Evaluation of the Earthquake Intensity Measure for a Seismic PSA

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1. Introduction

In this study, the earthquake intensity measure was estimated by using the structure responses – base shear, story drift, top acceleration and top displacement – for a KSNP containment building for 30 sets of near-fault ground motions [1,2]. Seven parameters, that is, peak ground acceleration (PGA), peak ground velocity (PGV), spectral acceleration (Sa), velocity (Sv), spectrum intensity for acceleration (SIa), velocity (SIv) and displacement (SId), were used to represent alternative ground motion intensity measures (IMs). Then regression analyses of each parameter were performed. From their results, the best parameter for the derivation of a seismic PSA was estimated [3].

2. Role of Intensity Measures for SPRA

In the Seismic Probabilistic Risk Assessment (SPRA), the role of the alternative ground motion intensity measures (IMs) as the link between a seismic hazard and a structural analysis has been identified. Sufficiency and efficiency of an IM, as well as its hazard computability, have been recognized as criteria for judging the adequacy of a candidate IM. Here, a sufficient IM is defined as one that yields damage conditionally and independent, given a IM, of a earthquake magnitude, source-to-site distance and any other ground motion characteristics that can affect a structural response [4]. An efficient IM is one that results in a relatively small variability of a damage given a IM. The hazard computability can be defined as the effort required in order to determine the hazard curve in terms of the proposed IM.

3. Type of Intensity Measures

In this study, seven parameters were used to represent ground motions resulting from 30 sets of near-fault ground motions.

The peak ground acceleration (PGA) is the most common way of expressing the intensity of a ground motion. 30 sets of records that have the closest distance to the rupture surface of less than 20km and a earthquake magnitude greater than of equal to 5.7. The peak ground velocity (PGV) is another parameter that is frequently used to characterize the intensity of a ground motion. The spectral acceleration (Sa) is the best-known parameter to structural engineers. This is the peak elastic acceleration of a KNSP containment building for the fundament frequencies for a given damping ratio, here it is 5%. The spectral velocity (Sv) is the peak elastic velocity at that time. The spectrum intensity was first introduced by Housner [5] as a measure of the intensity of an earthquake. The spectrum intensity is defined as the average of the pseudo-acceleration (SIa), velocity (SIv) and displacement (SId) spectral values between T=0.1 and 2.5 seconds. The equations of SIa, SIv and SId are represented in equations (1), (2), and (3).

$$SI_a = \frac{1}{2.4}\int_{0.1}^{2.5} S_a(T,h)dT \qquad (1)$$

$$SI_v = \frac{1}{2.4}\int_{0.1}^{2.5} S_v(T,h)dT \qquad (2)$$

$$SI_d = \frac{1}{2.4}\int_{0.1}^{2.5} S_d(T,h)dT \qquad (3)$$

4. Evaluation of the Intensity Measure

In this study, two regression models were used for the regression analysis. The expressions for these regression models are as follows:

$$y = a \cdot x + b \quad \text{(Linear Model)} \qquad (4)$$

$$y = a \cdot x^b + c \quad \text{(Power Model)} \qquad (5)$$

where ‘ a ’, ‘ b ’ and ‘ c ’ are unknown regression coefficients, ‘ x ’ is a ground motion parameter, PGA, PGV, Sa, Sv, SIa, SIv, or SId, and y is the failure criteria, base shear, story drift, top acceleration, or top displacement, for a KSNP containment building respectively.

For example, Fig 1. shows the linear regression results of the top displacement in accordance with the normalized intensity measures(PGA, Sa, SIa) for a KSNP containment building and Fig 2. shows the power regression results of that.

Table. 1 and Table. 2 show the correlation coefficients by the regression model IMs. Here, if a regression model can explain all of the variations, the correlation coefficient is equal to 1. On the other hand, an extremely poor model would result in the correlation coefficient value near zero. As seen from Table. 1 and 2, Sa is the best parameter for a derivation of the regression models. Conversely, PGV is the poorest parameter. Fig.3 and Fig.4 show the figures for the correlation coefficients of the linear and power model IMs.

