Numerical simulation of strong motion around Adapazari basin during the 1999 Kocaeli, Turkey Earthquake

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The Kocaeli Earthquake of August 17, 1999 (Mw 7.4) brought destructive damage to Adapazari, Turkey. The most severely damaged area was the downtown of Adapazari located 8-10 km away from the fault. We proposed the subsurface structure model of the basin, and simulated the strong ground motions during the main shock using 3D finite-difference methods.

The 3-dimensional shape of the bedrock around this area has been reported (Komazawa et al. 2002). We, however, did not know the detailed velocity structures. The seismic refraction and reflection survey were carried out to determine the velocity structures of the basin. Two blasts were performed out at northern and southern edges of the Adapazari Basin on June 14 and 16, 2002, and the artificial seismic waves were observed at 80 sites along the 16 km-long survey line which traversed the basin. These records show that the apparent velocity is about 4.0 km/sec and the trend of first-arrival traveltimes change at 8200 m from southern blasting point (hearafter, the location along the survey line is represented by the 'distance' from the southern blasting point).

We estimate the subsurface structure under the survey line in order to represent the observed traveltimes. The subsurface structure at the region where the ground motions for the both shot can be calculated using the ordinary stripping method, and that at the other region is also estimated to represent the observed first-arrival traveltimes using a trial and error method. The obtained P-wave velocity of soil is 2100 m/sec, and these of bedrock are 5100 m/sec at 0-8280 m of distance, 3800 m/sec at 8280-15600 m. The velocity structures near the blasting points have been estimated based on array observations of microseism. The results show that we must consider at least three soil layers over the bedrock. Fig. 1 shows the estimated structure and the first-arrival traveltimes calculated from this model. The calculated traveltimes agrees well with the observed.

The 2D model proposed in the previous section is extended to a 3D model which is represented by the cubic B-spline functions. Gravity anomaly, the velocity structure based on array and single-site observations of microseism are also used for estimating 3D structure. The upper rock layer is assumed to exist over 1400 m of depth in the northern area from 40'45'30" N, where the bedrock velocity of 2D model change from 5000 to 3800 m/sec. Fig. 2 shows the depth of bedrock of the estimated 3D model on the Adapazari basin. The proposed 3D model consists of three soil and two rock layers.

The strong ground motion during the Kocaeli Earthquake is simulated numerically using finite-difference method. Sekiguchi and Iwata (2002) is used for the source model of the simulation. The model for simulation with 100 m of grid spacing, and 0.0079 sec of time step makes the effective frequency range up to 0.4 Hz. Simulated E-W waveforms are compared with the observed ones at SKR (the only one record on the basin observed) during the main shock as shown Fig. 3. The distinct phase of the simulated waveform agrees well with the observed. Fig. 4 shows the simulated the distribution of peak velocity on the Adapazari basin. It is shown that the ground motions are significantly greater at the downtown of Adapazari. Finally, the waveform on ground surface is calculated using the horizontally layered mediums around the downtown. The 1D structure models are assume to have the same physical parameters and thickness of each layer with those at Adapazari of the 3D model. The peak velocity calculated by 1D model is 43.35 m/sec, whereas that by 3D model is 136.46 m/sec. This result shows the peak velocity of 3D model is amplified three times by the basin effect.

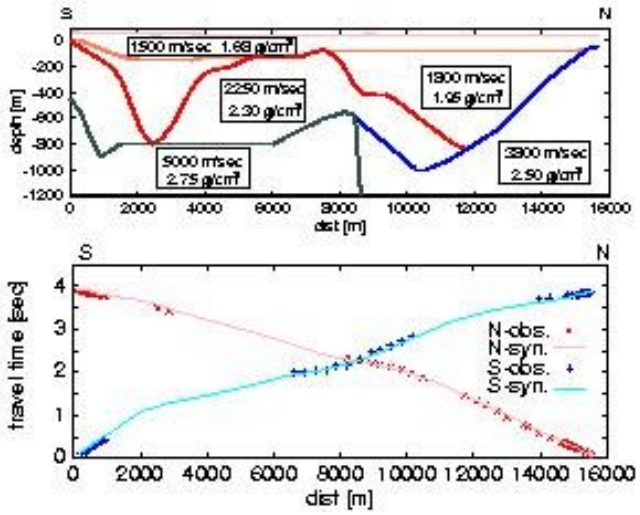

Fig. 1: 2D model under the survey line

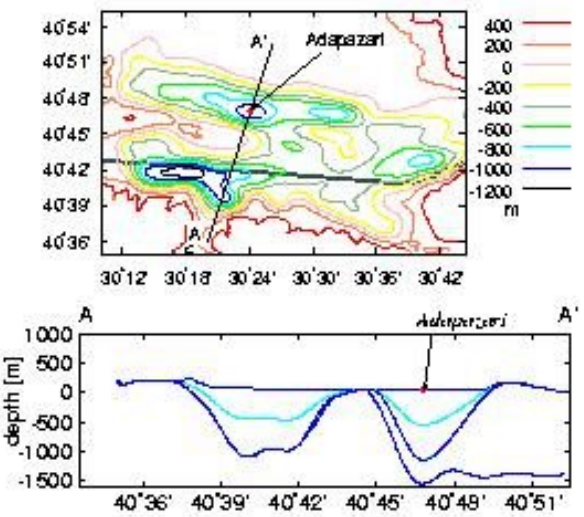

Fig. 2: 3D model of subsurface structure of the Adapazari basin

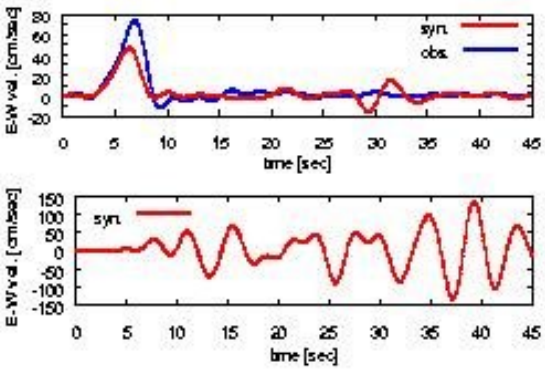

Fig. 3:Simulater waveform using 3D model and observed ones

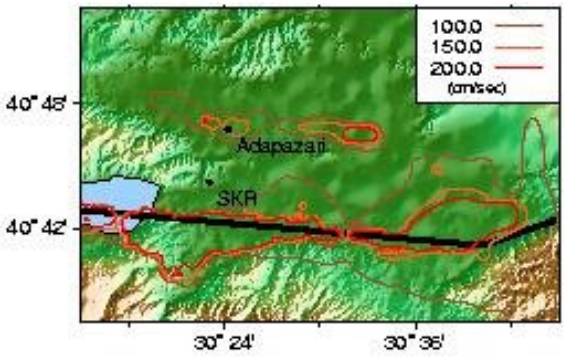

Fig. 4: Simulated distribution of peak velocity