

**Progress Report**  
**Probabilistic Seismic Hazard Analysis of Southern California**

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The Phase III report makes important contributions to the practice of seismic hazard analysis in southern California. The Phase III working group, based on the review of the regional earthquake ground motion and site conditions data, has developed a regional site condition map and the related site response amplification factors for seismic hazard analysis. It is the objective of this study to investigate the effects of this new information on the probabilistic seismic hazard analysis (PSHA) of southern California. During the course of this study, we have conducted a number of PSHA scenario studies at various sites to test and compare different findings on attenuation equations and site conditions. Following is the result of one set of investigation. The final results of all studies will be published in Phase III report.

The Phase III report defines three site categories, Quaternary (Q), Tertiary (T), and Mesozoic (M), for characterizing site conditions for the PSHA. Each site category is identified by a shear wave velocity for its top 30-m materials. The report provides site response amplification factors for these three site categories as a function of frequency and peak ground acceleration. Specific amplification factors, for long period motions, are also introduced to account for the basin-effects on earthquake ground motions.

In this study, we use the CDMG/USGS fault database for southern California, as is reported on the USGS web-site, for the analysis. The model and the PSHA programs are validated by reproducing hazard curves from the CDMG report and the PGA hazard map for the entire region of southern California as is published on the USGS web-site.

Three attenuation equations, as recommended by the working group, are used for the analysis. These equations are published by Geomatrix, Joyner/Boore/Fumal (JBF), and Abrahamson/Silva. The SCEC's site amplification factors are reported as correction factors for the Geomatrix rock-site attenuation equation to account for different site conditions. Here, we refer to the modified Geomatrix attenuation equation, based on the SCEC's site amplification values,

as Y1 and Y2 equations. The Y2 equation reflects the basin-effects on ground motions and is defined only at 3.0 s period.

Sites along three cross sections crossing major faults in southern California are selected for the PSHA. For ground motions calculations, the Q- and T-sites are characterized as soil-site conditions and the M-sites are characterized as rock-site condition. For the JBF attenuation equation, the site amplification factors are calculated based on the average 30-m shear wave velocities of different site categories. We use spectral acceleration values with 10% probability of exceedance in 50 years to compare and evaluate the results of the PSHA based on different attenuation equations and site condition information.

The site amplification factors for all site categories and for ground motions with PGA values less than 0.2 g are amplitude dependent. In southern California, the majority of sites, specially those used in this study, are close to major active faults. The hazard calculation of these sites, for the defined probability of exceedance in this study, are dominated by earthquakes with PGA values higher than 0.2 g at the sites. Consequently, the hazard calculations are dominated and can be interpreted by the amplitude independent site amplification factors corresponding to those of  $PGA > 0.2$  g.

The results of the analysis are presented by a number of hazard plots over different cross sections. This provides direct comparison between the results of the PSHA based on different attenuation equations and site condition information. Following is a brief summary of the results. In this summary, most of the comparisons are made between the PSHA results based on Y1/Y2 and Geomatrix attenuation equations. The reason is that Y1 and Y2 equations are developed based on the Geomatrix rock-site equation. Comparisons of the results of the PSHA based on Y1/Y2 and Geomatrix rock/soil-site attenuation equations provide the most direct assessment of how SCEC's site categories and amplification factors affect the state-of-the-practice of the PSHA.

### ***Sites with M site conditions***

The Y1 equation calculates slightly higher SA values than the Geomatrix rock-site equation at 0.1 s period. The equation, however, calculates lower SA values than the Geomatrix equation at longer periods. The JBF attenuation equation

calculates noticeably lower SA values than all other equations at 0.1 and 0.3 s periods. However, at 1.0 s period the JBF equation gives similar SA values as other equations.

### ***Sites with T site conditions***

The largest differences between the Y1- and Geomatrix PSHA results are observed for 0.3 s spectral values for this site condition category. The Y1 equation calculates about 30% higher SA values than the Geomatrix soil-site equation. At 1.0 s period, the SA values from these two equations are fairly close. At 3.0 s period, the Y1 equation calculates lower SA values than the Geomatrix soil-site equation. Including the basin effects for the sites within the basin, i.e. using the Y2 attenuation equation, the SA values from Y2 and Geomatrix PSHA become rather close.

### ***Sites with Q site conditions***

At 0.1 and 0.3 s periods, Y1 and Geomatrix soil-site equations give rather similar hazard values at most sites. At 1.0 and 3.0 s periods, Y1 equation gives about 25% lower hazard values than the Geomatrix soil-site equation. Including the basin effects for the sites within the basin, i.e. using Y2 attenuation equation, the hazard values at 3.0 s period become rather close to the corresponding Geomatrix hazard-values. However, the basin effects in the Y2 equation is depth dependent and at some locations Y2 equation calculates higher, up to 50% higher, SA values than the Geomatrix soil-site equation. This is an important consideration for the design of large scale structures such as water tanks.

Abrahamson/Silva attenuation equation calculates higher ground motion values at sites over the hanging walls of the thrust/reverse faults. The results of this study indicate that the hanging-wall effects at sites close to reverse/thrust faults are significant. The hanging-wall effects are in the same order of magnitude and in cases higher than the site condition effects on the PSHA.