大都市における建物や構造物の被災度予測を組み込んだ緊急地震速報システムの提案

Proposal of earthquake early warning system estimating damage assessment of buildings and structures in metropolitan area

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An earthquake of magnitude 5.2 with focal depth of 57 km occurred beneath Tokyo bay on September 12, 2015. Shaking intensities by this earthquake are ranging from 2 to 5- in a small areas of nearly same hypocentral distances. This observation suggests that it is almost impossible to predict accurate shaking intensity by the present EEW system operated by JMA, which determines hypocenters and magnitude and transmits them for the estimation of shaking intensity at user's location, because the spatial large change in observed shaking intensity is originated to the existence of very strong lateral heterogeneity in the site amplification factors and the complexed deep structure but not in the estimation errors of hypocenter location or magnitude. We proposed to install a new EEW system specialized for the metropolitan areas.
2. Why we need a new EEW system specialized for metropolitan areas
1) The present EEW system has about 30 km of blind zone in focal areas where most of earthquake damages occur, owing to the limitation of the number of seismic stations. 2) There are large estimation errors of seismic intensity owing to the large lateral heterogeneity of site amplifications. It is shown that estimated values of site amplifications with 250m mesh do not able to greatly decrease estimation errors. 3) Each building has different strength and the natural period. Estimation of earthquake damage should be done based on the response of building to the earthquake shaking. 4) Because the earthquake damages are huge in metropolitan areas, which is limited in a small area in general, specialized earthquake early warning system for urban area seems to be effective.
3. Proposed EEW system in metropolitan areas
1) Install seismometers with an interval of several hundred meters which send observed real-time waveform data to their data center. 2) Register data of user's buildings or structures to the data center, such as the location, dumping factor, and strength of buildings. 3) At a time of strong shaking, the data center predicts shaking intensity using real-time P wave data transmitted from the closest station. It also calculates response of buildings associated with the ground shaking and estimates damage assessment of individual buildings. 4) The data center sends these computed results to each owner of building or users so as to do something for the mitigation of earthquake damage. Since there are seismic stations closed to each building in the proposed EEW system, we can consider that shaking at each building are approximated by the shaking recorded at the closest station. Therefore, we can consider that the proposed system can issue accurate EEW information to individual users. It is also pointed out that shaking intensity is predicted by the use of near-by stations, there are almost no blind zone.

4. Effectiveness of the proposed system
We checked the accuracy of shaking intensity estimation by the proposed system. We estimated values of shaking intensity using 1800 P wave data recorded by K-net station and found that the average estimation error of shaking intensity is 0.5. Since the shaking intensity is predicted by the use

of waveform data at near-by station in the proposed system, we are able to consider that the average estimation error obtained by K-net data is approximated to that by the proposed system. We also calculated estimated errors of shaking intensity estimation from the attenuation equation with putting parameters of hypocenter location and magnitude used in the present EEW system. The average error in this case is 0.91, which is much larger than the value of 0.51. The proposed system compute the response of each building associated with ground shaking. it may be possible to issue warning about the fall down of unfixed furniture.

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