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Database of Newmark displacements, Arias intensities, and Dobry
durations for selected horizontal-component strong-motion records

By
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ABSTRACT

As part of a general study of earthquake-induced landslides, 227 digitized strong-motion records from 17 earthquakes, mostly in California, were analyzed to determine Arias intensity, Dobry duration, and Newmark displacements for six values of critical acceleration. These properties were compiled in a database and tabulated together with the epicentral and hypocentral distances and distance to the closest point of rupture where known. These data will prove useful in estimating the displacements of earthquake-induced landslides.

REVIEW OF NEWMARK ANALYSIS

One of the most widely used methods for calculating the stability of natural or artificial slopes under earthquake loading conditions is that proposed by Newmark (1965). A horizontal acceleration sufficient to reduce the factor of safety of a slope to 1.0 can be calculated using limit-equilibrium methods. This acceleration is termed the *critical acceleration*. Just because the critical acceleration is exceeded at some point during an earthquake does not mean that the slope will fail. Slope failure also depends on the duration and frequency of the shaking. By twice integrating that portion of a strong-motion record where the critical acceleration is exceeded, a permanent displacement is calculated. If the permanent displacement of the sliding mass is large enough to cause loss of coherence and strength, failure may ensue. The value of the critical displacement will vary with the material and type of failure, but Wilson and Keefer (1985, p. 330) have proposed a value of 10 cm for coherent slides that are common in California. The critical acceleration is a property of the slope, and a Newmark displacement is a property of the strong-motion record which may be calculated for any given value of critical acceleration.

Other properties of the strong-motion records which may be useful in predicting ground failure are the Arias (1970) intensity and the Dobry duration (Dobry and others, 1978). Arias intensity is a measure of the severity of seismic shaking as recorded by a strong-motion record and has been empirically related to observed ground failure (Wilson and Keefer, 1985). Dobry duration is defined as the time needed to build up between 5 and 95 percent of the total Arias intensity of the record.

METHODS

Purpose and Scope

As part of a general study of earthquake-induced landslides, 227 digital strong-motion records from earthquakes in California, Canada, Hawaii, and Iran were analyzed to determine Arias intensity, Dobry duration, and Newmark displacements for critical accelerations of 0.02, 0.05, 0.1, 0.2, 0.3, and 0.4 g, which span the range of practical interest. It is anticipated that these data, together with earthquake magnitudes and distances, will prove useful in estimating the probability of earthquake-induced landsliding in a region.

File Naming Convention

Each file (acceleration record) consists of a two- to four-character station code followed by a hyphen and the directional component of the record. The station descriptions and codes are listed in table 1. There is some duplication of file names where the same stations recorded different earthquakes.

Earthquakes Recorded

Strong-motion records from 17 different earthquakes were analyzed. Only six of these occurred outside California and four of those were the closely-related Nahanni, Northwest Territories, Canada, earthquakes of November-December 1985. Table 2 lists the characteristics of these earthquakes.

Database Organization

Properties of the strong-motion records were compiled in a database on a DOS-based microcomputer using dBASE IV. Four related database files were used:

1. The RECORDS database file contains details of each strong-motion record including date and time of record, digitization interval, number of data points, record length, and maximum acceleration.
2. The STATIONS database file contains station descriptions, codes, latitudes and longitudes, and notes on ownership or control.
3. The EVENTS database file contains the event name, date and origin time, latitude and longitude of the epicenter, focal depth, and various measures of magnitude for each earthquake.
4. The NEWMARK database file contains Newmark displacements for six values of critical acceleration, Arias intensities, Dobry durations, and distances to the epicenter, hypocenter, and closest point of rupture.

Newmark displacements were calculated using DOS-compatible BASIC programs originally developed by R.C. Wilson and described by Jibson (1993), one of which I modified slightly. Values of Arias intensity, Dobry duration, and distances for events other than the Loma Prieta and Nahanni earthquakes were provided by R.W. Jibson.

Results

Table 3 lists the values of Newmark displacements for the six values of critical acceleration together with the Arias intensity, Dobry duration, epicentral and hypocentral distances, and the distance to the closest point of rupture, where known. Blanks in the Newmark displacement fields indicate that the critical acceleration is greater than the peak acceleration for that record. Zeroes indicate that the critical acceleration was exceeded, but that the displacement was less than 0.5 mm.

REFERENCES

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Table 1. Seismic recording station codes and locations.

