



Evaluation of the Relation between Seismic Input Energy and Spectral Velocity

Deprem Giriş Enerjisi İle Spektral Hız Arasındaki İlişkinin İrdelenmesi

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Abstract

Energy based seismic design concept is getting attention owing to its advantages over the conventional methodologies. Particularly, the consideration of duration and frequency content of the earthquake record are chief superiority of the concept. For this original design procedure, accurate determination of seismic input energy is crucially important. Because of solving energy balance equation is a tedious job, the seismic input energy is determined in terms of *equivalent velocity* in the literature mostly. However, it was also shown that this relation is valid for only undamped systems. Therefore, this study aims to provide the nonsteady relation between seismic input energy and equivalent velocity for damped systems. Intensive response history analyses were performed by using plenty of earthquake records those were selected by considering the impulsive characteristics (ordinary and pulse-like) and shear wave velocity. It was found that the relation given in the literature for seismic input energy and spectral velocity relation is not true for damped systems. Dependently, it is proposed a set of coefficients considering structural damping properties to modify the existing relation.

Keywords: Input energy, Spectral velocity, Energy balance equation, Energy based seismic design.

Öz

Deprem etkisine göre tasarım için önerilen enerji esaslı analiz yöntemleri sahip oldukları üstünlükler nedeniyle gün geçtikçe daha fazla ilgi görmektedir. Analizde depremin süresi ve frekans içeriğinin dikkate alınabiliyor olması bu tür yöntemlerin en önemli üstünlükleridir. Enerji esaslı analiz yöntemlerinin başarılı sonuç üretebilmesi için yapı sistemine giren deprem enerjisinin “doğru” tahmini önem taşımaktadır. Enerji denge denkleminin çözümüyle giren deprem enerjisini elde etmek zahmetli bir işlem olduğundan, bu büyüklük literatürde genellikle eşdeğer spektral hız cinsinden ifade edilmektedir. Bu ilişkinin sadece sönümsüz sistemler için geçerli olacağı literatürde tartışılmaktadır. Bu bağlamda, yapısal sönümün yapıya aktarılan deprem enerjisi ile eşdeğer hız arasındaki ilişkiye olan etkisi bu çalışmada araştırılmıştır. Çok sayıda deprem kaydı ve farklı sönüm özellikleri için zaman tanım alanında analizler gerçekleştirilmiştir. Deprem kayıtlarının seçiminde kayma dalgası hızı (V_{s30}) ve kayıt türü (sıradan ve darbe etkili) değişkenleri dikkate alınmıştır. Gerçekleştirilen analizler sonucunda, yapıya

aktarılan deprem enerjisi ile eşdeğer spektral hız arasındaki ilişkinin farklı sönüm özellikleri için aynı olmadığı görülmüştür. Mevcut ilişki için yeni katsayılar önerilmiştir.

Anahtar Kelimeler: Giren enerji, spektral hız, enerji denge deklemi, enerji esaslı sismik tasarım.

1. Introduction

Current seismic design codes propose force and displacement-based analyses methods. The calculated representative horizontal loads are applied to story levels after reduced with a factor of R . This factor depends on predicted ductility level of the structure and material over-strength factor. The design is completed as structure resists to the reduced loads safely. However, the displacements and damage distribution are not certain in the procedure. Alternatively, displacement-based procedures were described as a comprehensive design method by several researches, [1]. Ultimate top displacement of the structure is predicted through the capacity curve and code-oriented acceleration spectrum. Strains on the structural members are able to be computed by the procedure and classified as proportional with the critical values. Nevertheless, the procedure disregards duration based cumulative damage and frequency content of the earthquake record, [2].

The developing seismic design concept namely *energy based seismic design* directly considers duration related cumulative damage, frequency content of earthquake record and hysteretic behavior of structural members. Moreover, energy is a scalar term whereas force and displacement are vectors. Therefore, it was mentioned that it will be a comprehensive design methodology in the near future, [1, 3]. The concept firstly introduced by Housner [4]. After that energy balance equation were derived by Akiyama [5] in time domain, Equation 1 where \ddot{u} , \dot{u} , u and \ddot{u}_g are relative acceleration, velocity, displacement of a single degree of freedom system (*SDOF*) and ground acceleration, respectively. The terms m , c and $f(u)$ take part in the equation are also mass, damping and restoring force characteristics of the system, respectively. Left side of the equation stands for kinetic energy (E_k), damping energy (E_d) and strain energy (E_s), respectively. Right side of the equation is so-called as input energy (E_i).

$$m \int \ddot{u} \dot{u} dt + c \int \dot{u}^2 dt + \int f(u) \dot{u} dt = -m \int \ddot{u}_g \dot{u} dt \quad (1)$$

Uang and Bertero [6] derived absolute energy balance equation (Equation 2) and compared with the relative one. In the equation, \ddot{u}_t and \dot{u}_t are absolute acceleration and velocity of a *SDOF* system and u_g is displacement component of the earthquake record. The study concluded that the absolute and relative energy equations produce akin results for a constant ductility level.

$$\frac{m \dot{u}_t^2}{2} + c \int \dot{u}_t du + \int f(u) du = m \int \dot{u}_t du_g \quad (2)$$

Since solution of the energy balance equation requires tedious computational efforts, some researchers proposed prediction equations and attenuation relations to determine input energy which is key term in the energy balance equation. Initially, Akiyama [5] utilized equivalent velocity (V_E) to predict the input energy, Equation 3 where m represents the mass.

$$\left(\frac{E_i}{m}\right)_{max} = \frac{V_E^2}{2} \quad (3)$$

Kuwamura and Galambos [7] computed V_E by considering dominant period (T_c) and intensity (I_e) of earthquake record, Equation 4. The intensity was determined by Equation 5.

$$V_E = \begin{cases} \frac{\sqrt{T_c I_e} 1.2T}{2 T_c} & T \leq T_c \\ \frac{\sqrt{T_c I_e}}{2} & T > T_c \end{cases} \quad (4)$$

$$I_e = \int \ddot{u}_g^2 dt \quad (5)$$

Chai et al. [8] suggested a formulation for V_E based on the studies of Akiyama [5] and Kuwamura and Galambos [7], Equations 6-7

where PGV is peak ground velocity, PGA is peak ground acceleration and t_d is significant duration of the earthquake.

$$V_E = \Omega_V PGV \quad (6)$$

$$\Omega_V = \begin{cases} 1.2 \times 0.69 \left(\frac{PGA}{PGV} t_d\right)^{3/8} \frac{T}{T_c} & T \leq \frac{T_c}{1.2} \\ 0.69 \left(\frac{PGA}{PGV} t_d\right)^{3/8} & T > \frac{T_c}{1.2} \end{cases} \quad (7)$$

Several regression models were also derived to compute V_E in the literature, [2, 9-11].

Energy based design procedures were proposed for steel [12] and reinforcement concrete [13] structures. In these studies, input energy was predicted by using spectral velocity, Equation 8.

$$E_I = \frac{1}{2} m SV^2 \quad (8)$$

Similarly, Güllü et al. [14] predicted elastic input energy using spectral velocity (SV), structural period (T) and dominant period (T_c) of earthquake record, Equation 9.

$$E_I = 0.07 \frac{2g}{\pi} SV^2 \frac{T}{T_c} \quad (9)$$

Recently, Cheng et al. [15] proposed prediction equations for constant-strength and constant ductility input energy spectra. Energy equivalent velocity V_E was preferred in the study.

Input energy was computed by Equation 3 independent from the calculation method of V_E .

Güllü et al. [3] performed shake table tests on $SDOF$ systems to obtain the input energy experimentally. The experimental results were compared with the predictions of V_E equations. It was shown that most of the equations under estimate input energy especially for near-fault type records. They concluded that discrepancy between the estimations of equations and the experimental results is related with damping property of the structure.

Most of the literature studies were performed by considering 5% damping ratio even Akiyama [5] proved that the relation (Equation 3) is valid for undamped systems.

In this paper, the relation between elastic relative input energy and spectral velocity is investigated for varying structural damping

properties. The damping ratios of 0, 2, 5, 10, 20 and 40% were used. One thousand historical earthquake records were utilized to make comparisons between their input energy and spectral velocity counterparts.

Based on the results of the numerical study, new coefficients are proposed for Equation 3 to account structural damping properties.

2. Material and Method

The relation between seismic input energy per unit mass (E_I/m) and spectral velocity (SV) are discussed here for varying structural damping properties. Large number of historical records (1094) were gathered from PEER NGA database [16]. The important properties of the records are listed in Appendix 1. The records were used without scaling and grouped by considering shear velocity (V_{s30}) and impulsive characteristics. The classification of the records is seen in Table 1. There is limited number of records for the soils with V_{s30} parameters higher than 1500 m/s. It should be noted that only horizontal components of the earthquakes were considered in the study.

Table 1. The classification of the selected earthquake records.

V_{s30} (m/sec)	Ordinary Record	Pulse Like Record	Group No
0-179	202	12	1
180-359	200	116	2
360-759	200	140	3
760-1499	200	10	4
>1500	8	6	5
Σ	810	284	
Σ	1094		

Energy balance equation for each earthquake record were solved by homemade software called as *PW-SPECTs*, [17-18]. The software uses a fully automatic genetic algorithm. Totally, 3.29×10^6 response history analyses (501 period \times 1094 record \times 6 damping ratios) were performed for this purpose. After the seismic input energy per unit mass (E_I/m) and velocity (SV) spectra were constructed for the records,

best-fit analyses are performed for each group in Table 1 to identify the relation between E_I/m and SV spectra.

