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Critical Advancements in Strong Ground Motion and Site Effect Studies 25 Years after the Chi-Chi Earthquake

Chun-Hsiang Kuo[1,2,3], Che-Min Lin[3], Shu-Hsien Chao[3], Jyun-Yan Huang[3], and Chun-Te Chen[4]

[1] Department of Earth Sciences, National Central University, Taiwan

[2] Earthquake-Disaster & Risk Evaluation and Management Center (E-DREaM), National Central University, Taiwan

[3] National Center for Research on Earthquake Engineering, Taiwan

[4] Disaster Prevention Technology Research Center, Sinotech Engineering Consultants (Inc.), Taiwan

Strong motions of the Chi-Chi earthquake and many other earthquakes have been recorded by the Taiwan Strong Motion Instrumentation Program (TSMIP) stations. The records are crucial for improvements in strong motion prediction, seismic hazard analysis, seismic design, and other engineering applications. This poster introduces critical advancements in strong ground motion and site effect studies after the 1999 Chi-Chi earthquake. Some of those advancements have been applied to mitigate seismic hazards in Taiwan. Three subjects are included in this poster: site effect, near-fault ground motion, and ground motion model (GMM). Site conditions of the free-field strong motion stations are essential for analyzing the records. Therefore, shallow shear-wave velocities (Vs) at those stations were investigated by borehole and PS-logging to obtain V_{S30} (Time-average Vs in the top 30 meters), a useful parameter in building code. Those results can be found on the Engineering Geological Database for TSMIP (EGDT) website (https://egdt.ncree.org.tw/). Detail site amplifications and V_S structures of plains and basins have been delineated by high-density measurements of microtremors. Figure 1(a) shows the predominant frequency map for plains and basins in Taiwan. Furthermore, a generic rock model representing engineering bedrock property for the whole of Taiwan has been proposed to understand regional differences in strong motions. The strong motion records of the Chi-Chi earthquake show very special behavior, especially those with short distances to the fault, as shown in Figure 1(b). Large amplitude and long-period velocity pulses are believed to cause significant seismic damage, especially for medium and high-rise buildings. Except for the Chi-Chi earthquake, several earthquakes with magnitudes of around six that occurred in Taiwan can generate strong motions with pulse-like velocities. Studies of those velocity pulses that occurred during recent earthquakes, such as the 2018 Mw 6.4 Hualien earthquake, 2022 Mw 6.6 Guanshan earthquake, and 2022 Mw 7.0 Chihshang earthquake, are introduced. The ground motion records with pulse-like velocities in Taiwan were analyzed. The data is available from the Database of Near-Fault Strong Motions with Pulse-like Velocity (NFPV) website (http://nfpv.ncree.org.tw/). The SSHAC (Senior Seismic Hazard Analysis Committee) Level 3 project was conducted in Taiwan (https://sshac.ncree.org.tw/index.htm), and advanced GMMs were therefore developed under this project. The NCREE19 GMM, a GMM developed using only Taiwan strong motion data, was further integrated with horizontal-to-vertical spectra ratio (HVSR) and spatial correlation, becoming a partial

non-ergodic GMM. The non-ergodic response spectra at two sites having similar V_{S30} can be very different even under the same scenario, as shown in Figure 1(c).

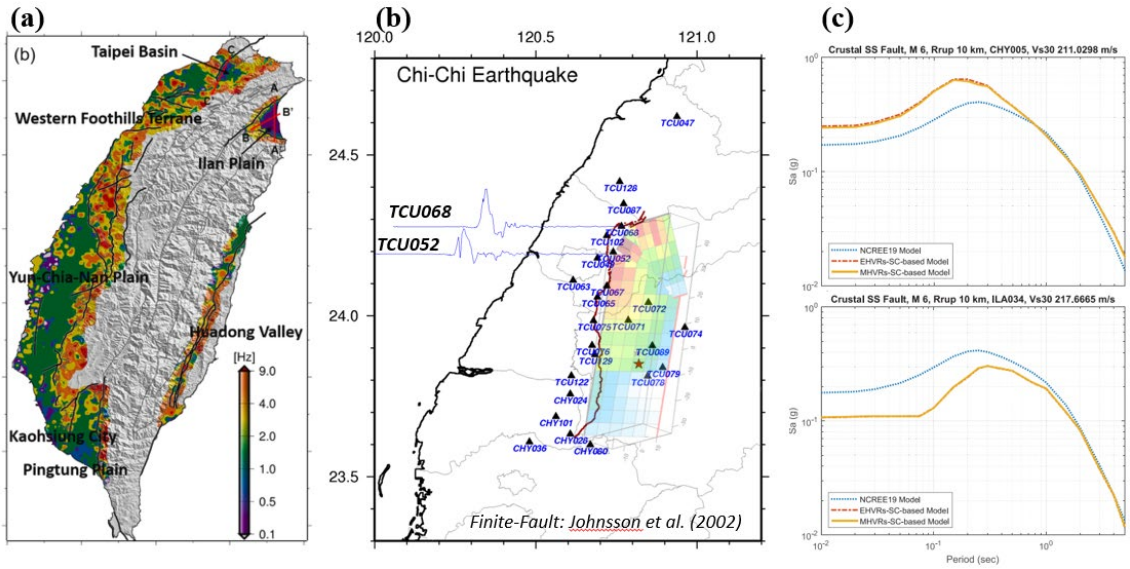

Figure 1. (a) Predominant frequency map for plain and basin areas derived by microtremor measurement in Taiwan. (b) Pulse-like velocities at TCU052 and TCU068 stations during the Chi-Chi earthquake. (c) Acceleration response spectra predicted by ergodic (blue) and partial non-ergodic (red and yellow) GMMs.

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