

Figure 4: 18 Story Building Building with Floor Plans.

Web site: ***https://virtualshaker.caltech.edu/***

SCEC VShaker

VShaker is a set of tools developed at SCEC that
(a) provides formatted ground motion time-history input to Frame3D software, and
(b) processes and visualizes Frame3D structural analysis output from Virtual Shaker.

VShaker converts the intensity measure of ground motion data obtained from velocity to acceleration. If required, the data is trimmed to only include strong ground motion.

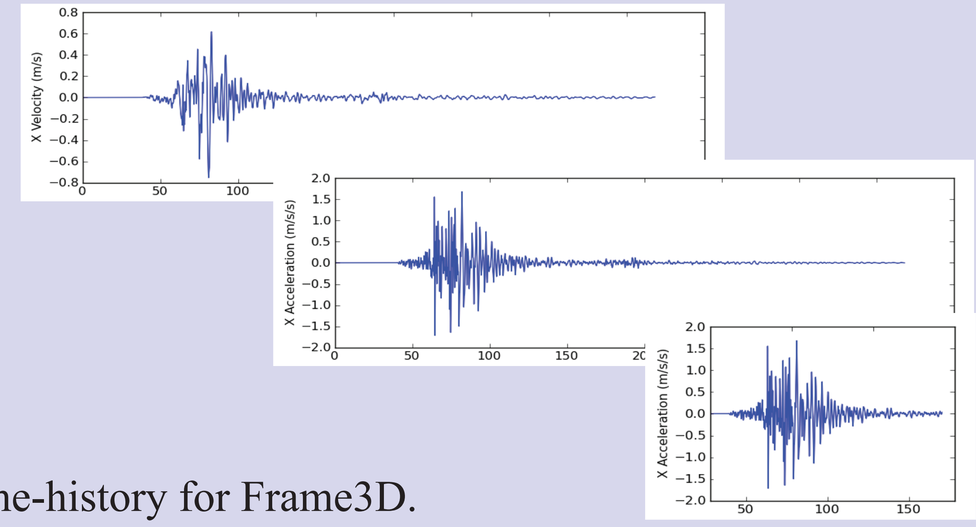

Figure 5: Formatting ground motion time-history for Frame3D.

VShaker first combines Frame3D structural model and response data with ground motion synthetics to build three-dimensional geometric representations of the structure at specified time intervals.

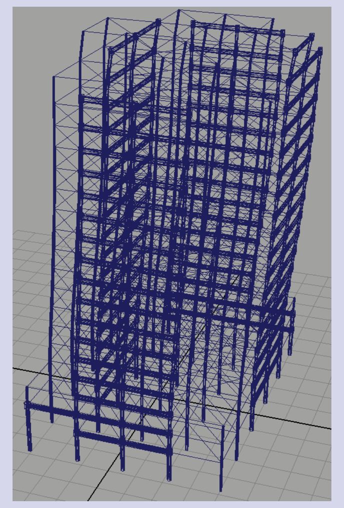

Figure 6: Three-dimensional geometric representations of the structure.

These geometric representations are output as Wavefront OBJ files - a universal file format supported by major 3D rendering programs. This file format allows us to specify colors, textures and materials to create useful illustration of the structure.

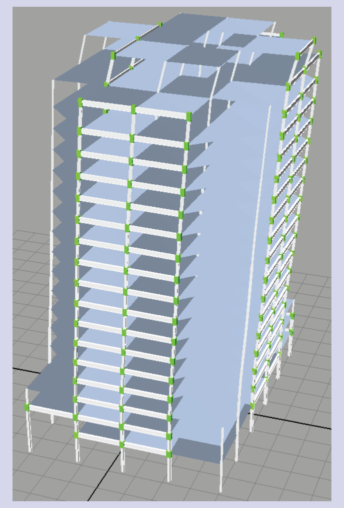

Figure 7: Three-dimensional geometric representations of the structure with surface coloring to show beams, nodes and plane zones.

VShaker can use the structural response data obtained from Frame3D to highlight degree of displacement and damage. In this illustration the node displacement data was used to color map the nodes to show degree of displacement.

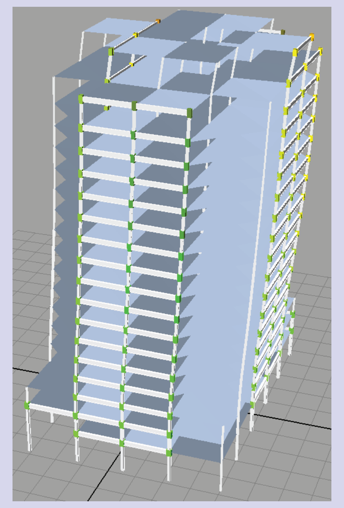

Figure 8: Three-dimensional geometric representations of the structure with color mapped nodes to indicate degree of displacement.

