Fişa suspiciunii de plagiat / Sheet of plagiarism's suspicion	Indexat la: 42/06

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Suspicious work	Authentic work

OS	Bibire, L., Cobrea, C.R., "Theoretical considerations about the influence of seismological parameters on high structure response", *Modelling and Optimization in the Machines Building Field (MOCM)*, vol.2, no.12, 2005, p.171-174.
OA	Iervolino, I., Cornell, C.A., "Record Selection for Nonlinear Seismic Analysis of Structures", *Earthquake Spectra*, vol.21, no.3, August 2005, pp.685-713. Disponibil la: http :// wpage . unina . it / iuniervo / papers / Iervolino_and_Cornell_SPECTRA.pdf.

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Record Selection for Nonlinear Seismic Analysis of Structures

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This study addresses the question of selection and amplitude scaling of accelerograms for predicting the nonlinear seismic response of structures. Despite the current practices of record selection according to a specific magnitude-distance scenario and scaling to a common level, neither aspect of this process has received significant research attention to ascertain the benefits or effects of these practices on the conclusions. This paper hypothesizes that neither these usual principal seismological characteristics nor scaling of records matters to the nonlinear response of structures. It then investigates under what conditions this hypothesis may not be sustainable. Two classes of records sets are compared in several case studies: one class is carefully chosen to represent a specific magnitude and distance scenario, the other is chosen randomly from a large catalog. Results of time-history analyses are formally compared by a simple statistical hypothesis test to assess the difference, if any, between nonlinear demands of the two classes of records. The effect of the degree of scaling (by first-mode spectral acceleration level) is investigated in the same way. Results here show (1) little evidence to support the need for a careful site-specific process of record selection by magnitude and distance, and (2) that concern over scenario-to-scenario record scaling, at least within the limits tested, may not be justified. [DOI: 10.1193/1.1990199]

INTRODUCTION

This paper presents a determinedly transparent study of the question of selection and scaling of accelerograms for predicting the nonlinear dynamic response of a structure at a specific site. The preferred current practice is to carefully select records that reflect the expected magnitude, distance, and other characteristics of the source of the events that are in some sense most likely to threaten the structure. The records are then typically scaled to some common representative level. Neither aspect of this process, neither selection nor scaling, has received significant research attention to ascertain their effects on the conclusions. This paper approaches these subjects inversely; it hypothesizes that neither the usual principal seismological characteristics nor scaling of records matters to the nonlinear response of structures. It then investigates under what conditions this hypothesis may not be sustainable. The study deals with *ordinary records*; softer soil site and specific near-fault effects, such as directivity-induced pulses, both of which may cause narrow-band response spectra are carefully avoided. Nonlinear analysis case stud-

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ies consider different periods, force-displacement characteristic relationships (backbones), ductility levels, and structural types. Sets of two classes of records are compared in each case: one class is carefully chosen to represent a specific magnitude and distance scenario (a "target set"), and another class is chosen randomly from a large catalog (an "arbitrary set") and scaled to match the target set in general amplitude. Results of time-history analyses are formally compared by a simple statistical hypothesis test to assess the difference, if any, between nonlinear demands of the two classes of records. The effect of the degree of scaling (by first-mode spectral acceleration level) is investigated in the same way. Results here show (1) little evidence to support the need for careful site-specific process of record selection by magnitude and distance, and (2) that concern over scenario-to-scenario record scaling, at least within the limits tested, may not be justified. This study does not explain the role of systematic spectral shape deviations, such as those due to soft soil, directivity, or scenarios calling for non-median ground motions.

MOTIVATION AND FRAMEWORK

The study is aimed at improving the bases for guidelines for earthquake engineering practice in terms of (1) characteristic that should be taken into account in accelerograms selection, (2) scaling of records in order to get scenario (target) intensity, and (3) sufficient size of record sets. Moreover, it will also shed light on other issues such as structural period and/or backbone sensitivity.

The current state of best practice (e.g., U.S. Nuclear Regulatory Commission 2001) in selecting accelerograms for assessing the nonlinear demand of structures is based on first disaggregating (McGuire 1995), by causative magnitude and distance (M and R), the site's probabilistic seismic hazard analysis (PSHA) for the level of spectral acceleration (at a period near that of the first mode of the structure) at a specified probability (say, a 2% chance of exceedance in 50 years). The records are then chosen to match within tolerable limits the mean or modal value of the M and R, i.e., the expected value or most likely value of these characteristics given that exceedance. The records may also be selected for the expected style of faulting type and soil type, but we shall focus on M and R. Finally, the records are usually scaled to match in some average way the uniform hazard spectrum (UHS) or, as it is often recommended, precisely to the UHS level at a period near that of the first period of the structure when the structure is known (Shome et al. 1998). Several observations can be made about this procedure. For example, it is an unstated but implicit assumption that all this care is taken about the selected records' earthquake properties (e.g., M and R) because they (may) matter to linear or nonlinear response. But little information on this effect is available from earthquake engineers to pass on to the seismologist responsible for the selection. Lack of knowledge of the influence of seismological parameters on the structural response has driven the seismologists to be prudent and assume that all features (magnitude, faulting style, etc.) matter to structural response, and so they do their best to provide records accordingly.

