Analytical solution of near-field term, intermediate term, far-filed term, and quasi-static displacement due to rectangular fault in a homogeneous whole space

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Sato (1975, JPE) derived analytical solution on seismic wavefield excited by rectangular fault in whole space, but this solution was not separated into near-field term, intermediate term, far-field term (“separated analytical solution”). The separated analytical solution has not been derived and theoretical analysis on near-field terms (near-field term + intermediate term) has not been performed. The effect of near-field terms or quasi-static deformation nearest fault could be observed at the 2016 Kumamoto earthquake. Here we derived separated analytical solution and investigated the contribution of near-field terms nearest fault with a variety of slip angles. In addition, we derived quasi-static displacements solution in two cases. One of cases is pure quasi-static displacement, the other is quasi-static displacement with S-wave travel time (quasi-static S). Using these analytical solutions, we compared near-field terms with quasi-static displacements.

We consider the fault model which is same as Sato (1975). Rupture front looks like line, whose rupture velocities along strike and dip are constant. Slip time function is ramp function, whose risetime is constant. Here we integrated over strike direction displacement field by point source, near-field term, intermediate term, far-filed term, and quasi-static displacements (e.g. Aki & Richards, 2002).

Fig.1 shows an example of fault model. Numerical calculation setting is P-wave velocity:6.0 km/s, S-wave velocity:3.5 km/s, Length of fault:60 km, Width of fault:15 km, slip amount:2.0m, risetime:2.5 s, slip angle:0°(strike-slip fault), rupture velocity:2.5 km/s. We consider two cases about the direction of rupture as examples. One of cases (a) is that rupture propagates forward to strike-direction, the other (b) is that rupture propagates upward obliquely. Calculation results are doubled due to the effect of free surface.

Fig.2 shows displacement, near-filed terms, far-field terms and quasi-static displacement in case (a). In case (a), at stations in direction of rupture far-field terms mainly contributes to ground motion in FN component. This shows forward directivity. Near-field terms are not influenced by forward directivity. In case (b), the contribution of far-field terms is nearly equal to that of near-field terms because that of far-field terms becomes smaller than case (a). Quasi-static displacement is different from Near-field terms. In FP component, near-field terms mainly contribute to ground motion in both (a) and (b). Quasi-static displacement is similar to near-field terms compared with FN component and behaviors like ground motion because far-field terms little contributes to ground motion.

Keywords: near-field term, quasi-static displacement, forward directivity, analytical solution, rectangular fault

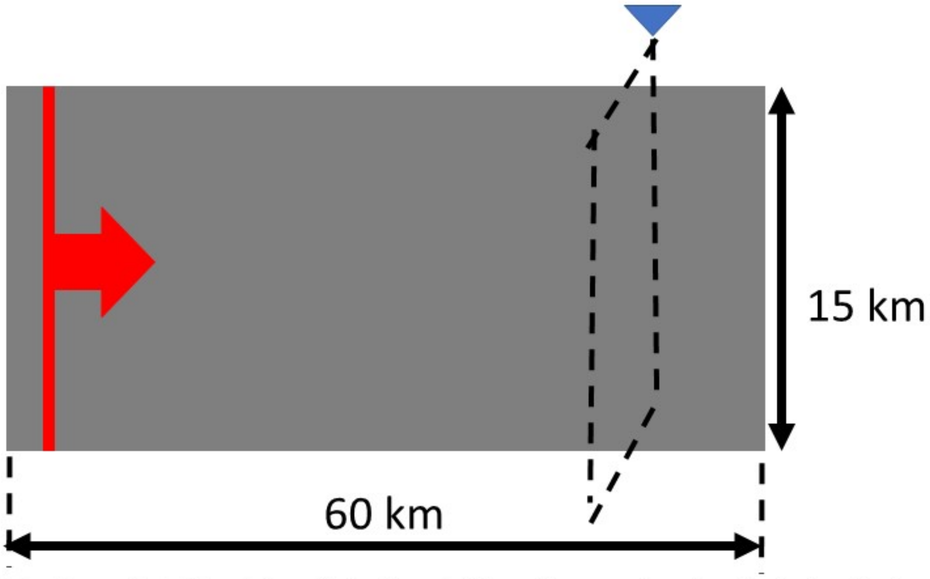

Fig.1 Fault model. Blue triangle is the station. Gray region is whole fault plane. Red line and Vector is rupture front and the direction of rupture.

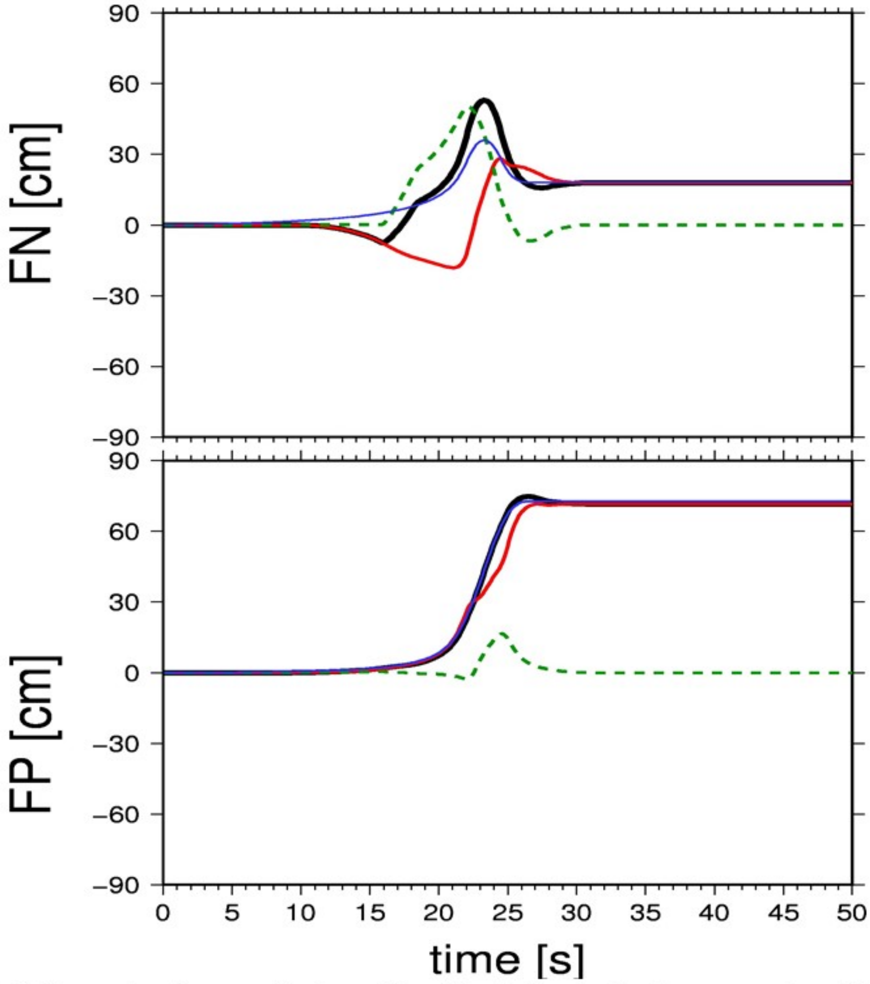

Fig.2 Example of numerical results. . Black line indicates ground motion. Red and green dashed line show near-field terms and far-field terms. Blue line denotes quasi-static deformation.