Fişa suspiciunii de plagiat / Sheet of plagiarism's suspicion	Indexat la: 50/06

Opera suspicionată (OS) Suspicious work	Opera autentică (OA) Authentic work

OS	BIBIRE Luminița, COBREA Codrin Robert. Solution and amplitude scaling of accelerograms for predicting the nonlinear seismic response of structures. In: Modelling and Optimization in the Machines Building Field (MOCM). 11(**2**). 2005. p.167-170.
OA	IERVOLINO, I., CORNELL, C.A. Record Selection for Nonlinear Seismic Analysis of Structures, In: Earthquake Spectra. 3(**21**). August 2005, p.685-713. Available at: http :// wpage . unina .it / iuniervo / papers / Iervolino _ and _ Cornell _ SPECTRA . pdf.

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Incadrarea plagiatului se face din **Fişa de argumentare a faptei de plagiat** alăturată.

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Actualizat la 7 iulie 2015.

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Record Selection for Nonlinear Seismic Analysis of Structures

Iunio Iervolino[a),b)] **and C. Allin Cornell,**[b)] M.EERI

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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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.

The records in the target sets are named T1a, T1b, T2a, T2b, T3a, and T3b. Sets with a common number such as T1a and T1b contain components from precisely the same 10 three-component recordings. The "a" and "b" refer to the fact that one horizontal component is used in "a" and the other in "b." In Table A1 (see Appendix), records in T1a, T2a, and T3a are listed so that all target sets can easily be retrieved in the PEER online database.

CLASS OF ARBITRARY SETS

These sets were chosen effectively randomly from the catalog without regard to magnitude or distance subject only to the general constraints presented above (California, soil type, and distance). The *arbitrary sets* are 10 sets of 10 records each.[1] They come from California events in a comparatively wide range of moderate magnitudes ($6.4 < M < 7.4$) and distances ($15 < R < 50$ km). The records in each set are chosen randomly (*without* replacement) first from the list of events, ensuring 10 different events in this case, and then from the available distances within each selected event to the degree possible; because of limits on the number of recordings/distances in such event, it was necessary to have two records from one event in some cases in order to construct 10 arbitrary sets. The upper bound is the limit of the catalog; the lower bound of 6.4 was selected because it is a full magnitude unit below the upper value and because there are sufficient events and records in the catalog that in practical application one need go no lower than this to have a large sample from which to select the relatively few records (3 to 10) that are needed in an application.

The sets in the arbitrarily chosen group are named from A1a, A1b to A5a, A5b. The "a" and "b" apply as above. Records belonging to A1a–A5a are reported in Table A2 (see Appendix).

In short, unusual care has been taken in selecting records in the A and T sets to make the individual samples within the A and T sets as nearly random and exclusive (non-overlapping) as possible. The A and T sets, of course, overlap one another. Details about these sets' M-R differences and similarities may be found elsewhere (Iervolino 2004); they are also discussed in the conclusions section below.

DESIGN OF ANALYSES AND CASE STUDIES

To establish the validity of the (over) simply stated hypothesis that "it does not matter how one selects records," a series of structures have to be chosen. In order to make the conclusions of the study broad, wide-ranging cases have been considered. The different structural features considered to be most meaningful to be investigated are as follows: (1) first natural period, (2) force-deformation or hysteresis relationship, (3) target ductility, (4) number of degrees of freedom, and (5) structural type (concrete or steel). For each of these factors a wide range has been considered in order to help establish the limits of acceptance of the hypothesis.

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[1] One of the A sets (A5) is actually made of nine accelerograms since one of the chosen stations has only one recorded component; A5b is therefore made up of only nine elements.

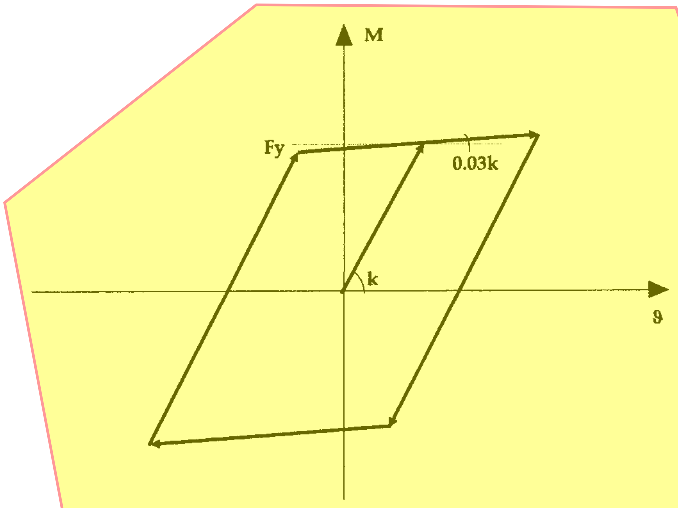

Figure 1. SDOF bilinear hysteresis.