Code	Location (in California unless noted)	Lat. (°N)	Long. (- = °W)
ADC	Anderson Dam, Crest	37.166	-121.628
ADD	Anderson Dam, Downstream	37.166	-121.628
ADL	Anderson Dam. Left Abutment	37.166	-121.628
BA	Brawley Airport #5060	32.990	-115.510
BC	Bonds Corner #5054	32.693	-115.338
BC2	Battlement Creek (Site 3), NWT	62.126	-123.833
BC4	(2 and 4 are event codes)		
BMC	Bulk Mail Center #5129	33.990	-118.160
BV12	Bear Valley Station 12 #1481	36.660	-121.250
BV14	Bear Valley Station 14 #1483	36.570	-121.040
CAL	Calipatria Fire Station #5061	33.130	-115.520
CC	Coyote Creek #1445	37.118	-121.572
CC4	Coachella Canal Station 4 #5066	33.360	-115.590
CC3	Coachella Canal Station 3 #5065	33.510	-115.770
CLF	San Francisco - Cliff House #58132	37.780	-122.510
CLX	Calexico Fire Station #5053	32.669	-115.492
CPT	Capitola - Fire Station #47125	36.974	-121.952
CRL	Corralitos - Eureka Canyon Rd. #57007	37.046	-121.803
DHT	San Francisco - Diamond Heights #58130	37.740	-122.430
E1	El Centro Array 1 #5056	32.960	-115.319
E2	El Centro Array 2 #5115	32.920	-115.370
E3	El Centro Array 3 #5057	32.890	-115.380
E4	El Centro Array 4 #955	32.860	-115.430
E5	El Centro Array 5 #952	32.860	-115.470
E6	El Centro Array 6 #942	32.840	-115.490
E7	El Centro Array 7 #5028	32.830	-115.500
E8	El Centro Array 8 #958	32.810	-115.530
E10	El Centro Array 10 #412	32.780	-115.570
E11	El Centro Array 11 #5058	32.750	-115.590
E12	El Centro Array 12 #931	32.720	-115.640
E13	El Centro Array 13 #5059	32.709	-115.683
EC	El Centro - IVID Substa. #117	32.790	-115.550
EDA	El Centro Differential Array	32.800	-115.540
EMY	Emeryville, 6363 Christie Ave., S Ground Suite	37.844	-122.295
FRE	Calaveras Array, Fremont, Emerson Ct.	37.535	-121.929
G1	Gilroy Array Station 1 #1408	36.973	-121.572
G2	Gilroy Array Station 2 #1409	36.982	-121.556
G3	Gilroy Array Station 3 #1410	36.991	-121.536
G4	Gilroy Array Station 4 #1411	37.000	-121.521
G6	Gilroy Array Station 6 #1413	37.036	-121.484
GAR	Garvey Reservoir Abutment Bldg. #709	34.050	-118.110
GGB	Golden Gate Bridge, San Francisco	37.806	-122.472
GGP	Golden Gate Park #1117	37.770	-122.480
HAD	Hollister Airport Differential Array	36.888	-121.413
HCH	Hollister City Hall Annex	36.851	-121.402
HL	University of HAWAII, Hilo		
HP	Holtville Post Office #5055	32.810	-115.380
HSP	Hollister - South Street and Pine Drive #47524	36.848	-121.397
HV	Halls Valley #1422	37.340	-121.710

Table 1. Seismic recording station codes and locations -- continued.

