Simulation of Earthquake Faulting Process and Strong Ground Motion

Takashi MIYATAKE[(1)]

(1) Earthquake Research Institute, University of Tokyo, Yayoi, 1-1-1, Bunkyo, Tokyo, 113-0032, Japan (e-mail:miyatake@eri.u-tokyo.ac.jp; phone +81-3-5841-5696; fax: +81-3-5841-5693).

Abstract

Using dyanamic model of source process, two kinds of simulation are carried out, ie.(1) simulation of source process in order to estimate dynamic parameters of the faulting process, and (2) simulation of strong ground motion generated from physically reasonable source model.

Introduction

In the present paper, I disucss the following two topics.
(1) Strong ground motion simulation using dynamic modeling.
After the 1995 Kobe earthquake, the near fault strong ground motions are payed attension and the prediction of strong motion generated from potential earthuqake are taken an interest for preventing the earthquake disaster. The near-fault ground motion is sensitive for faulting process, so resonable source model are required for simulation. Dynamic model is physicaly reasonable model for simulation of near-source ground motion. Using the model, the relationship between the strong ground motion and source process are investigated.
(2) Estimation of dynamic faulting parameters.
Waveform inversion techniques reveal the faulting process of earthquakes which are on the basis of kinematic modeling of source process. The kinematic faulting parameters, such as slip, rise time, rupture velocity (rupture time) are estimated for many earthquakes. Recently, more physical, or dynamic parameters, (stress drop, frictional parameters) are trying to be estimated. This process requires the dynamic modeling of source process. Quin [1], Miyatake[2,3], Mikumo and Miyatake[4,5], Olsen, et al[6] have been reconstructed the dynamic faulting processes. In the present paper, the rupture process of the 1999 Kocaeli, Turkey, earthquake are shown.

Strong Ground Motion Simulation

Relationship between Faulting Process and Strong Ground Motion

The relationship between faulting process and spatial pattern of strong ground motion generated from strike slip fault was studied by Inoue and Miyatake[7]. The same for dip slip fault are shown in the present paper. Fig.1 shows the spatial pattern of vertical component of ground velocity waveforms. Although the directivity effect is surely appeared for dip fault event, it is weaker than that from strike slip fault.

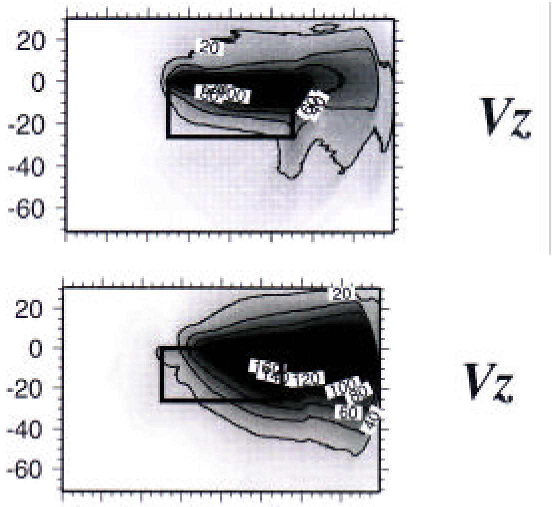

Fig.1 : Peak Ground Velocity for the dip slip fault. The upper shows the case for rake andgle of 90degree and the lower for rake angle of 0degree. The square indicates the fault. The rupture starts from a point on the left margin of the fault and propagates to the right.

Effect of Surface Layers and Surface Break

Sometimes, the fault slip appeared on the ground for earthquake of Magnitude more than 6.5. It is well known that ground motion are very sencitive for surface layer. It amplified the ground motion. On the other hand, the stress drop on the fault in sedimental layer would be low considering low rigidity, and it would desrease the peak amplitude of seismic wave. So these effects are studied.

