SCALING OF GROUND MOTION RECORDS FOR NONLINEAR TIME HISTORY ANALYSIS OF STRUCTURES

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Nonlinear time history analysis is the most appropriate method for seismic analysis of structures that is being increasingly used. The results of this method strongly depend on the selected ground motion records and their scaling procedure. In order to achieve reliable analysis results, the ground motion records should be properly scaled so that lead to accurate estimation of the median values of the engineering demand parameters (EDPs) and reduction of the record-to-record variability in the EDPs.

In this paper a new method for scaling of ground motion records is proposed in which the nonlinear behavior of structures is considered. In the proposed method, named SSSP (Scaling based on Story Shear-based Pushover), the MDOF (Multiple Degree of Freedom) system is transformed to an equivalent inelastic SDOF (Single Degree of Freedom) system and the scaling is done in a way that the peak displacement of the equivalent inelastic SDOF system subjected to the scaled record, is equal to inelastic spectral displacement (target displacement).

The characteristic parameters of the equivalent inelastic SDOF system are determined through pushover analysis in which the load pattern is derived from the modal story shear profile of the structure. Therefore, the effect of the higher modes and interaction between them are considered in the equivalent inelastic SDOF system (Shakeri et al., 2010).

The target displacement is determined by averaging the values of the peak displacement of inelastic SDOF system subjected to a large number of unscaled ground motion records.

The proposed method was evaluated through a typical 8-Story structure and compared to the current scaling method in the Iranian 2800-code. The scaling of ground motion records was evaluated in two different methods denoted as 2800-a and 2800-b according to 2800-code. The analytical model was simulated regarding nonlinear behavior of the structure. 21 near-fault records were selected for this investigation (Kalkan and Chopra, 2010). The ground motions were divided into 3 sets each containing 7 records (listed in Table 1) and the efficiency and accuracy of the proposed method were separately evaluated for each set.

Figure 1-a shows the median values of EDPs determined by the nonlinear time history analysis of the structure subjected to the scaled records of set 1 against the benchmark values which is defined as the median value of the EDPs subjected to the 21 unscaled ground motions. As presented in this Figure, the SSSP method estimates median values of EDPs due to scaled records much closer to the benchmark values in comparison to the 2800-code scaling procedure.

The dispersion of EDPs due to scaled ground motions (set 1) is presented in Figure 1-b. As shown in this figure, the dispersion of EDPs due to the proposed scaling method is much smaller compared to the 2800-code scaling procedure. These results establish the accuracy and efficiency of the proposed procedure and demonstrate its superiority over the 2800-code scaling procedure.

Table 1. Selected Earthquake Ground Motions

No.	Earthquake	Year	Station	M	Rcl (km)	PGA (g)	Ground motion set number
1	Tabas, Iran	1978	Tabas	7.4	2.1	0.85	1
2	Imperial Valley	1979	EC Meloland Overpass FF	6.5	0.1	0.3	1
3	Imperial Valley	1979	El Centro Array #7	6.5	0.6	0.46	3
4	Superstition Hills	1987	Parachute Test Site	6.5	1.0	0.46	2
5	Loma Prieta	1989	LGPC	6.9	3.9	0.56	3
6	Erzincan, Turkey	1992	Erzincan	6.7	4.4	0.51	1
7	Northridge	1994	Jensen Filter Plant	6.7	5.4	0.59	2
8	Northridge	1994	Newhall - W Pico Canyon Rd	6.7	5.5	0.46	3
9	Northridge	1994	Rinaldi Receiving Sta	6.7	6.5	0.84	3
10	Northridge	1994	Sylmar - Converter Sta	6.7	5.4	0.61	1
11	Northridge	1994	Sylmar - Converter Sta East	6.7	5.2	0.83	2
12	Northridge	1994	Sylmar - Olive View Med FF	6.7	5.3	0.84	3
13	Kobe, Japan	1995	Port Island	6.9	3.3	0.26	1
14	Kobe, Japan	1995	Takatori	6.9	1.5	0.62	2
15	Kocaeli, Turkey	1999	Yarimca	7.4	4.8	0.35	2
16	Chi-Chi, Taiwan	1999	TCU052	7.6	0.7	0.35	1
17	Chi-Chi, Taiwan	1999	TCU065	7.6	0.6	0.81	2
18	Chi-Chi, Taiwan	1999	TCU068	7.6	0.3	0.57	3
19	Chi-Chi, Taiwan	1999	TCU084	7.6	11.2	1.16	1
20	Chi-Chi, Taiwan	1999	TCU102	7.6	1.5	0.3	2
21	Duzce, Turkey	1999	Duzce	7.2	6.6	0.54	3

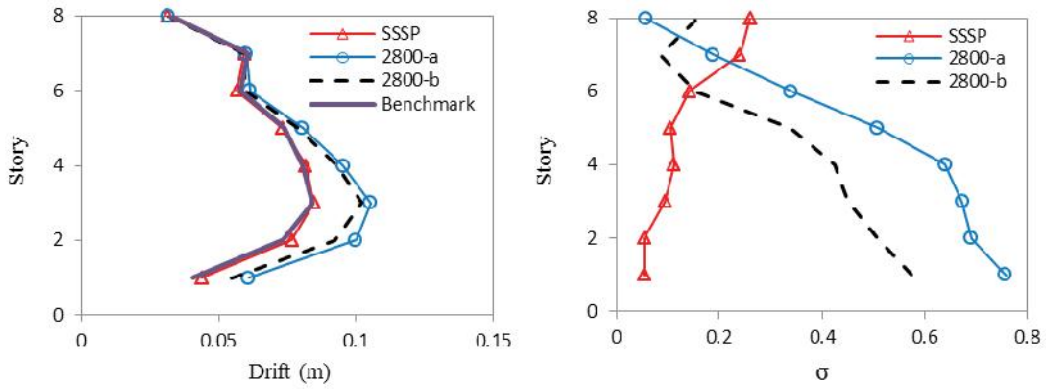

Figure 1. Median and Dispersion of EDPs for ground motion set 1 scaled according to SSSP and 2800-code procedures

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