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PREDICTED GROUND MOTIONS FOR MAKRAN SUBDUCTION INTERFACE BASED ON A STOCHASTIC FINITE-FAULT MODEL

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Studies concerned with estimating earthquake hazard analysis require the prediction of strong ground motion. It is well known that some of the larger uncertainties in earthquake hazard analysis are caused by uncertainties in seismic wave attenuation. Predictive attenuation relationships have been developed for peak ground acceleration based on simulated records for Makran subduction interface. A suite of ground motions has been simulated for a range of magnitude and distances based on the stochastic finite fault ground-motion model (Motazedian and Atkinson, 2005). The theoretical attenuation relationship, which has been developed for the peak ground acceleration and spectral acceleration, is applicable to earthquakes of Mw 7.5 to 9 at a distance up to 200 km.

The stochastic finite-fault model was validated against some recorded events such as; 1985 M 8.0 Michoacan, Mexico, the 1985 M 8.0 Valpariso, Chile, and the 2003 M 8.1 Tokachi-Oki, Japan earthquakes (Yagi, 2004). These subduction zone megathrust earthquakes were recorded at several rock sites located near the fault rupture. The result was compared with global studies of subduction zone megathrust such as Cascadia Subduction Zone (Gregor et al., 2002; Atkinson and Macias, 2009).

For the Makran megathrust earthquakes, four different rupture geometries were used to model the M 7.5 to 9 events. The geometries only differ in their respective fault lengths. A fault dip of 8 to the north with a rupture width of 90 km was selected to represent average properties of the Makran subduction zone geometry. A regional crustal attenuation ($Q_s=63f^{0.98}$) and velocity model was used with the stochastic finite-fault model simulations. The parametric uncertainties associated with the variation in source, path, and site effects were included in the development of the ground motions. A functional form was fit to the ground-motion model simulations to develop region-specific attenuation relationships for the Makran megathrust rupture zone for both rock and soil site conditions.

The simulation results were fit to a functional form of

$$LnY= C_1+ C_2*M+ (C_3+C_4*M)*Ln[R+exp(C_5)] +C_6*(M-10)^3 \pm\sigma$$

where Y is the peak ground-motion parameter, R is closest distance to the rupture plane, and $C_1 - C_6$ are coefficients fit to the data for rock and soil site conditions.

The total uncertainty was based on a combination of the modeling and parametric uncertainties (sigmas). Uncertainty in stress drop causes uncertainty in simulated response spectra of about ±50%. Uncertainties in the attenuation model produce even larger uncertainties in response spectral amplitudes – a factor of about two at 100 km, becoming even larger at greater distances (Atkinson and Macias, 2009). It is thus important to establish the regional attenuation model for ground-motion simulations. It also suggests that combining data from regions with different attenuation characteristics – in particular Japan and Mexico – into a global "subduction zone database" for development of global empirical ground-motion prediction equations, may not be a sound practice.

Figure 1 is a plot of the PGA attenuation with rupture distance for soil-site conditions. Also shown are the Youngs et al. (1997, Cascadia megathrust) relationships for M 8.0 and 9.0 events. Both relationships predict similar PGA values at distance out to 100–150 km.

These newly developed attenuation relationships for Makran subduction zone megathrust earthquakes can be used in both the probabilistic and deterministic seismic-hazard studies for engineering design for the Oman Sea.

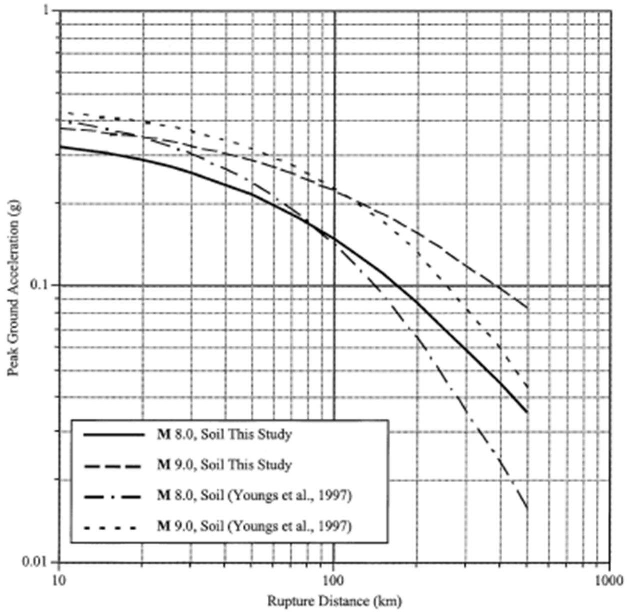

Figure 1. Comparison between Youngs et al. (1997) model and this model for peak horizontal acceleration for soil-site conditions for M 8.0 and 9.0.

REFERENCES

Atkinson, G.M., and Macias, M. (2009). Predicted ground motions for great interface earthquakes in the Cascadia subduction zone. *Bulletin of the Seismological Society of America*, *99*(3), 1552-1578.

Gregor, N.J., Silva, W.J., Wong, I.G., and Youngs, R. (2002). Ground-motion attenuation relationships for Cascadia subduction zone megathrust earthquakes based on a stochastic finite-fault modeling. *Bull. Seism. Soc. Am.*, *92*, 1923-1932.

Motazedian, D. and Atkinson, G. (2005). Stochastic finite-fault modeling based on a dynamic corner frequency. *Bull. Seism. Soc. Am.*, *95*, 995-1010.

Yagi, Y. (2004). Source rupture process of the 2003 Tokachi-oki earthquake determined by joint inversion of teleseismic body wave and strong ground motion data. *Earth Planets and Space*, *56*, 311-316.

Youngs, R.R., Chiou, S.J., Silva, W.J., and Humphrey, J.R. (1997). Strong ground motion attenuation relationships for subduction zone earthquakes. *Seism. Res. Lett.*, *68*, 58-73.