Some specific characteristics of the records such as relations between Joyner-Boore distance (R_{JB}),

V_{s30} , Arias intensity I_a [19] and significant duration t_d [20] with moment magnitude (M_w) are shown in Figure 1.

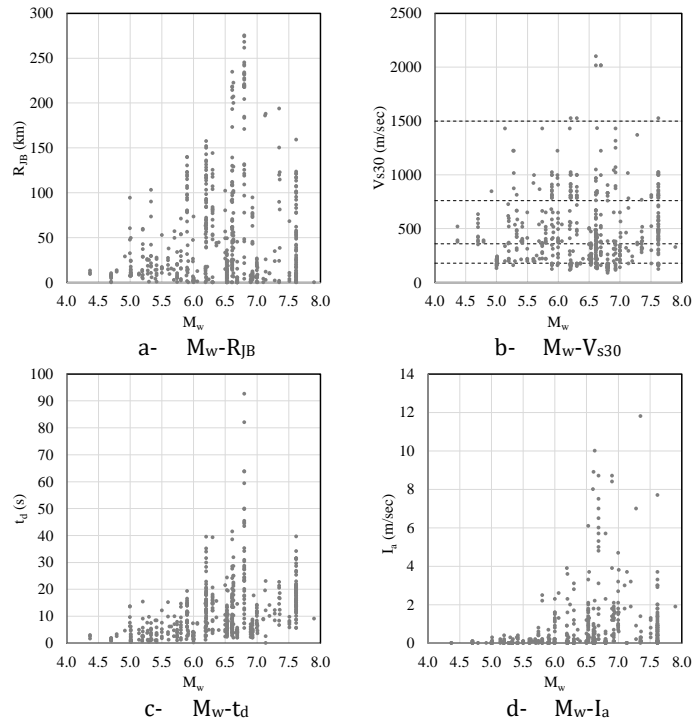


Figure 1. Some characteristics of the selected records.

3. Results

The achieved intensive response history analyses demonstrated that Equation 3 can be utilized for undamped systems. A similar evaluation was also made by Akiyama [5] depending on his closed form solutions.

E_I/m vs. SV relations obtained from the performed analyses were exemplified in Figures 2-5. The coefficients obtained from the analyses are collected in Table 2 for all cases.

Average value of coefficients was determined as 0.521 and 0.508 for ordinary and pulse-like records in undamped systems, respectively.

The coefficient of 0.5 in Equation 3 is not appropriate for damped systems, see Figures 2-5. It tends to increase with rising of damping, see Table 2. Because of the results deviate in a large range in high-damped systems (10% and more),

the quadratic equation produces unsatisfactory approximations, see Figures 4e and 4f.

Since energy content of pulse like records is larger, the coefficients obtained for them are also larger. For instance, the pulse like records have a coefficient of 1.786 where the ordinary records' coefficient is 1.051 in the case of $\xi=10\%$.

The data about pulse-like earthquakes is very limited in the databases. Dependently, the coefficients for pulse-like earthquakes were obtained from very limited number of records for some cases.

In addition to E_I/m vs. SV relation, damping effect on E_I/m was also discussed in this paper. Although several researchers concluded that damping scarcely effect input energy [21-25], recent studies [3, 18, 26-28] proved the opposite judgement.

In this study, input energies of the records computed for the considered damping ratios (0, 2, 5, 10, 20 and 40%) were scaled to the input energy generated for 5% damping, Fig. 6. The figure consists of the graphics representing damping vs. E_I/m relations for all the groups (grey solid lines). The average of the results is

also shown on the figure with black dashed lines. It is realized that the effect of damping on E_I/m is significant. For instance, E_I/m of an undamped system is 2.5 times larger than the 5% damped system.

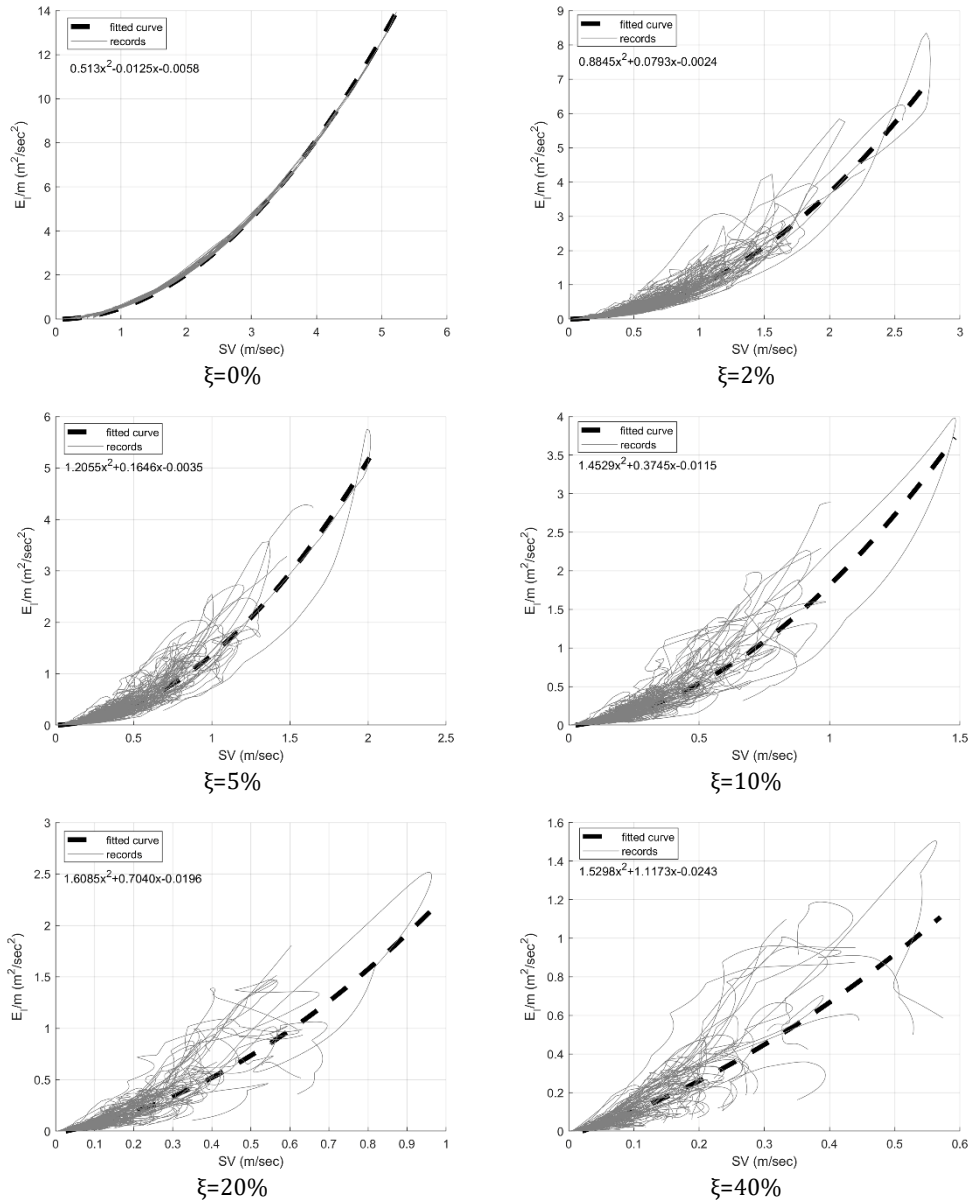


Figure 2. Input energy – spectral velocity relations of ordinary records with $V_{s30} < 180$ m/s.

