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Analysis of the Rupture Process of the 1999 Kocaeli (Turkey) Earthquake Using Dynamic Modeling

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The shear rupture process of the 1999 Kocaely (Turkey earthquake) was studied from the results of dynamic modeling. The3D staggered-grid Finite-Difference Method (FDM) was used for the numerical simulation of the rupture process and wave propagation. The dynamic parameters (dynamic stress drop, strength excess and critical slip Dc) needed for dynamic simulation were estimated from the result of kinematic wave form inversion. The kinematic source model of Sekiguchi and Iwata (2002) was used. The final slip of the dynamic model was constrained with the kinematic results. First we solved the elastodynamic equation of the continuous medium assuming the slip distribution obtained by kinematic fault model as a boundary condition along the fault. The result of this calculation is the shear stress function distribution in space and time. From this function we can estimate approximately the dynamic stress drop and the strength excess (relative fault strength). The dynamic stress drop used for the dynamic simulation is adjusted in order to constraint the final slip of kinematic model. The Dc was estimated assuming that the first time peak slip-velocity of kinematic model corresponds to the time of the slip-weakening distance. This assumption provided apropiate values for dynamic rupture simulation (Dc=0.2 to 2.2m). Our final dynamic model approximately matched the final slip distribution determined by the kinematic inversion.

The main results of our paper are as follow: At the east (Izmit Bay) and west (Sapanca Lake) part of the fault, the highest values of strength excess (around 12MPa) and dynamic stress drop (around 30Mpa) were found. Suggesting barriers that were broken during the earthquake (asperities zone). At the central band of the fault, from the hypocenter to the east-forward direction the relative strength values have very low values, (about 0.2 to 1.0 MPa) suggesting weakness zone and probably broken region before the earthquake. This weakness zone has not enough resistant to slip. During the dynamic rupture propagation, this zone started to slip before the S wave arriving, so with super-shear rupture velocity. The existence of super-shear rupture velocity during this earthquake has been observed from the analysis of the recordings (e.g. Ellsworth and Celebi, 1999). The near source ground motion simulated by our dynamic model provides a satisfactory fitting with the strong motion data.