Code	Location (in California unless noted)	Lat. (°N)	Long. (- = °W)
IV2	Iverson (Site 1), NWT	62.202	-124.370
IV3	(2 and 3 are event codes)		
MPV	Menlo Park VA Hospital, Bldg. 137	37.468	-122.157
NOR	Norwalk, 12400 Imperial Highway #634	33.920	-118.070
OAK	Oakland - 2-Story Office Bldg. #58224	37.806	-122.267
OHW	Oakland - Outer Harbor Wharf #58472	37.816	-122.314
OW	Ocotillo Wells - Burro Bend Cafe #5050	33.140	-116.130
PAV	Palo Alto VA Hospital, Basement	37.400	-122.140
PC	Plaster City Storehouse #5052	32.790	-115.860
PF2	Parkfield Station 2 #1013	35.730	-120.290
PF5	Parkfield Station 5 #1014	35.700	-120.330
PF8	Parkfield Station 8 #1015	35.670	-120.360
PFS	Palmdale Fire Station #262	34.580	-118.110
PHT	San Francisco - Pacific Heights #58131	37.790	-122.430
PRS	San Francisco - Presidio #58222	37.792	-122.457
PTS	Parachute Test Site #5051	32.930	-115.700
RDW	Apeel Array #2, Redwood City	37.520	-122.250
RNC	San Francisco - Rincon Hill #58151	37.790	-122.390
SAL	Salinas #1414	36.670	-121.640
SBC	Santa Barbara Courthouse #283	34.420	-119.700
SBG	Goleta Station, U.C. Santa Barbara	34.420	-119.860
SCZ	Santa Cruz - UCSC/Lick Lab. #58135	37.001	-122.060
SFP	Pacoima Dam	34.350	-118.390
SJB	San Juan Bautista #1377	36.860	-121.540
SM1	Slide Mountain (Site 2), NWT	62.234	-124.168
SM2	(1 and 2 are event codes)		
SM8	Superstition Mountain - Site 8 #286	32.955	-115.823
SNV	Sunnyvale, Colton Avenue	37.340	-121.756
SSW	Salton Sea Wildlife Refuge #5062	33.180	-115.620
SUL	Stanford University, SLAC Lab.	37.419	-122.205
SUP	Stanford University Parking Garage	37.432	-122.172
T2	Temblor Station 2 #1097	35.750	-120.260
TAB	TransAmerica Building, San Francisco, Basement	37.800	-122.400
TGH	San Francisco - Telegraph Hill #58133	37.800	-122.410
TI	Tabas, IRAN	33.600	56.920
TRI	Treasure Island #58117	37.825	-122.373
TS	Taft School #1095	35.150	-119.460
VER	Vernon, 481 Loma Vista Ave. #288	34.000	-118.200
WBA	Whittier, 7215 Bright Ave. #804	33.977	-118.036
WLA	Wildlife Liquefaction Array #5210	33.100	-115.530
WND	Whittier Narrows Dam - Upstream #289	34.030	-118.050
YBI	Yerba Buena Island #58163	37.810	-122.360

Table 2. Earthquake characteristics for strong-motion records used in this report.

Event Name	Date (UTC)	Time (UTC)	Lat. (°N)	Long. (- = °W)	Depth (km)	----- Magnitudes -----		
						M	M _L	M _b
Loma Prieta	10/18/89	0004	37.037	-121.883	18.0	7.1		
Superstition Hills	11/24/87		33.010	-115.860	5.0	6.5		
Whittier Narrows	10/01/87		34.049	-118.081	14.6	6.0	5.9	6.6
Nahanni 4, NWT	12/25/85	1542	62.020	-124.130				5.7
Nahanni 3, NWT	12/23/85	0548	62.190	-124.240				5.5
Nahanni 2, NWT	12/23/85	0516	62.190	-124.240	6.0		6.9	6.4
Nahanni 1, NWT	11/09/85	0446	62.210	-124.270				4.8
Imperial Valley 79	10/15/79		32.644	-115.309	10.0	6.5	6.6	
Coyote Lake	08/06/79		37.110	-121.530	9.6	5.8	5.9	
Tabas, IRAN	09/16/78		33.359	57.411	10.0	7.4	7.7	6.5
Santa Barbara	08/13/78		34.370	-119.720	12.5	5.1	5.7	
Hilo, HAWAII	11/29/75		19.334	-155.024	5.0	7.2		7.2
San Fernando	02/09/71		34.412	-118.400	8.4	6.6	6.4	
Parkfield	06/27/66		35.940	-120.470	5.0	6.1	5.3	6.2
San Francisco	03/22/57					5.3		
Kern County	07/21/52		35.000	-119.033	15.0	7.5	7.7	
Imperial Valley 40	05/18/40		32.730	-115.530	10.0	7.0	7.1	

Table 3. Newmark displacements, Arias intensity, Dobry duration, and hypocentral and rupture distances for selected strong-motion records.

