Available online at www.sciencedirect.com
SCIENCE DIRECT
Engineering Geology 79 (2005) 288–290
ENGINEERING GEOLOGY
www.elsevier.com/locate/enggeo

Discussion

Discussion of "An attenuation relationship based on Turkish strong motion data and iso-acceleration map of Turkey" by Ulusay et al., Eng. Geol., 74: 265–291 (2004)

E. Kalkan[a,*], P. Gülkan[b]

[a]Department of Civil and Environmental Engineering, University of California at Davis, Davis, CA 95616, United States
[b]Department of Civil Engineering, Middle East Technical University, Ankara 06531, Turkey

Received 21 September 2004; accepted 28 January 2005
Available online 10 March 2005

Keywords: Attenuation; Ground motion; Response spectrum; Turkey earthquakes; Uncertainty

Accumulation of strong motion recordings following the 1999 earthquakes in Turkey has facilitated studies towards developing vernacular site–distance–magnitude dependent spectral shapes and ground motion prediction relationships for Turkey. The paper by Ulusay et al. (2004) produced a PGA attenuation equation based on 221 records from 122 events that occurred in Turkey between 1976 and 2003. Because of our own work in this regard (Gülkan and Kalkan, 2002; Kalkan and Gülkan, 2004), we believe the evolution of ground motion predictions for the same or similar regions is of interest.

In our earlier study (Gülkan and Kalkan, 2002), we utilized data from 47 stations that recorded 93 horizontal components during 19 distinct events to generate ground motion prediction expressions for Turkey. Recently, this study has been updated by considering 57 distinct earthquakes that occurred during 1976–2003 with 112 records and 223 horizontal acceleration time series (Kalkan and Gülkan, 2004). Predicted spectral coordinates for 46 spectral periods were also included in Gülkan and Kalkan (2002) and Kalkan and Gülkan (2004).

Ground motion estimation in Turkey is affected in general by two major limitations. The first is the absence of precise knowledge on the site classification of stations. The other is the contamination of much of the data due to the interference of buildings where the sensors are located. Besides the inevitable uncertainties that has been driven by these factors into ground motion predictions, site observations reported by Bakir et al. and Safak et al. state that aftershock recordings from the two major 1999 events in Turkey were affected by highly nonlinear soil behavior in the epicentral region due to the strong shaking (Bakir et al., 2002; Safak et al., 2000). Such phenomena may have produced additional epistemic uncertainties in aftershock records classified under the same geological descriptor. It should be noted that probabilistic

* Corresponding author. Tel.: +1 530 754 4958; fax: +1 530 752 7872.
E-mail address: ekalkan@ucdavis.edu (E. Kalkan).

0013-7952/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.enggeo.2005.01.010

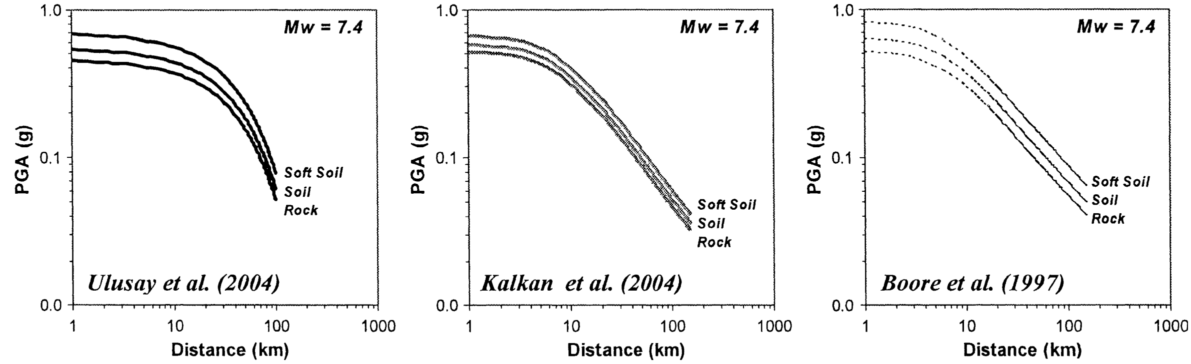

Fig. 1. Comparisons of PGA attenuation relations for Mw 7.4 earthquake at rock, soil and soft soil sites.

