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To: "Greg Hardy" <ghardy@arescorporation.com>, "Kassawara, Bob" <RKASSAWA@epri.com>, "Robert Kennedy" <bob@rpkstruct.com>, <dpmoore@southernco.com>, "Gurbuz, Orhan" <ogurbuz@bechtel.com>, <cij@nei.org>, <ajm1@nrc.gov>, <gxb1@nrc.gov>, <wrschmidt@direcway.com>, <saa3@nrc.gov>
Date: 8/19/05 9:48PM
Subject: RE: ESP Working Meetings at ARES Offices, June 22-23

Per my email yesterday on sending some material in advance of the meetings next week, I am attaching two documents for your review:
1) Power Point with a few slides on the S2.1 task. The key piece of this is some of the results from the results of the Benchmark study comparing the results of the CLASSI analyses on the benchmark problem to the SASSI results. As you can see for the cases without wave passage effects, the comparisons are nearly exact. We have also shown the effects to a typical response spectrum on Rock using the appropriate reductions for incoherence. We will be going over this in detail on Wednesday but this give everyone a chance to review it a bit before the meeting.
2) I have also attached a copy of Norm's writeup on the CAV model for task G1.2. I believe that some of you have already seen this writeup but others may not have had a chance to review it yet.
See you all on Tuesday.
Greg

<<cav_paper_draft00.doc>> <<Task 2 1 Incoherency.ppt>>

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From: Greg Hardy
Sent: Thursday, August 18, 2005 7:37 PM
To: Greg Hardy; 'Kassawara, Bob'; 'Robert Kennedy'; 'dpmoore@southernco.com'; 'Gurbuz, Orhan'; Cedric Jobe (cij@nei.org); ajm1@nrc.gov; Goutam Bagchi (gxb1@nrc.gov); William Schmidt (wrschmidt@direcway.com); Syed Ali (saa3@nrc.gov)
Cc: 'jasjjoh@aol.com'; Steve Short; 'Norm Abrahamson'; Kelvin L. Merz; 'Ostadan, Farhang'; 'John M Richards'; Dee Woods; 'Sandell, Layla'
Subject: RE: ESP Working Meetings at ARES Offices, June 22-23

Gentlemen,
The meetings in our offices next week are scheduled for Tuesday and Wednesday August 23 and 24. These are working meetings and the schedule is flexible, but I have attached a draft agenda for the two days meetings in the PowerPoint file. Goutam will be attending by phone

due to travel conflicts, but both Andy and Syed Ali from the NRC will be attending in person.
Please come business casual, this is a working meeting. We will be meeting in our larger ground floor conference room for both days of the meeting (to the left as you come in the door, there will be a sign on the room). The meeting will start at 9AM on both Tuesday and Wednesday to allow for those flying in from Northern California to reach the office. I would estimate that we would end the meeting sometime late Thursday afternoon, pending the discussion length with both TRAG and the NRC.
I have attached a map of the area showing the location of the ARES office for those of you that have not been here before (there are two slide in power point, one is the area and one is a close up of our office location). If you are staying at either of the Double Tree hotels near our office it is an easy walk to our building. If you are driving there is a parking garage next to our building.
I have also attached a presentation that Kelly did that will walk you thought the process of using the response reduction procedure for S2.2 in case you want to spend some time getting up to speed before the meeting. It is the second bullet under S2.2 Current Project activities on the agenda for Tuesday. I will also send out some results tomorrow on the benchmark problem for S2.1. Let me know if you have any questions and I look forward to seeing most of you next week.
Thanks Greg
<< File: ARES map detail.ppt >> << File: August 23-24 2005 ARES ESP Mtg Agenda .ppt >> << File: Task 2 2 Applied Reduce.ppt >>

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Use of Minimum CAV in Seismic Hazard Analyses

N. Abrahamson and J. Watson-Lamprey

Abstract

1 Introduction

2 Empirical Model of CAV for WUS

2.1 Definition of CAV

The parameter CAV is given by the integral of the absolute value of acceleration. To make the CAV value insensitive to the coda waves (small amplitudes that can continue on for a long time after the strong shaking), Reed and Kennedy (1988) restricted the integration for computing CAV to 1-second time windows that included a PGA of at least 0.025g. This definition of CAV is given by:

$$CAV = \sum_{i=1}^{N} H(pga_i - 0.025) \int_{t=t_i}^{t_i+1} |a(t)| dt$$

where N is the number of 1-second time windows in the time series, pga_i is the peak ground acceleration in time window i, t_i is the start time of time window i, and H(x) is the Heaviside function (unity for x>0 and 0 otherwise).

2.2 Empirical Data Set

The PEER NGA data set consists of 3551 recordings from 173 earthquakes in active shallow crustal regions of the world. From this primary dataset individual earthquakes and records were taken out to form the final data set that was used for the analyses. A description of the earthquakes removed as well as the reason can be found in Appendix A. The data set used for this research can be found in Appendix B.

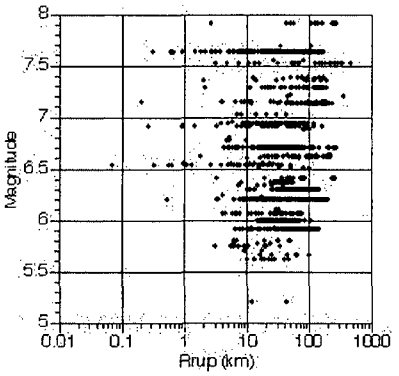


Figure 1. Plot of mag-distance pairs.

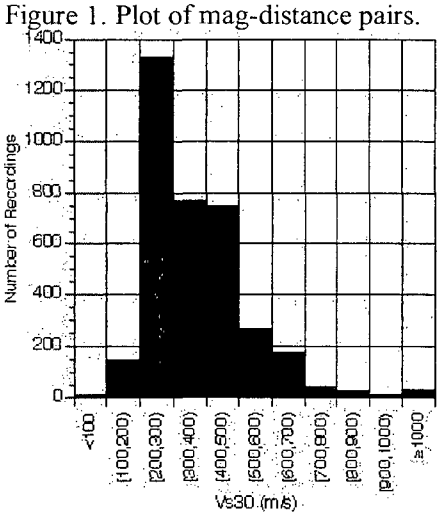


Figure 2. Plot of distribution of vs30 values

2.3 Model for CAV

The CAV at the surface was calculated for all records in the NGA PEER data set. The results for all components whose CAV value is greater than zero are shown in Figures 3 and 4.

