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Building Damage Ratios and Ground Motion Characteristics during the 2011 off the Pacific coast of Tohoku Earthquake

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The relationship between building damage ratios and ground motion characteristics, such as peak ground accelerations (PGAs), peak ground velocities (PGVs), JMA seismic intensities (I_JMAs), spectral intensities (SIs), acceleration response spectra (Sa) and pseudo velocity response spectra (pSv) was discussed for the 2011 off the Pacific coast of Tohoku Earthquake. In this study, damage ratio is defined as the ratio of the number of damaged buildings including collapsed, half-collapsed and partially damaged ones, to the total number of buildings in each district (an administrative unit, such as a city, or town). The damage statistics were obtained from the Fire and Disaster Management Agency published on January 13, 2012. The districts mainly damaged by tsunami were excluded. It was found that DRs correlated better with velocity indices such as PGVs, pSv and SIs than acceleration ones such as PGAs, Sa and I_JMAs, and DRs correlated better with pSv at 0.5 s than those at 1.0 s and 1.5 s from the view of coherence coefficients. In general, DRs tended to increase with the level of ground motion characteristics, but the damage ratios in some districts did not correspond to suitable level of ground motion characteristics. It was suggested that the ground motion characteristics at the K-NET and KiK-net stations might not represent those in the damaged districts because the stations are far away from the damaged areas.

In order to establish the relationship between building damage ratios and ground motion characteristics in the damaged areas, the estimations of ground motion at the damaged sites were performed based on microtremor measurements. They were accomplished by the product of bedrock motions and site amplification factors at the damaged sites. The ground motions on bedrock under damaged sites and observation stations were assumed to be the same. The bedrock motions under the damaged sites were estimated from observation spectra on surface divided by site amplification factors at the observation station. Then the ground motions were estimated from the product of the bedrock motions and site amplification factors at the damaged sites. Therefore, it was necessary to find the subsurface S-wave velocity structures both at the observation station and damaged site to estimate site amplification factors. Based on one dimensional Haskell multiple reflection theory, the S-wave velocity structures were obtained by inversion of the microtremor H/V spectral ratios. We conducted microtremor measurements and building damage survey at the observation station and the damaged sites. The H/V spectral ratios of microtremor at the observation station showed good consistency with those of ground motions from small earthquakes, which indicated that the inversion of microtremor H/V spectral ratios was feasible, just as the seismic motion ones. The ground motion characteristics at the damaged sites estimated by the above procedure were related with the damage ratios.

Keywords: ground motion characteristics, building damage ratio, S-wave velocity structure, H/V spectral ratio