

STRONG MOTION DURING EARTHQUAKES

by

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SYNOPSIS

Duration of strong motion is defined and is partially tabulated for 80 components of 27 accelerograms from 11 earthquakes. Duration data are then used to obtain approximations of relative energy attenuation in the near field.

DURATION OF STRONG MOTION

Cloud and Perez (1969)¹ defined duration of strong motion during earthquakes as the total time single component acceleration (both positive and negative) was above any level. Table 1 gives duration, so defined, for four levels of acceleration, and shows the number of contributory acceleration pulses. For comparison, table 1 also gives duration defined as the time between first and last acceleration peak of 100 gal (cm/sec²). Letters "E" and "F" in the distance column indicate measurement is to earthquake epicenter or fault. Intensity as defined by Arias (1970)² is shown in the last column.

By any criteria, except duration, strong motion at the very unusual Pacoima dam site is the maximum recorded to date. However, the combination of strong-motion and duration as recorded at El Centro, 8244 Orion, Taft and Olympia is of more engineering significance, in my opinion, since these sites are more representative of where structures are built.

RELATIVE ENERGY ATTENUATION

Duration as defined by Cloud and Perez is a curve of the time that recorded acceleration was above various levels. When the curve is numerically integrated, starting with zero time at maximum acceleration, the result is a velocity approximation associated with the energy that must be dissipated at a given point during an earthquake. Using the formula $E=1/2MV^2$ (Ft/lbs) with the assumptions that "M" is a constant, relative energy attenuation can be approximated by the term " $1/2V^2 = C_E$ ".

Preliminary results from 14 accelerograph records are shown in table 2, and divided by 100 in the graph adjacent to the table. The data suggest that at points in the near field of earthquakes the energy level approaches an upper bound at about magnitude 6.5.

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The data also suggest Pacoima dam and Ferndale were sites that deviated from the plane of reference used, due to differences in amplification of motion.

REFERENCES

1. Cloud, WK and Virgilio Perez, "Strong Motion Records and Acceleration". Proceedings of the 4th WCEE. 1969
2. Arias, A, "A Measure of Earthquake Intensity". Seismic Design For Nuclear Power Plants - pp 438-483. M.I.T. Press 1970

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TABLE 1 DURATION AND INTENSITY