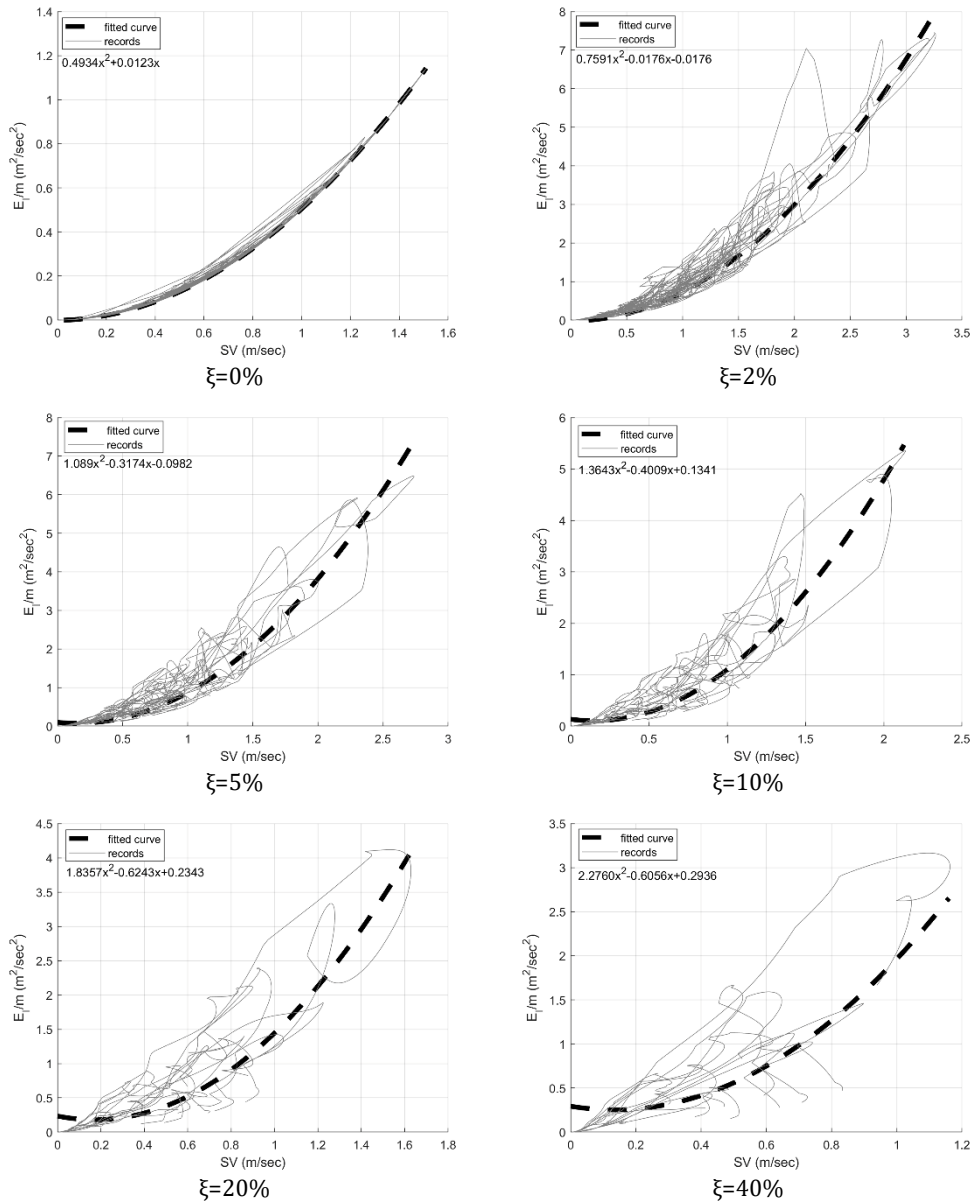


Figure 3. Input energy – spectral velocity relations of pulse-like records with $V_{s30} < 180$ m/s.

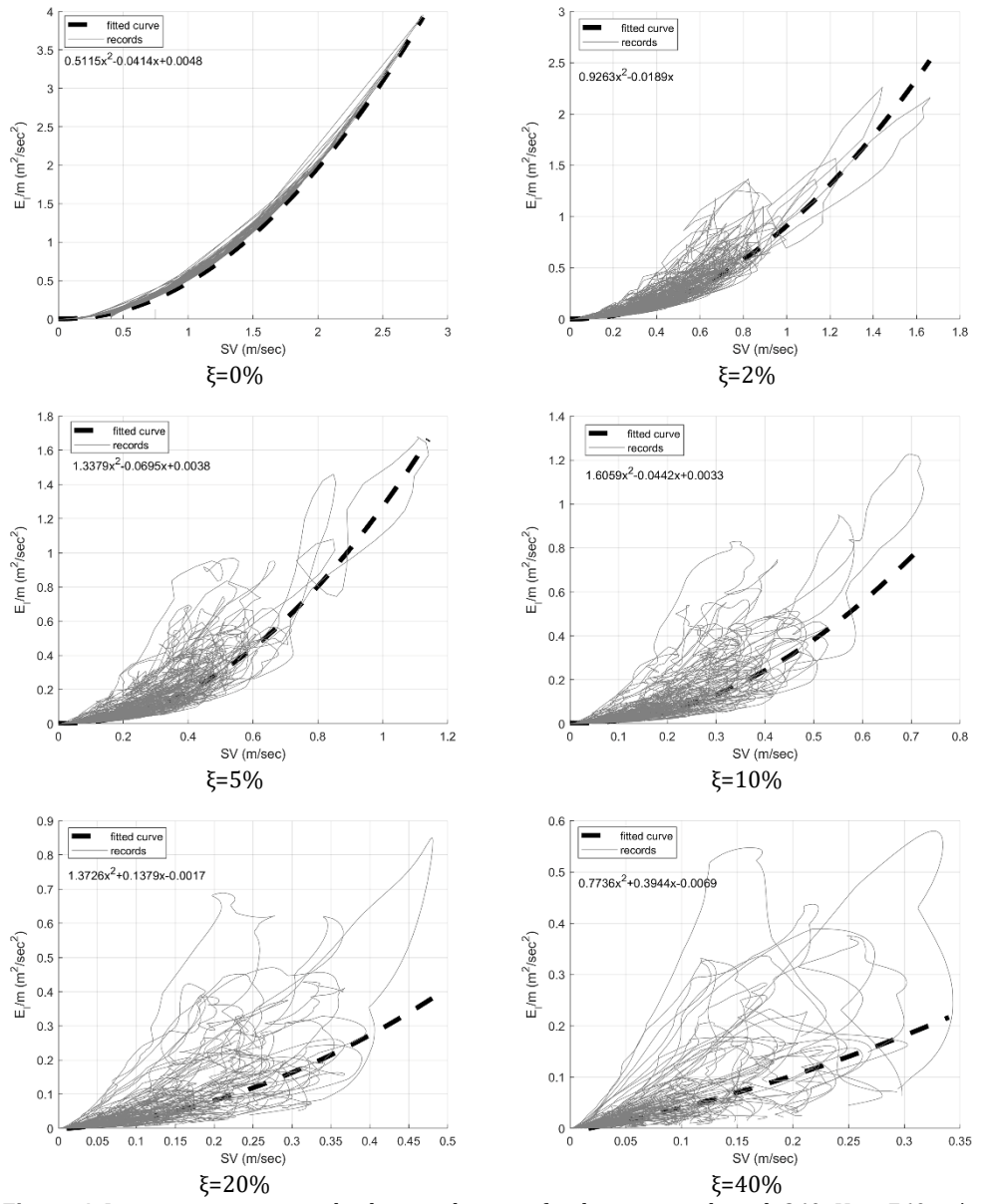


Figure 4. Input energy – spectral velocity relations of ordinary records with $360 < V_{s30} < 760$ m/s.

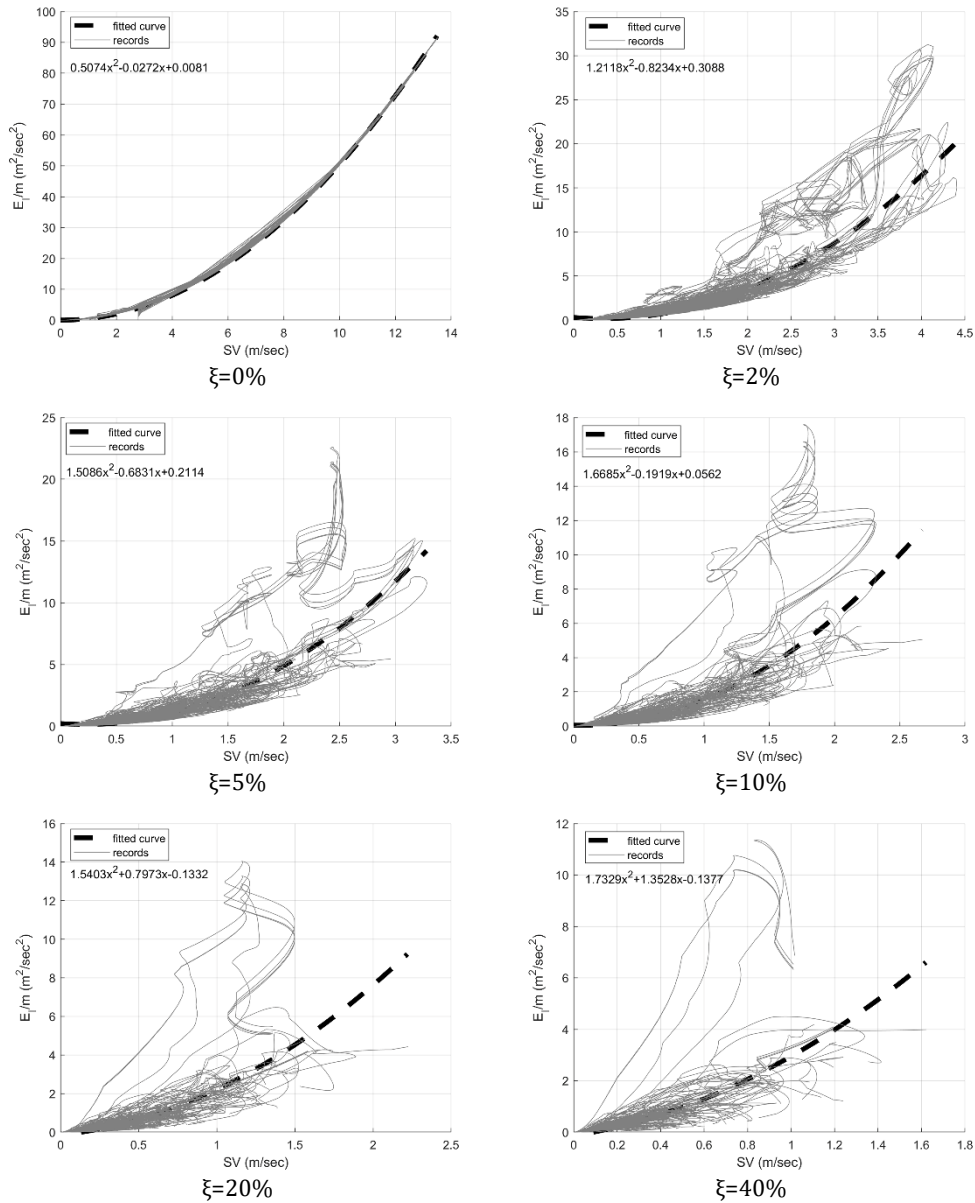


Figure 5. Input energy – spectral velocity relations of pulse-like records with $360 < V_{s30} < 760$ m/s.

