Long-Period Ground Motion of Tokyo Metropolitan Area during the Deep Event occurred off West of Ogasawara Islands

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1. Introduction
The large earthquake with M8.1 has occurred in the west off Ogasawara Island at 628 km in depth on May 30, 2015. This event data give several merits for empirical site factor study of Tokyo Metropolitan area. Large magnitude means the high-SN ratio in long-period band. Deep epicenter means the incident wave was body wave with high incident angle. Long distance makes the radiation pattern effect small in the observation network area. In this study, the empirical amplification factor in long-period band of 2 to 10 s using the data observed in the Tokyo metropolitan area.
2. Data
The acceleration data observed by K-NET and KiK-net located in Kanagawa, Tokyo, Chiba, Saitama and Ibaraki prefecture were used in this study. The velocity data observed at the thermal power stations of TEPCO around Tokyo bay area were used, too. Almost K-net seismometers were triggered at S-wave and P-wave portion of the data was lost. It was not problem because the analysis target in this study was S-wave portion.
3. Propagation in sediment layers
The propagation characteristics of S-wave portion were checked by comparison of the wave forms between ground surface and the bore hole at KiK-net stations. Significant phase propagated from deep underground and reflected at ground surface. The time lag between the input phase and the reflected phase was coincident with the time calculated from subsurface velocity model.
The F-K spectral analysis of S-wave portion were performed using dense K-NET stations located in the east part of Tokyo. The result shows that the low-frequency wave propagation velocity was over 6km/s in horizontal direction. It means that the S-wave propagate from bedrock with high incident angle.
4. Spectral ratio to the rock site
First, the Fourier spectra were made from the S-wave portion of acceleration records with the time window of 81.92 s by FFT methods. The spectra were smoothed by Parzen window of 0.05 Hz width. Next, the Fourier spectral ratios were made by division of the ground surface data at each station by the ground surface data at TKYH13. TKYH13 is located in the Kanto Mountain in west of Kanto plain. At TKYH13, there are almost no amplification in lower frequency band than 1Hz from the bedrock with Vs=2500m/s at 100 m depth to ground surface. We can consider the record of TKYH13 the outcrop bedrock data in low frequency band.
The value of spectral ratio becomes bigger from the west station to the east station. The spatial distribution of spectral ratios at about 8 s and the distribution of the bedrock depth are almost conformable except for the southern part and northern part of Chiba prefecture. If a period becomes shorter, the correlation of spatial distribution of spectral ratio with the seismic bedrock depth is worse. This means that the short period ground motions was affected by the more shallow subsurface structure.
5. Discussion and conclusions
We compared the spectral ratios to TKYH13 in this study and the site amplification factors from the bedrock calculated from the subsurface structure models made from the past investigations. The results show that the spectral ratios were higher than the theoretical amplification factor in the Kanto basin. However, the spectral ratios between ground surface to the bedrock at each station

accorded with the theoretical ratio calculated from subsurface structure model. These results mean that the incident wave from the seismic bedrock at deep sediment stations were bigger than incident wave at TKYH13. This spacial change in the Tokyo metropolitan area may be given under the influence of the plate structure like the abnormality seismic intensity area.

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Keywords: Deep Event, Long-Period, Metropolitan Area, Body Wave, Spectral Ratio