Characteristics of long-period ground motion in the Yufutsu plain during the Tokachi-oki, Japan, earthquake in 2003

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We outline the characteristics of long-period ground motion with periods from several seconds to around 10 s during the Tokachi-oki, Japan, earthquake in 2003 (MJMA=8.0, provisional) derived from the K-NET and the KiK-net strong ground motion data and so on, especially focusing on the Yufutsu plain. This earthquake generated sloshing in many large oil storage tanks in Hokkaido, Japan to cause damage to them. The damage in the Tomakomai city in the Yufutsu plain was so serious that 165 of 283 large tanks whose capacities are over 1,000 kl suffered. Furthermore, fires broke out at a crude oil tank and a naphtha tank, both of which are located around the Tomakomai western port and both of whose capacities are about 30,000 kl, immediately after the quake and two days after the event, respectively. At the naphtha tank with a floating roof, the fire rose from all over the naphtha surface, which is difficult to extinguish the fire, and finally lasted for about 44 hours. It has been 39 years since such fire occurred at the floating-roof tanks in Japan last at the time of 1964 Niigata earthquake. The typical damage to the tanks directly caused by sloshing ocurred at floating roofs and some of them were so seriously broken that they sank into oil. This resulted in several dangerous tanks in which the contained oil was always exposed to the atmosphere. It is long-period strong ground motion with periods from several seconds to around 10 s that generates sloshing in large tanks damaged by this earthquake. For example, the fired naphtha tank had the first-order sloshing natural period of about 7 s.

Fig. 1 shows that although the large long-period motions were observed even during the 1993 event southwest off Hokkaido and the 1994 event east off Hokkaido, the 2003 Tokachi-oki earthquake exceeds them in peak amplitudes. The vicinity of the Tomakomai western port was hit by the largest shaking for the last two decades in terms of long-period motion. During the 1993 event southwest off Hokkaido the 9-to-10-s-period components dominated, while during this event the 4-to-8-s-period components did.

Fig. 2 shows that he long-period strong motion was not confined to the vicinity of the Tomakomai western port but extended in the Yufutsu plain and the eastern part of the Ishikari plain with the strongest motion visiting the area along the north-to-south axis connecting from the center of the Yufutsu plain to the center of the eastern part of the Ishikari plain. The velocity responses are different even among the three sites in the Tomakomai city (Tomakomai Western Port, JMA-Tomakomai and Tomakomai Oil Storage Yard) and the vicinity of the Tomakomai western port was hit by the strongest long-period shaking.

The velocity ground motion records inside and outside the Yufutsu plain and along the coasts of the districts of Hidaka and Iburi from the epicenter to the Yufutsu plain suggest that the long-period strong motions inside the plain were mainly composed of surface waves excited by thick sediments of the plain. According to the past reflection exploration by artificial earthquakes, the thickness of sediments with a P-wave velocity under 4.2 km/s is about 5 km at most around Naganuma in the northern part of the plain and 5 to 8 km east of the downtown of the Tomakomai city.

Velocity response contour maps for the southern Hokkaido show that although the velocity responses at a period of 7 s are large even in the plains of Tokachi and Kushiro located in the eastern Hokkaido, the plains of Yufutsu and Ishikari exceed the plains in the eastern Hokkaido in them even though the latter are closer to the seismic source region.

Acknowledgements

This study owes to strong ground motion data from the K-NET and the KiK-net of the National Research Institute of Earth Science and Disaster Prevention, the Japan Meteorological Agency and the seismographs of municipalities, and the strong-motion earthquake records in Japanese ports.

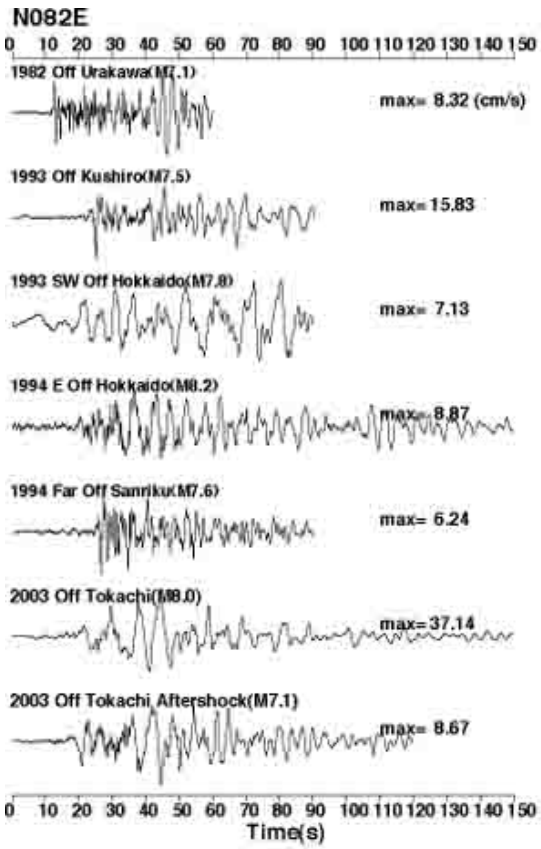

Fig.1 Velocity waveforms (0.05-5 Hz; nearly EW) ovserved at Tomakomai western port during past big earthquakes.

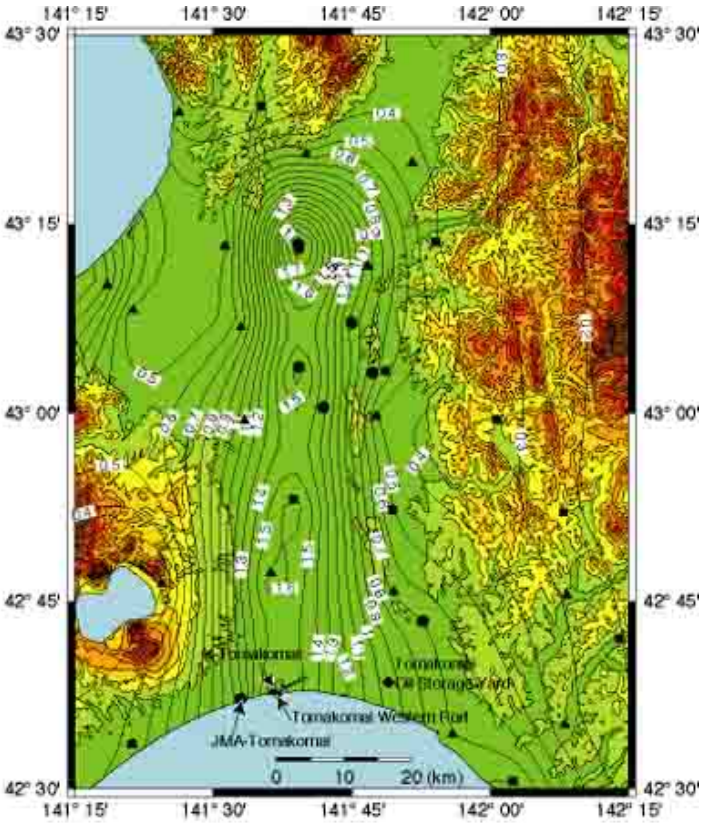

Fig.2 Contour map of velocity responses (h=1%) at a period of 7 s calculated from the EW components of the observed accelerograms.