Station	Earthquake		Dist KM	Component	Max. Accel gals	Duration and No. Times Accel. Than												1st to last 100 gal Peak Sec	Arias Intensity	
	Date	M				25 gal				50 gal				100 gal						200 gal
						sec	Times	sec	times	sec	Times	sec	Times	sec	Times					
Pacoima Dam Calif.	2/9/71	6.5	3.2F	Vert S16E S74W	700 1200 1225	7.61 8.33 8.86	133 92 107	6.41 7.55 7.74	118 91 103	4.23 5.92 5.66	99 82 95	1.80 3.21 2.77	44 58 54	9.1 9.0 10.0	446.3 916.1 835.2					
8244 Orion Los Angeles, CA	"	"	20E	Vert N-S E-W	175 250 135	12.34 12.76 12.10	116 96 88	5.12 6.99 5.21	14 65 55	0.57 2.32 0.60	15 28 11	- 0.08 -	- 1 -	8.8 11.4 9.7	70.0 130.6 69.1					
4680 Wilshire Los Angeles, CA	"	"	38E	Vert N75W N15E	80 85 115	1.19 5.37 5.40	46 62 63	0.10 0.77 1.36	5 16 24	- - 0.11	- - 3	- - -	- - -	- 2.8 -	6.8 18.2 23.8					
Santa Felicia Dam Abutment, CA	"	"	33E	Vert S08E S82W	85 220 220	1.02 4.50 3.54	38 103 113	0.14 1.42 1.26	9 18 39	- 0.37 0.50	- 21 -	- 0.01 -	- 1 -	- 1.92 -	5.5 31.2 13.6					
Santa Felicia Dam Crest., CA	"	"	"	Vert S15E S75W	65 205 180	3.98 11.40 8.34	52 73 75	0.34 5.50 3.10	10 41 31	- 0.82 0.61	- 9 -	- 0.02 -	- 1 -	- 6.2 3.4 -	78.7 50.4 7.0					
3470 Wilshire Los Angeles, CA	"	"	39E	Vert N-S E-W	50 135 115	0.01 6.64 6.33	1 65 58	- 1.96 1.60	- 28 29	- 0.32 0.09	- 4 -	- 3 -	- - -	- 4.3 5.1 -	36.1 25.8 3.5					
250 E. First Los Angeles, CA	"	"	41E	Vert N36E N54W	105 125 125	5.16 4.79 4.79	73 77 77	1.55 1.48 1.48	50 31 31	0.02 0.06 0.06	1 2 2	- - -	- - -	- 0.02 2.8 -	22.1 22.9 6.0					
445 Figueroa Los Angeles, CA	"	"	41E	Vert N52W S38W	55 145 125	1.40 3.58 5.01	41 43 70	0.02 1.28 1.50	2 16 32	- 0.27 0.04	- 4 -	- - -	- - -	- 2.8 0.7 -	22.4 22.1 7.3					
L.A. Water & Power Los Angeles, CA	"	"	41E	Vert N50W S40W	75 130 180	1.83 4.49 4.57	53 69 89	0.10 0.97 1.32	6 19 34	- 0.14 0.16	- 3 -	- - -	- - -	- 2.9 1.1 -	20.7 23.5 3					
Wheeler Ridge CA	"	"	89	Vert N-S E-W	15 30 25	- 0.4 0.2	3 1 -	- - -	- - -	- - -	- - -	- - -	- - -	- 0.8 0.8 -	- 3 8					
El Centro, CA	5/18/40	6.5 to 7.1	6.5	Vert N-S EW	265 345 215	7.56 16.70 17.13	254 191 197	3.05 8.43 8.81	130 129 128	0.64 2.95 2.13	38 45 45	0.05 0.37 0.05	5 10 2	7.2 24.9 24.6	58.4 196.6 140.3					
El Centro, CA	12/30/34	6.5	56E	Vert N-S E-W	70 165 175	2.69 10.43 10.64	79 117 118	0.27 3.90 4.47	15 61 69	- 0.40 0.68	- 11 -	- - -	- - -	- 9.7 13.2 -	10.0 57.1 65.6					
El Centro, CA	4/8/68	6.5	66E	Vert N-S E-W	35 140 60	0.12 5.23 3.73	6 48 38	- 0.90 0.07	- 8 1	- 0.06 -	- 1 -	- - -	- 0.06 -	2.8 23.5 14.9						
Taft, CA	7/21/52	7.7	40E	Vert N21E S69E	115 175 185	7.13 10.21 10.73	135 146 154	1.42 3.57 3.87	48 58 69	0.05 0.44 0.63	3 11 14	- - -	- - -	- 8.4 10.8 9.7	28.6 57.6 63.1					
Santa Barbara, CA	"	"	98E	Vert S48E N42E	50 130 90	1.15 6.50 5.27	31 38 37	- 1.48 1.46	- 12 14	- 0.14 -	- 1 -	- - -	- - -	- 0.14 -	8.3 29.2 24.4					
Olympia, Wash.	4/13/49	7.1	16E	Vert N04W N86E	105 180 285	5.55 12.44 14.15	166 197 214	0.67 5.34 7.56	36 121 135	0.01 1.04 1.79	1 34 49	- 0.65 1 -	- - -	- 0.01 19.1 15.5	20.7 82.3 121.6					
Olympia, Wash.	4/29/65	6.5	56E	Vert N05W N86E	75 145 -	2.03 6.17 -	88 142 -	0.12 2.19 -	10 72 -	- 0.31 -	- 12 -	- - -	- - -	- 3.7 -	9.1 35.7 -					
Eureka, CA	12/21/54	6.6	24E	Vert N11W N79E	100 170 270	1.94 3.80 5.34	54 34 43	0.25 2.00 2.70	14 18 22	0.01 0.54 1.14	1 10 12	- 0.23 -	- 6 -	- 0.01 3.4 3.3	8.4 34.6 72.9					
Ferndale, CA	"	"	40E	Vert N44E N46E	45 160 205	0.81 8.32 5.33	11 35 34	- 3.18 1.89	- 19 14	- 0.87 0.43	- 8 4	- 0.01 1 -	- - -	- 2.4 1.4 -	5.7 55.2 38.0					
Cholame-Shandon #2 Parkfield, CA	6/27/56	5.6	.08F	Vert N65E	270 495 -	5.54 7.61 -	116 44 -	2.69 4.02 -	73 32 -	0.67 1.54 -	38 12 -	0.03 0.73 -	3 6 -	4.6 3.8 -	51.4 183.7 -					
Cholame-Shandon #5 Parkfield, CA	"	"	5.3F	Vert N85E N05W	160 435 380	3.77 5.74 5.60	115 56 85	1.22 3.24 2.55	49 37 54	0.18 1.23 0.88	14 18 18	- 0.19 0.18	- 5 2	- 1.9 3.1 -	21.8 88.0 67.7					
Cholame-Shandon Temblor Parkfield, CA	"	"	6.4F	Vert N65W S25W	155 270 365	1.14 2.75 2.89	35 42 32	0.19 1.12 1.38	7 18 18	0.03 0.48 0.64	1 8 7	- 0.12 0.13	- 2 3	- 0.03 1.5 1.3	6.1 32.3 46.6					
Cholame-Shandon #8 Parkfield, CA	"	"	9.2F	Vert N50E N40W	125 260 270	2.26 5.47 5.23	97 83 77	0.55 1.93 1.88	33 46 41	0.02 0.32 0.43	3 10 12	- 0.02 0.08	- 1 2	- 0.3 1.9 -	10.9 33.0 40.1					
Cholame-Shandon #12 Parkfield, CA	"	"	14.8F	Vert N39W N51E	60 70 65	1.68 0.93 0.90	14 19 16	0.04 0.07 0.03	4 9 6	- - -	- - -	- - -	- - -	- - -	- - -					
Hollister, CA	4/8/61	5.6	21E	Vert S01W N89W	50 75 185	0.27 4.20 5.38	9 46 40	0.01 0.30 1.23	1 10 14	- 0.25 4 -	- - -	- - -	- - -	- 0.6 -	3.4 13.7 26.6					
Lima, Peru	10/17/66	7.5	160° E	Vert N82W N08E	125 265 395	4.30 9.32 9.30	21 49 75	1.15 5.06 5.05	16 44 70	0.03 1.47 1.79	6 34 60	- 0.05 0.33	- 13 40	- - -	- - -					
3407 6th Street Los Angeles, CA	2/9/71	6.5		Vert N-S E-W	65 165 175	1.40 6.73 6.53	53 74 100	0.07 3.06 2.23	4 45 50	- 0.60 0.35	- 14 9	- - -	- - -	- 4.8 3.0 -	6.8 47.4 37.6					