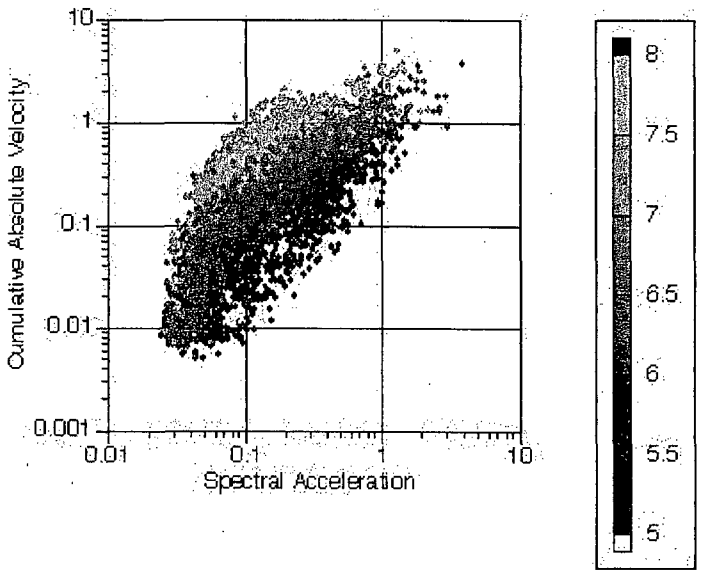


Figure 3. Plot of CAV vs Sa, separated by Magnitude for 10 Hz

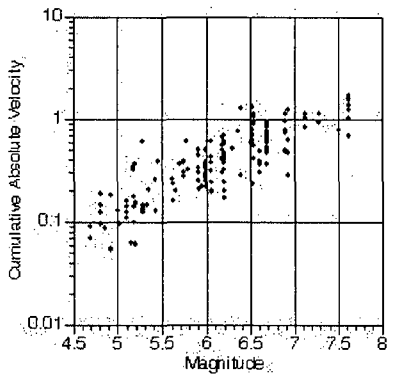


Figure 4. Plot of CAV vs Mag for 0.4g < Sa < 0.5g for 10 Hz

These plots show that the CAV depends strongly on spectral acceleration and earthquake magnitude and it is approximately lognormally distributed. Using the ln(CAV) as the dependent variable requires that we eliminated all of the cases with zero CAV. The CAV is zero if the PGA of the recording is less than 0.025g. This reduces the data set to 4423 recordings from 141 earthquakes. Therefore, the model derived here is conditional on the peak acceleration being greater than 0.025g. To account for this condition, an additional term is added to the CAV model to account for the probability of the PGA being less than 0.025g for a given spectral acceleration and magnitude, This is discussed below in section 2.4.

The model for median CAV given that the PGA is greater than 0.025g is given by

where Sa(f) is spectral acceleration in g, M is the moment magnitude, Vs30 is the shear-wave velocity in m/s and Rrup is the shortest distance to the rupture surface in km. The coefficients for this model can be found in Table 1.

The residuals from this model are shown in Figures 5 – 8.

