Source model composed of asperities for the 2004 Mid Niigata Prefecture, Japan, earthquake ($\mathbf{M_{JMA}}$=6.8) by the forward modeling using the empirical Green's function method

K. Kamae[1], T. Ikeda[2], and S. Miwa[2]

[1]*Research Reactor Institute, Kyoto University, Osaka 590-0494, Japan*
[2]*Technical Research Institute, Tobishima Corp., Chiba 270-0222, Japan*

(Received February 12, 2005; Revised April 28, 2005; Accepted May 2, 2005)

A preliminary source model composed of asperities for the 2004 Mid Niigata Prefecture, Japan, earthquake (M_{JMA}=6.8) was estimated by the empirical Green's function method. The source parameters for two asperities located on the fault plane were determined from the comparisons of the synthesized broad-band ground motions with the observed ones at several stations including near source. Furthermore, we performed the preliminary nonlinear analysis of the sedimentary soils to reproduce the observed ground motions at NIG019 of K-NET. Resultantly, we pointed out the need of more asperity in northern part on the fault plane and the importance of the quantitative analysis of the nonlinearity of the sedimentary soils at K-NET stations.

Key words: Source model, asperity, forward modeling, empirical Green's function method, nonlinear analysis.

1. Introduction

On 23th October 2004, the Mid Niigata Prefecture, Japan, earthquake (M_{JMA}=6.8) struck the Chuetsu district in Niigata Prefecture, and caused the heavy damages since the 1995 Hyogo-ken Nanbu earthquake. In this earthquake, destructive strong ground motions showing the instrumental seismic intensity 7 by the Japan Meteorological Agency (JMA), which is the maximum seismic intensity in Japan, have been recorded at strong-motion observation stations in the near-source area. The understanding of the source characteristics for explaining such broad-band strong ground motion recordings is very important for the strong ground motion prediction to mitigate seismic disasters from future large earthquakes. This paper provides a preliminary source model for the 2004 Mid Niigata Prefecture earthquake estimated by the empirical Green's function method (Irikura, 1986). The advantage of this method is that it includes the propagation path and local site effects and estimates basically broad-band ground motions as long as the aftershock recordings are accurate enough in broad-frequency band. Furthermore, this method is convenient and robust in case of having many aftershock recordings as the empirical Green's functions and having difficulty in calculating the theoretical Green's functions because of complicated underground structure around the corresponding region. In our simulation, we determine a source model composed of asperities which is capable of reproducing broad-band strong ground motions using a forward modeling approach. We assume that ground motions are generated from two asperities, each of which has a uniform stress drop with a finite extent on the fault plane and obeys an ω^{-2} spectral scaling. Their locations are basically determined referring to the inverted slip models, e.g., by Honda *et al*. (2005). This procedure is the same as Kamae and Irikura (1998) and Kamae and Kawabe (2004).

2. Strong Ground Motion Data

We used broad-band acceleration data at five stations (NIG017, NIG019, NIG020, NIG021, NIG022) by K-NET of the National Research Institute for Earth Science and Disaster Prevention. The locations of these stations are shown in Fig. 1 together with the epicenters and the focal mechanisms of the mainshock and the aftershocks used here as the empirical Green's functions. Table 1 and Table 2 show the information of the mainshock and the aftershocks, respectively. We used Aftershock-1 for synthesizing the ground motion from Asp-1 at NIG017, NIG019, NIG021, NIG022, and for Asp-2 at NIG017, Aftershock-2 for Asp-2 at NIG019, NIG021, NIG022, Aftershock-3 for Asp-1 and Asp-2 at NIG020. We selected the aftershocks as the empirical Green's functions from these locations and the existence of recordings. The source parameters (fault area and stress drop) of the aftershocks were estimated roughly from the displacement source spectra calculated by the borehole data of KiK-net which are not affected strongly by the reflected wave from the surface. We used the aftershock data bandpass-filtered (0.3–10.0 Hz at NIG017, 0.5–10.0 Hz at NIG019 and NIG020, 0.2–10.0 Hz at NIG021 and NIG022) depending on the quality of each aftershock waveform data.

3. Source Model and Synthetics

Several inverted source models have already been estimated from teleseismic data or/and strong ground motion data (e.g. Honda *et al*., 2005; Hikima and Koketsu,