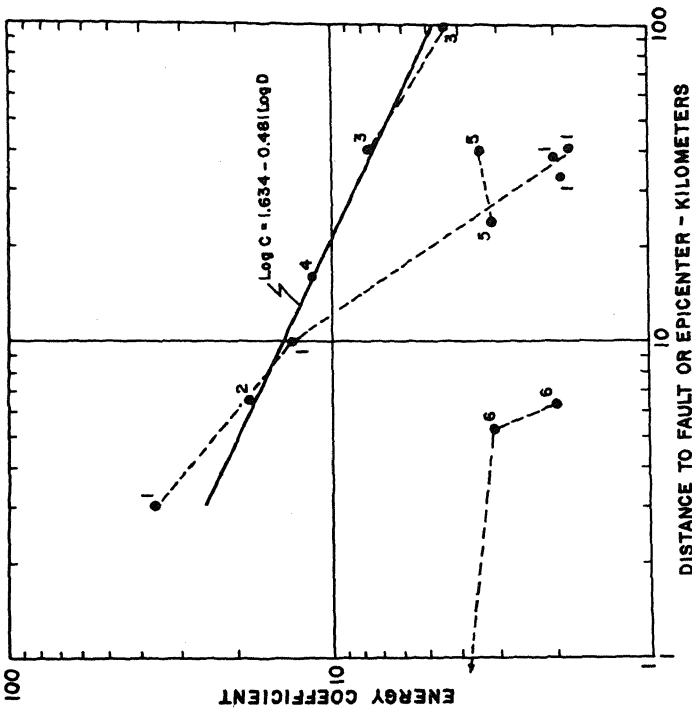


TABLE 2 RELATIVE ENERGY COEFFICIENTS

Station	Date	M	Dist KM	Component	Coefficient (C _r)
1 Pacoima Dam	2/9/71	6.5	3F	Vert	690
				S16E	1520
				S74W	1400
1 8244 Orion	"	"	10F	Vert	380
				N-S	570
				E-W	380
1 Santa Felicia Dam (Abut)	"	"	33E	Vert	20
				S08E	90
				S82W	80
1 4680 Wlshite	"	"	38E	Vert	30
				N75W	90
				N15E	80
1 L.A. Water & Power Bldg.	"	"	41E	Vert	30
				S40W	70
				N50W	70
1 El Centro	5/18/40	6.5	6.5F	Vert	200
				N-S	870
				E-W	770
3 Taft	7/21/52	7.7	40E	Vert	180
				N21E	340
				S69E	260
3 Santa Barbara	"	"	98E	Vert	80
				S48E	200
				N42E	160
4 Olympia, Wash.	4/13/49	7.1	16E	Vert	140
				N86E	600
				N04W	430
5 Eureka	12/21/54	6.6	24E	Vert	40
				N79E	180
				N11W	90
5 Ferndale	"	"	40E	Vert	30
				N44E	180
				N46W	130
6 Parkfield #2	6/27/56	5.6	.08F	Vert	120
				N65E	250
				N35W	(250?)
6 Parkfield #5	"	"	5.3F	Vert	50
				N85E	150
				N05W	110
6 Parkfield #8	"	"	9.2F	Vert	30
				N50E	90
				N40W	80