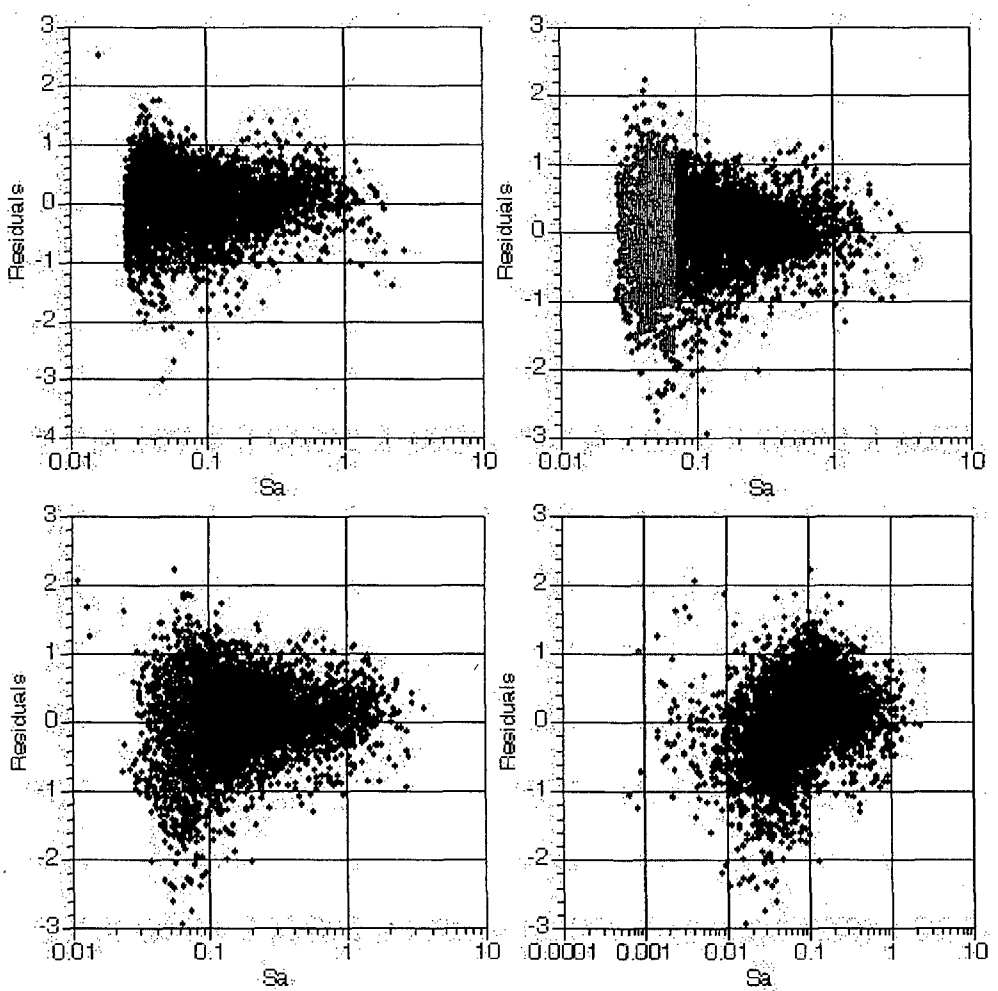


Figure 5 Residuals vs Sa for 20 Hz, 10 Hz, 5 Hz and 1 Hz

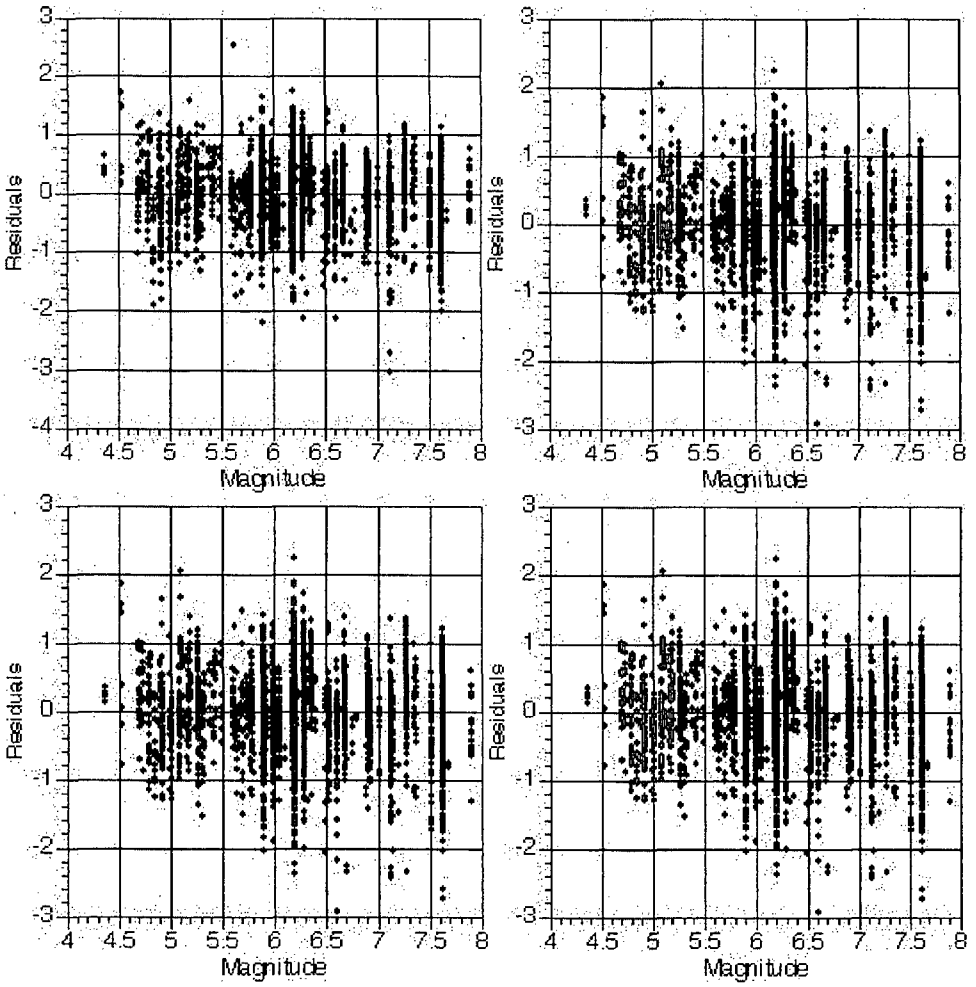
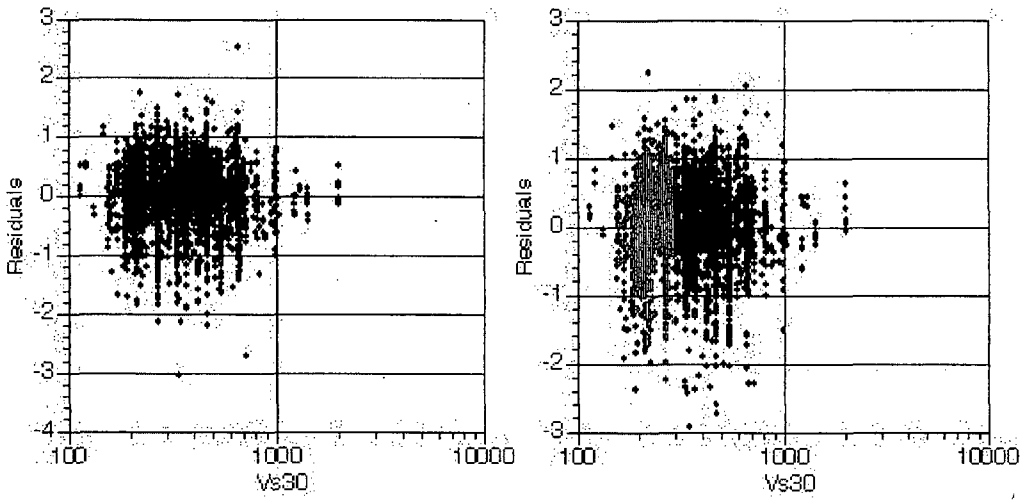


