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Prediction of long-period ground motion intensity for earthquake early warning
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The 2011 Mw 9.1 Tohoku-oki earthquake caused strong shakings of high rise buildings constructed on deep sedimentary basins in Japan. During the earthquake, many people got into difficulty with their movements inside the high rise buildings even on the Osaka basin located at distances as far as about 750 km from the epicentral area. Japan Meteorological Agency (JMA) has started to provide people with information on intensity of long-period ground motions based on the absolute velocity response spectra (1.6 to 7.8 s) of the observed records on the grounds (Aizawa et al., 2013). The intensity scale of long-period ground motions is classified into four: 1, 2, 3, and 4 having spectral values of 5 to 15 cm/s, 15 to 50 cm/s, 50 to 100 cm/s, and more than 100 cm/s, respectively. The spectra were computed at natural periods of 1.6 to 7.8 s using 5% of critical damping. The maximum value of the computed spectra among 1.6 to 7.8 s defines the class of intensity. We have recently constructed empirical prediction equations of absolute velocity response spectra in the period range of 1 to 10s aiming for earthquake early warning application (e.g., Dhakal et al., 2013). The equations use JMA displacement magnitude and hypocentral distance as basic parameters. Earthquakes having JMA magnitude 6.3 or larger and focal depths shallower than 50 km were used. One of the difficulties in empirical prediction of long-period ground motions is to effectively include the effects of local geological structure such as 3-D basin effects in the prediction equations. To simplify this problem, we obtained site correction factors at K-NET and KiK-net strong motion sites as the mean value of the logarithmic residuals. To make predictions possible at sites other than the strong motion observation sites, we derived correction coefficients based on the relationships between the average residuals and depths of deep sedimentary layers, which are available for whole Japan at Japan Seismic Hazard Information Station (J-SHIS). We found that the standard deviations are minimized by corrections using the depth of layer having Vs value of 1.4 km/s.

To define intensity at a site, we obtained the maximum value of the predicted spectra among T=1.6 to 7.8 s using the empirical prediction equations explained above. However, we found that the maximum predicted values were somewhat biased against the observed maximum values. Therefore, we applied an additional correction factor to the maximum predicted values to finally obtain the intensities. When a prediction equation was constructed using the maximum value of the observed spectra as the independent parameter, the additional correction factor was eliminated as the resulting residuals were normally distributed; also, the predicted intensities were almost identical to those obtained based on the regression analysis results for each natural period. In this study, we illustrate and discuss the application of empirical prediction equations for the prediction of JMA intensity of long-period ground motions for earthquake early warning application.

References
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