The question of how best to select records is equivalent to asking, What earthquake parameters do we have to try to match when selecting the records? The concept of parsimony in engineering practice implies that the easiest way to try to answer this question is by first assuming that "it doesn't matter," which is equivalent to saying that the choice of records is a non-issue. Then, whether and under what conditions this assumption cannot be sustained is evaluated by a large number of examples and cases studies. In this framework, several structural types are considered belonging to both single-degree-of-freedom (SDOF) and multi-degree-of-freedom (MDOF) systems. SDOF systems are chosen to vary across a range of periods, backbones, and target ductilities. The MDOF systems belong to moderate period structures and have been chosen to represent quite different structural configurations. They include older reinforced concrete structures and steel moment-resisting frames with brittle connections.

The following procedure is used to test the importance of considering M and R when selecting records. First, a "target" group of sets is selected from a narrow magnitude-distance (M-R scenario) bin of available records. Then three size 10 samples of target sets are selected; each has two subsets representing the two horizontal components, yielding a total of six samples of size 10. The target sets scenario is a comparatively high-M, small-R one. To minimize potential directivity effects all values of R are greater than 15 km. For each structure considered, these records in the sample target sets are scaled to their overall median spectral acceleration at the first-mode period. This intra-bin scaling has been shown to be a good practice with respect to reducing the variance of the results of nonlinear analyses without introducing bias (Shome et al. 1998). The reduced variance increases the power of the statistical test to follow.

Second, another group of records, referred to as "arbitrary sets," is considered. As will be discussed in more detail below, these arbitrary sets are characterized by having been chosen (almost) at random with respect to the same features, M and R, which were carefully considered in the target sets. Five size 10 samples are selected, the two horizontal components yielding a total of 10 arbitrary samples of size 10. The arbitrary sets are also scaled to the common median first-mode period spectral acceleration of the target sets in order to mimic how any selected set of records might be scaled to the design target response spectrum.

Third, the structure in question is subjected to a nonlinear dynamic analysis under each of the many records. Median responses are estimated for all 6 plus 10 (16) record sets. The median of each of the arbitrary sets is compared with each of the target sets (6 times 10, or 60 comparisons). The comparison of medians is statistical and performed by a simple, conventional hypothesis test (Benjamin and Cornell 1970). Consistent with the assumption that "record selection doesn't matter," the null hypothesis is that the ratio of arbitrary-set median response to target-set median response is unity, i.e., that the medians are equal.

The question of the effect of scaling proposed record sets (such as one of these arbitrary sets) to the desired level (e.g., that of the median of the target sets here) was addressed next. The 10 arbitrary sets did not require a degree of scaling significantly greater than 1 to reach the median of the six targets above. Therefore, another group of stronger target sets was constructed for this phase of the study. These were selected from records obtained within 15 km. As described below; care was taken to avoid records with significant directivity effects. In all other respects the same three steps above were repeated. The null hypothesis is, again, that such scaling "does not matter" (i.e., that median response to a scaled arbitrary set is the same as that median response to the target set).

CLASSES AND RECORDS

All the records used came from the Pacific Earthquake Engineering Research Center (PEER) database (http://peer.berkeley.edu/smcat/), ensuring uniform processing. However, all the accelerograms in both of the groups of sets have been selected with some boundary conditions in order to better reduce the influence of those factors that are not in the objective of the study. In particular, only California events have been considered, recorded on NEHRP C-D soil class and coming from free-field or one-story building instrument housing. These features make the records definable as "ordinary," avoiding site and housing response effects. Moreover, for addressing the selection issue, the records belong to the *far field* (defined here as closest distance to rupture greater than 15 km) in order to better avoid directivity pulse-type effects. Other features such as hanging/foot wall and fault mechanism are permitted to vary among the record sets considered, as they do not cause systematic peaks in the spectra. Next we address how the various record sets were selected from the "reduced" catalog defined above.