File Name	Arias Intensity (m/s)	Dobry Duration (s)	Epicentral Distance (km)	Hypocentral Distance (km)	Rupture Distance (km)	--- acceleration (in g)	Newmark displacements (cm) for critical to	0.1	0.2	0.3	0.4
Loma Prieta earthquake of October 18, 1989, USGS records.											
ADC-340	1.478	10.2	27	32		70.7	29.6	8.3	0.3	0.0	0.0
ADC-250	2.316	12.2	27	32		104.3	53.5	23.3	3.6	0.1	0.0
ADD-340	0.840	10.9	27	32		39.3	14.6	3.7	0.1	0.0	0.0
ADD-250	0.836	10.5	27	32		45.6	15.0	3.7	0.1	0.0	0.0
ADL-340	0.090	13.4	27	32		2.6	0.0	0.0	0.0	0.0	0.0
ADL-250	0.094	15.7	27	32		6.7	0.0	0.0	0.0	0.0	0.0
EMY-350	0.528	15.4	97	99		62.2	10.3	1.8	0.0	0.0	0.0
EMY-260	0.914	8.9	97	99		111.8	50.6	15.4	0.2	0.0	0.0
FRE-180	0.336	17.8	56	59		13.7	2.0	0.0	0.0	0.0	0.0
FRE-090	0.324	17.8	56	59		14.1	2.8	0.5	0.0	0.0	0.0
GGB-360	0.288	7.5	100	102		20.6	6.0	0.2	0.0	0.0	0.0
GGB-270	0.512	6.0	100	102		44.2	20.1	7.7	0.0	0.0	0.0
HAD-255	1.064	13.1	45	48		86.2	28.8	9.9	0.6	0.0	0.0
HAD-165	0.821	11.8	45	48		71.7	19.9	3.7	0.0	0.0	0.0
HCH-180	1.081	12.1	47	50		117.9	55.8	14.2	0.0	0.0	0.0
HCH-090	0.819	17.4	47	50		100.7	32.0	7.9	0.9	0.0	0.0
MPV-110	0.310	25.1	54	57		27.4	1.3	0.0	0.0	0.0	0.0
MPV-020	0.519	16.6	54	57		36.1	10.0	3.2	0.3	0.0	0.0
PAV-302	0.761	13.9	47	50		68.5	17.7	4.0	0.2	0.0	0.0
PAV-212	0.823	13.0	47	50		72.8	12.8	1.5	0.0	0.0	0.0
RDW-133	0.743	11.8	63	66		56.6	20.2	5.3	0.0	0.0	0.0
RDW-043	1.306	8.4	63	66		106.4	55.3	24.2	2.8	0.0	0.0
SNV-360	0.786	25.3	43	47		107.4	17.4	1.1	0.0	0.0	0.0
SNV-270	0.668	21.2	43	47		139.6	18.5	0.9	0.0	0.0	0.0
SUL-360	0.937	11.6	51	54		72.4	23.4	6.2	0.6	0.0	0.0
SUL-270	0.578	12.5	51	54		44.9	16.6	2.5	0.0	0.0	0.0
SUP-360	0.615	12.5	51	54		51.6	11.3	1.8	0.0	0.0	0.0
SUP-090	0.591	12.2	51	54		40.8	10.8	1.5	0.0	0.0	0.0
TAB-261	0.210	8.0	97	99		14.8	2.3	0.0	0.0	0.0	0.0
TAB-171	0.219	10.2	97	99		12.0	2.5	0.0	0.0	0.0	0.0

Table 3. Newmark displacements, Arias intensity, Dobry duration, and hypocentral and rupture distances for selected strong-motion records -- continued.

File Name	Arias Intensity (m/s)	Dobry Duration (s)	Epical Distance (km)	Hypocentral Distance (km)	Rupture Distance (km)	--- Newmark displacements (cm) for critical acceleration (in g) equal to	0.05	0.1	0.2	0.3	0.4
Loma Prieta earthquake of October 18, 1989, CDMG records.											
CLF-000	0.092	10.3	99	101		4.5	0.1	0.0	0.0	0.0	0.0
CLF-090	0.136	7.3	99	101		15.9	3.3	0.0	0.0	0.0	0.0
CPT-000	4.382	12.2	9	20		186.5	100.8	37.6	6.8	0.9	0.0
CPT-090	2.373	13.2	9	20		104.8	47.6	20.4	3.6	0.3	0.0
CRL-000	3.256	6.9	7	19		144.3	69.4	28.6	6.2	2.8	1.3
CRL-090	2.572	8.0	7	19		136.7	69.1	32.1	7.3	1.1	0.0
DHT-000	0.140	8.8	92	94		7.0	0.9	0.0	0.0	0.0	0.0
DHT-090	0.106	9.4	92	94		6.8	0.2	0.0	0.0	0.0	0.0
HSP-000	2.222	16.5	48	51		197.3	80.3	24.6	3.8	0.5	0.0
HSP-090	0.791	29.7	48	51		84.1	14.8	1.9	0.0	0.0	0.0
OAK-200	0.406	11.9	92	94		34.1	9.8	1.1	0.0	0.0	0.0
OAK-290	0.656	12.7	92	94		72.4	22.4	4.4	0.1	0.0	0.0
OHW-035	0.722	8.7	94	96		59.6	23.2	6.5	0.6	0.0	0.0
OHW-305	0.990	7.0	94	96		92.5	41.8	16.3	1.7	0.0	0.0
PHT-270	0.054	11.1	84	86		4.6	0.1	0.0	0.0	0.0	0.0
PHT-360	0.040	12.4	84	86		1.4	0.0	0.0	0.0	0.0	0.0
PRS-000	0.155	10.5	98	100		8.7	1.1	0.0	0.0	0.0	0.0
PRS-090	0.265	8.6	98	100		17.0	3.1	0.2	0.0	0.0	0.0
RNC-000	0.055	13.9	95	97		1.0	0.0	0.0	0.0	0.0	0.0
RNC-090	0.068	11.5	95	97		7.0	0.4	0.0	0.0	0.0	0.0
SCZ-000	2.666	9.5	16	24		69.7	34.3	13.2	1.8	0.3	0.0
SCZ-090	2.044	9.7	16	24		40.6	17.5	5.5	0.7	0.1	0.0
TGH-000	0.026	11.5	97	99		0.3	0.0	0.0	0.0	0.0	0.0
TGH-090	0.046	9.5	97	99		3.7	0.3	0.0	0.0	0.0	0.0
TRI-000	0.144	6.0	98	100		12.2	0.9	0.0	0.0	0.0	0.0
TRI-090	0.361	4.5	98	100		40.3	11.2	0.1	0.0	0.0	0.0
YBI-000	0.016	21.7	96	98		0.0	0.0	0.0	0.0	0.0	0.0
YBI-090	0.043	8.3	96	98		2.2	0.0	0.0	0.0	0.0	0.0