Table 2. Coefficients for E_i/m -SV relation.

Ordinary						Pulse-like						Gr
0%	2%	5%	10%	20%	40%	0%	2%	5%	10%	20%	40%	ξ
0.513	0.885	1.206	1.453	1.609	1.530	0.493	0.759	1.089	1.364	1.836	2.276	1
0.580	0.807	0.760	0.583	0.300	0.280	0.541	1.202	1.934	3.323	5.123	6.209	2
0.512	0.926	1.338	1.606	1.373	0.774	0.507	1.212	1.509	1.669	1.540	1.733	3
0.503	0.623	0.712	0.804	0.852	1.013	0.498	1.021	1.248	1.321	1.817	2.373	4
0.498	0.719	0.814	0.809	0.653	0.531	0.501	0.893	1.174	1.251	1.026	0.314	5
0.521	0.792	0.966	1.051	0.957	0.826	0.508	1.017	1.391	1.786	2.268	2.581	Avr

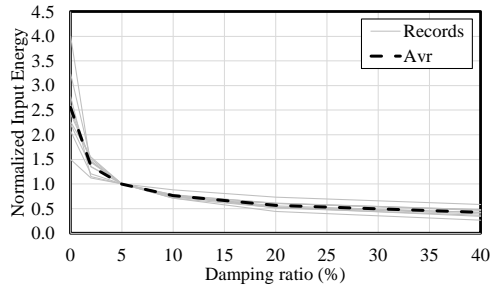


Figure 6. Variation of input energy by damping ratio.

4. Discussion and Conclusion

Energy equivalent velocity equation given in Equation 3 is generally preferred to calculate seismic input energy. It was evaluated by extensive response history analyses for the earthquakes with different characteristics and structural damping properties in this paper. Following results can be concluded:

- The equation is indisputably valid for undamped systems.
- For the damped systems, it is obtained new coefficients for the equation those vary in the range of 0.508-2.578. However, equivalent parameters should not be utilized for the systems that damped higher than 5%.
- The obtained coefficients for the equation tend to increase with rising of damping.
- The deviations between the results of the numerical analyses and estimations of the quadratic relation are increasing for larger damping ratios.
- The deviation is larger for pulse-like records in general.
- The quadratic equation even with the modified coefficient cannot represent the E_I/m vs. SV relation for high-damped systems.
- Damping is extremely effective on E_I/m .

References

- [1] Structural Engineers Association of California (SEAOC) VISION 200 Committee. 1995. Performance Based Seismic Design of Buildings; vol 1.
- [2] Chou, C.C, Uang, C.M. 2000. Establishing Absorbed Energy Spectra - An Attenuation Approach. *Earthquake Engineering and Structural Dynamics*, Cilt. 29, No. 10, s. 1441-1455.
- [3] Güllü, A., Yüksel, E., Yalçın, C., Dindar, A.A., Özkaynak, O., Büyükoztürk, O. 2019. An Improved Input Energy Spectrum Verified by The Shake Table Tests *Earthquake Engineering and Structural Dynamics*, Cilt. 48, s. 27-45. DOI: 10.1002/eqe.3121.
- [4] Housner, G.W. 1956. Limit Design of The Structures to Resist Earthquakes. 1st World Conference on Earthquake Engineering, Berkeley: California.
- [5] Akiyama, H. 1985. Earthquake Resistant Limit State Design for Buildings. University of Tokyo Press.
- [6] Uang, C.M, Bertero, V.V. 1990. Evaluation of Seismic Energy in Structures. *Earthquake Engineering and Structural Dynamics*. Cilt. 19, No. 1, s. 77-90.
- [7] Kuwamura, H., Halambos, T.V. 1989. Earthquake Load for Structural Reliability. *Journal of Structural Engineering*. Cilt. 115, No. 6, s. 1446-1462.
- [8] Chai, Y.H., Fajfar, P., Romstad, K.M. 1998. Formulation of Duration-Dependent Inelastic Seismic Design Spectrum. *Journal of Structural Engineering*. Cilt. 124, No. 8, s. 913-934.
- [9] Chapman, C.M. 1999. On the Use of Elastic Input Energy For Seismic Hazard Analyses. *Earthquake Spectra*. Cilt. 15, No.1, s. 607-635.
- [10] Cheng, Y., Lucchini, A., Mollaioli, F. 2014. Proposal of New Ground Motion Prediction Equations for Elastic Input Energy Spectra. *Earthquakes and Structures*. Cilt. 7, No. 4, s. 485-510.
- [11] Alıcı, F.S., Sucuoğlu, H. 2016. Prediction of Input Energy Spectrum: Attenuation Models and Velocity Spectrum Scaling. *Earthquake Engineering and Structural Dynamics*. Cilt. 45, No. 13, s. 2137-2161.
- [12] Merter, O., Bozdağ, Ö., Düzgün, M. 2012. Energy-Based Design of Steel Structures According to the Predefined Interstory Drift Ratio. *Teknik Dergi*. Cilt. 23, No. 1, s. 5777-5798.
- [13] Merter, O., Uçar, T. 2017. Energy-Based Design Base Shear for RC Frames Considering Global Failure Mechanism and Reduced Hysteretic Behavior. *Structural Engineering and Mechanics*. Cilt. 63, No. 1, s. 23-35.
- [14] Güllü, A., Yüksel, E., Yalçın, C., Dindar, A.A., Özkaynak, H. 2017. Experimental Verification of the Elastic Input Energy Spectrum and a Suggestion. *International Conference on Interdisciplinary Perspectives for Future Building Envelopes*. Istanbul: Turkey.
- [15] Cheng, Y., Lucchini, A., Mollaioli, F. 2019. Ground-Motion Prediction Equations for Constant-Strength and Constant-Ductility Input Energy Spectra. *Bulletin of Earthquake Engineering*. <https://doi.org/10.1007/s10518-019-00725-x>
- [16] PEER Ground Motio Database, NGA-West2. <http://ngawest2.berkeley.edu/>.
- [17] Güllü, A. Determination of the Inelastic Displacement Demand and Response Control of Steel Structures by Seismic Energy Equations. Istanbul Technical University, Institute for Science and Technology, PhD Dissertation, 178s, İstanbul.
- [18] Güllü A, Yüksel E. 2019. Piece-wise Exact Computation of Seismic Energy Balance Equation. *International Conference on Civil, Structural & Environmental Engineering Computing*. September 16-19, Riva del Garda, Italy.
- [19] Arias, A. 1985. A Major of Earthquake Intensity. Hansen, R., J., ed. 1985. MIT Press Cambridge.
- [20] Trifunac, M.D., Brandy, A.G. 1975. A Study on the Duration of Strong Ground Motion. *Bulletin of the*

- Seismological Society of America. Cilt. 65, No. 3, s. 585-626.
- [21] Lopez-Almansa, F., Yazgan, A.U., Benavent-Climent, A. 2013. Desing Input Energy Spectra for High Seismicity Regions Based on Turkish Registers. Bulletin of Earthquake Engineering. Cilt. 11, s. 885-912.
- [22] Alici, S.F., Sucuoğlu, H. 2018. Elastic and Inelastic Near-Fault Input Energy Spectra. Earthquake Spectra. Cilt. 24, No. 2, s. 611-637.
- [23] Sütçü, F., Inoue, N., Hori, N. 2006. Damper Design of a Structure with a Displacement Controlled Soft-Story. Journal of Structural Engineering (Architectural Institute of Japan). Cilt. 52B, s. 255-260.
- [24] Benavent-Climent, A., Zahran, R. 2010. An Energy Based Procedure for the Assessment of Seismic Capacity of Existing Frames: Application to RC Wide Beam System in Spain. Soil Dynamics and Earthquake Engineering. Cilt. 30, s. 354-367.
- [25] Bruneau, W., Wang, N. 1996. Some Aspects of Energy Methods for the Inelastic Seismic Response of Ductile SDOF Structures. Engineering Structures. Cilt. 18, No. 1, s. 1-12.
- [26] Ye, L., Cheng, G., Qu, Z. 2009. Study on Energy-Based Seismic Design Method and the Application for Steel Braced Frame Structures. International Conference on Urban Earthquake Engineering. Tokyo, Japan.
- [27] Zhou, Y., Song, G., Huang, S., Wu, H. 2019. Input Energy Spectra for Self-Centering SDOF Systems. Soil Dynamics and Earthquake Engineering. Cilt. 121, s. 293-305.
- [28] Zhou, Y., Song, G., Tan, p. Hysteretic Energy Demand for Self-Centering SDOF Systems. Soil Dynamics and Earthquake Engineering. Cilt. 125, s. 105703.

