Rethinking Seismic Hazard Mitigation Research: Insights from the 1999 Chi-Chi to 2024 Hualien Earthquakes

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This presentation provides an overview of the evolution of seismic hazard mitigation strategies from the 1999 M_w7.6 Chi-Chi earthquake to the 2024 M_w7.5 Hualien earthquake. It includes probabilistic seismic hazard assessment (PSHA) and earthquake early warning (EEW) systems.

Before a devastating earthquake, a PSHA is crucial for quantifying the impact of potential seismic events. Prior to 1999, active faults and seismogenic structures in Taiwan were neither clearly identified nor well investigated. Consequently, most PSHA efforts relied on earthquake catalogs, which lacked information on long-term seismic activity. The 1999 Chi-Chi earthquake highlighted the importance of identifying seismogenic structures and active faults based on geomorphological observations. Subsequently, several seismogenic structures were identified, and their activities investigated using geological, geomorphological, and geodetic evidence. The Chi-Chi event resulted in the complete rupture of the Chelungpu fault. In contrast, the rupture behavior of the Hualien earthquake was relatively complex, complicating seismic hazard evaluations using simplistic models. One solution is to adopt the models, which accounts for the possibility of multiple-structure ruptures and can forecast larger seismic events than those typically characterized.

To mitigate seismic risk during the coseismic period, developing rapid reporting and earthquake early warning (EEW) systems is essential. Before 1999, the Central Weather Bureau (currently the Central Weather Administration, CWA) developed the Taiwan Rapid Earthquake Information Release System, which announced earthquake information approximately one minute after occurrence (Wu et al., 1997). This system was effective during the Chi-Chi event. Post-Chi-Chi, researchers in Taiwan have continued to develop EEW systems that provide warnings before strong ground shaking occurs (Wu and Teng, 2002). In recent years, a deep learning-based warning system has been developed. When retroactively applied to the 2024 Hualien earthquake, the system predicted an CWA intensity greater than 4 across most of central and northern Taiwan within 7 seconds of the first P-wave arrival at the initial station. This optimization enhances the effectiveness of Taiwan's earthquake early warning system by providing longer warning times and generating more accurate intensity maps.

Given Taiwan's frequent exposure to earthquake hazards, we have leveraged valuable experience and extensive databases to develop several research initiatives aimed at seismic hazard mitigation. The evolution of seismic hazard mitigation strategies in Taiwan, from the 1999 Chi-Chi earthquake to the 2024 Hualien earthquake, highlights significant advancements in both PSHA and EEW. These advancements collectively enhance the effectiveness of seismic risk mitigation and emphasize the importance of ongoing research and technological innovation in earthquake preparedness and response.

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