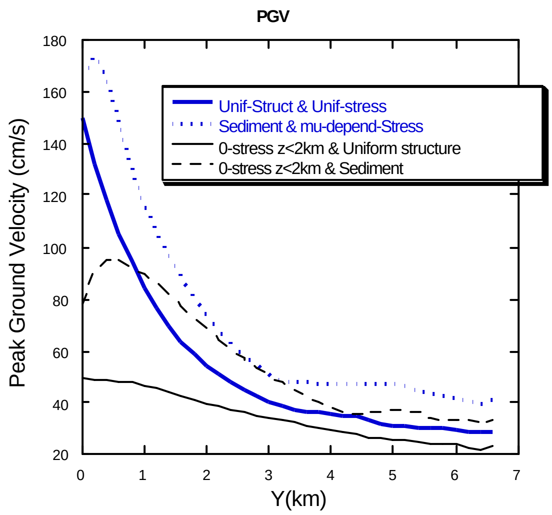

Fig.2 Peak Ground Velocity vs distance from the fault.

Estimation of Dynamic Parameters and Strong Ground Motion Simulation

Dynamic rupture processes were reconstructed with constraint of the kinematic parameters inferred by waveform inversion. One of the example is the 1999, Kocaeli, Turkey earthquake which provided nearfield seismic data, especialy, seismic waveforms very close to the fault. I reconstructed the dynamic rupture process of the 1999, Kocaeli, Turkey earthquake with constraint of the kinematic parameters inverted by Yagi and Kikuchi (1999). Yagi and Kikuchi revised and published the inversion model in GRL,2000. I reexamined the earthquake. The method used here are mainly based on Miyatake(1992) except that the slip-weakening frictional law is assumed. Firstly, the (final or static) stress drop distribution are estimated as an initial model using the kinematic slip distribution estimated by Yagi and Kikuchi [8].Okada's code was employed in the computation. The static stress drop distribution estimated . Second step is the rupture propagation using dynamic crack with assumed rupture time distribution on the fault estimated in Yagi and Kikuchi[8]. The peak stress just before the rupture are also estimated and is considered to be strength excess distribution. Third step is spontaneous rupture propagation on the condition of the above strength excess and stress drop distribution. The ground motion near the fault are also computed. The distributions are adjusted in order to fit (1) the slip distribution (2) the rupture time distribution and (3) ground velocity waveform at several stations.

Fig.3 shows the strength excess distribution and stress drop distribution. Fig. 4 shows the dynamic model rupture process.

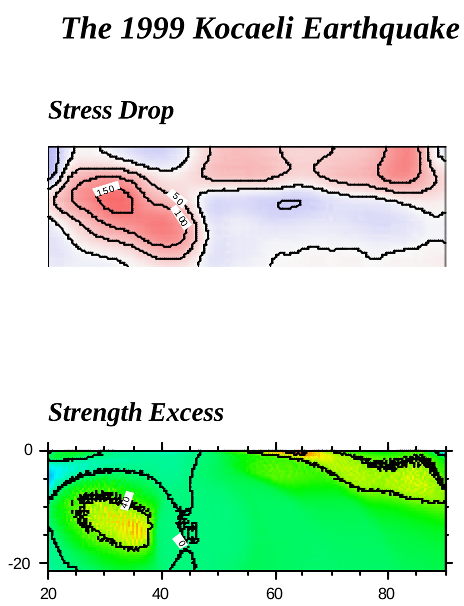

Fig.3 The strength excess distribution and the stress drop distribution.