Table 3. Newmark displacements, Arias intensity, Dobry duration, Dobry duration, and hypocentral and rupture distances for selected strong-motion records -- continued.

File Name	Arias Intensity (m/s)	Dobry Duration (s)	Episentral Distance (km)	Hypocentral Distance (km)	Rupture Distance (km)	--- Newmark displacements (cm) for critical acceleration (in g) equal to	0.1	0.2	0.3	0.4
Nahanni, Northwest Territories, Canada, earthquakes of November-December 1985.										
SM1-330	0.085	0.6	6			0.0	0.0	0.0	0.0	0.0
SM1-240	0.098	0.4	6			0.0	0.0	0.0	0.0	0.0
BC2-360	0.417	12.0	22			0.0	0.0	0.0	0.0	0.0
BC2-270	0.406	11.3	22			0.1	0.0	0.0	0.0	0.0
IV2-010	4.447	8.0	7			90.0	47.9	8.1	4.3	2.5
IV2-280	4.044	8.0	7			149.5	59.2	4.2	1.5	0.5
SM2-330	1.064	9.6	7			35.5	12.1	0.2	0.0	0.0
SM2-240	0.992	9.9	7			41.9	13.6	0.5	0.1	0.0
IV3-010	0.079	4.1	7			1.2	0.3	0.0	0.0	0.0
IV3-280	0.035	4.5	7			0.7	0.0	0.0	0.0	0.0
BC4-360	0.028	3.8	19			0.1	0.0	0.0	0.0	0.0
BC4-270	0.024	3.5	19			0.1	0.0	0.0	0.0	0.0
Imperial Valley, Calif., earthquake of October 15, 1979.										
BA-315	0.450	14.5	42	43	8.0	27.2	11.4	3.8	0.0	0.0
BA-225	0.310	15.0	42	43	8.0	25.6	3.7	0.3	0.0	0.0
BC-230	6.000	9.8	6	12	5.4	217.4	116.8	55.4	21.3	3.6
BC-140	3.900	9.7	6	12	5.4	142.0	67.4	26.8	5.3	1.1
CAL-315	0.100	25.4	57	58	21.1	4.6	0.1	0.0	0.0	0.0
CAL-225	0.150	26.7	57	58	21.1	4.4	0.5	0.1	0.0	0.0
CC4-135	0.200	10.4	84	85	44.4	12.4	3.1	0.2	0.0	0.0
CC4-45	0.120	11.4	84	85	44.4	5.3	0.4	0.0	0.0	0.0
CLX-315	0.750	15.4	15	18	10.7	31.1	7.5	0.9	0.0	0.0
CLX-225	0.860	11.1	15	18	10.7	37.3	11.6	2.7	0.2	0.0
E1-230	0.220	20.7	37	38	21.1	4.6	0.4	0.0	0.0	0.0
E1-140	0.280	15.2	37	38	21.1	10.5	1.0	0.0	0.0	0.0
E2-230	1.000	11.8	31	33	14.6	32.1	7.6	2.3	0.5	0.0
E2-140	1.280	8.9	31	33	14.6	66.5	24.6	5.7	0.3	0.0
E3-230	0.690	14.2	28	30	11.9	47.7	7.9	1.4	0.0	0.0
E3-140	1.140	11.7	28	30	11.9	70.4	25.4	3.0	0.0	0.0
E4-230	0.940	10.3	26	28	6.0	182.2	51.9	5.0	0.2	0.0
E4-140	1.330	6.7	26	28	6.0	95.0	41.2	18.5	5.5	0.4

Table 3. Newmark displacements, Arias intensity, Dobry duration, and hypocentral and rupture distances for selected strong-motion records -- continued.