Web site: ***https://scec.usc.edu/it/VShaker***

M8 - Building Response Study

VShaker was used to evaluate the response of 18 story steel buildings with fundamental periods of 4.54 seconds subjected to acceleration records from the SCEC M8 Simulation. This building was simulated at eight locations spread out across Southern California.

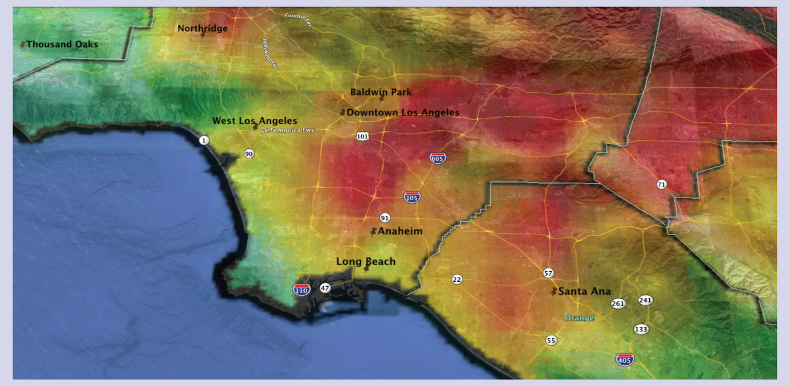

Figure 9: Eight building site locations used in the study.

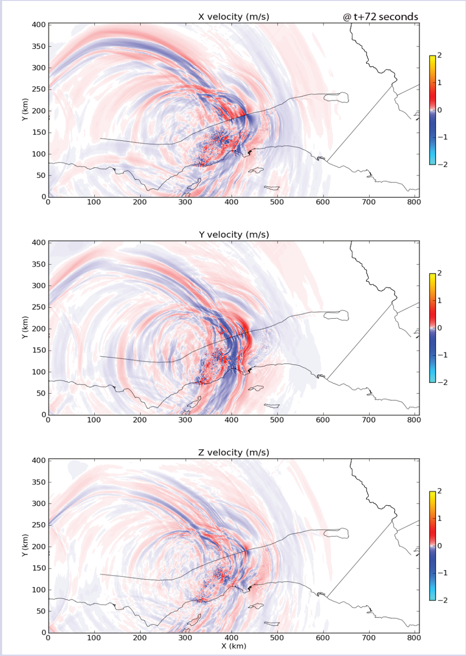

Figure 10: M8 Simulation snapshot showing ground velocity waveforms at 72 seconds from start of the simulation.

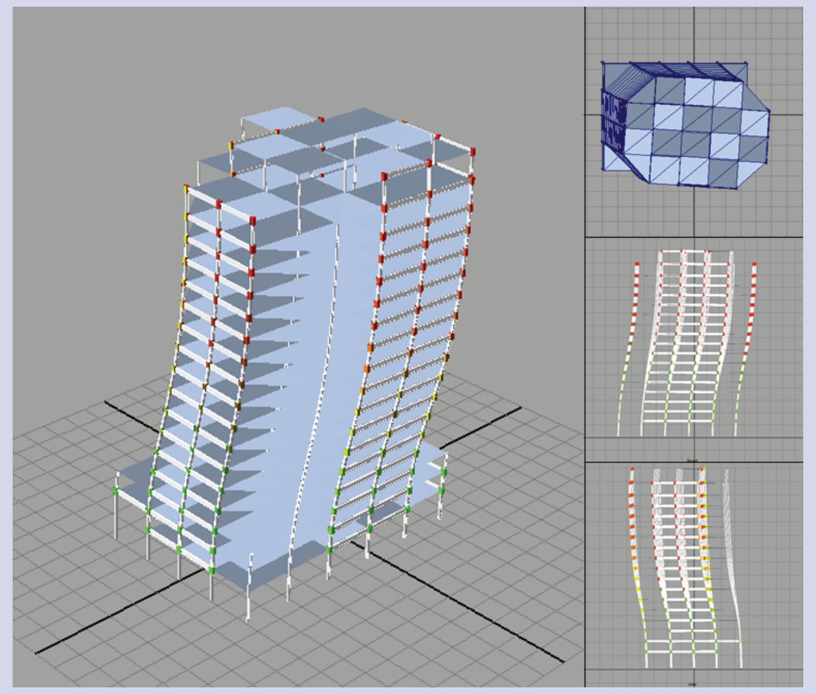

Figure 11: Plot of building response for Northridge site at 72 seconds from start of the simulation.

The locations were chosen based on a previous study conducted by Krishnan et al., on the response of tall steel buildings for the magnitude 7.9 1857 southern San Andreas Earthquake. The building responses obtained for the eight sites were comparable to the results reported in the previous study.