

## Geotechnical Earthquake Engineering

### Assignment #3 – Predicting Rock Ground Motions (GMPE/Attenuation Relationships)

Your answers to these questions should be reported in a memorandum format (i.e. a short, typed report detailing your answers as clearly and concisely as possible). Use text to state assumptions and answer questions where appropriate. However, the information will most effectively be conveyed by citing tables and figures placed within the text. A plethora of useful information (journal articles for select attenuation relationships, the Virginia Tech GMPE report by Russell Green with associated Matlab scripts and Excel files, NGA West, East, and subduction spreadsheets, etc.) for this assignment may be found on blackboard:

#### Background Information for Questions 1 and 2

Southern California was strongly shaken by the Northridge earthquake ( $M_w = 6.7$ ) on January 17, 1994. The fault rupture was primarily dip-slip, along a previously unknown thrust fault. The surface projection of the approximate fault rupture plane, is shown in Figure 1. Additionally, this figure shows the locations of strong motion stations in the Los Angeles metropolitan area (listed in Table 1). Answer Questions 1 and 2 below.

1. Predict the maximum horizontal ground acceleration (geometric mean of the horizontal components) at the strong motion stations listed in Table 1 and indicated in Figure 1 (all are rock sites). Use the Abrahamson and Silva (1997), Idriss (2008), and Boore et al. (1997) attenuation relationships. Only calculate the median ground motions (i.e., do not consider the standard error terms at this time). How well do the predictions compare with the ground motions recorded at these sites during the 1994 Northridge earthquake? Which predictions were good or bad and what might be the cause for the observed results?

Recorded PGA for each station is provided in Table 1 along with the closest distance to the fault rupture plane distance. You will need to estimate the Joyner-Boore distance for use in the Boore, Joyner and Fumal 1997 relationship.

Please express your results in a table which includes all strong motion stations and values for rupture distance, Joyner-Boore distance, recorded PGAs, and predicted PGA from each relationship. Also, include a plot of distance versus predicted/measured PGA for comparison along with other comparison plots, errors, etc which may be useful to explain the results.

2. For the Pacoima Dam and Mt. Wilson stations, use the Abrahamson and Silva (1997), the Abrahamson and Silva (2008), and NGA\_West 2 (set weights equal for all methods) attenuation relationships to predict the full acceleration response spectrum at these rock sites. Assume the following for Abrahamson and Silva (2008) and NGA\_West 2:  $V_{s30} = 760 \text{ m/s}$ ,  $W = 20 \text{ km}$ ,  $Z_{tor} = 5 \text{ km}$ , dip angle ( $\delta$ ) = 40 deg.,  $Z_{1.0} = 34 \text{ m}$  and rake angle ( $\lambda$ ) = 100 degrees (from Wald et al., BSSA Vol. 86). All other values can be obtained from the information provided in this assignment, the journal article, or use default values. The actual response spectra obtained from the recorded ground motions for these two sites are presented in Figure 2. How do the measured response spectra compare with those predicted from the three GMPE approaches? Comment on similarities and discrepancies. What are possible causes for any discrepancies? Please provide a summary table of input values.

Note: I have prepared an Excel file titled “RS\_PacD&MtWil.xls” that contains the response spectra obtained from the recorded ground motions at the Pacoima Dam and Mt. Wilson stations.

It may be found in the folder noted above. You may use this information, for comparison purposes, to plot the measured and predicted RS at each site in the same figure. Use a semi-log plot format.

**Table 1**

Record	Distance (km)*	PGA1 (g)	PGA2 (g)
Pacoima Dam Downstream	9.3	0.434	0.415
Topanga	23.6	0.266	0.364
Lake Hughes #4	32.3	0.084	0.057
Lake Hughes #9	28.4	0.217	0.165
Mt. Wilson	36.9	0.234	0.134
Rolling Hills Estates	46.6	0.116	0.106
Rancho Palos Verdes	55.2	0.072	0.054
Burbank	20.0	0.163	0.120

\*Closest distance to the fault rupture plane.

