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Accounting for Basin Effects Will Improve Seismic Risk Assessments

Harold Magistrale
FM Global, Norwood, MA, USA (harold.magistrale@fmglobal.com)

A fundamental problem in assessing the seismic risk of properties and providing loss prevention solutions is determining the distribution, amplitude, frequency characteristics, and duration of strong ground motion from potential future earthquakes. This task is complicated by the strong effects that three-dimensional (3D) geologic structures, such as sediment-filled basins, have on ground shaking. Numerical studies of seismic wave propagation have shown that ground motions are amplified and have longer durations within basins, and there are observations of basin-edge-generated surface waves and of basin-focusing effects on ground motions. Further, basins typically host deep and/or soft unconsolidated soils that commonly experience enhanced ground motions. Evaluation of the seismic hazards and risks to the basin properties requires 3D numerical ground motion simulations to quantify the contributions of deep basin structure and shallow site conditions to ground motions. These simulations require 3D seismic velocity models. Here, we review these contributions as determined in a mature model of the Los Angeles, California, basin; introduce a new model of the Salt Lake City, Utah, basin; and report on preliminary ground motion simulations in the Salt Lake model.

Both models consist of detailed, rule-based representations of the major populated sediment-filled basins, embedded in a 3D crust over a variable depth Moho, over upper mantle velocities. The basins are parameterized as a set of objects and rules implemented in a computer code that generates seismic velocities and density at any desired point. The shallow basin velocities are directly constrained by geotechnical borehole logs and detailed surface site response unit mapping based on surface geology and Vs30 measurements.

Based on simulations of a suite of earthquakes in the Los Angeles basin model, Day et al. (2008) model the effect of sedimentary basin depth on long period (2 to 10 s) response spectra. They determine the basin amplification factor as a function of depth to Vs=1.5 km/s (a measure of basin depth), and find period-dependent amplifications of $\sim$1.5 to 8 relative to a 1D hard rock reference structure. Recent simulations (Rotan et al., 2009) of a M7 earthquake on the Wasatch fault zone in the Salt Lake basin model show a similar strong effect of basin structure on strong ground motions.

These results indicate that the strong influences of basin structures on earthquake ground motions must be accounted for to achieve rational seismic hazard and risk assessments.