Estimate of deep structure under Yufutsu Plain using array microtremor survey

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1. Introduction

The 2003 Offshore Tokachi Earthquake (Mj8.0) has excited long period ground motion, of which dominant period ranging from several seconds to over 10 seconds, in Yufutsu Plain. A lot of petroleum tanks in the plain suffered damage by consequential sloshing and some were severely damaged. Since long period ground motions have also been observed in the past big earthquakes in this area, deep geological structure is supposed to be an important factor in producing this phenomenon. In this work, in order to obtain more exact information of the deep structure, we conducted a series of array microtremor surveys with large array aperture and long observation time, and estimated the shear wave velocity (Vs) structure at three sites in Yufutsu Plain.

2. Microtremor observation

Array microtremor surveys were conducted in three sites with array centers at (1) an oil storage base (ATM) in the eastern Tomakomai area, (2) an oil refinery (TIP) in the urban area of Tomakomai and (3) the Chitose K-NET earthquake observation station (HKD-184, CTS). On each site, 3 or 4 triple-concentric-triangle arrays named L, M and S respectively are used. The radius of circumcircle of each array as listed below was designed by sensitivity analysis method (Feng et al, 2000) with consideration to the local situations.

ATM : L1/2598m, L2/2309m, M/866m, S/230m

TIP : L/1882m, M/1010m, S/289m

CTS : L/2309m, M/722m, S/173m

3. Data analysis

In dispersion analysis, we used both the spatial autocorrelation coefficients (SPAC) method and the frequency-wavenumber (F-K) method. In this analysis, we firstly used F-K method to check if the data contain more than one mode. Then, in the case they contain only one mode, we used SPAC method, and in the case more than two, F-K method. The frequency band of phase velocity for the three sites obtained by this analysis are ATM: 0.12-5.0Hz, TIP: 0.14-4.3Hz, and CTS: 0.13-6.0Hz.

For Vs structure analysis, we used a hybrid method that combined the genetic algorithm (GA) and least square technique (LSQ) together. Before the main analysis, with a thorough review of existing information and a preliminary analysis, we made a rough estimate of the Vs structure, of which Vs and thickness of each layer we used as a set of center values in the main analysis. In the main analysis, the model search ranges were set to 75 percent to 125 percent range of the center value for the Vs and 50 percent to 150 percent range of the center value for the layer thickness with exception of that for the Vs of the bottom layer (seismic basement) 95 percent to 105 percent range of 3200m/s.

4. Estimated Vs structure

As a result of the inversion analysis, the estimated Vs values at the three sites are; lower than 0.3 km/s, 0.4 - 0.5 km/s, 0.7 - 0.8 km/s, 1.15 - 1.40 km/s, 1.65 - 1.85 m/s, 2.2 km/s, and 3.2 km/s in order from the surface to the bottom. The first and second layers are interpreted to be corresponding to the Quaternary, and other layers are corresponding to the Pliocene, the upper Miocene, the middle Miocene, the lower Miocene to upper Cretaceous respectively, with reference to existing deep drilling data. In addition, the top depths of the seismic basement are 6.3km at ATM, 5.1km at TIP and 3.7km at CTS. These results are consistent with existing data. As the next step of our research, we will create a regional model including Yufutsu Plain and carry out analysis on the generation of long period ground motion.