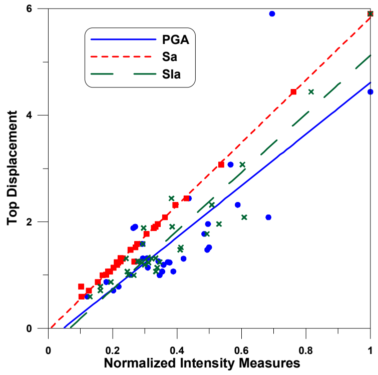

Fig. 1 Regession analysis for linear model

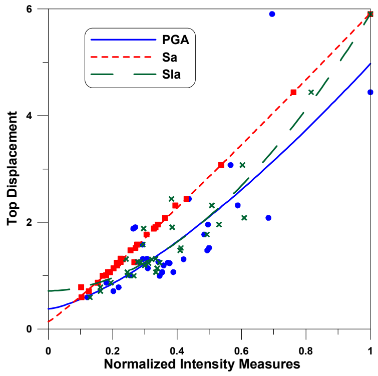

Fig. 2 regression analysis for power model

Table.1 Correlation coefficient of linear model IMs

	PGA	PGV	Sa	Sv	SIa	SIv	SId
BS	0.819	**0.268**	**0.992**	0.974	0.946	0.892	0.600
ST	0.815	**0.265**	**0.993**	0.976	0.945	0.889	0.596
TA	0.817	**0.238**	**0.981**	0.981	0.931	0.851	0.510
TD	0.788	**0.228**	**0.998**	0.986	0.938	0.872	0.548

Table.1 Correlation coefficient of power model IMs

	PGA	PGV	Sa	Sv	SIa	SIv	SId
BS	0.822	**0.362**	**0.992**	0.977	0.960	0.920	0.603
ST	0.819	**0.357**	**0.993**	0.979	0.960	0.920	0.598
TA	0.831	**0.329**	**0.981**	0.982	0.945	0.882	0.512
TD	0.795	**0.322**	**0.998**	0.992	0.961	0.914	0.552

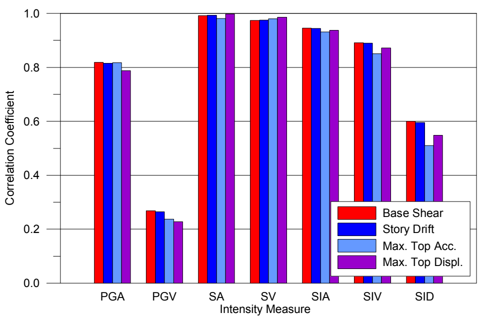

Fig. 3 Correlation coefficient of linear model IMs

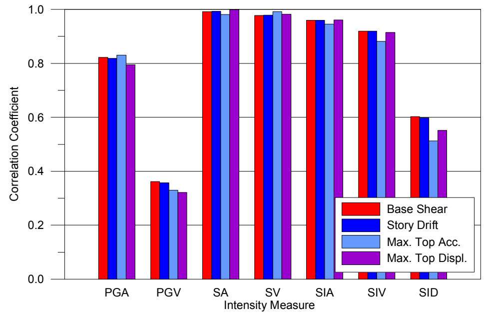

Fig. 4 Correlation coefficient of power model IMs

5. Conclusion

For an evaluation of the earthquake intensity measure for a seismic PSA, this study used 30 sets of near-fault ground motion records. Then regression analyses of the failure criteria for a KSNP containment building were carried out to evaluate a proper intensity measure by using two regression models and seven ground motion parameters. The regression analysis results demonstrate the correlation coefficients of the failure criteria in terms of the candidate IM. From the results, spectral acceleration (Sa) is considered as the best parameter for a evaluation of the intensity measure for a seismic PSA. Conversely, the use of PGV results in the poorest correlation.

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