1 Abstract

Blind thrust faults and well-mapped faults such as the San Andreas, form a major risk for earthquakes in Southern California. Studies done by Shaw et al. (1996) & Weldon et al. (2005) point to the high hazard associated with the San Andreas fault, especially for tall buildings which are more sensitive to long period motions. Considered to be the most ductile of structural systems, in recent earthquakes, significant number of moment frame buildings had fracture in beam-to-column connections. Motivated by the large number of existing buildings of this type in the Los Angeles basin & the hazard posed by the San Andreas fault, we are conducting a suite of simulations to quantify the risk to these buildings from San Andreas earthquakes over the next 30 years. The procedure outlined by Krishnan et al. (2006) is being followed.

i. Large number of stochastic source models are being generated for earthquakes in the magnitude range of 6.0 - 8.0. Unilateral rupture propagation (with rupture directivity from North - South & South - North) considered.

ii. Using SPECFEM3D, synthetic seismograms are generated at various sites across SoCal.

iii. FRAME3D models of two steel moment frame buildings in the 20-story class and one steel building in the 40-story class (dual lateral force-resisting system of braced frame core with perimeter moment frame) will be analyzed under the synthetic 3-component waveforms.

iv. Probabilistic economic losses will be computed at each location under each scenario. Finally, annualized probabilistic economic losses will be compared at each location under each scenario. Finally, annualized economic losses will be computed by assigning probabilities of occurrence of each scenario over the next 30 years using the Uniform California Earthquake Rupture Forecast (UCERF 3.0).

2 Stochastic Slip Modeling

a. Slip generation for magnitude (Mw) 6.0-7.0 earthquakes

i. Given Mw to be simulated, rupture area(A) is determined by Hanks & Bakun relation.

ii. Rupture length L is determined assuming seismogenic depth d to be 20km (constraint: minimum aspect ratio - length to depth of 1:1 is maintained).

iii. Fault area is discretized in 0.5 km x 0.5 km patches to capture 2 sec, wave period.

iv. Log-normal distribution used to characterize slip.

v. Mean and standard deviation are calculated using seismic moment vs. mean displacement relation and past earthquake data.

vi. Asperity studies by Somerville et al.(1999) are incorporated.

b. Slip generation for magnitude (Mw) 7.0-8.0 earthquakes

i. Fault is segmented stochastically. The slip generation methodology for Mw 6.0-7.0 earthquakes is used to generate slip in each segment.

ii. Normal distribution (mean and standard deviation from studies by Klinger 2009) is used to determine segment length Ls, which is constrained to stay within one standard deviation of the mean.

iii. Segment mean slip is constrained to be greater than 10% of the standard deviation of all segment mean slips (to avoid negligible segment mean slip).

3 Rupture Velocity

Whether rupture propagates at sub-Rayleigh or super-shear speeds depends upon the initial stress distribution on the fault.

![Rupture Velocity Diagram](image)

Here the stresses on the fault are inferred from World stress maps. Two propagation scenarios are considered.

i. Rupture ramps up to sub-Rayleigh speed of 0.87Cs and propagates at that speed for the remaining rupture length.

ii. Rupture ramps up to sub-Rayleigh speed and then transitions to the super-shear speed of 1.67Cs for the remaining rupture length.

4 Source-Time Functions

Traditionally kinematic source-inversions represented source-time functions using triangular or modified sinusoidal curves. Given that these are empirical, we have chose to use source-time functions measured in laboratory earthquakes. However such data is limited to narrow range of sub-Rayleigh & super-shear speeds.

![Source-Time Function Diagram](image)

5 Ground Motion Simulations

3-component ground motion wave forms are computed at 450 analysis sites spread across SoCal on a uniform grid of 7km x 7km using SPECFEM3D.

![Ground Motion Simulations Diagram](image)

6 Future Work

The ground motions generated will be used for conducting non-linear dynamic analysis of FRAME3D models for two steel moment frame buildings (20-story class) and one dual system building (40 story class) at each of the 450 sites across SoCal, the results of which will be used in probabilistic economic loss quantification.

7 References


8 Acknowledgement

The authors acknowledge the funding provided by the National Science Foundation (NSF Award No. 0820909). We also acknowledge the support of the Gordon and Betty Moore Foundation for their support on this project.