#### Background Information for Question 3

The next generation attenuation (NGA) relationships documented in the February 2008 edition of *Earthquake Spectra* (Vol. 24) are for shallow crustal earthquakes in active tectonic regions (i.e., tectonic environments similar to California). The NGA East attenuation relationships used in central and eastern North America (i.e., intraplate earthquakes or stable tectonic regions) are for stable tectonic regions. However, there is more uncertainty regarding ground motion predictions in these areas due to the shortage of recorded data from significant earthquakes in the central and eastern U.S. It is interesting to compare the ground motions predicted in the western U.S. versus ground motions predicted in the central U.S. Answer Question 3 below.

- For a  $M_w = 8.0$  earthquake on the San Andreas fault (strike-slip), use the NGA\_West 2 GMPEs to predict the acceleration response spectra for two rock sites: one located 10 km from the fault and one located 100 km from the fault. Assume default values for all unknowns. For a  $M_w = 8.0$  earthquake in the New Madrid Seismic Zone, use the NGA\_East Spreadsheet to predict the acceleration response spectra for two rock sites: one located 10 km from the fault and one located 100 km from the fault. Compare and contrast the response spectra for the sites located 10 km away from the San Andreas and New Madrid faults, respectively (i.e., plot them together). Compare and contrast the response spectra for the sites located 100 km away from the San Andreas and New Madrid faults, respectively (i.e., plot them together).

Note: The predictions you just made are for “rock” ground motions and do not reflect the amplification/deamplification of ground motions caused by the overlying soil, which can be significantly thick in the Mississippi Embayment of the New Madrid Seismic Zone. We will address soil considerations next.

