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An examination of τ_c-*Pd* earthquake early warning method using a strong-motion building array

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ABSTRACT

The use of characteristic period τ_c and peak displacement amplitude *Pd* of the initial P wave in earthquake early warning (EEW) was proposed by Wu and Kanamori [1–4]. Here we apply this approach to strong-motion records from a building sensor array installed in Taitung County, Taiwan. This building was damaged during the 2006 M_w=6.1 Taitung earthquake with a peak ground velocity (PGV) of up to 38.4 cm/s at an epicentral distance of 14.5 km. According to our analysis, the peak displacement amplitude *Pd* is a better indicator for the destructiveness of an earthquake than τ_c because τ_c is more sensitive to the signal-to-noise ratio (SNR) than *Pd*. In accordance with previous studies, only the structurally damaging Taitung earthquake generated a *Pd* value larger than 0.5 cm (a threshold for identifying damaging events). Using *Pd* as an indicator for destructive earthquakes does not lead to missing or false alarms for EEW purposes.

1. Introduction

Taiwan is located on the western circum-Pacific seismic belt with a measured plate boundary convergence rate of about 8 cm/year [5] and has been repeatedly hit by damaging earthquakes [6]. Some of the disastrous events have inflicted severe casualties and great property losses. In all likelihood the damages caused by earthquakes will continue and even increase as the population and the economy grow. It is therefore crucial for Taiwan to seek means for alleviating the earthquake losses through scientific research. EEW system has become one of the most effective tools for real-time seismic hazard mitigation [7]. In a well-established EEW system, the characteristic period τ_c and the peak displacement amplitude *Pd* of the initial P wave are two important parameters, and they have been used to determine the magnitudes and the shaking intensity [1–4,8–11] of earthquakes. Furthermore, the parameter *Pd* can also be used for magnitude estimation for EEW purpose [12,13]. Frequent earthquakes and abundant high-quality near-field strong-motion records in Taiwan provide valuable data for examining the efficacy of the τ_c and *Pd* methods for practical earthquake early warning purpose.

In this study, we use the strong-motion records from a building sensor array in Taitung, Taiwan, to perform the EEW analysis. The strong-motion sensors were installed in 1996 in a building belonging to the fire bureau of Taitung County, Taiwan. The building was damaged during the 2006 M_w=6.1 Taitung earthquake [14]. Fig. 1 shows photographs of this building before and after that damaging event. Before the Taitung earthquake, this system had recorded a number of small to large earthquakes, including the 1999 M_w=7.6 Chi-Chi (epicentral distance=125.0 km and PGV=7.1 cm/s, [15]) and the 2003 M_w=6.8 Chengkung (epicentral distance=42.2 km and PGV=23.5 cm/s, [16]) earthquakes. However, those relatively large events had not caused damage to this building. The valuable records from those earthquakes provided by this sensor array offer an excellent opportunity for us to examine the use of τ_c and *Pd* measurements at a single site for onsite EEW purpose. Furthermore, different placements of sensors around the building allow us to study the impact of the locations of seismometers on the results in EEW analyses.

2. Data

The strong-motion records come from sensors distributed in the building with 4 floors above ground and one in the basement. Force balance acceleration (FBA) sensors were deployed at specific locations on each floor, and an additional one with three free-field channels was installed outside of the building. The network is comprised of a total of 22 channels with a central recording system on a personal computer. Among the channels 6 are vertical

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