Probabilistic seismic hazard assessment of response spectra for whole Japan (part 1: Selection of ground motion prediction equations)

*Nobuyuki Morikawa[1], Junichi Miyakoshi[2], Hiroyuki Fujiwara[1]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Ohsaki Research Institute, Inc.

The seismic intensity or peak velocity is used in the probabilistic national seismic hazard maps for Japan. However, seismic hazard assessment of response spectra is useful in seismic risk assessment and engineering field. In this study, we try to assess seismic hazard of the response spectra by using the seismic activity model in the national seismic hazard maps for Japan. In this paper, we mention selection of ground motion prediction equations (GMPEs) used in the assessment, and the results are shown in the next report.
In Douglas (2019), 290 GMPEs for spectral ordinates published after 1973 are summarized, of which about 50 are derived from strong-motion records mainly observed in Japan. The 2003 Tokachi-oki earthquake was the first magnitude 8-class earthquake in the world where strong-motion records observed by the nation-wide dense networks, K-NET and KiK-net. It is very important to use the GMPE obtained using the record of the 2003 earthquake, because the contribution of large subduction earthquakes on seismic hazard assessment in Japan is extremely large. In this study, we carry out the assessment of 5%-damped acceleration response spectra whose period is shorter than 5 seconds all over Japan on the engineering bedrock (Vs=400m/s). So we select GMPEs that satisfy the following conditions.
a. It has been published as a peer-reviewed paper.
b. It was derived from records mainly observed in Japan, including records of the 2003 Tokachi-oki earthquake.
c. It is included peak acceleration and 5% damped acceleration response spectra whose period ranges from 0.1 to 5 seconds and can evaluate on the engineering bedrock.
d. It is possible to consider the difference of source and path characteristics in earthquake type (crustal, subduction plate-boundary, and subduction intra-plate).
e. It is modeled anomalous seismic intensity distribution.
f. It does not target specific earthquakes or observation points only.
g. It is used records of magnitude 9-class mega-earthquake.
As the result, two sets of GMPEs by Morikawa and Fujiwara (2013) and Zhao et al. (2016) were selected. However, with regard to the above condition g, it is inevitable that the uncertainties concerning the applicability to the earthquakes in Nankai trough are large because both GMPEs are used records the 2011 Tohoku great earthquake only for magnitude 9-class. In order to consider such uncertainty, we decide to add the latest GMPE, Goda and Atkinson (2009)’s, that satisfies other conditions.
The difference is large in the short distance or mega-earthquake, which number of records is quite few, among three GMPEs. By the way, the dataset for deriving the GMPE is constructed by each researchers. As the result,
1. Methods of filtering applied to observed waveforms and definition of horizontal maximum amplitude are different each other.
2. The magnitude and fault model selected are different for each other.
3. Indicators related to site amplification, such as site class and Vs30, are not unified.
This situation makes it impossible to compare among GMPEs under exactly the same conditions. This is not limited to the three GMPEs selected here, but is a problem common to all Japanese GMPEs that do not have derived from the same dataset. In seismic hazard assessment including mega-earthquakes and very close distance to the source fault with quite few observation records, it is necessary to use multiple

GMPEs in consideration of epistemic uncertainty. In case of seismic hazard assessment targeting a specific site, there is also the idea that each GMPE is weighted based on consistency with observation records. However, in order to evaluate its consistency, it is necessary to construct a unified standard dataset and to use GMPEs derived based on it that can be compare under the same conditions.

Keywords: Seismic hazard assessment, Response spectra, Peak acceleration, Ground motion prediction equation