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Attenuation Relationships of Peak Ground Acceleration and Velocity for Crustal Earthquakes in Taiwan

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Abstract Strong seismic ground-motion data obtained by the Taiwan Strong Motion Instrumentation Program (TSMIP) and Central Mountain Strong Motion Array (CMSMA) are used to derive new attenuation relationships for the vertical and horizontal peak ground acceleration (PGA) and peak ground velocity (PGV) for crustal earthquakes in Taiwan. More than 7900 three-component accelerograms recorded from 51 crustal earthquakes in Taiwan, with M_w magnitudes ranging from 4.0 to 7.1, have been analyzed to study the dependence of peak ground motion parameters on magnitude, distance, regional and local site effects, through attenuation relationships.

We first found that, for both PGA and PGV, the attenuation relationships decay faster with distance for the vertical component than for the horizontal component. Also, the attenuation relationships decay faster with distance for the vertical PGA than for the vertical PGV. We further compared the attenuation relationships for three subregions (CHY, IWA, and NTO) and the whole Taiwan region (TWN). It is found that the CHY area has higher ground motion, either in PGA or PGV, than the other areas, especially at near-source distances. This is because the CHY area is located on a thick, recent alluvial plain. Comparison of our new attenuation relationships with strong-motion data from the 1999 Chi-Chi earthquake (M_w 7.7) and the 2003 Cheng-Kung earthquake (M_w 6.8) shows that the attenuation relationships developed for $M_w \leq 7$ can be extrapolated to make reasonable estimates of strong motion from larger $M_w \geq 7$ earthquakes. Finally, we analyzed the residuals to investigate variations of PGA and PGV with respect to site conditions. The results show that (1) the residual contour maps, especially for the PGV, have high consistency with the regional geology and topography of Taiwan. (2) The PGV residual contours reveal that Taipei Basin, Changhua Plain, Chianan Plain, Pingtung Valley, Ilan Plain, and Taitung Longitudinal Valley have high residual values. Note that most major metropolitan areas all fall in high residual areas. (3) The site classification based on geologic criteria by Lee *et al.* (2001) can be simplified into three classes, that is, class E for soft soils, a combination of classes C and D for dense and stiff soils, and class B for rocks. These three site classes are mostly distributed, respectively, in the alluvial plains at an elevation less than 50 m, in terraces and hills at an elevation less than 1000 m, and in high mountainous areas.

Introduction

Well-documented assessment of seismic hazards is a fundamental step in the process of earthquake disaster mitigation. Seismic hazard assessment requires ground-motion attenuation models. Estimates of expected ground motion at a given site from earthquakes of different magnitudes and distances are fundamental input to earthquake hazard assessment. These estimates are usually obtained from equations, called attenuation relationships, that express ground-motion parameter values as a function of magnitude and distance (and, in some cases, other variables, such as site condition and style of faulting).

Beginning in 1991, the Seismology Center of Central Weather Bureau (CWBSC) embarked on a six-year seismic strong-motion instrumentation program, known as the Taiwan Strong Motion Instrumentation Program (TSMIP) (Shin, 1993). The main goal of this program is to collect high-quality instrumental recordings of strong earthquake shaking. These data are crucial for improving the earthquake-