Conference Article

How Different Scaling and Matching Approaches Affect the Base Shear?

Anas Al Johmani[1], Ebru Harmandar[2*]

[1] Mugla Sıtkı Koçman University, ORCID ID: https://orcid.org/0000-0002-7641-8572,
[2] Mugla Sıtkı Koçman University, ORCID ID: https://orcid.org/0000-0001-9802-2993,
* Correspondence: ebruharmandar@mu.edu.tr

Received 15 October 2024
Received in revised form 21 December 2024
In final form 22 December 2024

4th International Conference on Design, Research and Development
(RDCONF 2024)
December 19 - 20, 2024

Reference: Al Johmani, A., & Harmandar, E. (2024). How different scaling and matching approaches affect the base shear? Orclever Proceedings of Research and Development, 5(1), 197-209.

Abstract

Proper selecting and scaling of earthquake data are very important to obtain an accurate input which is compatible with the target spectrum for the dynamic analysis of the structures. In this study, six sets of earthquake data were selected where each set contained 11 earthquakes. Magnitude, site conditions, fault mechanisms as well as the distance from the faults are considered as the selection criteria. Then, the selected earthquake data were scaled in three different methods, mainly, time domain scaling, spectral matching in frequency domain and spectral matching in time domain. The scaled data was used to perform the time history analysis on a 5-storey and 11 storey reinforced concrete buildings located in Turkey. At the end, the results are compared with respect to the engineering demand parameter (base shear). As expected, the results are affected with respect to fault mechanism and distance. The highest predicted lateral force on the base of the system due to seismic loads is calculated based on the method, spectral matching in frequency domain.

Keywords*:* *Scaling methods, time history analysis, ASCE 7-16, reinforced concrete structures*

1. Introduction

In order to perform the linear or/and non-linear dynamic analysis of a structure, sets of earthquake ground motions have to be properly selected. In a study done by Ref. [1], the selection process of the time histories was reviewed. It states that there are three selection criteria: the first is earthquake records selection based on the distance (R) and magnitude (M), the second criterion of selection is based on the spectral matching, while the third selection process is based on the intensity measures. It was found that the magnitude factor has an influence on the response quantities. However, on the other hand, the distance was found to be a poor indicator of the structural response and so it is used as an additional criterion in the selection process. Another additional criterion is the soil type because it is known according to many studies that the soil type affects the seismic motions by altering the amplitude as well as the computed response spectra [2]. According to Ref. [3], regarding the selection process, it is stated that earthquake records in an ideal situation should be selected based on the source, path and site conditions including the magnitude, distance from the fault, the fault type, and directivity. The most important parameters that have significant effects on the nonstationary characteristics of the waves are the magnitude, distance and the directivity. It is also stated that the magnitude of an earthquake is the most important parameter that has to be first included in the search for time histories. It is also recommended that when searching for and choosing earthquake recordings, the magnitude should have a range within 0.5 units of the design earthquake, the distance from the fault is to be restricted within 10 km from the nearest fault in the region and can be extended to be in the range of 20 km for sites that are located in farther distances from the fault. Modifying earthquake ground motions to match the target response spectrum is highly important for engineers and it is one of the first steps that has to be done right in order to achieve reliable results for the time history analysis. Many researchers studied the different scaling methods and their advantages and disadvantages. Generally, there are three main methods. The first one is the time domain scaling, the second one is spectral matching in the frequency domain and thirdly the spectral matching in the time domain [4, 5].

Ref. [6] proposed four scaling methods to examine the displacement responses of simple structures for performance based assessment: (1) Geometric mean scaling, (2) spectral matching using RSPMATCH software, (3) first mode period scaling and (4) the distribution scaling method. The results were that the geometric mean scaling preserved the irregular spectral shapes of the ground motion records

Ref. [3] developed a new method about spectral matching that modify the earthquake records to a target spectrum that produce no drifts in the velocity and displacement

https://doi.org/10.56038/oprd.v5i1.526

profiles. The approach uses a new tapered cosine wavelet that modify the acceleration time histories. This method with the new cosine wavelet assures convergence as well as stability in the spectrally matched results. This wavelet is implemented in RspMatch and SeismoMatch software.

Ref. [7] studied on the time domain scaling effects on reinforced concrete structures and tall shear walls. A 56-storey tower that is located in Iran – Tehran. 3 scaling methods were used to modify the earthquake records: (1) scaling by optimization method, (2) uniform scaling and (3) physical approach scaling. The findings were that the scaled valued across the different scaling methods were considerably different but, however, the demand parameter values were close to each other. They concluded that uniform scaling is most appropriate to perform for seven ground motion sets among the other two methods. On the other hand, when ground motion records are scarce and less than seven, other scaling approaches have effects that are more significant. The conclusion of the abovementioned study that if the design target spectrum is taken as a measure of demand requirement that would be added to the structure in case of an earthquake, then optimization method produce more coincide average spectrum. In addition, the scaling factors should not be very different from each other so that they change the idea behind selection of each record.