Figure 6 Residuals vs M for 20 Hz, 10 Hz, 5 Hz and 1 Hz



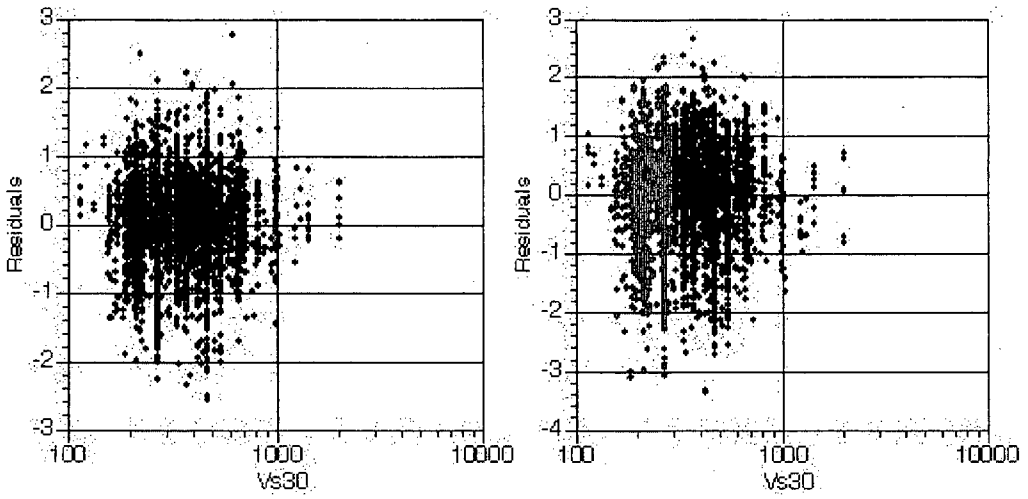


Figure 7 Residuals vs ln(vs30) for 20 Hz, 10 Hz, 5 Hz and 1 Hz

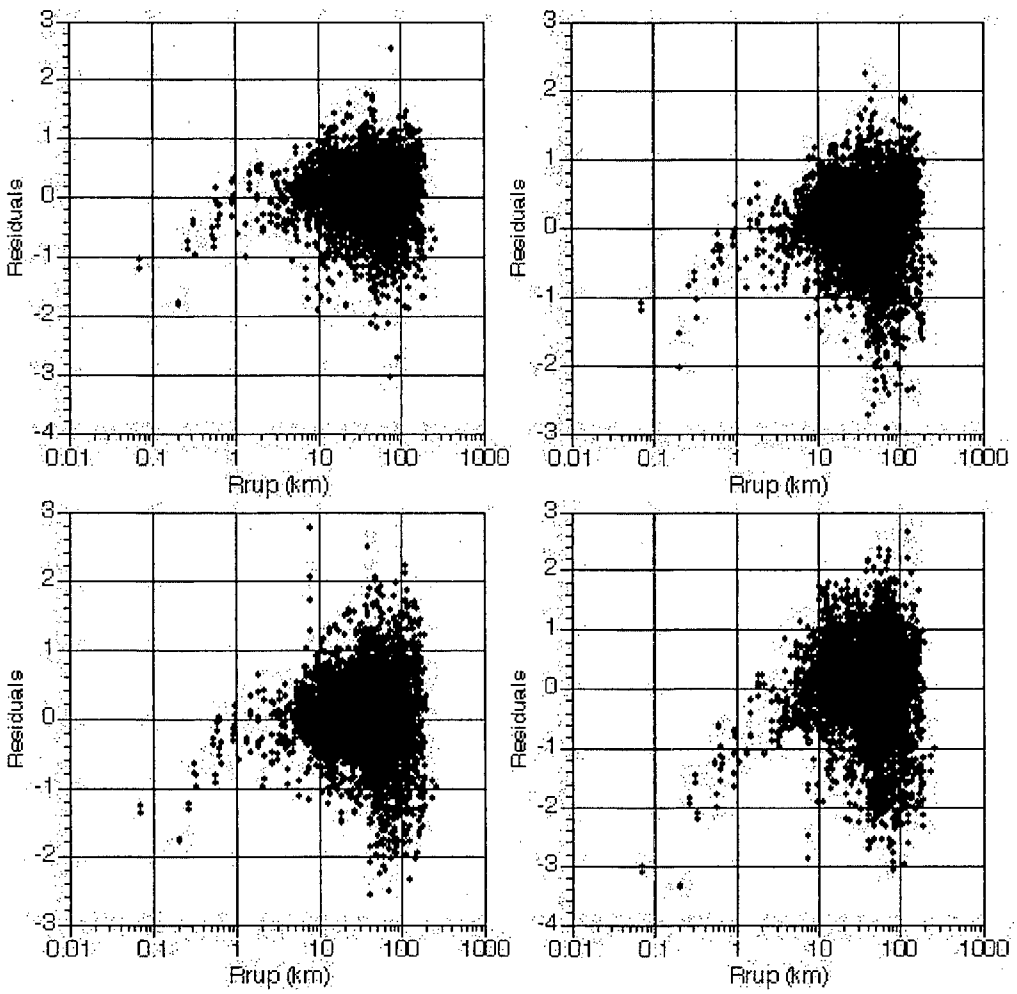


Figure 8 Residuals vs distance for 20 Hz, 10 Hz, 5 Hz and 1 Hz

The standard deviation as a function of Sa is plotted in Figure 9. This figure shows that the data are heteroscedastic. Based on the Sa dependence, the functional form for the standard deviation is given by:

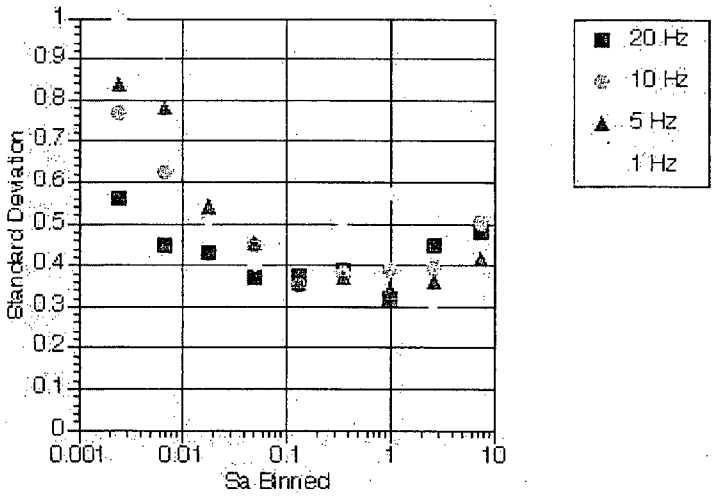


Figure 9 Standard deviation as a function of Sa for 20 Hz, 10 Hz, 5 Hz and 1 Hz

A regression analysis was performed using Maximum likelihood using this model for variable standard deviation. The resulting coefficients are listed in Table 2.