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Appendix 1. Important properties of the selected records.

RSN	Earthquake	M _w	R _{fb} (km)	V _{s30} (m/s)
1	"Helena_Montana-01"	6	2.07	593.35
2	"Helena_Montana-02"	6	2.09	551.82
3	"Humbolt Bay"	5.8	71.28	219.31
4	"Imperial Valley-01"	5	32.44	213.44
5	"Northwest Calif-01"	5.5	52.73	219.31
6	"Imperial Valley-02"	6.95	6.09	213.44
7	"Northwest Calif-02"	6.6	91.15	219.31
8	"Northern Calif-01"	6.4	44.52	219.31
9	"Borrego"	6.5	56.88	213.44
10	"Imperial Valley-03"	5.6	24.58	213.44
11	"Northwest Calif-03"	5.8	53.73	219.31
12	"Kern County"	7.36	114.62	316.46
13	"Kern County"	7.36	122.65	415.13
14	"Kern County"	7.36	81.3	514.99
15	"Kern County"	7.36	38.42	385.43
16	"Northern Calif-02"	5.2	42.69	219.31
17	"Southern Calif"	6	73.35	493.5
18	"Imperial Valley-04"	5.5	15.11	213.44
19	"Central Calif-01"	5.3	25.11	198.77
20	"Northern Calif-03"	6.5	26.72	219.31
21	"Imperial Valley-05"	5.4	13.78	213.44
22	"El Alamo"	6.8	121	213.44
23	"San Francisco"	5.28	9.74	874.72
24	"Central Calif-02"	5	7.28	198.77
25	"Northern Calif-04"	5.7	56.94	219.31
26	"Hollister-01"	5.6	19.55	198.77
27	"Hollister-02"	5.5	17.2	198.77
28	"Parkfield"	6.19	17.64	408.93
30	"Parkfield"	6.19	9.58	289.56
31	"Parkfield"	6.19	12.9	256.82
32	"Parkfield"	6.19	63.34	493.5
33	"Parkfield"	6.19	15.96	527.92
34	"Northern Calif-05"	5.6	27.36	219.31
35	"Northern Calif-06"	5.2	37.11	198.77
36	"Borrego Mtn"	6.63	45.12	213.44
37	"Borrego Mtn"	6.63	222.42	316.46
38	"Borrego Mtn"	6.63	199.84	217.92
39	"Borrego Mtn"	6.63	207.14	415.13
40	"Borrego Mtn"	6.63	129.11	442.88
41	"Lytle Creek"	5.33	103.23	450.28
42	"Lytle Creek"	5.33	21.33	477.22
43	"Lytle Creek"	5.33	17.4	813.48
44	"Lytle Creek"	5.33	29.18	301.95
45	"Lytle Creek"	5.33	18.39	667.13
46	"Lytle Creek"	5.33	73.46	316.46
47	"Lytle Creek"	5.33	90.25	425.34
48	"Lytle Creek"	5.33	29.49	421.44
49	"Lytle Creek"	5.33	42.14	667.13
50	"Lytle Creek"	5.33	10.7	486
51	"San Fernando"	6.61	55.2	280.56
52	"San Fernando"	6.61	173.16	360.45
53	"San Fernando"	6.61	111.88	241.41

54	"San Fernando"	6.61	214.32	338.54
55	"San Fernando"	6.61	111.37	385.69
56	"San Fernando"	6.61	61.79	235
57	"San Fernando"	6.61	19.33	450.28
58	"San Fernando"	6.61	92.25	477.22
59	"San Fernando"	6.61	89.37	813.48
60	"San Fernando"	6.61	217.54	184.75
61	"San Fernando"	6.61	218.17	256.82
62	"San Fernando"	6.61	96.81	301.95
63	"San Fernando"	6.61	25.58	634.33
64	"San Fernando"	6.61	59.52	394.18
65	"San Fernando"	6.61	43.95	308.35
66	"San Fernando"	6.61	139.14	328.09
67	"San Fernando"	6.61	130	591
68	"San Fernando"	6.61	22.77	316.46
69	"San Fernando"	6.61	58.99	217.92
70	"San Fernando"	6.61	22.23	425.34
71	"San Fernando"	6.61	13.99	602.1
72	"San Fernando"	6.61	19.45	600.06
73	"San Fernando"	6.61	17.22	670.84
74	"San Fernando"	6.61	193.25	303.79
75	"San Fernando"	6.61	108.56	443.85
76	"San Fernando"	6.61	109.01	441.25
77	"San Fernando"	6.61	0	2016.13
78	"San Fernando"	6.61	24.16	452.86
79	"San Fernando"	6.61	25.47	415.13
80	"San Fernando"	6.61	21.5	969.07
81	"San Fernando"	6.61	35.54	529.09
82	"San Fernando"	6.61	68.84	248.98
83	"San Fernando"	6.61	52.64	421.44
84	"San Fernando"	6.61	205.77	354.06
85	"San Fernando"	6.61	108.01	459.37
86	"San Fernando"	6.61	124.79	442.88
87	"San Fernando"	6.61	30.7	667.13
88	"San Fernando"	6.61	24.69	389
89	"San Fernando"	6.61	61.75	669.48
90	"San Fernando"	6.61	124.38	322.42
91	"San Fernando"	6.61	61.72	487.23
92	"San Fernando"	6.61	68.38	347.67
93	"San Fernando"	6.61	39.45	298.68
94	"San Fernando"	6.61	61.64	486
95	"Managua_Nicaragua-01"	6.24	3.51	288.77
96	"Managua_Nicaragua-02"	5.2	4.33	288.77
97	"Point Mugu"	5.65	15.48	248.98
98	"Hollister-03"	5.14	9.99	1428.14
99	"Hollister-03"	5.14	8.85	198.77
100	"Hollister-03"	5.14	8.56	335.5
101	"Northern Calif-07"	5.2	28.73	567.78
102	"Northern Calif-07"	5.2	8.2	219.31
103	"Northern Calif-07"	5.2	28.48	368.72
104	"Northern Calif-07"	5.2	58.78	594.83
105	"Northern Calif-07"	5.2	59.7	518.98
106	"Oroville-01"	5.89	7.79	680.37
107	"Oroville-02"	4.79	13.55	391.76
108	"Oroville-02"	4.79	12.07	377.25
109	"Oroville-04"	4.37	9.22	519.15

