RAPID ESTIMATION OF FRAGILITY CURVES USING ENDURANCE TIME METHOD

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Randomness of earthquakes' inherent causes scattering of structural responses. The most complex methods such as risk, hazard analysis and the performance based design try to estimate seismic response properly. Most of the time, damage probability of structures are studied using fragility curves. Multi-strip analysis (MSA) and incremental dynamic analysis (IDA) are the most analysis methods which evaluate seismic response in different intensity measures (IMs) (Vamvatsikos, 2002; Jalayer, 2003). Numerous nonlinear dynamic analyses needed in mentioned methods lead to complexity and time consuming process of them. Endurance time analysis (ETA) evaluates structural responses in different IMs by using artificial intensifying acceleration functions with least dynamic analysis (Jamshidi and Estekanchi, 2012). In this study, fragility curves are rapidly and easily estimated using ETA method. In this paper a new approach has been suggested to obtain fragility curves rapidly. Hence, the capability of ETA is evaluated to determine fragility carves by making use of equivalent SDOF in-lieu of MDOF system. Finally the outcomes are compared with MSA.

In Figure 1, seismic response resulted from 44 ground motions located on soil type II in MSA and 3 artificial acceleration function of series "e" in ETA for a 2-story 2D steel moment resisting frame are illustrated. Peak ground acceleration (PGA) is chosen for IM and roof displacement is the indicator of engineering demand parameter (EDP). It can be seen that the mean of response resulted from ETA for both MDOF and equivalent SDOF predict the mean of MSA ones. Response of MDOF and equivalent SDOF are too close in both MSA and ETA. Hence, using equivalent SDOF instead of MDOF is logical. Structural responses have less scattering in ETA in comparison with MSA.

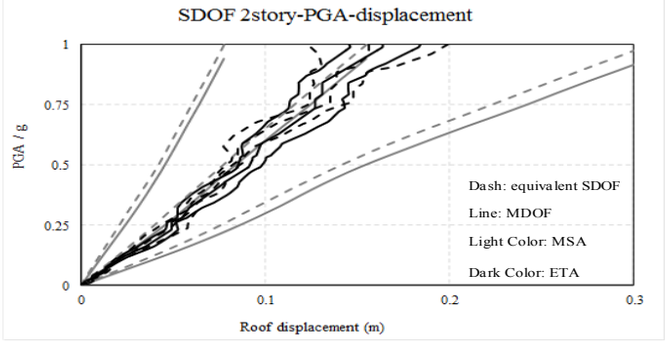

Figure 1. Response distribution of 2D MRF and its equivalent SDOF determined by MSA and ETA

Fragility curves in four damage threshold defined in HAZUS (HAZUS-MH MR3 (2003)) (including slight, moderate, extensive and complete) are evaluated by employing response distribution of structures. Fitted fragility parameters in MSA and ETA for MDOF and its equivalent SDOF are shown in Table 1. It is observed that the intensity measures with probability of exceedance of 50% (IM_{Mean}) are close in all analysis but standard deviations (β_{IM}) are different. These results were predictable from Figure 2 which mean of response for MSA and ETA were close while obvious differences in response distributions were observed.

Table 1. Parameters of fragility function estimated by MSA and ETA

		Slight		Moderate		Extensive		Complete	
		IM_{Mean}	β_{IM}	IM_{Mean}	β_{IM}	IM_{Mean}	β_{IM}	IM_{Mean}	β_{IM}
MDOF	**MSA**	0.1365	0.6703	0.2844	0.7104	0.7760	0.6590	1.7716	0.5620
	ETA	0.1295	0.0838	0.2619	0.1214	0.7672	0.1588	3.0071	0.1000
Equivalent SDOF	**MSA**	0.1573	0.6606	0.3231	0.6728	0.8323	0.6226	1.8423	0.5404
	ETA	0.1293	0.0779	0.2507	0.1412	0.7533	0.1178	3.0071	0.1000

Results show that considering an uncertainty factor of 0.6 in ETA based fragility curves conclude MSA based fragility curves. These differences come back to low deviation of response in ETA due to process of generating artificial acceleration functions. Therefore, modified fragility curves obtained by ETA from equivalent SDOF are compared to MSA ones in MDOF in Figure 2 by utilizing Equation 1.

$$P(D > d_i \mid IM) = 1 - P(D < d_i \mid IM) = 1 - \Phi\left(\frac{ln(IM_i) - ln(IM_{Mean})}{\beta_{IM}}\right) \qquad (1)$$

Where; $P(D > d_i \mid IM)$ is probibality of exceedance in ith responce from demand thoshold given IM, IM_i is the ith intensity measure, IM_{Mean} is intensity measures with probability of exceedance of 50%, β_{IM} is logarithmic standard deviation of response. Finally, utilizing ETA and equivalent SDOF leads to determine fragility curves rapidly with least error to achieve fragility curves of MSA for MDOF system.

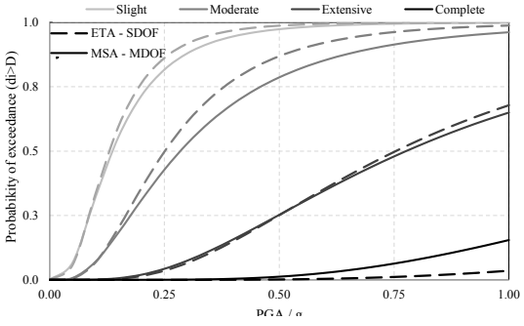

Figure 2. ETA and MSA obtained fragility curves for SDOF and MDOF respectively

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