seismic hazard analysis (PSHA) is intended to evaluate the hazard from discrete independent releases of seismic energy (Kramer, 1996). Therefore aftershock records were intentionally excluded in Gülkan and Kalkan (2002) and Kalkan and Gülkan (2004), while in Ulusay et al. (2004) majority of the records (numbered 121–189 in Table 1 of Ulusay et al., 2004) were from Kocaeli and Duzce aftershocks. Another difference between two studies is the exclusion of data with respect to closest distance. Our data was first

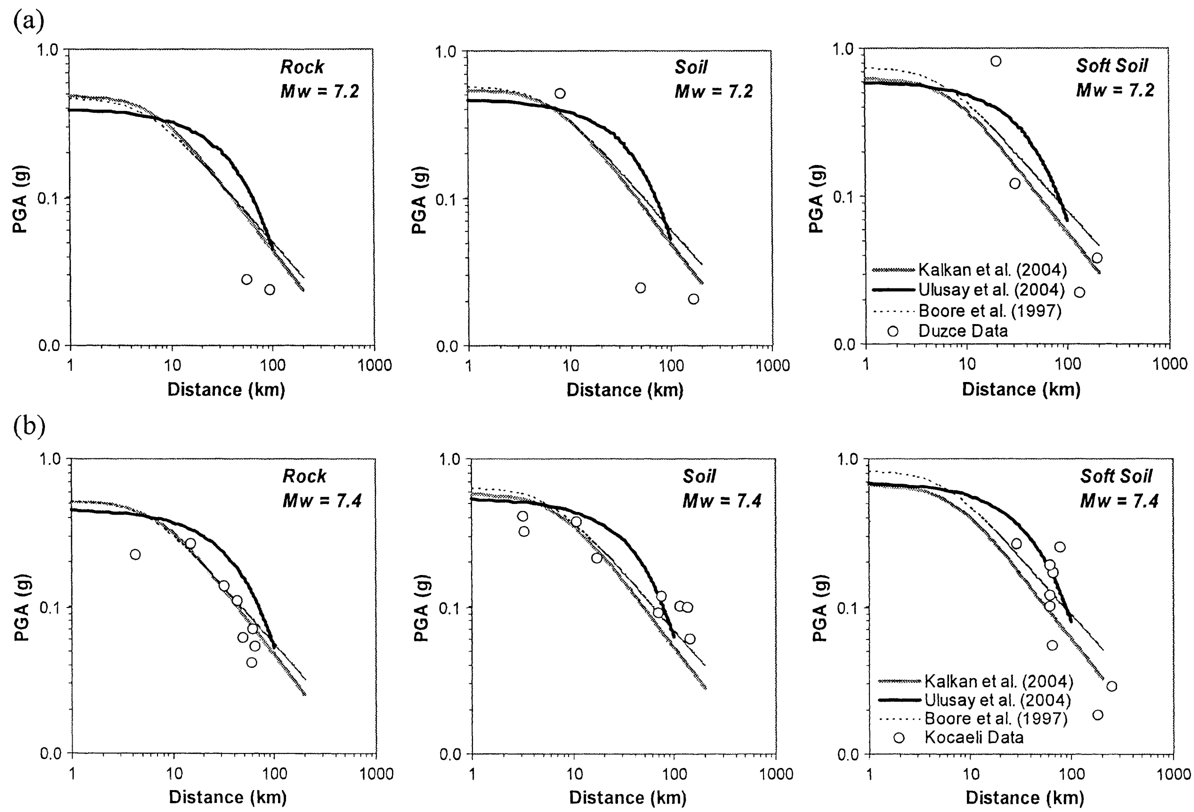

Fig. 2. Comparisons of PGA attenuation relations with recorded data from 1999 (a) Mw 7.2 Duzce and (b) Mw 7.4 Kocaeli earthquakes at rock, soil and soft soil site conditions.

limited to 100 km as in Ulusay et al. (2004), while in Kalkan and Gülkan (2004) farther distant records (up to 250 km) were also accounted.