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110	"Oroville-04"	4.37	13.37	391.76	166	"Imperial Valley-06"	6.53	49.1	336.49
111	"Oroville-04"	4.37	11	377.25	167	"Imperial Valley-06"	6.53	13.52	259.86
112	"Oroville-03"	4.7	5.95	427.38	169	"Imperial Valley-06"	6.53	22.03	242.05
113	"Oroville-03"	4.7	0	634.85	170	"Imperial Valley-06"	6.53	7.31	192.05
114	"Oroville-03"	4.7	7.35	418.97	171	"Imperial Valley-06"	6.53	0.07	264.57
115	"Oroville-03"	4.7	7.38	589.8	172	"Imperial Valley-06"	6.53	19.76	237.33
116	"Oroville-03"	4.7	0.77	514.91	173	"Imperial Valley-06"	6.53	8.6	202.85
117	"Oroville-03"	4.7	8.67	391.76	174	"Imperial Valley-06"	6.53	12.56	196.25
118	"Oroville-03"	4.7	8.7	352.22	175	"Imperial Valley-06"	6.53	17.94	196.88
119	"Oroville-03"	4.7	4.79	548.76	176	"Imperial Valley-06"	6.53	21.98	249.92
120	"Oroville-03"	4.7	10.2	377.25	178	"Imperial Valley-06"	6.53	10.79	162.94
121	"Friuli_Italy-01"	6.5	49.13	496.46	179	"Imperial Valley-06"	6.53	4.9	208.91
122	"Friuli_Italy-01"	6.5	33.32	249.28	180	"Imperial Valley-06"	6.53	1.76	205.63
123	"Friuli_Italy-01"	6.5	80.37	352.05	181	"Imperial Valley-06"	6.53	0	203.22
124	"Friuli_Italy-01"	6.5	102.05	356.39	182	"Imperial Valley-06"	6.53	0.56	210.51
125	"Friuli_Italy-01"	6.5	14.97	505.23	183	"Imperial Valley-06"	6.53	3.86	206.08
126	"Gazi_USSR"	6.8	3.92	259.59	184	"Imperial Valley-06"	6.53	5.09	202.26
127	"Friuli_Italy-03"	5.5	10.56	310.68	185	"Imperial Valley-06"	6.53	5.35	202.89
128	"Friuli_Italy-03"	5.5	16.33	412.37	186	"Imperial Valley-06"	6.53	35.64	212
129	"Friuli_Italy-03"	5.5	16.26	649.67	187	"Imperial Valley-06"	6.53	12.69	348.69
130	"Friuli_Italy-02"	5.91	10.99	310.68	188	"Imperial Valley-06"	6.53	30.33	316.64
131	"Friuli_Italy-02"	5.91	41.37	249.28	190	"Imperial Valley-06"	6.53	24.61	362.38
132	"Friuli_Italy-02"	5.91	14.65	412.37	191	"Imperial Valley-06"	6.53	31.92	242.05
133	"Friuli_Italy-02"	5.91	14.37	649.67	192	"Imperial Valley-06"	6.53	14.75	193.67
134	"Izmir_Turkey"	5.3	0.74	535.24	193	"Imperial Valley-07"	5.01	10.83	223.03
135	"Santa Barbara"	5.92	23.75	465.51	194	"Imperial Valley-07"	5.01	24.26	208.71
136	"Santa Barbara"	5.92	0	514.99	195	"Imperial Valley-07"	5.01	11.17	231.23
137	"Tabas_Iran"	7.35	119.77	377.56	196	"Imperial Valley-07"	5.01	49.4	242.05
138	"Tabas_Iran"	7.35	24.07	324.57	197	"Imperial Valley-07"	5.01	23.76	237.33
139	"Tabas_Iran"	7.35	0	471.53	198	"Imperial Valley-07"	5.01	10.73	202.85
140	"Tabas_Iran"	7.35	89.76	302.64	199	"Imperial Valley-07"	5.01	13.61	196.25
141	"Tabas_Iran"	7.35	193.91	280.26	200	"Imperial Valley-07"	5.01	17.32	188.78
142	"Tabas_Iran"	7.35	150.33	354.37	201	"Imperial Valley-07"	5.01	14.54	162.94
143	"Tabas_Iran"	7.35	1.79	766.77	202	"Imperial Valley-07"	5.01	9.69	208.91
144	"Dursunbey_Turkey"	5.34	5.57	585.04	203	"Imperial Valley-07"	5.01	8.56	205.63
145	"Coyote Lake"	5.74	5.3	561.43	204	"Imperial Valley-07"	5.01	7.4	203.22
146	"Coyote Lake"	5.74	10.21	1428.14	205	"Imperial Valley-07"	5.01	7.32	210.51
147	"Coyote Lake"	5.74	8.47	270.84	206	"Imperial Valley-07"	5.01	8.18	206.08
148	"Coyote Lake"	5.74	6.75	349.85	207	"Imperial Valley-07"	5.01	7.87	202.26
149	"Coyote Lake"	5.74	4.79	221.78	208	"Imperial Valley-07"	5.01	7.69	202.89
150	"Coyote Lake"	5.74	0.42	663.31	209	"Imperial Valley-08"	5.62	9.39	193.67
151	"Coyote Lake"	5.74	33.69	281.61	210	"Livermore-01"	5.8	29.19	517.06
152	"Coyote Lake"	5.74	20.44	367.43	212	"Livermore-01"	5.8	23.92	403.37
153	"Coyote Lake"	5.74	20.44	362.98	213	"Livermore-01"	5.8	34.66	367.57
154	"Coyote Lake"	5.74	19.46	335.5	214	"Livermore-01"	5.8	15.19	377.51
155	"Norcia_Italy"	5.9	31.43	401.34	215	"Livermore-01"	5.8	15.84	384.47
156	"Norcia_Italy"	5.9	1.41	585.04	216	"Livermore-01"	5.8	53.35	650.05
157	"Norcia_Italy"	5.9	13.21	535.24	217	"Livermore-02"	5.42	27.76	517.06
158	"Imperial Valley-06"	6.53	0	259.86	219	"Livermore-02"	5.42	10.03	403.37
159	"Imperial Valley-06"	6.53	0	242.05	220	"Livermore-02"	5.42	26.07	367.57
160	"Imperial Valley-06"	6.53	0.44	223.03	221	"Livermore-02"	5.42	0.79	387.04
161	"Imperial Valley-06"	6.53	8.54	208.71	222	"Livermore-02"	5.42	7.94	550.88
162	"Imperial Valley-06"	6.53	10.45	231.23	223	"Livermore-02"	5.42	14.31	377.51
163	"Imperial Valley-06"	6.53	23.17	205.78	224	"Livermore-02"	5.42	19.09	384.47
164	"Imperial Valley-06"	6.53	15.19	471.53	225	"Anza (Horse Canyon)-01"	5.19	12.24	724.89
165	"Imperial Valley-06"	6.53	7.29	242.05	226	"Anza (Horse Canyon)-01"	5.19	5.85	617.78

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227	"Anza (Horse Canyon)-01"	5.19	13.8	360.45	1054	"Northridge-01"	6.69	5.54	325.67
230	"Mammoth Lakes-01"	6.06	1.1	382.12	1063	"Northridge-01"	6.69	0	282.25
231	"Mammoth Lakes-01"	6.06	12.56	537.16	1084	"Northridge-01"	6.69	0	251.24
233	"Mammoth Lakes-02"	5.69	2.91	382.12	1085	"Northridge-01"	6.69	0	370.52
234	"Mammoth Lakes-02"	5.69	14.28	537.16	1086	"Northridge-01"	6.69	1.74	440.54
285	"Irpinia_Italy-01"	6.9	8.14	649.67	1091	"Northridge-01"	6.69	23.1	996.43
292	"Irpinia_Italy-01"	6.9	6.78	382	1106	"Kobe_Japan"	6.9	0.94	312
316	"Westmorland"	5.9	16.54	348.69	1108	"Kobe_Japan"	6.9	0.9	1043
326	"Coalinga-01"	6.36	43.83	173.02	1114	"Kobe_Japan"	6.9	3.31	198
334	"Coalinga-01"	6.36	41.04	178.27	1119	"Kobe_Japan"	6.9	0	312
451	"Morgan Hill"	6.19	0.18	561.43	1120	"Kobe_Japan"	6.9	1.46	256
452	"Morgan Hill"	6.19	53.89	116.35	1147	"Kocaeli_Turkey"	7.51	68.09	175
455	"Morgan Hill"	6.19	14.9	1428.14	1148	"Kocaeli_Turkey"	7.51	10.56	523
459	"Morgan Hill"	6.19	9.85	663.31	1161	"Kocaeli_Turkey"	7.51	7.57	792
566	"Kalamata_Greece-02"	5.4	4	382.21	1165	"Kocaeli_Turkey"	7.51	3.62	811
568	"San Salvador"	5.8	2.14	489.34	1176	"Kocaeli_Turkey"	7.51	1.38	297
569	"San Salvador"	5.8	3.71	455.93	1182	"Chi-Chi_Taiwan"	7.62	9.76	438.19
608	"Whittier Narrows-01"	5.99	26.3	160.58	1193	"Chi-Chi_Taiwan"	7.62	9.62	427.73
643	"Whittier Narrows-01"	5.99	23.4	1222.52	1209	"Chi-Chi_Taiwan"	7.62	24.13	169.52
680	"Whittier Narrows-01"	5.99	6.78	969.07	1212	"Chi-Chi_Taiwan"	7.62	48.49	172.1
703	"Whittier Narrows-01"	5.99	47.25	996.43	1228	"Chi-Chi_Taiwan"	7.62	42.15	169.84
718	"Superstition Hills-01"	6.22	17.59	179	1229	"Chi-Chi_Taiwan"	7.62	77.19	160.67
722	"Superstition Hills-02"	6.54	18.48	266.01	1244	"Chi-Chi_Taiwan"	7.62	9.94	258.89
723	"Superstition Hills-02"	6.54	0.95	348.69	1245	"Chi-Chi_Taiwan"	7.62	36.06	804.36
729	"Superstition Hills-02"	6.54	23.85	179	1247	"Chi-Chi_Taiwan"	7.62	50.61	175.68
732	"Loma Prieta"	6.93	43.06	133.11	1256	"Chi-Chi_Taiwan"	7.62	53.3	789.18
759	"Loma Prieta"	6.93	43.77	116.35	1257	"Chi-Chi_Taiwan"	7.62	52.46	1525.85
760	"Loma Prieta"	6.93	45.42	126.4	1307	"Chi-Chi_Taiwan"	7.62	101.24	909.09
764	"Loma Prieta"	6.93	10.27	308.55	1310	"Chi-Chi_Taiwan"	7.62	86.61	124.27
765	"Loma Prieta"	6.93	8.84	1428.14	1319	"Chi-Chi_Taiwan"	7.62	83.02	782.59
766	"Loma Prieta"	6.93	10.38	270.84	1334	"Chi-Chi_Taiwan"	7.62	78	158.13
767	"Loma Prieta"	6.93	12.23	349.85	1347	"Chi-Chi_Taiwan"	7.62	57.69	996.51
780	"Loma Prieta"	6.93	94.56	169.72	1352	"Chi-Chi_Taiwan"	7.62	113.39	913.77
788	"Loma Prieta"	6.93	72.9	895.36	1357	"Chi-Chi_Taiwan"	7.62	101.23	155.32
789	"Loma Prieta"	6.93	83.37	1315.92	1366	"Chi-Chi_Taiwan"	7.62	106.72	1010.4
795	"Loma Prieta"	6.93	75.96	1249.86	1371	"Chi-Chi_Taiwan"	7.62	158.96	806.48
797	"Loma Prieta"	6.93	74.04	873.1	1378	"Chi-Chi_Taiwan"	7.62	123.56	1004.58
802	"Loma Prieta"	6.93	7.58	380.89	1402	"Chi-Chi_Taiwan"	7.62	38.36	491.08
803	"Loma Prieta"	6.93	8.48	347.9	1421	"Chi-Chi_Taiwan"	7.62	99.54	167.18
804	"Loma Prieta"	6.93	63.03	1020.62	1432	"Chi-Chi_Taiwan"	7.62	116.64	816.9
808	"Loma Prieta"	6.93	77.32	155.11	1440	"Chi-Chi_Taiwan"	7.62	120.84	1023.45
828	"Cape Mendocino"	7.01	0	422.17	1442	"Chi-Chi_Taiwan"	7.62	95.31	807.68
838	"Landers"	7.28	34.86	370.08	1445	"Chi-Chi_Taiwan"	7.62	107.42	856.38
879	"Landers"	7.28	2.19	1369	1446	"Chi-Chi_Taiwan"	7.62	117.31	1022.77
900	"Landers"	7.28	23.62	353.63	1452	"Chi-Chi_Taiwan"	7.62	92.01	887.68
962	"Northridge-01"	6.69	45.44	160.58	1475	"Chi-Chi_Taiwan"	7.62	56.03	569.98
982	"Northridge-01"	6.69	0	373.07	1476	"Chi-Chi_Taiwan"	7.62	28.04	406.53
983	"Northridge-01"	6.69	0	525.79	1477	"Chi-Chi_Taiwan"	7.62	30.17	489.22
1004	"Northridge-01"	6.69	0	380.06	1478	"Chi-Chi_Taiwan"	7.62	40.88	423.4
1011	"Northridge-01"	6.69	15.11	1222.52	1479	"Chi-Chi_Taiwan"	7.62	35.68	393.77
1013	"Northridge-01"	6.69	0	628.99	1480	"Chi-Chi_Taiwan"	7.62	19.83	478.07
1044	"Northridge-01"	6.69	3.16	269.14	1481	"Chi-Chi_Taiwan"	7.62	25.42	297.86
1045	"Northridge-01"	6.69	2.11	285.93	1482	"Chi-Chi_Taiwan"	7.62	19.89	540.66
1050	"Northridge-01"	6.69	4.92	2016.13	1483	"Chi-Chi_Taiwan"	7.62	22.06	362.03
1051	"Northridge-01"	6.69	4.92	2016.13	1485	"Chi-Chi_Taiwan"	7.62	26	704.64
1052	"Northridge-01"	6.69	5.26	508.08	1486	"Chi-Chi_Taiwan"	7.62	16.74	465.55