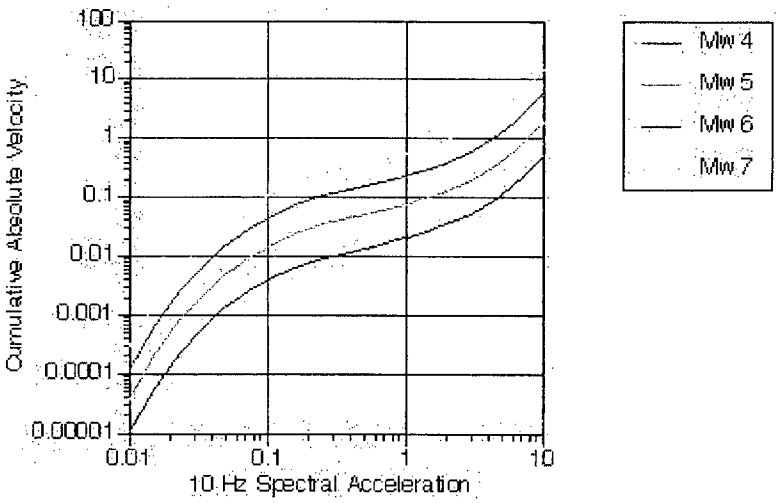


Figure 10 CAV model results for Rrup = 15km and Vs30 = 2800 m/s

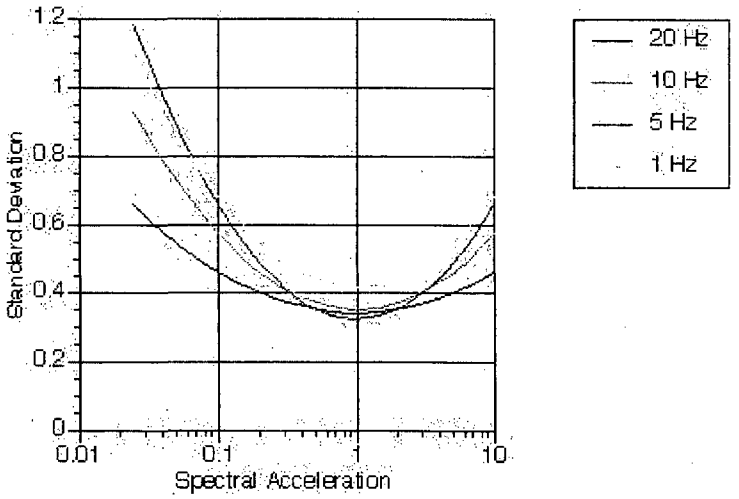


Figure 11 CAV model Standard Deviation

2.4 Model for P(pga>0.025g)

Since the above CAV model is conditional on the PGA being greater than 0.025g, a complete model for CAV needs a second term for the probability of PGA>0.025g given the spectral acceleration and the magnitude. The following functional form was used to model the PGA:

The data set used to estimate the coefficients is the same as that for the CAV model, but with the addition of the records with zero CAV. This expanded the data set to 6784 recordings from 141 earthquakes. The coefficients for this model can be found in Table 3.

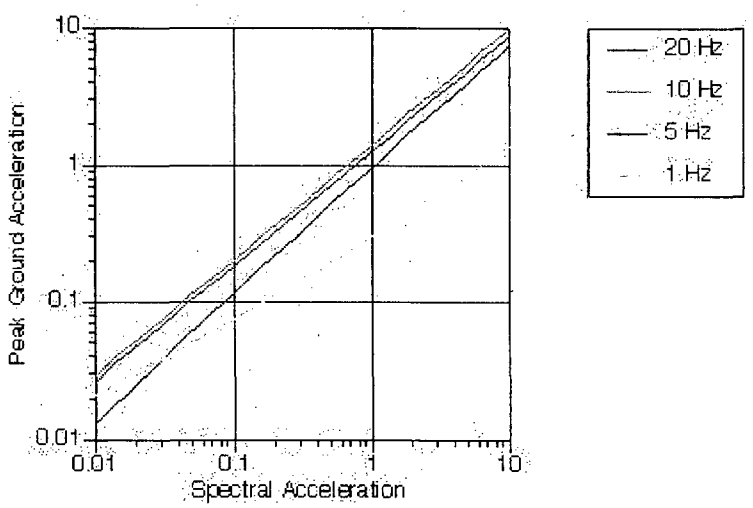


Figure 12 PGA model for Mw = 6, Rrup = 15 km and Vs30 = 2800 m/s

2.5 Probability of Exceeding specified CAV value

Using the two models developed above, the probability of exceeding a CAV value of 0.016g-sec is given by

where F(z) is the cumulative normal distribution and e_{CAV} is the number of standard deviations in the CAV model that will yield 0.16g-sec.

3 Comparison with Empirical Recordings from EUS Earthquakes

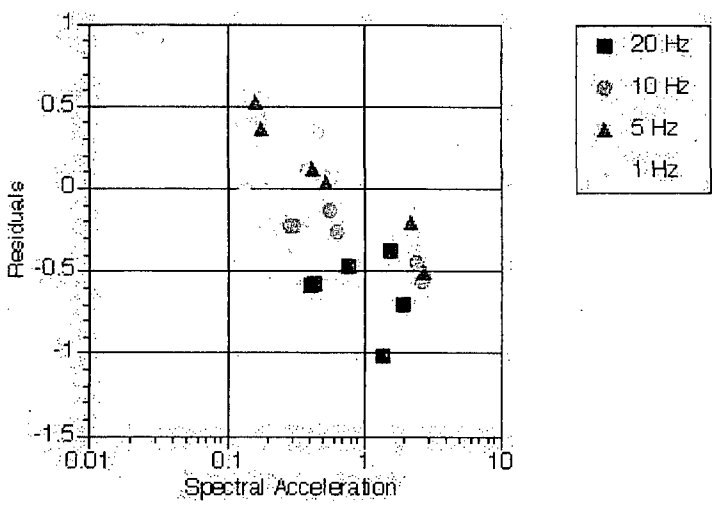


Figure 13 Nahanni Residuals

Figure 14 Saguenay Residuals

Compute CAV values from Saguenay data. Plot residuals from Saguenay earthquake as compared to WUS model. Plots with Sa on the x-axis, CAV residual on y-axis

See list of EUS recorded ground motions given in Toro et al (1997)
Compute CAV residuals from these data in addition to Saguenay.