File Name	Arias Intensity (m/s)	Dobry Duration (s)	Epicentral Distance (km)	Hypocentral Distance (km)	Rupture Distance (km)	--- Newmark displacements (cm) for critical acceleration (in g) equal to	0.05	0.1	0.2	0.3	---
E5-230	1.690	9.5	28	30	2.8	300.9	110.7	31.7	4.5	0.2	0.0
E5-140	1.660	8.3	28	30	2.8	89.0	30.4	8.2	1.1	0.0	0.0
E6-230	1.780	8.3	27	29	0.1	292.0	118.6	18.7	0.5	0.0	0.0
E6-140	1.500	11.5	27	29	0.1	149.2	73.5	20.7	1.3	0.0	0.0
E7-230	1.720	4.8	26	28	1.5	272.9	142.5	65.5	14.0	4.5	0.6
E7-140	0.860	6.8	26	28	1.5	111.8	32.9	9.6	1.4	0.1	0.0
E8-230	1.500	5.8	27	29	5.2	96.6	32.9	8.5	1.4	0.1	0.0
E8-140	1.600	6.8	27	29	5.2	122.7	65.7	24.2	3.5	0.9	0.3
E10-50	0.570	13.1	27	29	10.3	78.1	22.5	1.2	0.0	0.0	0.0
E10-320	0.690	12.0	27	29	10.3	66.6	14.2	2.1	0.0	0.0	0.0
E11-230	1.620	8.0	27	29	13.8	66.9	27.9	11.2	1.3	0.0	0.0
E11-140	1.990	9.0	27	29	13.8	92.0	31.5	10.7	1.1	0.1	0.0
E12-230	0.330	19.8	30	32	19.7	16.0	1.7	0.0	0.0	0.0	0.0
E12-140	0.390	19.8	30	32	19.7	21.1	2.3	0.1	0.0	0.0	0.0
E13-230	0.270	22.3	34	35	23.6	8.1	0.7	0.1	0.0	0.0	0.0
E13-140	0.270	21.5	34	35	23.6	10.2	1.2	0.0	0.0	0.0	0.0
EDA-360	2.120	6.6	26	28	6.6	119.6	60.7	27.3	3.9	0.9	0.1
EDA-270	1.730	7.1	26	28	6.6	130.2	41.8	13.6	1.4	0.1	0.0
HP-315	0.850	13.1	19	21	6.9	92.0	21.4	2.7	0.0	0.0	0.0
HP-225	0.880	11.9	19	21	6.9	87.4	23.0	3.3	0.0	0.0	0.0
PC-135	0.057	11.4	52	53	33.0	0.8	0.0	0.0	0.0	0.0	0.0
PC-45	0.031	12.1	52	53	33.0	0.2	0.0	0.0	0.0	0.0	0.0
PTS-315	0.220	17.0	47	48	14.8	8.2	1.7	0.4	0.0	0.0	0.0
PTS-225	0.200	18.2	47	48	14.8	8.5	1.2	0.0	0.0	0.0	0.0
SM8-135	0.210	6.7	57	58	27.1	4.1	1.1	0.2	0.0	0.0	0.0
SM8-45	0.088	11.8	57	58	27.1	1.4	0.2	0.0	0.0	0.0	0.0

Table 3. Newmark displacements, Arias intensity, Dobry duration, and hypocentral and rupture distances for selected strong-motion records -- continued.

