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Earthquake Damage Evaluation of 2018 Hokkaido Eastern Iburi Earthquake Based on Estimated Substructure by Microtremor Observation at Oiwake, Hayakita and Mukawa

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1. Introduction

On September 6th 2018, an earthquake measuring M_{JMA} 6.7 (M_{w} 6.6) occurred at a depth of about 37 km in the eastern Iburi region of southern Hokkaido, Japan. The earthquake was named "The 2018 Hokkaido Eastern Iburi Earthquake" by the Japan Meteorological Agency (JMA). During the earthquake, JMA seismic intensity 7 was recorded in Atsuma town and 6+ was recorded in Abira and Mukawa towns. Some masonry structures had heavy damage and some wooded houses had severe damage in these towns, but the damage was scattered within the towns. In order to investigate the cause of the heavy or severe damage and the reason of the scatter, microtremor measurements were conducted to identify the subsurface structure in these towns. The site planning for this microtremor observation was based on the damaged areas, because of the great damage caused by the earthquake. As key areas of damage, Mukawa town, Hayakita and Oiwake districts of Abira town were selected as target sites. Therefore, the subsurface structure would be estimated based on the result of microtremor observation. And then through the estimated subsurface structure to predict strong motion and analyze damage ratio, the aim of this study, damage evaluation, could be evaluated.

2. The Overview of the Microtremor Observation

As described in detail by Ye et al. [1], the microtremor observation at the target sites were conducted during November 22nd and 24th, 2018. The single-station measurement and array measurement was conducted in order to obtain the microtremor Horizontal-to-Vertical spectral ratio (MHVR) and the phase velocity, respectively. This information will be used to identify the subsurface structure at the target sites. The designed single-station microtremor observation points were designed that the interval between points are about 100m on lines that go through the damaged and undamaged parts of the town. The array apertures were up to about 10 meters in order to estimate the shallow subsurface features. The duration of observation for each point was 15 minutes. Figure 1 shows the observation points at Hayakita as an example.

3. The Result of Microtremor Observation

In order to calculate the MHVRs, the total duration was separated to 40.98 sec segments overlapping 50%, and then averaged. The segments with traffic noise was neglected. The predominant frequency of Oiwake district is about 2.3 to 6.3 Hz and of Hayakita district is about 1.5 to 6.1 Hz shown in Figure 2. On the other hand, Mukawa district has first peaks at low frequency ranging from 0.7 to 1.0 Hz. The peak frequency of Oiwake and Hayakita was quite high, it can be inferred that the strong motion affected by shallow structure.

4. Subsurface Structure Estimation

All the layer structure model of three sites were made from the borehole data of K-NET [2] of respective site and the deep subsurface structure from J-SHIS [3]. Then by modifying the thickness of layers of layer structure model in order to make the predominant frequencies of the theoretical MHVRs match the observed one of K-NET single-station point, the initial subsurface structure can be obtained. The result of array observations – theoretical phase velocity dispersion curve what was analyzed by nc-CCA (noise compensated Centerless-Circular-Array) method [4], was used as reference to check the initial subsurface structure. On the basis of the initial subsurface structure, using the same method of adjusting thickness of layer, the 1D subsurface structure of each single-station can be determined. Directional dependence of H/V spectral ratios were analyzed to check the effect of lateral heterogeneity in the region.

5. Damage Rate of Wooden Houses

The estimated 1D subsurface structure is used to predict strong ground motion by DYNEQ [5] during the 2018 Hokkaido Eastern Iburi earthquake. And the predicted strong motion finally serves to predict the damage rate of wooden houses by using Nagato and Kawase [6] building group damage prediction model. Then through comparing the theoretical damage ratio with the actual observed damage rate of wooden houses during the earthquake, it is considered in what extent the damage can be the estimated by the 1D analysis considering the estimated subsurface structure.

6. Summary

The subsurface structure was estimated by microtremor observation what is relatively simple and economic method. And through the strong motion simulated from estimated subsurface structure, it was tested if the damage ratio and damage distribution can be simulated numerically.

Acknowledgments

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Reference

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Figure 1 Microtremor observation sites at Hayakita

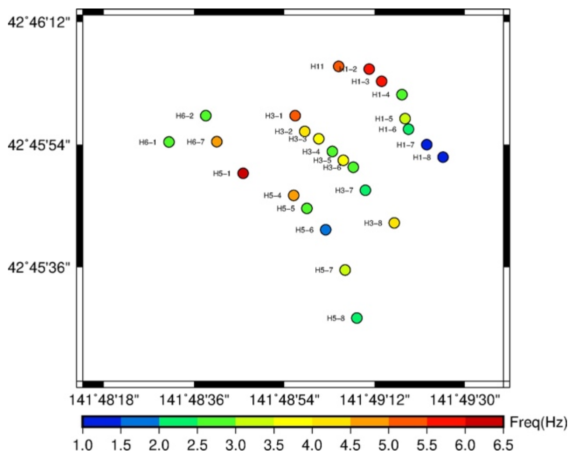

Figure 2 Predominant frequency of Hayakita