If warranted, develop simple scale factor to adjust model from WUS to EUS

4 CAV from the Point Source Stochastic Model for EUS

4.1 Background of use of point source model in EUS

4.2 EUS model parameters

4.3 Application of point source model to generate set of time series

4.4 Comparson of CAV from simulations with WUS model

4.5 More elegant solution using RVT directly

5 Methodology for Application of Minimum CAV in Seismic Hazard Analyses

The CAV models given above can be easily used to modify the results from a standard hazard analysis to remove the earthquakes that have no damage potential.

A standard hazard analysis will yield a hazard curve, $\nu(Sa_{Rock}(f)>z_k)$, and the deaggreagation, $Deagg(M_i<M<M_{i+1}, R_j<R<R_{j+1}Sa(f)>z_k)$. Using these two pieces of information, we can compute the rate of occurrence of spectral acceleration over a small acceleration range from a specified magnitude and distance range:

$$\nu(z_1 <$$

Let ν' be the hazard curve for potentially damaging ground motions (CAV>0.16g-sec), then

The deaggregation for the CAV filter hazard curve is given by:

Deagg'(M

6 Example Application

7 References

McCann, M. W. and J. W. Reed (1989). Proceedings: Engineering Characterization of Small-Magnitude Earthquakes, EPRI Report NP-6389, June 1989.

Reed (1988). A criterion for determining exceedance of the operating basis earthquake, EPRI Report NP-5939, July 1988.

Table 1.

	Frequency (Hz)										
Parameter	25	20	15	10	6.667	5	3.333	2.5	2	1.5	1
a_1	-3.7209	-3.7837	-3.9032	-4.1671	-4.6662	-3.6163	-3.6064	-3.4818	-3.3178	-2.9521	-2.5554
a_2	0.7940	0.8257	0.8734	0.9202	0.9024	0.8296	0.7233	0.6416	0.5654	0.4700	0.4165
a_3	-0.1561	-0.1652	-0.1592	-0.0977	-0.0570	-0.0559	-0.0308	-0.0276	-0.0559	-0.0417	-0.0613
a_4	2.9674	2.9326	2.7950	2.5437	2.7034	2.6108	2.4599	2.4785	2.4163	2.2628	2.2631
a_5	-1.0456	-1.0101	-0.8959	-0.6934	-0.6822	-0.9050	-0.7591	-0.7908	-0.8043	-0.7921	-0.9483
a_6	0.1439	0.1359	0.1144	0.0801	0.0726	0.1303	0.0979	0.1022	0.1094	0.1085	0.1432
a_7	-0.3696	-0.3966	-0.4378	-0.4097	-0.3823	-0.3513	-0.2480	-0.2129	-0.1821	-0.1390	-0.0983
a_8	-0.1355	-0.1457	-0.1621	-0.1733	-0.1865	-0.1924	-0.2257	-0.2393	-0.2442	-0.2958	-0.3730
x	-3.5	-3.5	-3.5	-3.5	-3.5	-2.8	-2.8	-2.8	-2.8	-2.8	-2.8
y	0	0	0	0	0	0.0608	0.0608	0.0608	0.0608	0.0608	0.0608

Table 2. CAV Standard Deviation Model Coefficients

	Frequency (Hz)										
Parameter	25	20	15	10	6.667	5	3.333	2.5	2	1.5	1
b1	0.3113	0.3395	0.3555	0.3490	0.3284	0.3203	0.3228	0.3179	0.3137	0.3386	0.4161
b2	0.0235	0.0233	0.0273	0.0424	0.0580	0.0631	0.0711	0.0670	0.0647	0.0635	0.0500

Table 3. Sa to PGA Model Coefficients

	Frequency (Hz)										
Parameter	25	20	15	10	6.667	5	3.333	2.5	2	1.5	1
c_1	-	-	0.2254	0.1819	0.1237	-	-0.5165	-0.6363	-0.7151	-0.8531	-0.7567
c_2	0.0545	0.0840	0.1470	0.1983	0.1871	0.1268	0.0452	-	-0.0286	-0.0649	-0.0341
c_3	0.9186	0.8995	0.8492	0.8420	0.8289	0.8354	0.8620	0.8519	0.8708	0.7902	0.6301
c_4	-0.0074	-0.0075	-0.0072	-	-	-	0.0092	0.0142	0.0277	0.0219	0.0129
c_5	-0.0405	-0.0578	-0.1065	0.1154	-0.1122	-0.0904	-	0.0289	0.0558	0.0956	0.1033
c_6	-	-	-0.0448	0.0967	-0.1478	-0.1506	-0.0844	-0.0215	0.0282	0.0842	0.1141
c_7	-	-	-	0.0027	0.0043	-	-0.0197	-0.0379	-0.0530	-0.0738	-0.0990
sigma	0.1155	0.1581	0.2113	0.2642	0.2875	0.2974	0.3346	0.3794	0.4205	0.4644	0.5352

Appendix A

Data Introduction:

From this primary data set individual earthquakes and records were taken out to form the final data set that was used for the analyses.

EARTHQUAKES

Earthquakes were removed if the M was less then 5.0 or if the source of the earthquake was in a region other than shallow crustal.

M5.0

Individual earthquakes from the Flat file were used if the moment magnitude of the event was greater than or equal to M 5.0. The Table 1 lists the fifteen earthquakes that were removed.

Source Location

Individual earthquakes from the Flat file were used if the epicenter of the earthquake was located in the shallow crustal region. Table 2 lists nineteen the earthquakes that did not met this criteria.

TAIWAN SMART1

Taiwan SMART1 earthquakes were removed for ? Table 3 lists the Taiwan SMART 1 Earthquakes.

RECORDINGS

Individual recordings from the Flat file were used if they were considered a reliable estimate of free-field ground motion. The factors considered for this criterion were the validity of the Vs30 and the structure type.