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1487	"Chi-Chi_ Taiwan"	7.62	35	520.37	2492	"Chi-Chi_ Taiwan-03"	6.2	59.24	169.84
1489	"Chi-Chi_ Taiwan"	7.62	3.76	487.27	2493	"Chi-Chi_ Taiwan-03"	6.2	98.42	160.67
1491	"Chi-Chi_ Taiwan"	7.62	7.64	350.06	2508	"Chi-Chi_ Taiwan-03"	6.2	59.99	804.36
1492	"Chi-Chi_ Taiwan"	7.62	0	579.1	2510	"Chi-Chi_ Taiwan-03"	6.2	72.24	175.68
1493	"Chi-Chi_ Taiwan"	7.62	5.95	454.55	2514	"Chi-Chi_ Taiwan-03"	6.2	65.46	789.18
1496	"Chi-Chi_ Taiwan"	7.62	10.48	403.2	2561	"Chi-Chi_ Taiwan-03"	6.2	125.18	158.13
1498	"Chi-Chi_ Taiwan"	7.62	17.11	272.67	2633	"Chi-Chi_ Taiwan-03"	6.2	103.2	999.66
1501	"Chi-Chi_ Taiwan"	7.62	9.78	476.14	2687	"Chi-Chi_ Taiwan-03"	6.2	93.15	845.34
1502	"Chi-Chi_ Taiwan"	7.62	16.59	645.72	2715	"Chi-Chi_ Taiwan-04"	6.2	38.59	169.52
1503	"Chi-Chi_ Taiwan"	7.62	0.57	305.85	2718	"Chi-Chi_ Taiwan-04"	6.2	61.1	172.1
1505	"Chi-Chi_ Taiwan"	7.62	0	487.34	2734	"Chi-Chi_ Taiwan-04"	6.2	6.02	553.43
1510	"Chi-Chi_ Taiwan"	7.62	0.89	573.02	2736	"Chi-Chi_ Taiwan-04"	6.2	56.35	169.84
1511	"Chi-Chi_ Taiwan"	7.62	2.74	614.98	2737	"Chi-Chi_ Taiwan-04"	6.2	84.01	160.67
1515	"Chi-Chi_ Taiwan"	7.62	5.16	472.81	2753	"Chi-Chi_ Taiwan-04"	6.2	39.3	804.36
1518	"Chi-Chi_ Taiwan"	7.62	55.14	999.66	2755	"Chi-Chi_ Taiwan-04"	6.2	63.37	175.68
1519	"Chi-Chi_ Taiwan"	7.62	6.98	538.69	2759	"Chi-Chi_ Taiwan-04"	6.2	65.26	789.18
1528	"Chi-Chi_ Taiwan"	7.62	2.11	389.41	2805	"Chi-Chi_ Taiwan-04"	6.2	116.17	913.77
1529	"Chi-Chi_ Taiwan"	7.62	1.49	714.27	2818	"Chi-Chi_ Taiwan-04"	6.2	119.21	150.18
1530	"Chi-Chi_ Taiwan"	7.62	6.08	494.1	2929	"Chi-Chi_ Taiwan-04"	6.2	68.95	845.34
1531	"Chi-Chi_ Taiwan"	7.62	12.87	410.45	2955	"Chi-Chi_ Taiwan-05"	6.2	66.53	169.52
1548	"Chi-Chi_ Taiwan"	7.62	13.13	599.64	2958	"Chi-Chi_ Taiwan-05"	6.2	88.66	172.1
1550	"Chi-Chi_ Taiwan"	7.62	8.27	462.1	2975	"Chi-Chi_ Taiwan-05"	6.2	83.74	169.84
1571	"Chi-Chi_ Taiwan"	7.62	121.45	826.15	2976	"Chi-Chi_ Taiwan-05"	6.2	113.51	160.67
1587	"Chi-Chi_ Taiwan"	7.62	62.11	845.34	2989	"Chi-Chi_ Taiwan-05"	6.2	69.76	804.36
1599	"Duzce_ Turkey"	7.14	187.99	175	2990	"Chi-Chi_ Taiwan-05"	6.2	90.92	175.68
1602	"Duzce_ Turkey"	7.14	12.02	293.57	2995	"Chi-Chi_ Taiwan-05"	6.2	44.36	789.18
1613	"Duzce_ Turkey"	7.14	25.78	782	2996	"Chi-Chi_ Taiwan-05"	6.2	49.84	1525.85
1649	"Sierra Madre"	5.61	37.63	996.43	3042	"Chi-Chi_ Taiwan-05"	6.2	134.67	909.09
1709	"Northridge-06"	5.28	18.53	1015.88	3044	"Chi-Chi_ Taiwan-05"	6.2	119.18	124.27
1715	"Northridge-06"	5.28	13.15	1222.52	3053	"Chi-Chi_ Taiwan-05"	6.2	117.03	782.59
1843	"Yountville"	5	94.18	133.11	3062	"Chi-Chi_ Taiwan-05"	6.2	109.71	158.13
1852	"Yountville"	5	47.65	169.72	3091	"Chi-Chi_ Taiwan-05"	6.2	149.89	150.18
1943	"Anza-02"	4.92	28.79	845.41	3094	"Chi-Chi_ Taiwan-05"	6.2	157.44	1004.58
2114	"Denali_ Alaska"	7.9	0.18	329.4	3117	"Chi-Chi_ Taiwan-05"	6.2	135.78	167.18
2175	"Chi-Chi_ Taiwan-02"	5.9	67.81	169.52	3135	"Chi-Chi_ Taiwan-05"	6.2	131.28	807.68
2178	"Chi-Chi_ Taiwan-02"	5.9	92.14	172.1	3138	"Chi-Chi_ Taiwan-05"	6.2	142.68	856.38
2192	"Chi-Chi_ Taiwan-02"	5.9	79.64	169.84	3139	"Chi-Chi_ Taiwan-05"	6.2	151.93	1022.77
2193	"Chi-Chi_ Taiwan-02"	5.9	119.96	160.67	3145	"Chi-Chi_ Taiwan-05"	6.2	127.97	887.68
2207	"Chi-Chi_ Taiwan-02"	5.9	78.6	804.36	3194	"Chi-Chi_ Taiwan-05"	6.2	91.5	999.66
2209	"Chi-Chi_ Taiwan-02"	5.9	94.3	175.68	3251	"Chi-Chi_ Taiwan-05"	6.2	84.68	845.34
2215	"Chi-Chi_ Taiwan-02"	5.9	56.46	789.18	3282	"Chi-Chi_ Taiwan-06"	6.3	53.54	169.52
2263	"Chi-Chi_ Taiwan-02"	5.9	122.96	909.09	3285	"Chi-Chi_ Taiwan-06"	6.3	76.99	172.1
2266	"Chi-Chi_ Taiwan-02"	5.9	107.49	124.27	3302	"Chi-Chi_ Taiwan-06"	6.3	69.66	169.84
2275	"Chi-Chi_ Taiwan-02"	5.9	105.24	782.59	3303	"Chi-Chi_ Taiwan-06"	6.3	103.8	160.67
2284	"Chi-Chi_ Taiwan-02"	5.9	98.04	158.13	3318	"Chi-Chi_ Taiwan-06"	6.3	62.46	804.36
2296	"Chi-Chi_ Taiwan-02"	5.9	80.14	996.51	3319	"Chi-Chi_ Taiwan-06"	6.3	79.2	175.68
2317	"Chi-Chi_ Taiwan-02"	5.9	122.52	167.18	3324	"Chi-Chi_ Taiwan-06"	6.3	47.81	789.18
2328	"Chi-Chi_ Taiwan-02"	5.9	139.47	816.9	3325	"Chi-Chi_ Taiwan-06"	6.3	52.33	1525.85
2334	"Chi-Chi_ Taiwan-02"	5.9	118.29	807.68	3374	"Chi-Chi_ Taiwan-06"	6.3	107.04	782.59
2335	"Chi-Chi_ Taiwan-02"	5.9	130.24	856.38	3390	"Chi-Chi_ Taiwan-06"	6.3	82.06	996.51
2336	"Chi-Chi_ Taiwan-02"	5.9	139.9	1022.77	3403	"Chi-Chi_ Taiwan-06"	6.3	144.01	150.18
2339	"Chi-Chi_ Taiwan-02"	5.9	114.98	887.68	3420	"Chi-Chi_ Taiwan-06"	6.3	125.31	167.18
2396	"Chi-Chi_ Taiwan-02"	5.9	78.11	999.66	3429	"Chi-Chi_ Taiwan-06"	6.3	120.87	807.68
2447	"Chi-Chi_ Taiwan-02"	5.9	97.46	845.34	3430	"Chi-Chi_ Taiwan-06"	6.3	117.56	887.68
2473	"Chi-Chi_ Taiwan-03"	6.2	45.69	169.52	3473	"Chi-Chi_ Taiwan-06"	6.3	5.72	443.04
2476	"Chi-Chi_ Taiwan-03"	6.2	70.11	172.1	3475	"Chi-Chi_ Taiwan-06"	6.3	0	489.32

