DYNAMIC SIMULATION OF THE 1999 CHI-CHI EARTHQUAKE USING THE DEM

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Surface rupture of the September 20, 1999 Chi-Chi (Taiwan) earthquake (Ms= 7.6) was observed along about 80 km. Vertical displacements between 1.0 and 4.0m, as well as horizontal displacements of up to 9.0m, were registered along the fault trace. Although the largest displacements occurred at the northern part of the trace, structural damage was heavier in the southern part than in the former. In order to get better understanding of the complex damage distribution caused by this earthquake, the rupture process was numerically simulated. Since the faulting process appears to have been nearly pure thrust along the various fault segments, a 2D Discrete Element Model (DEM) was employed to perform a dynamic simulation of the rupture process of the fault and the near-fault ground motion.

The September 20, 1999 Chi-Chi (Taiwan) earthquake (Ms= 7.6) was originated on a low-angle reverse fault. Surface rupture was observed along about 80 km, starting at the southern end and extending northwards. Vertical displacements between 1.0 and 4.0m, as well as horizontal displacements of up to 9.0m, were registered along the fault trace. Although the largest displacements occurred at the northern part of the trace, structural damage was heavier in the southern part than in the former. In order to get better understanding of the complex damage distribution caused by this earthquake, the rupture process was numerically simulated. Since the faulting process appears to have been nearly pure thrust along the various fault segments, a 2D Discrete Element Model (DEM) was employed to perform a dynamic simulation of the rupture process of the thrust fault and the near-fault ground motion.

On account of the differences in the observed features of the rupture process in the northern and southern parts of the fault, each part was modeled independently. Both models share the following common assumptions: The dip of the fault is 33o; there is a surface sedimentary layer with a depth of 4km characterized by a set of P wave velocity (4.3 km/sec), S wave velocity (2.5 Km/sec) and density 2500 kg/m3. The basement (seismogenic zone) is a homogeneous medium with P wave velocity (6.1 km/sec), S wave velocity (3.5 Km/sec) and density 2700 kg/m3; the stress drop along the fault plane in the shallow surface layer is negligible; the ultimate stress, i.e. the strength excess on the fault surface in the shallow surface layer increases linearly with depth as a function of the normal stress; the slip-wakening friction model is adopted as the constitutive relation for the fault; the critical slip along the fault is larger near the surface than at greater depths. For the southern part, the existence of three asperities with relatively small widths (about 7 km) and stress drop between 1.5 MPa to 3Mpa was admitted in the basement underlying the sediments, and the critical slip 0.5m (surface layer) and 0.1m (deepest part). The northern part, on the other hand, is assumed to have just one asperity with larger width (15km) and higher stress-drop (between 1.5 MPa to 8MPa), the critical slip is 2.5m (surface layer) and 2.0m (deepest part.

The results show that the velocity ground motions in the northern part (hanging wall) in the frequency range of 0.5Hz-2Hz (natural frequency range of standard structures) are small near the surface break, thus, light structural damage might be predicted near the surface rupture. The model of the southern part presents smaller displacement than the model at the northern part. Even such difference between the northern and southern part, the ground motion in the southern part in the frequency range of 0.5Hz-2Hz is larger than in the northern. Moreover, the fault rupture propagation reaches to surface with a very slow velocity (about 1.2km/sec) in the northern part; however, in the southern part reaches the surface with higher velocity (about 3.0km/sec). These differences between both models could explain what happened during the 1999 Chi-Chi earthquake where the ground motion near the surface rupture on the northern part caused less damage in structures than the ground motion in the southern part. The results obtained by the simulation agree with the observed strong motion. The dynamic model presented herein gives a preliminary interpretation of such complex damage distribution during the earthquake and a better understanding of the complex pattern of the rupture process

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