Effects of Surface Geology on Seismic Motion of The 2011 Tohoku Earthquake in Monou-Cho, Ishinomaki

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Monou-cho is located in Ishinomaki, Miyagi Prefecture. Oda and Toda (2011) conducted single microtremor measurements at 46 points along the Higashihama-Kaido in Ishinomaki, and investigated the predominant frequency from the H/V. In addition, damage investigation was conducted in same area using the method of Yahata and Yamazaki (2008), and the 310 houses in this area were visually ranked from A to F. This method and H/V were compared and evaluating the relationship between H/V and house damage. As a result, they revealed that predominant frequencies of area received significant destruction have multiplex peaks or broad range from 2 Hz to 4 Hz. However, the damage was not serious at all points where the predominant frequency was 2.5 Hz or higher. There was a fact that the damage was small in the area with predominant frequency around 1 Hz, which caused great damage during the Southern Hyogo Earthquake1995. From the above facts, issues such as the need to clarify the detailed underground structure and amplification characteristics in Monou-cho remain.

In this study, we evaluate the amplification of seismic motion in Momo-cho by comparing the house damage during the 2011 The Tohoku Earthquake investigated in Oda and Toda (2011), S-wave velocity structures obtained by using microtremor miniature array method and the seismic response of the 2011 The Tohoku Earthquake.

In this study, microtremor array observations were performed at 27 points, approximately 4km along the Higashihama-Kaido. Based on these observations, a dispersion curve is calculated by the Centerless Circular Array (CCA) method (Cho et. al., 2006). Then, S-wave velocity structures at each point were estimated by Simulated Annealing. The initial models for Simulated Annealing were generated from SIM (Simplified Inversion Method) (Pelekis and Athanasopoulos, 2011) and the nearby borehole data. Using these results, we analyzed the seismic response characteristics of the 2011 Tohoku Earthquake in Monou-cho using the equivalent linear analysis program (SHAKE91) based on the one-dimensional multi-reflection theory. In this analysis, we focused mainly on the acceleration response spectrum and the transfer function from basement to ground surface.

As a result of the estimation of the S-wave velocity structure, it was found that the basement was found at shallower location in the center of Monou-cho, and the basement was found deeper toward the north and south. In addition, it was found that the basement of the southern Monou-cho had a larger drop, and the basement was found deeper than the northern area. This basement is almost the same depth of the Onuki Formation in comparison with borehole data.

As a result of comparing S-wave velocity structure and the seismic response characteristics, the rank of the damage increased in the center of Monou-cho despite the small value of AVS30. A comparison between the acceleration response spectrum of the 2011 Tohoku Earthquake, the transfer function and the distribution of house damage, it is found that response acceleration in the range of 0.25 to 0.5 seconds was larger in the center of Monou-cho where house damage was larger. However, this is inconsistent with the conventional interpretation that the acceleration response spectrum with a period of 1-2 seconds affects house damage.

The acceleration response spectrum of the 1995 Hyogo-ken Nanbu Earthquake, the 2004 Chūetsu Earthquake and 2011 The Tohoku Earthquake at Nakatsuyama Daini Elementary School have peaks at the period of 1 second. It was found that peaks can be also confirmed around 0.25 to 0.5 seconds. In other words, the acceleration response around 0.25 to 0.5 seconds and 1 to 2 seconds may affect the damage of the wooden house. Near surface structure in the center of Monou-cho which amplify the ground motion around 2-3Hz (about 0.3-0.5 seconds) could be the factor that caused serious damage.

Keywords: Microtremor array method, Basement, Seismic response characteristics, Acceleration response spectrum, Transfer function, Local damage

