# Long-period ground motions from the 2003 Tokachi-oki earthquake and sloshing in oil tanks

# Kazuki Koketsu[1]; Ken Hatayama[2]; Takashi Furumura[3]; Yasushi Ikegami[4]; Shinichi Akiyama[4]

[1] Earthq. Res. Inst., Univ. Tokyo; [2] Natl. Res. Inst. Fire & Disaster; [3] ERI, Univ. Tokyo; [4] CRC Solutions

The 2003 Tokachi-oki earthquake (M8.0) generated large long-period ground motions on various sedimentary basins in Hokkaido. In particular, on the Yufutsu basin where City of Tomakomai is located, their amplitudes were as large as 30cm/s with long duration of nearly 3 minutes and damaged many oil tanks, while the basin is 250km away from the epicenter. Since these long-period ground motions have a central period range of 5s to 9s, they should have caused sloshing in 30,000kl tanks having eigen periods close to 7s, which is the average of the period range. The crude-oil and naphtha tanks catching fire also belong to this class of 30,000kl. We performed eigen-vibration analyses with the finite element method for the naphtha tank and found its primary eigen period to be 7.12s.

In order to simulate these long-period ground motions, we set up a simulation box of 72km x 92km around Tomakomai and build a underground structure model referring to the results of reflection surveys and micro-tremor explorations. In addition, we introduce liquid parts for the sea where seismic motions mainly traveled. Since we cannot model the whole region including the source region due to the limitations of a computer, we make borehole seismograms at a station located near the outer boundary incident to the simulation box as plane waves. The ground motions by these incident waves are simulated using the voxel finite element method. The simulated ground motion at the Tomakomai K-NET station well agrees with the observed record. According to the simulation results, basin surface waves are generated at the edge separating the Yufutsu basin and the Hidaka mountain range, as well as at the edge of the undersea extension of the Yufutsu basin. These two surface wave trains meet around City of Tomakomai. This is a reason for the large long-period ground motions there.

We also carry out finite element simulations of sloshing in the oil tanks using general FEM codes. When we vibrate the FEM tank model with the ground motion record observed at the Tomakomai K-NET station, the oil surface motion is simulated with the maximum height of 2.68m. The oil surface first oscillates in the east-west direction because of the larger east-west ground motion. The oscillation direction then turns to northwest-southeast when the north-south ground motion becomes large in the later portions. In the simulation result we can find that the high-surface zone is rotated along the inner wall of the oil tank.