File Name	Arias Intensity (m/s)	Dobry Duration (s)	Epical Distance (km)	Hypocentral Distance (km)	Rupture Distance (km)	--- acceleration (in g)	Newmark displacements (cm) for critical to	0.2	0.3	0.4
Superstition Hills, Calif., earthquake of November 24, 1987.										
BC-230	1.120	9.9	60	60	39.0	71.4	28.5	7.6	0.1	0.0
BC-140	0.890	10.6	60	60	39.0	38.8	11.7	1.7	0.0	0.0
CAL-315	0.690	13.2	34	34	27.8	24.9	6.6	1.7	0.1	0.0
CAL-225	0.480	13.9	34	34	27.8	34.2	3.3	0.5	0.0	0.0
CC3-135	0.079	13.4	56	56	51.2	2.2	0.1	0.0	0.0	0.0
CC3-45	0.061	13.8	56	56	51.2	1.2	0.1	0.0	0.0	0.0
CLX-315	0.600	11.5	51	51	28.9	37.5	9.3	1.9	0.0	0.0
CLX-225	0.660	11.2	51	51	28.9	60.1	16.0	4.1	0.0	0.0
E1-230	0.093	11.2	51	51	35.6	1.5	0.0	0.0	0.0	0.0
E1-140	0.140	10.8	51	51	35.6	11.8	0.1	0.0	0.0	0.0
E13-230	0.360	11.3	37	37	19.5	21.1	4.8	0.9	0.0	0.0
E13-140	0.250	12.1	37	37	19.5	10.8	1.1	0.0	0.0	0.0
OW-315	0.180	14.9	30	31	28.9	7.1	0.4	0.0	0.0	0.0
OW-225	0.120	15.0	30	31	28.9	4.7	0.2	0.0	0.0	0.0
PC-135	0.540	12.5	24	25	21.8	26.4	5.0	0.6	0.0	0.0
PC-45	0.360	13.6	24	25	21.8	18.9	2.7	0.1	0.0	0.0
PTS-315	3.040	10.9	17	18	0.1	295.9	123.7	46.3	6.4	0.2
PTS-225	4.150	10.1	17	18	0.1	666.1	299.4	134.5	25.4	0.1
SM8-135	6.760	12.2	7	9	5.9	277.6	137.0	62.4	18.2	1.5
SM8-45	3.810	12.0	7	9	5.9	52.4	26.6	10.2	1.1	0.0
SSW-315	0.380	14.1	29	29	25.6	31.2	5.6	0.1	0.0	0.0
SSW-225	0.260	12.9	29	29	25.6	12.0	0.8	0.0	0.0	0.0
WLA-360	0.760	13.7	32	32	24.7	104.7	22.9	2.1	0.0	0.0
WLA-90	0.480	15.7	32	32	24.7	15.2	2.6	0.1	0.0	0.0

Table 3. Newmark displacements, Arias intensity, Dobry duration, and hypocentral and rupture distances for selected strong-motion records -- continued.

File Name	Arias Intensity (m/s)	Dobry Duration (s)	Epicentral Distance (km)	Hypocentral Distance (km)	Rupture Distance (km)	--- acceleration (in g)	Newmark displacements (cm) equal to	for critical	---
Whittier Narrows, Calif., earthquake of October 1, 1987.									
BMC-10	0.830	7.2	10	18	11.4	19.1	7.7	2.9	0.0
BMC-280	1.230	5.5	10	18	11.4	46.6	23.9	11.1	0.8
GAR-60	0.950	5.7	3	15	10.5	23.9	8.1	2.4	0.0
GAR-330	1.150	3.6	3	15	10.5	30.1	15.0	5.3	0.0
NOR-90	0.130	12.5	15	21	15.4	5.5	0.5	0.0	0.0
NOR-360	0.340	9.6	15	21	15.4	14.0	5.9	1.9	0.0
VER-7	0.700	8.0	12	19	13.1	25.6	10.9	2.9	0.0
VER-277	0.590	8.2	12	19	13.1	24.4	9.4	2.1	0.0
WEA-180	0.810	3.4	9	17	11.2	30.9	15.0	5.6	0.1
WBA-90	1.310	2.7	9	17	11.2	26.5	13.3	6.3	1.3
WND-152	0.690	7.5	4	15	10.0	15.6	5.7	1.8	0.0
WND-62	0.520	9.3	4	15	10.0	12.4	4.2	1.1	0.0
Coyote Lake, Calif., earthquake of August 6, 1979.									
BV12-310	0.085	10.0	56	57	39.0	3.3	0.0	0.0	0.0
BV12-220	0.073	12.8	56	57	39.0	2.6	0.0	0.0	0.0
BV14-220	0.064	12.4	74	75	58.0	1.8	0.0	0.0	0.0
BV14-310	0.033	14.2	74	75	58.0	0.3	0.0	0.0	0.0
CC-160	0.170	8.2	2	10	1.6	9.2	2.1	0.1	0.0
CC-250	0.310	4.0	2	10	1.6	13.4	5.1	1.0	0.0
G1-230	0.076	7.9	16	19	8.0	1.9	0.1	0.0	0.0
G1-320	0.084	6.0	16	19	8.0	2.2	0.5	0.0	0.0
G2-140	0.420	4.0	14	17	7.0	29.1	12.0	2.5	0.0
G2-50	0.260	7.7	14	17	7.0	11.2	2.5	0.4	0.0
G3-140	0.370	9.0	13	16	5.0	45.5	15.8	4.3	0.1
G3-50	0.410	8.2	13	16	5.0	31.5	10.4	1.5	0.0
G4-270	0.600	8.5	12	15	3.0	26.1	7.3	2.1	0.0
G4-360	0.500	11.7	12	15	3.0	32.0	6.9	1.6	0.0
G6-230	0.740	3.1	2	10	1.2	31.6	17.9	11.1	0.0
G6-320	0.490	4.2	2	10	1.2	18.2	8.7	3.7	0.0
HV-150	0.021	12.8	30	31	30.0	0.2	0.0	0.0	0.0
HV-240	0.023	12.2	30	31	30.0	0.2	0.0	0.0	0.0
SAL-160	0.049	10.7	50	51	38.0	1.6	0.3	0.0	0.0
SAL-250	0.056	10.9	50	51	38.0	2.0	0.0	0.0	0.0