SITE CLASSIFICATION

Soft soil sites historically have been inconsistent in the behavior of the recorded ground motions, in our analyses sites with $V_{S,30}$ less than 180 m/s, which made up 54 recordings, were removed. Table 4 lists 54 recordings with $V_{S,30}$ less than 180 m/s.

INSTRUMENT LOCATION.

The instrument structure can also influence the ground motion recording. Geomatrix C1 structure classification sites C, E, F, and G are considered to be structures that would significantly affect the recording and 107 recordings from these structures were removed. The description of these structure classifications are as follows: Geomatrix site class C classifies a two to four story structure of lightweight construction where the instrument is located at the lowest level in a basement and below the ground surface; Geomatrix site class E classifies five or more stories of heavy construction where the instrument is located at the lowest leveling a basement and below the ground level; Geomatrix site class F classifies a structure housing an instrument buried below the ground surface; Geomatrix site class G classifies a structure of light or heavy weight construction, where the instrument is not at the lowest level. Table 5 lists the 107 recordings with Geomatrix

structure classification C, E, F, and G.

STATIONS

Several stations were considered unreliable? Table 6 lists the stations that were considered unreliable.

MISSING INFORMATION

Recordings were also removed from the primary data set if the Vs30 of the site along with the Geomatrix site class C3 was missing. Vs30 missing measurements were substituted with a best estimate Vs30 value based on the known C3 site class. If the Geomatrix C3 class was also missing there was no other method employed to approximate an estimate of the Vs30 for the site and therefore, thus the recording was removed. Table 7 lists the recordings that were removed for this reason.

UNRELIABLE DATA

_Recordings that were removed if the data in general was considered to be unreliable. Table 8 lists the recordings that were considered unreliable.

EARTHQUAKES REMOVED

Table 1 – Magnitude less than 5.0

EQ#	EQ Name	Magnitude (Mw)	No. of Records for the EQ
37	Oroville-02	4.79	2
38	Oroville-04	4.37	3
39	Oroville-03	4.7	9
62	Mammoth Lakes-07	4.73	6
63	Mammoth Lakes-08	4.8	8
65	Mammoth Lakes-09	4.85	9
70	Irpinia, Italy-03	4.7	1
81	Coalinga-06	4.89	2
139	Stone Canyon	4.81	3
161	Big Bear-02	4.53	43
163	Anza-02	4.92	73
166	Gilroy	4.9	36
167	Yorba Linda	4.8	12

Table 2 – Source Location

EQ#	EQ Name	No. of Records for the EQ
3	Humbolt Bay	1
5	Northwest Calif-01	1
7	Northwest Calif-02	1
8	Northern Calif-01	1
11	Northwest Calif-03	1
13	Northern Calif-02	1
17	Northern Calif-03	1
22	Northern Calif-04	1
26	Northern Calif-05	1
35	Northern Calif-07	5
67	Trinidad	3
84	Trinidad offshore	2
93	Pelekanada, Greece	1
96	Drama, Greece	2
142	St Elias, Alaska	2

Table 3 – Taiwan SMART1

EQ#	EQ Name	No. of Records for the EQ
86	Taiwan SMART1(25)	9
95	Taiwan SMART1(33)	7
100	Taiwan SMART1(40)	8
109	Taiwan SMART1(45)	15

RECORDINGS REMOVED

Table 4 – Site Classification

Record	EQ#	EQ Name	$V_{S,30}$ (m/s)
178	50	Imperial Valley-06	162.94
201	51	Imperial Valley-07	162.94
452	90	Morgan Hill	116.35
608	113	Whittier Narrows-01	160.58
732	118	Loma Prieta	133.11
759	118	Loma Prieta	116.35
760	118	Loma Prieta	126.40
780	118	Loma Prieta	169.72
808	118	Loma Prieta	155.11
831	124	New Zealand-04	150.00
962	127	Northridge-01	160.58
1147	136	Kocaeli, Turkey	175.00
1212	137	Chi-Chi, Taiwan	172.10
1228	137	Chi-Chi, Taiwan	169.84
1229	137	Chi-Chi, Taiwan	160.67
1247	137	Chi-Chi, Taiwan	175.68
1310	137	Chi-Chi, Taiwan	124.27
1334	137	Chi-Chi, Taiwan	158.13
1357	137	Chi-Chi, Taiwan	155.32
1599	138	Duzce, Turkey	175.00
1843	160	Yountville	133.11
1846	160	Yountville	155.43
1852	160	Yountville	169.72
1861	160	Yountville	155.43
1866	160	Yountville	155.43
2040	166	Gilroy	155.43
2178	171	Chi-Chi, Taiwan-02	172.10
2192	171	Chi-Chi, Taiwan-02	169.84
2193	171	Chi-Chi, Taiwan-02	160.67
2209	171	Chi-Chi, Taiwan-02	175.68
2266	171	Chi-Chi, Taiwan-02	124.27
2284	171	Chi-Chi, Taiwan-02	158.13
2476	172	Chi-Chi, Taiwan-03	172.10
2492	172	Chi-Chi, Taiwan-03	169.84
2493	172	Chi-Chi, Taiwan-03	160.67
2510	172	Chi-Chi, Taiwan-03	175.68
2561	172	Chi-Chi, Taiwan-03	158.13
2718	173	Chi-Chi, Taiwan-04	172.10

2736	173	Chi-Chi, Taiwan-04	169.84
2737	173	Chi-Chi, Taiwan-04	160.67
2755	173	Chi-Chi, Taiwan-04	175.68
2818	173	Chi-Chi, Taiwan-04	150.18
2958	174	Chi-Chi, Taiwan-05	172.10
2975	174	Chi-Chi, Taiwan-05	169.84
2976	174	Chi-Chi, Taiwan-05	160.67
2990	174	Chi-Chi, Taiwan-05	175.68
3044	174	Chi-Chi, Taiwan-05	124.27
3062	174	Chi-Chi, Taiwan-05	158.13
3091	174	Chi-Chi, Taiwan-05	150.18
3285	175	Chi-Chi, Taiwan-06	172.10
3302	175	Chi-Chi, Taiwan-06	169.84
3303	175	Chi-Chi, Taiwan-06	160.67
3319	175	Chi-Chi, Taiwan-06	175.68
3403	175	Chi-Chi, Taiwan-06	150.18

