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Numerical Simulation of Interaction between Active Thrust Fault and Bridge. -Two Cases Study in Taiwan-

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Taiwan is located in the active orogenic belt where large earthquakes and active faulting occurred frequently and causes disasters. The Chi-Chi Earthquake and active faulting of Chelungpu Fault in 1999 caused heavy losses in middle Taiwan. There were seven bridges straddled the Chelungpu Fault collapsed or damaged. This shows that active faulting possess very threatening potential to the structural safety of the cross-fault bridges.

The Pi-Feng highway bridge and Dajia railway bridge on the Dajia River were located across active thrust faults of Chelungpu Fault and Sanyi Fault, respectively. The alignment of Pi-Feng highway bridge was crossed by Che-Lung-Pu fault with intersection at an angle of 48 degrees. Chi-Chi Earthquake caused a uplift of ground level for approximate 3 meters at upstream of the left bank of the bridge, and the fracture line (plane) of fault trace along North by East 48° passed through piers of P11 and P12, resulting the serious collapse of the superstructure and the flexural shear failure on the P11 caisson foundation which lead to toppling over of partial caisson foundations and the entire pier studs. The other Dajia railway bridge was crossed by Sanyi Fault with intersection at an angle of 45 degrees, Sanyi Fault was found to cut across the gravel of lower river terrace and the overburden soil layer on the river bank. According field investigation, we suspected that two faults may slip simultaneously during the Chi-Chi Earthquake and resulting in different degrees of damage to the bridges.

In order to understand the interaction behavior between the active thrust faulting and the bridge, the software PFC3D (Particle Flow Code) of the discrete element method was used to process numerical simulation for the above two cases in this study. The result reveals that there will be a trishear zone within the overburden soil as bedrock fault slipping, and create ground level difference due to permanent deformation across the fault trace on ground surface. The interaction of active thrust faults and bridges, such as deformation and displacement of bridge deck, inclination of piers, and collapse, occurred when the bridges located within the trishear zone of the overburden soil. The piers and piles themselves are also subjected to considerable stress concentration and damaged. And through the analysis of three different superstructure systems, it reveals that bridge with continuous multi-span and non-fixed-joint pier studs has better performance than that of fixed-joint continuous beams and simple beams when bridge straddle active thrust fault.