Table 3. Newmark displacements, Arias intensity, Dobry duration, and hypocentral and rupture distances for selected strong-motion records -- continued.

File Name	Arias Intensity (m/s)	Dobry Duration (s)	Epicentral Distance (km)	Hypocentral Distance (km)	Rupture Distance (km)	--- acceleration (in g)	--- Newmark displacements (cm) for critical	--- equal to	--- 0.4
Imperial Valley, Calif., earthquake of May 18, 1940									
EC-360	1.729	24.1	12	16	7.0	3231.3	2353.9	1454.6	379.0 0.0 0.0
Kern County, Calif., earthquake of July 21, 1952.									
SBC-42	0.212	23.1	89	90	89.0	13.1	0.4	0.0	0.0 0.0
SBC-132	0.242	23.9	89	90	89.0	27.5	4.4	0.2	0.0 0.0
TS-111	0.464	17.7	40	43	40.0	21.2	4.6	0.1	0.0 0.0
San Francisco, Calif., earthquake of March 22, 1957.									
GGP-10	0.022	2.6	12	13	11.0	0.5	0.0	0.0	0.0 0.0
GGP-100	0.031	2.4	12	13	11.0	0.5	0.0	0.0	0.0 0.0
Parkfield, Calif., earthquake of June 27, 1966.									
PF2-65	1.638	4.1	31	31	6.6	129.9	56.2	28.5	10.9 2.6 0.3
PF5-85	0.959	5.1	32	32	9.3	53.9	20.9	8.3	2.2 0.5 0.1
PF8-320	0.293	12.7	34	34	13.0	10.4	1.8	0.3	0.0 0.0 0.0
PF8-50	0.262	13.7	34	34	13.0	11.7	1.4	0.0	0.0 0.0 0.0
T2-295	0.230	6.7	41	41	16.6	9.8	2.6	0.7	0.0 0.0 0.0
T2-205	0.361	5.0	41	41	16.6	10.6	3.9	1.1	0.0 0.0 0.0
San Fernando, Calif., earthquake of February 9, 1971.									
PFS-210	0.174	19.0	33	34	33.0	6.8	0.4	0.0	0.0 0.0 0.0
PFS-120	0.235	18.2	33	34	33.0	17.3	1.0	0.0	0.0 0.0 0.0
SFP-164	9.081	6.7	8	12	3.0	310.7	196.4	112.8	39.2 15.3 7.5
Hilo, Hawaii, earthquake of November 29, 1975.									
HL-344	0.201	4.8	43	43	43.0	9.8	2.2	0.6	0.0 0.0 0.0
Santa Barbara, Calif., earthquake of August 13, 1978.									
SBG-180	0.930	10.2	14	19	3.2	53.8	18.2	5.3	0.8 0.0 0.0
Tabas, Iran, earthquake of September 16, 1978									
TI-344	9.187	16.3	59	60	3.0	442.4	215.4	92.5	19.5 4.9 1.5
TI-74	9.957	16.1	59	60	3.0	685.2	277.8	121.6	32.8 13.6 5.2

Table 3. Newmark displacements, Arias intensity, Dobry duration, and hypocentral and rupture distances for selected strong-motion records -- continued.

File Name	Arias Intensity (m/s)	Dobry Duration (s)	Epicentral Distance (km)	Hypocentral Distance (km)	Rupture Distance (km)	--- Newmark displacements (in g) equal to acceleration	0.02	0.05	0.1	0.2	0.3	0.4
Coyote Lake, Calif., earthquake of August 6, 1979.												
CC-250	0.245	3.8	2	10	1.6	10.3	3.3	0.5	0.0	0.0	0.0	0.0
G6-50	0.711	3.1	10	14	1.2	39.6	19.0	11.8	3.6	0.4	0.4	0.0