CLASS OF TARGET SETS

The target sets for the record selection study are designed to be representative of a specific scenario event (M and R) that might be the realistic threat at a particular site, here a moment magnitude 7 at 20 km, defined as closest distance to fault rupture. This target event was chosen to be as large and close as feasible, given the wish to have several samples of the target sets and given the limited number of large magnitude, close records in the catalog. (The records must also respect the general selection criteria presented just above.) In order to best represent what might occur in the future and to reduce correlation or "overlapping" due to event commonality, it is desirable to have the 10 records in each set come from 10 different events. This requirement conflicts with the desire to have a large target magnitude and to sample events close to the target in magnitude. The compromise was to use 5 events and 2 records per event. This decision led to 5 events with magnitude range 6.7 to 7.4. Starting from this point, 6 different sets of 10 records each have been arranged such that almost all the records are in the narrow distance range 20±5 km. The comparatively small sample size of 10 events in each set has been chosen because ten is the order of magnitude of size used in recommended earthquake engineering practice (which is typically as small as three to seven) (ICC 2000) (The total, or pooled, set of all records will also be considered, but the breakdown into sets of a more conventional size is considered more representative and hence more instructive and transparent.) Further, no two target sets have more than 1 record in common out of the 10; complete avoidance of overlap was not feasible because not all five events had the 12 records necessary to fill out the six target sets within or near the distance range. These selection limitations on events and records are designed to make the sets as nearly independent as possible given the limited number of records available.

Table 12. Ratio of medians drifts and standard errors for the T=0.1 sec bilinear SDOF. (Bold implies that the hypothesis test of equality is rejected at the 6% significance level.)

$\mu \approx 6$	NT1	NT2	$\mu \approx 2$	NT1	NT2
A1a	1.24	1.45	A1a	1.19	1.13
	0.37	*0.37*		*0.22*	*0.25*
A2a	0.87	1.00	A2a	1.06	0.99
	0.36	*0.37*		*0.18*	*0.22*
A3a	1.34	1.49	A3a	1.50	1.43
	0.39	*0.39*		*0.29*	*0.31*
A4a	1.19	1.24	A4a	1.35	1.26
	0.40	*0.42*		*0.27*	*0.30*
A5a	0.57	0.64	A5a	0.87	0.83
	0.36	*0.38*		*0.18*	*0.22*
A1b	1.24	1.42	A1b	1.43	1.36
	0.42	*0.42*		*0.29*	*0.31*
A2b	0.83	0.97	A2b	0.97	0.93
	0.36	*0.37*		*0.19*	*0.23*
A3b	1.30	1.57	A3b	1.31	1.24
	0.39	*0.39*		*0.27*	*0.30*
A4b	1.17	1.46	A4b	1.24	1.18
	0.37	*0.36*		*0.24*	*0.26*
A5b	0.65	0.74	A5b	0.90	0.86
	0.29	*0.30*		*0.15*	*0.19*
A	1.00	1.15	A	1.17	1.10
	0.28	*0.27*		*0.15*	*0.19*

SUMMARY OF CONCLUSIONS

Based on the investigation of the nonlinear response of a suite of model structures to sets of records selected to match a specific moderate-magnitude and distance scenario and other moderate-magnitude records selected arbitrarily, this study has found no consistent evidence to suggest that it is necessary to take great care in the selection of records with respect to such factors. The conclusion must be conditional on the characteristics of the uniform catalog available at the time of the study and on the selected magnitude limits. The magnitudes used were limited to moderate values (6.4 to 7.4) because (a) higher values (within the constraints cited above) were not available in the catalog, and (b) smaller values would in practice be unlikely to be chosen for a scenario event in the 7 range, as the catalog does not have an adequate number of 6.4 and larger events and records from which to choose a sample of typical size (10 or less). The mean magnitudes of the A and T sets are 6.6 and 7.1, respectively. The former number suggests, as expected, that the lower magnitudes in the range are more common than the larger. The latter number shows that the T set was indeed selected from the upper tail of the histogram of magnitudes in the catalog. The differential is 0.5 magnitude units. A

Table 13. Ratio of medians drifts and standard errors for the T=4 sec bilinear SDOF. (Bold implies that the hypothesis test of equality is rejected at the 6% significance level.)

