Probabilistic Fragility Curves for Decision Making on Upgrading Non-Confirming Wooden Houses

Yasuhiro Mori [1], Yukari Mizutani [1], Jaedo Kang [1], and Hideki Idota [2]
[1] *Dept. Environmental Engineering and Architecture, Nagoya University, Nagoya, Japan*
[2] *Nagoya Institute of Technology, Nagoya, Japan*
Correspondence: yasu@sharaku.nuac.nagoya-u.ac.jp

Keywords: Fragility curve, seismic risk information, non-conforming wooden house, upgrading, sense of values, alternatives, soil conditions

Upgrading the seismic performance of the approximately 11 million of existing non-conforming wooden houses in Japan is an urgent issue for disaster mitigation. The authors have developed a web tool to provide seismic risk information in order to promote seismic performance upgrading by answering questions such as “Is it necessary to upgrade to the level required by the current seismic code?” and “What if the upgrading is not carried out now, but in a few years?” [1)] For a matter of simplicity, the risk is expressed by “risk indexes” on a scale of 0 to 5. Because a sense of value is different from owner to owner, the risk is evaluated in four categories, including “Life safety”, “Total collapse”, “Necessity of evacuation”, and “Economic loss.” Using the tool, owners can compare the effect of several upgrading alternatives and make a reasonable decisions based on their own sense of values.

Risk information for a house owner is estimated within the web tool based on seismic hazard information and a deterministic fragility curve as a function of peak ground velocity (PGV) and seismic grade, *Ig*, based on seismic diagnosis. The fragility curve is developed based on a field survey following the Kobe earthquake in 1995[2)], an intra-plate earthquake. Naturally, the response and corresponding damage level of a house under seismic excitation depends on ground motion characteristics including soil conditions, propagation path characteristics, earthquake type, etc., should be treated as a random variable.

In this research, a set of probabilistic fragility curves are developed considering three types of soil conditions and two types of earthquakes. Fifty ground motions are simulated for each category assuming the mean power spectrum and probability distribution of phase differences, and are scaled so that the PGV is equal to 0.5, 1.0, 1.5, or 2.0 m/s. Three typical wooden houses are designed and upgraded so that *Ig* is equal to 0.3, 0.4, 0.7, 1.0, 1.3, or 2.0 by adding walls and/or braces. These houses are modeled as non-linear two degree-of-freedom systems and time history analysis is conducted using simulated ground motions. The results are statistically analyzed for each category of ground motion and simple probabilistic fragility models are developed. The appropriateness of the model is investigated by comparing the deterministic fragility curve based on the Kobe earthquake.

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2) Okada, S., & Takai, N. (2004) “Damage index functions of wooden buildings and reinforced buildings for seismic risk management,” *Proc. 13th World Conf. on Earthquake Engineering*, Paper No.727, 10pp.