経験的グリーン関数法における3次元速度構造での波線集中の影響に関する検討 ー2007年新潟県中越沖地震の場合ー

3-D effects of space-time ray concentration on the EGF simulation results: Case of the 2007 Chuetsu-oki earthquake

Petukhin Anatoly[1]; 川辺 秀憲 [2]; 宮腰 研 [1]; 岡崎 敦 [3]; 入倉 孝次郎 [4]
Anatoly Petukhin[1]; Hidenori Kawabe[2]; Ken Miyakoshi[1]; Atsushi Okazaki[3]; Kojiro Irikura[4]

[1] 地盤研究財団; [2] 京大・原子炉; [3] 関西電力; [4] 愛工大
[1] G.R.I.; [2] KURRI; [3] Kepco,Inc.; [4] Aichi Inst. Tech.

On July 16, 2007, Off Mid-Niigata earthquake (Mw6.6) stroke the Kashiwazaki-Karima nuclear power plant. Amplitudes of ground motions at the KK1 site for example, exceeded designed amplitudes 2.5 times. Three large pulses are observed clearly on the velocity and displacement seismic records. They are interpreted as the asperity pulses. Different source models and site effects were debated to explain unusually large amplitudes of these pulses. Among them are rupture plane location, asperity moment, rupture directivity effect, site ground conditions. In this study we try to find another explanation by evaluating 3-D velocity model effects like ray focusing effect and arrival time concentration effect. For this we used seismic ray theory and the EGF waveform simulation method.

3-D velocity model for Mid-Niigata area is developed by JNES. To develop model appropriate for the ray theory study we modified JNES velocity model using results of the seismic exploration (reflection) around the Kashiwazaki-Karima nuclear power plant. JNES model is constructed for the finite-difference simulations and for this reason has several constant velocity layers similar to the geological structure in the studied area. Actually, velocity inside a geological layer increases with depth due to the soil compaction for example. In order to model this effect, uppermost layers of the JNES model are further subdivided into three layers. Deep layers are remaining " constant velocity ". In order to make realistic velocity model and to avoid shadow zone effect of model basement, for this study we developed gradient velocity model from the modified JNES model.

We employed asperity source model of Kamae, 2008, calculations are made for the most debated Asperity 3 only and for the KK1 and KK5 sites. Ray amplitude for the 3rd pulse is larger at the KK1 site, which is in a good agreement with observation. This is due to the 3-D geometrical spreading effects in Vs=1.16 and Vs=0.8km/s layers: focusing on the concave shallow interfaces of under KK1 site and defocusing on the convex interfaces under KK5 site. In comparison with simulation results by the routine " constant Vs " EGF method, our 3-D method gives larger amplitudes of the 3rd pulse due to a time concentration effect of rupture starting from a point near surface in low-velocity layers and propagating downward into high-velocity layers. Considering of both these effects let us to assume a realistically smaller stress drop than in Kamae, 2008, model.

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