$\mu \approx 6$	NT1	NT2	$\mu \approx 2$	NT1	NT2
A1a	**0.70**	**0.78**	A1a	**0.77**	0.99
	0.11	*0.09*		*0.10*	*0.06*
A2a	0.89	1.01	A2a	0.92	**1.18**
	0.15	*0.14*		*0.11*	*0.08*
A3a	0.79	0.88	A3a	**0.78**	1.01
	0.12	*0.12*		*0.11*	*0.07*
A4a	0.81	0.91	A4a	0.85	1.08
	0.14	*0.13*		*0.10*	*0.06*
A5a	**0.75**	0.83	A5a	**0.73**	0.93
	0.14	*0.13*		*0.11*	*0.07*
A1b	**0.80**	0.92	A1b	0.90	1.16
	0.11	*0.10*		*0.12*	*0.08*
A2b	0.93	1.04	A2b	0.94	**1.21**
	0.15	*0.14*		*0.11*	*0.07*
A3b	**0.70**	**0.76**	A3b	**0.79**	1.01
	0.11	*0.09*		*0.11*	*0.07*
A4b	**0.72**	0.85	A4b	**0.77**	0.98
	0.14	*0.12*		*0.13*	*0.10*
A5b	0.67	**0.77**	A5b	0.81	1.04
	0.34	*0.13*		*0.32*	*0.08*
A	**0.77**	*0.87*	A	**0.82**	1.06
	0.09	*0.07*		*0.09*	*0.04*

reduction of the lower bound to, say, 6 would have somewhat facilitated meeting the authors' restrictions, designed to avoid overlapping of the samples for the A sets, but it would not have helped the more challenging T set selection. This lower-bound change would have reduced the overlap between records in the T sets with those in the A sets, which would have been somewhat beneficial statistically; it also would have increased the differential in mean magnitudes, which would likely have been a stronger challenge to the posed null hypothesis. As stated, the choice of a lower magnitude of 6.4 was based on the argument that it was the practical choice, while being a full magnitude unit below the largest value.

With respect to distance, a larger catalog, such as that currently under development under PEER, or a larger selected maximum distance (50 kilometers was chosen for reasons analogous to those for the 6.4 lower limit on magnitude) would create a larger mean distance differential between the A and T sets, now 32 versus 25 kilometers. This would not likely cause a greater challenge to the hypothesis because distance per se is known to have little effect on nonlinear response. It would, however, create a larger differential in the mean spectral accelerations, causing a less transparent interaction between the dis-

Table A3. Scaling target sets

Set	Event	Station	Record/Component
NT1	Coalinga 1983/05/02 23:42	1162 Pleasant Valley P.P.—yard	COALINGA/H-PVY045
NT1	Coalinga 1983/05/02 23:42	1162 Pleasant Valley P.P.—yard	COALINGA/H-PVY135
NT1	Imperial Valley 1979/ 10/15 23:16	5054 Bonds Corner	IMPVALL/H-BCR230
NT1	Imperial Valley 1979/ 10/15 23:16	5028 El Centro Array #7	IMPVALL/H-E07230
NT1	Loma Prieta 1989/10/18 00:05	47125 Capitola	LOMAP/CAP000
NT1	Loma Prieta 1989/10/18 00:05	57007 Corralitos	LOMAP/CLS090
NT1	Northridge 1994/01/17 12:31	77 Rinaldi Receiving Sta	NORTHR/RRS228
NT1	Northridge 1994/01/17 12:31	74 Sylmar—Converter Sta	NORTHR/SCS142
NT1	N. Palm Springs 1986/ 07/08 09:20	5070 North Palm Springs	PALMSPR/NPS210
NT1	Superstitn Hills(B) 1987/ 11/24 13:16	5051 Parachute Test Site	SUPERST/B-PTS225
NT2	Imperial Valley 1979/ 10/15 23:16	5054 Bonds Corner	IMPVALL/H-BCR140
NT2	Imperial Valley 1979/ 10/15 23:16	5060 Brawley Airport	IMPVALL/H-BRA315
NT2	Imperial Valley 1940/ 05/19 04:37	117 El Centro Array #9	IMPVALL/I-ELC180
NT2	Landers 1992/06/28 11:58	22170 Joshua Tree	LANDERS/JOS000
NT2	Loma Prieta 1989/10/18 00:05	47381 Gilroy Array #3	LOMAP/G03000
NT2	Loma Prieta 1989/10/18 00:05	47006 Gilroy—Gavilan Coll.	LOMAP/GIL337
NT2	Northridge 1994/01/17 12:31	90053 Canoga Pk—Topanga Cyn	NORTHR/CNP196
NT2	Northridge 1994/01/17 12:31	90009 N. Hollywood—Coldwater Cyn	NORTHR/CWC180
NT2	Superstitn Hills(B) 1987/ 11/24 13:16	01335 El Centro Imp. Co. Cent	SUPERST/B-ICC000
NT2	Superstitn Hills(B) 1987/ 11/24 13:16	5051 Parachute Test Site	SUPERST/B-PTS225

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