Table 5 – Instrument Structure

Record	EQ#	EQ Name	GMX's C1 - Instrument Structure
1	1	Helena, Montana-01	E
2	2	Helena, Montana-02	C
4	4	Imperial Valley-01	E
6	6	Imperial Valley-02	E
9	9	Borrego	E
10	10	Imperial Valley-03	E
13	12	Kern County	C
14	12	Kern County	C
15	12	Kern County	F
17	14	Southern Calif	C
18	15	Imperial Valley-04	E
19	16	Central Calif-01	C
21	18	Imperial Valley-05	E
22	19	El Alamo	E
24	21	Central Calif-02	C
26	23	Hollister-01	C
27	24	Hollister-02	C
32	25	Parkfield	C
35	27	Northern Calif-06	C
36	28	Borrego Mtn	E
38	28	Borrego Mtn	C
39	28	Borrego Mtn	C
51	30	San Fernando	C
53	30	San Fernando	C
69	30	San Fernando	C
79	30	San Fernando	C

80	30	San Fernando	C
90	30	San Fernando	C
99	34	Hollister-03	C
136	45	Santa Barbara	C
211	53	Livermore-01	C
218	54	Livermore-02	C
279	66	Almiros, Greece	C
367	76	Coalinga-01	E
434	87	Borah Peak, ID-01	E
435	87	Borah Peak, ID-01	C
436	87	Borah Peak, ID-01	C
438	87	Borah Peak, ID-01	C
440	87	Borah Peak, ID-01	G
441	87	Borah Peak, ID-01	C
462	90	Morgan Hill	C
482	92	Veroia, Greece	E
483	92	Veroia, Greece	C
493	96	Drama, Greece	C
564	106	Kalamata, Greece-01	E
565	107	Kalamata, Greece-02	E
566	107	Kalamata, Greece-02	E
633	113	Whittier Narrows-01	C
675	113	Whittier Narrows-01	C
676	113	Whittier Narrows-01	C
679	113	Whittier Narrows-01	C
680	113	Whittier Narrows-01	F
682	113	Whittier Narrows-01	C
748	118	Loma Prieta	C
774	118	Loma Prieta	E
775	118	Loma Prieta	F
777	118	Loma Prieta	C
793	118	Loma Prieta	C
798	118	Loma Prieta	C
814	119	Griva, Greece	E
866	125	Landers	C
911	126	Big Bear-01	C
982	127	Northridge-01	C
992	127	Northridge-01	C
1002	127	Northridge-01	C
1009	127	Northridge-01	E
1010	127	Northridge-01	E
1122	130	Kozani, Greece-01	E
1125	130	Kozani, Greece-01	C
1127	130	Kozani, Greece-01	E
1128	130	Kozani, Greece-01	C
1134	133	Kozani, Greece-04	C
1137	134	Dinar, Turkey	C
1138	134	Dinar, Turkey	C
1140	134	Dinar, Turkey	E
1144	135	Gulf of Aqaba	C

1161	136	Kocaeli, Turkey	C
1379	137	Chi-Chi, Taiwan	F
1441	137	Chi-Chi, Taiwan	F
1460	137	Chi-Chi, Taiwan	F
1514	137	Chi-Chi, Taiwan	C
1625	140	Sitka, Alaska	C
1685	150	Northridge-05	C
1703	151	Northridge-06	C
1756	157	San Juan Bautista	C
1757	157	San Juan Bautista	F
1760	158	Hector Mine	E
1793	158	Hector Mine	C
1864	160	Yountville	C
1939	163	Anza-02	G
1997	164	Gulf of California	E
2025	166	Gilroy	C
2035	166	Gilroy	C
2059	168	Nenana Mountain, Alaska	C
2080	168	Nenana Mountain, Alaska	C
2094	168	Nenana Mountain, Alaska	C
2117	169	Denali, Alaska	C
2137	170	Big Bear City	E
2333	171	Chi-Chi, Taiwan-02	F
2348	171	Chi-Chi, Taiwan-02	F
2392	171	Chi-Chi, Taiwan-02	C
2630	172	Chi-Chi, Taiwan-03	C
3134	174	Chi-Chi, Taiwan-05	F
3155	174	Chi-Chi, Taiwan-05	F
3191	174	Chi-Chi, Taiwan-05	C
3438	175	Chi-Chi, Taiwan-06	F
3476	175	Chi-Chi, Taiwan-06	C

Table 6 - Stations

Record	EQ#	EQ Name	Station Name
1402	137	Chi-Chi, Taiwan	NST
1485	137	Chi-Chi, Taiwan	TCU045
1487	137	Chi-Chi, Taiwan	TCU047
1524	137	Chi-Chi, Taiwan	TCU095
1549	137	Chi-Chi, Taiwan	TCU129
2367	171	Chi-Chi, Taiwan-02	TCU045
2423	171	Chi-Chi, Taiwan-02	TCU129
2601	172	Chi-Chi, Taiwan-03	TCU045
2603	172	Chi-Chi, Taiwan-03	TCU047

2637	172	Chi-Chi, Taiwan-03	TCU095
2658	172	Chi-Chi, Taiwan-03	TCU129
2874	173	Chi-Chi, Taiwan-04	TCU095
3172	174	Chi-Chi, Taiwan-05	TCU045
3198	174	Chi-Chi, Taiwan-05	TCU095
3217	174	Chi-Chi, Taiwan-05	TCU129
3485	175	Chi-Chi, Taiwan-06	TCU095
3507	175	Chi-Chi, Taiwan-06	TCU129

Table 7 – Missing Information

Record	EQ#	EQ Name
493	96	Drama, Greece
567	107	Kalamata, Greece - 02
1146	136	Kocaeli, Turkey
1150	136	Kocaeli, Turkey
1173	136	Kocaeli, Turkey
1174	136	Kocaeli, Turkey
1607	138	Duzce, Turkey

Table 8 – Unreliable Information

Record	EQ#	EQ Name	Reason
260	63	Mammoth Lakes-08	Dip Angle is incorrect.
1142	134	Dinar, Turkey	Is an identical record to R.1143.
1143	134	Dinar, Turkey	Is an identical record to R.1142.