NEW MAGNITUDE SCALING RELATION FOR EARLY WARNING IN TEHRAN

Mohammad SASANI
PhD Student, IIEES, Tehran, Iran
m.sasani@iiees.ac.ir

Mohammad Reza GHAYAMGHAMIAN
Associate Professor, IIEES, Tehran, Iran
mrgh@iiees.ac.ir

Anooshiravan ANSARI
Assistant Professor, IIEES, Tehran, Iran
a.ansari@iiees.ac.ir

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Concurrent with the development of urbanization, earthquake hazards pose serious threats to lives and property in urban areas. For seismic hazard mitigation, a practical earthquake forecast method appears to be far from realization, because of the extreme complexity involved in earthquake processes (e.g., Kanamori et al., 1997), but another approach to mitigate seismic hazards is the development of early warning systems (EWS) (Allen, 1978; Allen and Kanamori, 2003; Nakamura, 1988; Wu and Kanamori, 2005a). An EWS provides a few seconds to tens of seconds of warning time for impending ground motions, allowing for mitigation measures in the short term.

There are several methods to estimate the magnitude of an earthquake from the initial few seconds of the rupture. Nakamura (1988) first used the frequency content of the initial few seconds of P-wave arrivals. He suggested that larger events cause initial ground motion with longer periods than smaller events. Based on this outcome, the researchers used two important parameters to estimate magnitude of an earthquake in early stages of rupture. The first parameter is dominant ground motion period ($\tau_P^{\max}$) (Allen and Kanamori, 2003; Olson and Allen, 2005), and the second is average ground motion period (τ_c) (Kanamori, 2005; Wu and Kanamori, 2005a, 2005b). Recently, new methods such as artificial neural networks (Bose, 2006) and virtual seismologist (Cua, 2005; Yamada, 2007) have been also developed for such purpose.

In this study, we use the both $\tau_P^{\max}$ and τ_c methods to estimate the magnitude of earthquakes in Albors seismogenic zone of Iran. Due to the complicated tectonic nature of Iran, seismic activity is not uniform in the entire region. The highly seismogenic zones of Alborz and Kopet Dagh, extending along the northern borders of Iran and Afghanistan, constitute a part of the northern limit of the Alpine-Himalayan orogenic belt. These zones make contact with the stable Turan platform (Eurasia) to the north (Berberian, 1976a, 1976b). Because of including the Tehran city (capital of Iran) in the Alborz seismogenic zone, the earthquake recordings in this region are selected for the analysis here, and the above mentioned methods are applied. We used Road, Housing and Urban Development Research Center stations and analyzed 123 records from 1995 to 2011 with moment magnitude larger than 5. Then, $\tau_P^{\max}$ and τ_c have continuously calculated for each records. These parameters were determined for three time-windows of 2, 3 and 4 seconds after the time of P wave trigger. Next, these parameters are plotted against M_w on a log-linear scale and scaling relations have been developed among magnitude, $\tau_P^{\max}$ and τ_c . The $\tau_P^{\max}$ and τ_c observations from waveforms at individual stations exhibit large variability for a single earthquake, which probably can be attributed to the measurement error, site effects and path effects (Olson and Allen, 2005). Therefore, the mean of $\tau_P^{\max}$ and τ_c observations for each earthquake are used to estimate the scaling relationships.

Results show that we need at least 3 seconds duration after the P wave trigger to determine the $\tau_P^{\max}$ and τ_c . Meanwhile, this time can be decreased for smaller events (M_w around 5). Furthermore, we excluded some records from our analyzed data to examine the validity of the results. It is found that the derived scaling relations could estimate the earthquake magnitude well, and they can be reliably applied in early warning systems.

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