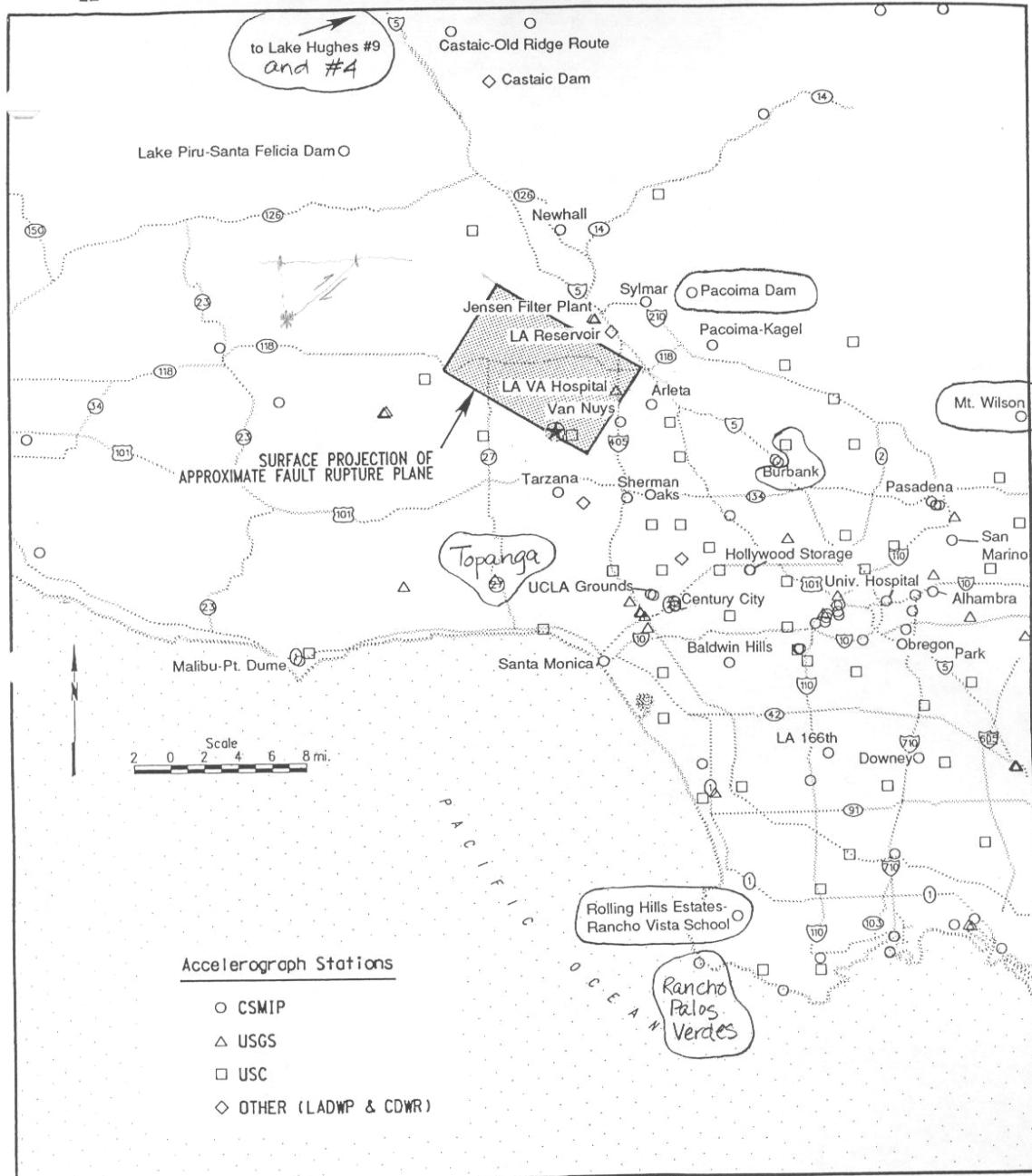


Fig. 1: Approximate locations of selected strong motion stations

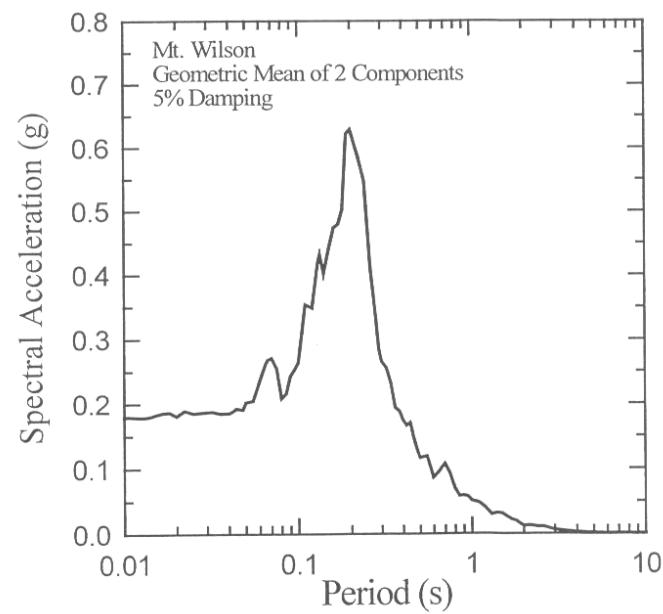
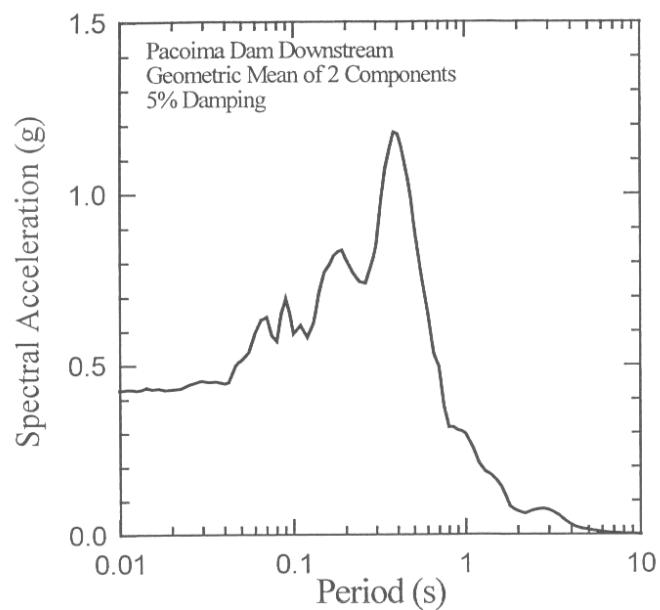


Figure 2