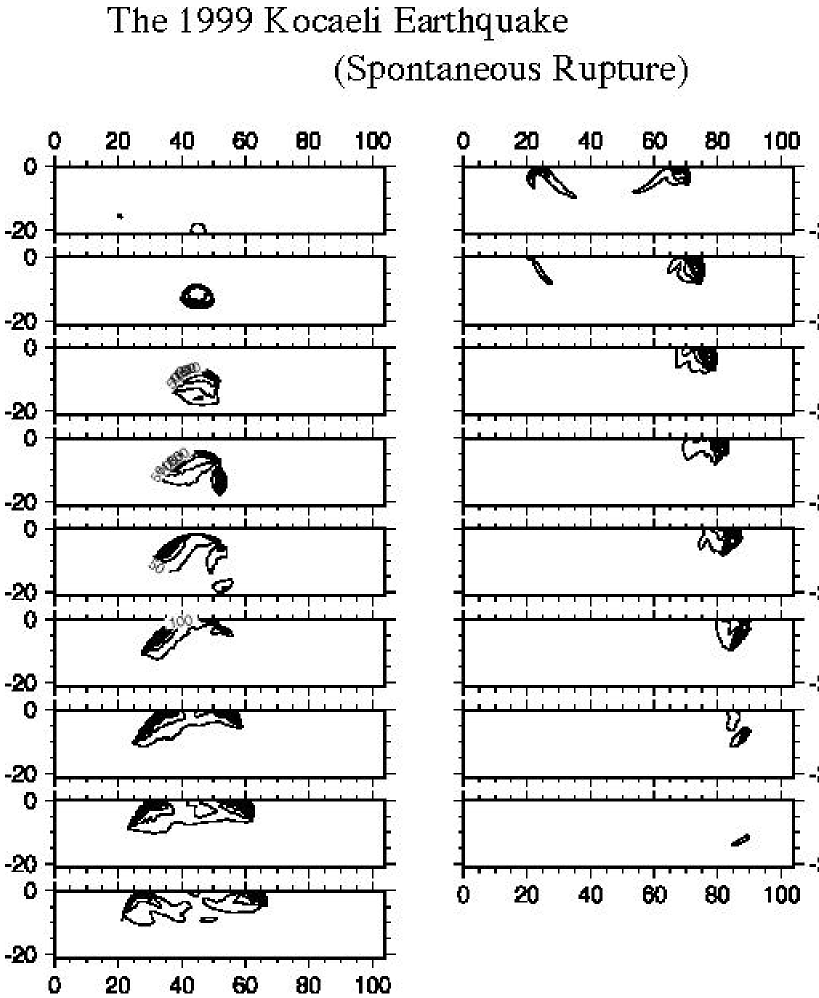

Fig.4 Snapshots of slip-rate on the fault.

References

[1] Quin, H, 1990, Dynamic stress drop and rupture dynamics of the October 15, 1979, Imperial Valley, California, earthquake, Tectonophysics 175, 93-117.

[2] Miyatake, T. (1992a), Dynamic rupture processes of inland earthquakes in Japan --Weak and Strong asperities, Geophys. Res. Lett., 19,1041-1044.

[3] Miyatake, T., (1992b), Reconstruction of dynamic rupture process of an earthquake with constraints of kinematic parameters, Geophys. Rese .Lett, 19, 349-352.

[4] Mikumo, T., and T. Miyatake (1993), Dynamic rupture processes on a dipping fault, and estimates of stress drop and strength excess from the results of waveform inversion, Geophys. J. Int., 112,481-496.

[5] Mikumo, T., and T. Miyatake (1995), Heterogeneous distribution of dynamic stress drop and relative fault strength recovered from the results of waveform inversion: the 1984 Morgan Hill California earthquake, Bull. Seism. Soc. Amer. 85, 178-193.

[6] Olsen, K., Madariaga, R., and Archuleta, R., 1997, Three dimensional dynamic simulation of the 1992 Landers earthquake, Science 278, 834-838.

[7] Inoue, T., and T. Miyatake, 1998, 3-D simulation of near-field strong ground motion:Bull. Seism. Soc. Amer., 88, 1445-1456.
[8] Yagi, and M. Kikuchi, 2000, ,Source rupture process of the Kocaeli, Turkey, earthquake of August 17, 1999, obtained by joint inversion of near-field data and teleseismic data, Geiphys. Res. Lett. in press.