Paper:

Earthquake Early Warning Technology Progress in Taiwan

Kuo-Liang Wen[*1,2,3], **Tzay-Chyn Shin**[*4], **Yih-Min Wu**[*5], **Nai-Chi Hsiao**[*4], **and Bing-Ru Wu**[*1]

[*1]National Science and Technology Center for Disaster Reduction, Taiwan
[*2]Institute of Geophysics, National Central University, Taiwan
[*3]National Center for Research on Earthquake Engineering, Taiwan
E-mail: wenkl@earth.ncu.edu.tw
[*4]Central Weather Bureau, Taiwan
[*5]Department of Geosciences, National Taiwan University, Taiwan
[Received April 16, 2009; accepted June 1, 2009]

The dense real-time earthquake monitoring network established in Taiwan is a strong base for the development of the earthquake early warning (EEW) system. In remarkable progress over the last decades, real-time earthquake warning messages are sent within 20 sec after an event using the regional EEW system with a virtual subnetwork approach. An onsite EEW approach using the first 3 sec of P waves has been developed and under online experimentation. Integrating regional and onsite systems may enable EEW messages to be issued within 10 sec after an event occurred in the near future. This study mainly discusses the methodology for determining the magnitude and ground motion of an event.

Keywords: earthquake, early warning, P wave, ground motion

1. Introduction

Geologically, Taiwan is located on the western circum-Pacific seismic belt which is one of the most active seismic regions in the world. In the last century, nearly a dozen destructive earthquakes have occurred in Taiwan, including the Meishan earthquake in 1906 ($M_L = 7.1$, 1,258 death), the Hisnchu-Taichung earthquake in 1935 ($M_L = 7.1$, 3,276 death), and the Chi-Chi earthquake in 1999 ($M_L = 7.3$, 2,455 death). Since the occurrence of earthquakes can not reliably predicted by current technology, progress is being made globally in the research and development of the earthquake early warning (EEW) system [1–5]. With advances in seismic instrumentation and communication networks, EEW is becoming a practical tool for reducing casualties and damage from major earthquakes [6–9]. Two major approaches are being applied in the EEW development:

1. Regional warning, or front detection, uses real-time earthquake monitoring networks to determine the earthquake location, magnitude, and ground-motion distribution and to send EEW messages to regions far from the epicenter.
2. Onsite warning uses onsite seismometers to detect P waves and estimate the earthquake magnitude and the strong onsite motion [10].

Regional warning provides more reliable EEW messages but requires longer processing time. Onsite warning complements regional warning to speed up EEW processing and to reduce blind zones where no onsite warnings are received. Both approaches have progressed markedly in Taiwan [11], but the EEW system is still undergoing online testing and has not been applied for disaster reduction practically.

2. Real-Time Strong-Motion Network in Taiwan

In the dense earthquake monitoring network of 688 free-field strong-motion stations constructed in the Taiwan Strong-Motion Instrumentation Program (TSMIP), currently 109 are telemetered for real-time monitoring as shown in **Fig. 1**.

A three-component force-balanced accelerometer with a 16-bit resolution and a full dynamic range of $\pm 2g$ was installed for each station. The real-time data are transmitted to Taipei headquarter via dedicated telephone lines in 50 Hz. This network serves as a base for developing the earthquake Rapid-Reporting System (RRS) and the EEW system [12–15]. The RRS, developed and operated by the Central Weather Bureau (CWB) since 1995, provides such useful information as earthquake location, magnitude, and ground-motion distribution one minute after an earthquake occurs. EEW provides warnings to distant urban areas from the epicenter with a few seconds to several dozen seconds of lead time before destructive S waves arrive. With a short lead time, automatic emergency measures should be preprogrammed and implemented to reduce the potential loss due to strong shaking.