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Technical Breakthrough Abstract

The 2022 Chihshang, Taiwan, Earthquake: Initial GEER Team Observations

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We recently returned from a post-earthquake reconnaissance trip to Taiwan sponsored by the National Science Foundation–funded Geoengineering Extreme Events Reconnaissance (GEER) Association. We studied the effects of the September 18, 2022 M_W6.9 Chihshang, Taiwan earthquake. The earthquake occurred on the Central Range strike-slip fault, with the rupture direction extending north from the epicenter. Nearfield seismic stations measured peak ground accelerations (PGAs) exceeding 0.5 g along the fault. Peak ground velocities (PGVs) increased in the direction of the rupture with average intensities of 8 cm/s near the epicenter, increasing along the fault to 89 cm/s at the northern terminus. The ground motion recordings of the east (approximately fault parallel) component indicated strong velocity pulses in the direction of the rupture (Fig. 1).

We found eight damaged bridges within 2 km of the fault, all with multiple spans of simply supported concrete deck girders founded on concrete piers: two bridges had multispan and foundation pier collapses, three bridges were closed for repair, and the remaining bridges were operational with reductions in service. Six bridges, including the two collapses, had longitudinal orientations perpendicular to the fault. All but one bridge spanned an ~800-m-wide braided river channel, with foundation elements supported by alluvial soils.

We initially assumed that earthquake-induced liquefaction caused the collapses; however, we did not find any surface manifestations—an observation echoed by our Taiwanese colleagues who were in the field immediately after the earthquake. The bridges also did not have major construction defects or signs of deterioration, suggesting that the seismic forces from the pulselike ground motion and fling effects may have been the primary cause of damage to the bridges. To lend further credence to our interpretation, the bridges at the northern end of the fault sustained more damage; the pulselike ground motions in this area were stronger.

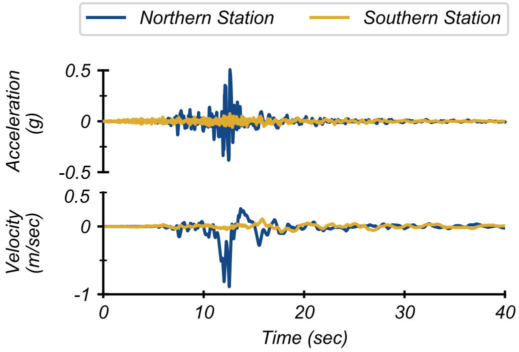

Fig. 1. (Color) Acceleration and velocity-time series located at northern (Station EYUL) and southern (Station TTN045) ends of the Central Range fault.

Implications

We saw bridge damage potentially caused by large-velocity pulses and differential displacements of the abutments caused by fling. The observed damage has important implications for design and retrofit of bridges in seismically active areas. For example, we should reexamine current seismic design guidelines and start considering earthquake motions rotated in bridge normal and bridge parallel directions.

Our team also is assessing why the alluvial sediments at the damaged bridge sites did not liquefy. Our current hypothesis is that the duration of strong shaking was not long enough to cause sufficient pore-water pressure buildup. We performed passive horizontal-to-vertical spectral ratio (HVSR) testing at the collapsed bridges to determine the underlying ground conditions. Our analyses will use the data from HVSR testing, ground motions records, supplemental data provided by our Taiwanese colleagues, and liquefaction analysis procedures for ground motions with pulselike directivity effects (e.g., Green et al. 2008). The findings have implications for liquefaction analysis procedures performed at sites susceptible to ground motion directivity effects.

Acknowledgments

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References

Green, R. A., J. Lee, T. M. White, and J. W. Baker. 2008. "The significance of near-fault effects on liquefaction." In *Proc., 14th World Conf. Earthquake Engineering*. Tokyo: International Association for Earthquake Engineering.

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