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3479	"Chi-Chi_ Taiwan-06"	6.3	81	999.66	4948	"Chuetsu-oki_ Japan"	6.8	245.24	147.06
3542	"Chi-Chi_ Taiwan-06"	6.3	84.03	845.34	4949	"Chuetsu-oki_ Japan"	6.8	275.3	163.55
3548	"Loma Prieta"	6.93	3.22	1070.34	4951	"Chuetsu-oki_ Japan"	6.8	267.98	148.51
3697	"Whittier Narrows-02"	5.27	26.14	160.58	4965	"Chuetsu-oki_ Japan"	6.8	242.95	135.18
3718	"Whittier Narrows-02"	5.27	25.04	1222.52	4969	"Chuetsu-oki_ Japan"	6.8	219.73	760.04
3744	"Cape Mendocino"	7.01	8.49	566.42	4989	"Chuetsu-oki_ Japan"	6.8	118.79	133.05
3746	"Cape Mendocino"	7.01	16.44	459.04	5006	"Chuetsu-oki_ Japan"	6.8	77.65	828.95
3799	"Hector Mine"	7.13	185.92	1015.88	5013	"Chuetsu-oki_ Japan"	6.8	125.46	803.57
3828	"Yountville"	5	60.29	155.11	5043	"Chuetsu-oki_ Japan"	6.8	232.55	904.15
3893	"Tottori_ Japan"	6.61	108.34	834.56	5048	"Chuetsu-oki_ Japan"	6.8	170.79	830.77
3895	"Tottori_ Japan"	6.61	99.64	760.54	5103	"Chuetsu-oki_ Japan"	6.8	217.49	106.83
3920	"Tottori_ Japan"	6.61	70.52	1047.01	5106	"Chuetsu-oki_ Japan"	6.8	183.23	144.14
3925	"Tottori_ Japan"	6.61	15.23	940.2	5117	"Chuetsu-oki_ Japan"	6.8	96.52	166.91
3934	"Tottori_ Japan"	6.61	16.6	138.76	5119	"Chuetsu-oki_ Japan"	6.8	109.16	139.13
3954	"Tottori_ Japan"	6.61	15.58	967.27	5120	"Chuetsu-oki_ Japan"	6.8	131.53	108.21
3962	"Tottori_ Japan"	6.61	45.98	169.16	5122	"Chuetsu-oki_ Japan"	6.8	130.55	133.05
3965	"Tottori_ Japan"	6.61	6.86	139.21	5126	"Chuetsu-oki_ Japan"	6.8	204.27	174.55
4040	"Bam_ Iran"	6.6	0.05	487.4	5129	"Chuetsu-oki_ Japan"	6.8	219.6	111.33
4065	"Parkfield-02_ CA"	6	1.37	383.9	5150	"Chuetsu-oki_ Japan"	6.8	221	138.54
4083	"Parkfield-02_ CA"	6	4.66	906.96	5151	"Chuetsu-oki_ Japan"	6.8	227.32	113.57
4097	"Parkfield-02_ CA"	6	1.6	648.09	5157	"Chuetsu-oki_ Japan"	6.8	217.55	141.79
4098	"Parkfield-02_ CA"	6	1.66	326.64	5161	"Chuetsu-oki_ Japan"	6.8	231.35	89.32
4100	"Parkfield-02_ CA"	6	1.63	173.02	5172	"Chuetsu-oki_ Japan"	6.8	225.96	146.72
4101	"Parkfield-02_ CA"	6	4.95	397.36	5181	"Chuetsu-oki_ Japan"	6.8	184.68	122.07
4102	"Parkfield-02_ CA"	6	2.55	230.57	5256	"Chuetsu-oki_ Japan"	6.8	48.1	173.09
4103	"Parkfield-02_ CA"	6	3.3	410.4	5257	"Chuetsu-oki_ Japan"	6.8	45.54	149.97
4107	"Parkfield-02_ CA"	6	0.02	178.27	5259	"Chuetsu-oki_ Japan"	6.8	27.92	174.55
4113	"Parkfield-02_ CA"	6	1.22	372.26	5260	"Chuetsu-oki_ Japan"	6.8	21.37	128.12
4115	"Parkfield-02_ CA"	6	0.88	265.21	6434	"Tottori_ Japan"	6.61	234.49	2100
4126	"Parkfield-02_ CA"	6	2.85	260.63	6887	"Darfield_ New Zealand"	7	18.05	187
4151	"Niigata_ Japan"	6.63	101.78	133.05	6897	"Darfield_ New Zealand"	7	5.28	295.74
4167	"Niigata_ Japan"	6.63	52.15	828.95	6906	"Darfield_ New Zealand"	7	1.22	344.02
4200	"Niigata_ Japan"	6.63	55.9	173.09	6911	"Darfield_ New Zealand"	7	7.29	326.01
4201	"Niigata_ Japan"	6.63	48	149.97	6927	"Darfield_ New Zealand"	7	5.07	263.2
4203	"Niigata_ Japan"	6.63	38	174.55	6928	"Darfield_ New Zealand"	7	25.21	649.67
4204	"Niigata_ Japan"	6.63	25.14	128.12	6942	"Darfield_ New Zealand"	7	26.76	211
4211	"Niigata_ Japan"	6.63	10.21	418.5	6959	"Darfield_ New Zealand"	7	19.48	141
4215	"Niigata_ Japan"	6.63	46.66	134.5	6960	"Darfield_ New Zealand"	7	13.64	293
4228	"Niigata_ Japan"	6.63	6.27	375	6962	"Darfield_ New Zealand"	7	0	295.74
4247	"Niigata_ Japan"	6.63	100.37	849.01	6966	"Darfield_ New Zealand"	7	22.33	207
4248	"Niigata_ Japan"	6.63	77.39	1432.75	6969	"Darfield_ New Zealand"	7	20.86	247.5
4312	"Umbria-03_ Italy"	5.6	14.67	922	6975	"Darfield_ New Zealand"	7	6.11	249.28
4438	"Molise-02_ Italy"	5.7	49.6	865	8119	"Christchurch_ New Zealand"	6.2	1.92	206
4451	"Montenegro_ Yugoslavia"	7.1	0	462.23	8123	"Christchurch_ New Zealand"	6.2	5.11	141
4458	"Montenegro_ Yugoslavia"	7.1	3.97	318.74	8161	"El Mayor-Cucapah_ Mexico"	7.2	9.98	196.88
4480	"L'Aquila_ Italy"	6.3	0	475	8164	"Duzce_ Turkey"	7.14	2.65	690
4482	"L'Aquila_ Italy"	6.3	0	552	8606	"El Mayor-Cucapah_ Mexico"	7.2	10.31	242
4483	"L'Aquila_ Italy"	6.3	0	717					
4847	"Chuetsu-oki_ Japan"	6.8	9.43	383.43					
4900	"Chuetsu-oki_ Japan"	6.8	274.22	162.09					
4915	"Chuetsu-oki_ Japan"	6.8	233.95	135.4					
4916	"Chuetsu-oki_ Japan"	6.8	261.44	158.16					
4926	"Chuetsu-oki_ Japan"	6.8	219.2	829.46					
4941	"Chuetsu-oki_ Japan"	6.8	217.94	143.47					
4942	"Chuetsu-oki_ Japan"	6.8	232.37	161.64					
4947	"Chuetsu-oki_ Japan"	6.8	241.67	166.02					