SINGLE-DEGREE-OF-FREEDOM SYSTEMS

Three different periods SDOF systems have been considered: very short (0.1 sec), moderate (1.5 sec), and very long (4 sec), in order to investigate if conclusions reached at moderate periods seem to hold at extreme periods. Most nonlinear SDOF system study is based on simple bilinear systems with a second stiffness equal to 3% of the first; see Figure 1 for a hysteresis rule example.

For each of the three periods, two yield strengths are selected to give median duc-

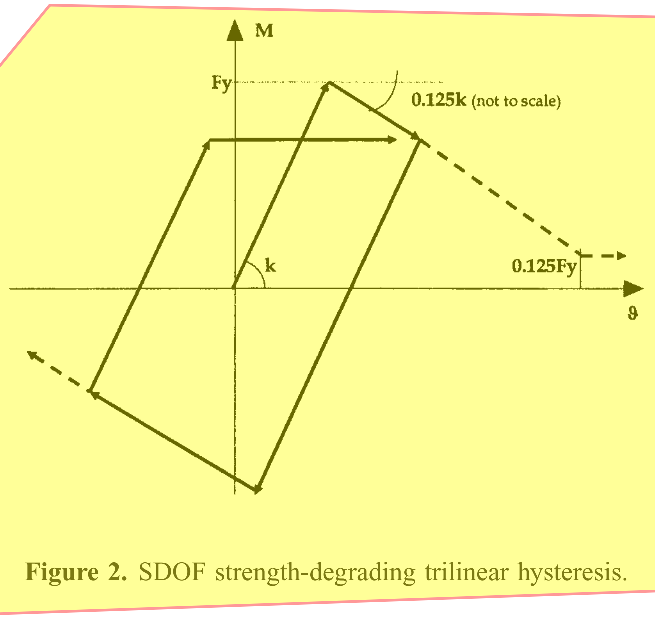

Figure 2. SDOF strength-degrading trilinear hysteresis.

tility of approximately 2 and 6 under the target records. Viscous damping is always 5% of critical. For the most interesting moderate period case (T=1.5 sec case), a second trilinear backbone with a degrading strength branch (see Figure 2) is considered, again with two strength levels. Table 1 summarizes the SDOF structural configurations analyzed under both the target and the arbitrary groups of sets.

MULTIPLE-DEGREE-OF-FREEDOM SYSTEMS

Both of the MDOF structural models are moment-resisting frames, one of reinforced concrete (RC) and one of steel. The former is an older, nonductile RC building in Van Nuys, California, studied as part of the PEER testbed program (Porter et al. 2002), while the other structure is the nine-story Los Angeles SAC steel building (Gupta and Krawinkler 1999) with brittle connections (Luco and Cornell 2000).

The reinforced concrete structure is modeled with strength-degrading moment and shear behavior in the nonlinear range of the member-end hinges. The Van Nuys building is a seven-story, 6,200-m^2 (66,000-sf) hotel located in the San Fernando Valley (Southern California). The hotel was built in 1966; its design refers to the 1964 Los Angeles City Building Code. The plan view of the building is rectangular, 21 m (63 ft) by 50 m (150 ft), three bays by eight bays, seven stories tall (see Figure 3). The reinforcing steel lacks modern ductile detailing. Moment frames along the perimeter provide the primary seismic force resistance. See the Van Nuys Testbed Committee (2002) for details. A two-dimensional (2-D) model of the transverse frame has analyzed here by DRAIN-2D software (Jalayer 2003). Its transverse vibration has a dominant period of about 0.85 sec.

The other analyzed MDOF is a 2-D model of the SAC LA-9 frame. It is one of the structures considered as part of the SAC steel project, designed to the 1994 *Uniform Building Code* (Figure 4). The nine-story benchmark structure is 45.73 m (150 ft) by 45.73 m (150 ft) in plan, and 37.19 m (122 ft) in elevation. The bays are 9.15 m (30 ft) on center, in both directions, with five bays each in the north-south and east-west directions (Gupta and Krawinkler 1999). The first natural period of this building is between 1.5 and 2 sec, corresponding to the moderate period SDOF already considered. The fracture of the "pre-Northridge" brittle connections is introduced into the DRAIN-2DX program using rotational spring elements at the ends of each elastic beam. The element was developed by Foutch and Shi (2002).

ANALYSES

The SDOF and MDOF cases presented have been analyzed with the groups of sets described as input. The considered response parameter is the peak in-time drift for the

Table 1. SDOF cases

Period	T=1.5 sec				T=0.1 sec		T=4 sec	
Backbone	Bilinear		Trilinear		Bilinear		Bilinear	
Ductility	2	6	2	6	2	6	2	6