The more quantitative comparison is next presented for the prediction of PGA values given by Ulusay et al. (2004) and Kalkan and Gülkan (2004) in Fig. 1 for Mw 7.4 in rock, soil and soft soil sites. Also shown in this figure are the predictions by Boore et al. (1997). Ulusay et al. (2004) and Boore et al. (1997) show more soft soil to rock and soil to rock amplifications compared to our study (Kalkan and Gülkan, 2004). In Fig. 2 ground motions predictions are compared with recorded data of Mw 7.4 Kocaeli and Mw 7.2 Duzce events (based on our database in Kalkan and Gülkan, 2004). In a general sense, our predictions seem consistently to fall below Boore et al. (1997). While this study (Ulusay et al., 2004) overestimates both predictions in Kalkan and Gülkan (2004) and Boore et al. (1997) in the distance range from 10 to 100 km, it underestimates them at distances less than 10 km. When compared to recorded data, there is a good correlation between three attenuation relationships despite the significant dispersion for some data points.

We would appreciate knowing the error terms associated with the predicted PGA in Ulusay et al. (2004). A better match with recorded data is a good sign, but whether the data is for median or some other fractile is an item that must be known by future users. We think that the iso-acceleration map derived from the ground motion prediction requires some form of probabilistic qualification because the likelihood of these values occurring is a direct design input for engineering use. A final comment is in regard to the earthquake zones map of Turkey in current use (Gülkan et al., 1993). This map makes absolutely no quantitative predictions as to what the PGA at a given point in the country will be at a given return period. The calculations were made on the basis of differentiating between zones for building design. Many people have had the incorrect impression that the basic design coefficient A_o in the code (Ministry of Public Works and Settlement of Turkey, 1998) and the PGA we calculated were one and the same. They were not. We determined the map on the basis of a then-available prediction equation.

References

Bakir, S., Sucuoglu, H., Yilmaz, T., 2002. An overview of local site effects and the associated building damage in Adapazari during the 17 August 1999 Izmit earthquake. Bulletin of the Seismological Society of America 92 (1), 509–526.

Boore, D.M., Joyner, W.B., Fumal, T.E., 1997. Equations for estimating horizontal response spectra and peak acceleration from Western North American earthquakes: a summary of recent work. Seismological Research Letters 68 (1), 128–153.

Gülkan, P., Kalkan, E., 2002. Attenuation modeling of recent earthquakes in Turkey. Journal of Seismology 6 (3), 397–409.

Gülkan, P., Yücemen, M.S., Başöz, N., Koçyiğit, A., Doyuran, V., 1993. A map for seismic zones in turkey according to recent data. Middle East Technical University, Earthquake Engineering Research Center Report 93-01 (in Turkish).

Kalkan, E., Gülkan, P., 2004. Site-dependent spectra derived from ground motion records in Turkey. Earthquake Spectra 20 (4).

Kramer, S.L., 1996. Geotechnical Earthquake Engineering. Prentice Hall, p. 122.

Ministry of Public Works and Settlement of Turkey, 1998. Turkish Seismic Code.

Safak, E., Erdik, M., Beyen, K., Carver, D., Cranswick, E., Celebi, M., Durukal, E., Ellsworth, W., Holzer, T., Meremonte, M., Mueller, C., Ozel, O., Toprak, S., 2000. Kocaeli Turkey earthquake of August 17 1999: Reconnaissance report chapter 5—recorded mainshock and aftershock motions. Earthquake Spectra 16, 97–112.

Ulusay, R., Tuncay, E., Sonmez, H., Gokceoglu, C., 2004. An attenuation relationship based on Turkish strong motion data and iso-acceleration map of Turkey. Engineering Geology 74 (3–4), 265–291.