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Shallow Crustal Structure from Short-Period Rayleigh-Wave Dispersion Data in Southwestern Taiwan

by Jen-Kuang Chung and Yeong Tein Yeh

Abstract Strong ground motions in the period range of 1 to 5 sec observed in Taiwan in a dense network during the Tapu earthquake (M_L = 5.8) of 15 December 1993 were dominated by fundamental-mode Rayleigh waves. The shallow crustal structure beneath this network was determined from the group velocity dispersion data using standard inversion techniques. Results show that an alluvial layer with a thickness of only about 160 m exists over the sedimentary structure in the western coastal plain. A clear lateral variation in the shear-wave velocity along a cross section perpendicular to the western structural grain (Ho, 1982) was resolved.

For the purpose of retrieving the ground motions to confirm the proposed model, forward modeling with a two-dimensional finite-element method was used and agreed well with the observed seismograms when slightly lower velocities than those of the inversions were used. It is concluded that the velocity model estimated using group velocity data cannot definitively correspond to the real one at such short distances and in such a complex structure. On the basis of quantitative simulations, a very soft surface layer must be crucial in the interpretation of the slow wave trains with long duration and the rare prograde particle motions. The results suggest that these surface waves may be generated by the conversion of body waves at the boundary of the western coastal plain and foothills.

Introduction

Short-period surface waves are often used to infer the shear-wave velocity structure in the upper few kilometers of the crust. Many previous studies commonly used surface waves recorded from relatively shallow earthquakes (MacBeth and Burton, 1985; Niazi and Chun, 1989) and seismic explosions (Kafka and Reiter, 1987; MacBeth and Burton, 1986, 1988; Yao and Dorman, 1992). Nevertheless, some of these studies documented difficulties in extracting evident surface waves from the background noise in the period range of approximately 0.2 to 1 sec because only weak surface waves are excited by relative small sources.

Strong motions also include significant surface waves, especially in sediment-filled areas (Bard and Bouchon, 1980). Tanaka *et al.* (1980) showed that surface waves with a period of around 8 sec are predominant in seismograms recorded at a station in Tokyo on sediments during large earthquakes. Wang *et al.* (1989) analyzed well-developed wave trains across the strong-motion array in Taiwan (SMART-1) generated from two large earthquakes in the Hualien area of Taiwan and identified a group of weak dispersive fundamental-mode Rayleigh waves that they used to derive the subsurface velocity structure of the Ilan plain. Underlying most numerical and experimental studies, insight into underground structures down to the basement remains an important objective for seismic hazard reduction. With this purpose in mind, strong motion obtained from a dense network in southwestern Taiwan during the Tapu earthquake (M_L = 5.8) of 15 December 1993 was investigated. Distinct, well-dispersed later phases in the records were analyzed and interpreted as Rayleigh waves. The shear-wave velocity structure beneath this strong-motion network was derived by inversion, utilizing fundamental-mode group velocities in the period range of 1 to 5 sec.

Using the two-dimensional finite-element method, the forward modeling of the seismic waveforms was carried out to simulate the behavior of surface waves within sedimentary layers. The purpose was twofold: first, to understand the reasons by which these well-dispersed surface waves can generate in such a closed region, and second, to predict the strong ground motions during large earthquakes in the future.

Strong-Motion Records

For seismic hazard assessment and microzonation studies, the Taiwan Strong Motion Instrumentation Program (TSMIP) has been in operation since July 1991. The configuration of the very dense strong-motion network deployed