Near Real-Time Mapping of Peak Ground Acceleration and Peak Ground Velocity Following a Strong Earthquake

by Yih-Min Wu, Tzay-Chyn Shin, and Chien-Hsin Chang

Abstract During a disastrous earthquake, the early assessment and timely reporting of the peak ground acceleration (PGA) and peak ground velocity (PGV) maps will be crucial in an effective emergency response operation. In this study, we first derive an empirical relationship between M_L and M_W. The PGA and PGV attenuation relationships are deduced with data from the Taiwan Strong Motion Instrumentation Program (TSMIP) and the Taiwan Rapid Earthquake Information Release System (TREIRS). Site corrections of the attenuation relationships for shallow and large earthquakes in Taiwan region are also obtained. Peak values of earthquake strong ground motion can be well determined in Taiwan as soon as the earthquake location is determined, and magnitudes are calculated by the TREIRS. This peak ground motion value information can be immediately turned into the calculated PGA and PGV maps that can be issued within two minutes of the earthquake origin time. During any disastrous earthquake, these maps are found to be very useful for immediate seismic damage assessment and dispatching of emergency response missions.

Introduction

Real-time seismic monitoring, especially for strong earthquakes, is an important tool for seismic hazard mitigation (Kanamori *et al.,* 1997; Teng *et al.,* 1997). It provides valuable near–real-time information for rapid earthquake emergency response, thereby mitigating the loss. With the importance of rapid earthquake information for seismic hazard mitigation being recognized, efforts to design and implement systems to provide a broad range of rapid earthquake information have recently been expanded (Heaton, 1985; Nakamura, 1988, 1989; Espinosa-Aranda, *et al.,* 1995; Gee *et al.,* 1996; Wu *et al.,* 1997, 1998, 1999; Wald *et al.,* 1999a,b). During the 1999 Chi-Chi, Taiwan, earthquake a severe test was put on the Taiwan Rapid Earthquake Information Release System (TREIRS) system (Shin *et al.,* 2000; Wu *et al.,* 2000). For the purpose of briefness, we use the term *T system* to mean the TREIRS in this article. We also report our experience and thoughts in the development and application of the T system.

The most common information available immediately following a damaging earthquake is its magnitude and epicenter. However, the damage pattern is not a simple function of these two parameters alone. More detailed information is needed for emergency response agencies to assess the situation for better details and accuracy. For example, for the 20 September 1999 Chi-Chi, Taiwan, earthquake, the city of Tung-Shih Town is in the region with the worst damage, even though it is about 50 km from the epicenter (Fig. 1). Thus, it is highly desirable to map out distributions of peak ground acceleration (PGA) and peak ground velocity (PGV) in the potentially damaged area. In 1995, the Central Weather Bureau (CWB) developed the T system by a real-time strong-motion network for intensity observations, magnitude, and hypocenter determination routinely after felt earthquakes in the Taiwan region (Teng *et al.,* 1997; Wu *et al.,* 1997).

The T system consists of 75 telemetered strong-motion stations in Taiwan (Fig. 2). Three-component force-balanced accelerometer (FBA) digital signals are continuously telemetered to the headquarters of the CWB in Taipei via leased telephone lines. The FBA signal is digitized at 50 samples per sec at a 16-bit resolution. The full recording range is $\pm 2g$. The interstation spacing of the T system is about 30 km. This spacing is still too large for the damage assessment due to complex geology in Taiwan (Lee *et al.,* 2001). On the other hand, the Taiwan Strong Motion Instrumentation Program (TSMIP) was successfully implemented six years ago by the CWB, with about 650 modern digital accelerographs at free-field sites (Fig. 2). The TSMIP signals are digitized at 200 samples per sec or higher and at 16-bit or higher resolution. Most accelerometer sensor recording ranges are $\pm 2g$. The TSMIP interstation spacing is about 5 km in metropolitan areas. It offers much more detailed description of ground shaking for damage assessment. But they are not continuously telemetered. In this study we combine the data from the T system and the TSMIP network to determine the site corrections. Then, the database of TSMIP site corrections