Estimation of earthquake ground level in Horinouchi area in the 2014 Northern Nagano earthquake

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The 2014 Northern Nagano Earthquake with Mj of 6.7 occurred on 22 November 2014. The JMA maximum intensity of 6 lower was observed in Otari village and Ogawa village. However, heavy damage was observed in Horinouchi and Mikkaichiba areas which are 5km away from the strong observation point with intensity of 5 higher. One of the reasons for the heady damage is low seismic performance of the damaged houses as reported in JAEE's team. However, strong motion features of main shock are not fully understood in the area... In this study, we estimated the ground motions in the damaged areas to know the reasons of the damage.

After the main shock, Chimoto et. al (2015) observed aftershock records around the damaged areas In this study, we analyzed these records with records observed at strong motion stations using the spectral inversion technique. This technique can divide ground motion spectra into site, source and propagation effects. We used records from 59 earthquakes including aftershocks between JMA magnitudes of 2.4 and 5.8, and the main shock. During strong shaking like the main shock, nonlinear behavior of soil layers can be observed. Thus, we set three conditions for the data selection in this inversion analysis.

1) For earthquake records with PGAs less than 100 gal except for the main shock,

2) the main shock records with PGAs less than 100 gal have site effects as same to those of weak shock,

3) the main shock records with PGAs more than 100 gal has site effects that are different from those of the weak motions. Under these conditions, different site effects for the weak motion and the main shock are estimated at the observation stations with PGAs more than 100gal during the main shock.

We investigated the relation of the estimated site effect for the weak shaking and the main shock at the observation stations. The differences of these site effects can be caused by the nonlinearity of the soft soil. Therefore, in this study, we defined Ra(f) as an ration of the site effect for the main shock to that of weak shaking. We investigated the relationship between this Ra and the S wave velocity profiles by our microtremor surveys. At the observation stations with PGAs of 400 gal during the main shock, it was found that the Ra is similar for the sites with similar average S wave velocities up to a depth of 10 m (hereafter, Vs 10). The Vs10 in Horinouchi area is 165m/s, and VS10 in Ogawa village is 151m/s. Therefore, it is indicated that Ras in Horinouchi area and Ogawa village are the same.

The spectra characteritics of the main shock at basement was calculated from the source effect of the main shock and the propagation effect, estimated by spectrum inversion. Furthermore, we estimated the site effect of the main shock in Horinouchi area from the site effect of weak shaking and Ra of Ogawa village for estimating the spectral features of the main shock in Horinouchi area by these multiplications of these factors.

As a result, it was found that the estimated earthquake ground motion level was about 2 times stronger

than the strong motion observation stations at a period of 1-1.5 seconds, which has large effects on the wooden houses. We also found that this motion is classified to a seismic intensity of 6 upper on the JMA scale. On the other hand, the estimated spectral power in this study is about 1/4 to 1/2 of the strong motion spectrum of past destructive earthquakes observed in areas with heavy damage of the wooden building.

From these discussions we have concluded that ground motion at periods of 1-1.5 seconds were slightly larger than the surrounding observation stations. However the low earthquake resistance of the damaged building in Horinouchi area must be also included in one of the reasons of the damage.

Keywords: Spectral inversion technique, 2014 Northern Nagano earthquake, Nonlinear site effect, Building damage