In this study, non-linear time history analysis is performed to study the effects of different scaling methods on two residential buildings, 5 and 11 floors buildings which are to be located at Muğla city in Turkey. Then, sets of 11 earthquake ground motions are to be selected based on the recommendation of the earthquake building codes. After the selecting process is done, these time histories of real earthquakes have to be scaled in order to match the design target spectrum. Since there are different scaling methods, the time histories will be scaled using different scaling methods and then the models of the building will be run. The results will be tabulated and assessed to see the effects of scaling methods on the engineering demand parameter.

2. Methodology

The time domain scaling approach scale the time histories up or down consistently by a scaling factor that can be either positive or negative in order to match the target spectrum. While it is hard to match the records to the target spectrum along the whole period, engineers tend to concentrate more on the period of interest of the building that is (0.2Tn to 1.5Tn) according to the earthquake building codes. This approach does not change the frequency content of the time history records. Additionally, the records could be scaled separately or the average of spectra could be scaled to match the target spectrum [4].

Eqs. (1) and (2) minimize the difference between the target spectrum and the actual spectrum that is being scaled in a least squared manner:

$$|\mathrm{Difference}| = \int_{\mathrm{Ts}}^{\mathrm{Tf}} (\alpha \mathrm{Sa}^{\mathrm{actual}}(\mathrm{T}) - \mathrm{Sa}^{\mathrm{target}}(\mathrm{T})) \quad (1)$$

$$min|\mathrm{Difference}| = \frac{d\,|\mathrm{Difference}|}{d\alpha} \quad (2)$$

The resulting Eq. (3) is derived from combining Eqs. (1) and (2):

$$\alpha = \frac{\sum_{\mathrm{T=TA}}^{\mathrm{TB}} \left(\mathrm{Sa}^{\mathrm{actual}} - \mathrm{Sa}^{\mathrm{target}}\right)}{\sum_{T=Ta}^{TB} (Sa^{actual})^2} \quad (3)$$

The second approach is called the spectral matching in the frequency domain. In this approach, sets of actual records are being used in order to produce motions that are similar to the target spectrum and almost typical. Engineers use real ground motions and then filter them in their frequency domains by their spectral ratios. The researchers take Fourier spectral amplitudes of the ground motion inputs that are being modified where the Fourier phase stays unchanged during the procedure. It is essential for the time domain non-linear analysis to preserve the phase characteristics because time histories can affect phase one's solutions. For the purpose of keeping the phase one applicable to the transfer function like with an imaginary zero components, Fourier amplitudes must be scaled. This approach is continuously performed iteratively till we achieve the desired matching over a period of time. The more this iterative approach is performed the more compatible results with target design spectrum is achieved [5].
Thirdly, scaling using the spectral matching approach in the time domain where one procedure is based on adjusting original time history records iteratively in time domain in order to accomplish a satisfied degree of compatibility with the target acceleration response spectrum. This is done by summing wavelets that have the desired period ranges and limited durations to the time histories added. So, the next thing in the approach is to add the wave packets at certain ranges where there is a big difference in the amplitudes in the time history. When performing the previous procedures, the phasing characteristics will be preserved as the time changes like the content of non-stationary frequencies [9]. This will result in records having response spectrums that coincide with a certain degree of tolerance to the target spectrum. Ref. [10] firstly presented the approach and later on, it was modified to be able to match spectra at many damping values at the same time [11]. Even though the matching in the time domain can be more difficult than matching in the frequency domain, however, it is able to maintain

https://doi.org/10.56038/oprd.v5i1.526

non-stationary characteristics of the time histories. One software called RSPMATCH was made by Ref. [12] making adjustments and improving on the algorithm of Ref. [11] in order to make it maintain the non-stationary characteristics of the ground motions for a more extended range of time histories.

3. Structural Modelling

Fig. 1 presents the plan of the sample 5-story (Building A) and 11-story (Building B) buildings for this study. Two main materials are used in the design of the buildings: Concrete (C25) and steel (S420) bars for reinforcement. Symmetrical design is chosen to eliminate the buckling effect. Height of Building A is 15 meters composed of 5 floors and Building B is 33 meters composed of 11 floors.
It is highly advisable to know the characteristics of the soil before commencing the design in order to know the behaviour of the soil. Differences in the soil properties have some effects on building that is under earthquakes. AFAD website (https://tdth.afad.gov.tr) is used to acquire the soil properties to be able to draw the design response spectrum based on SDS and SD1 values as well as the soil type (Table 1).

a) b)

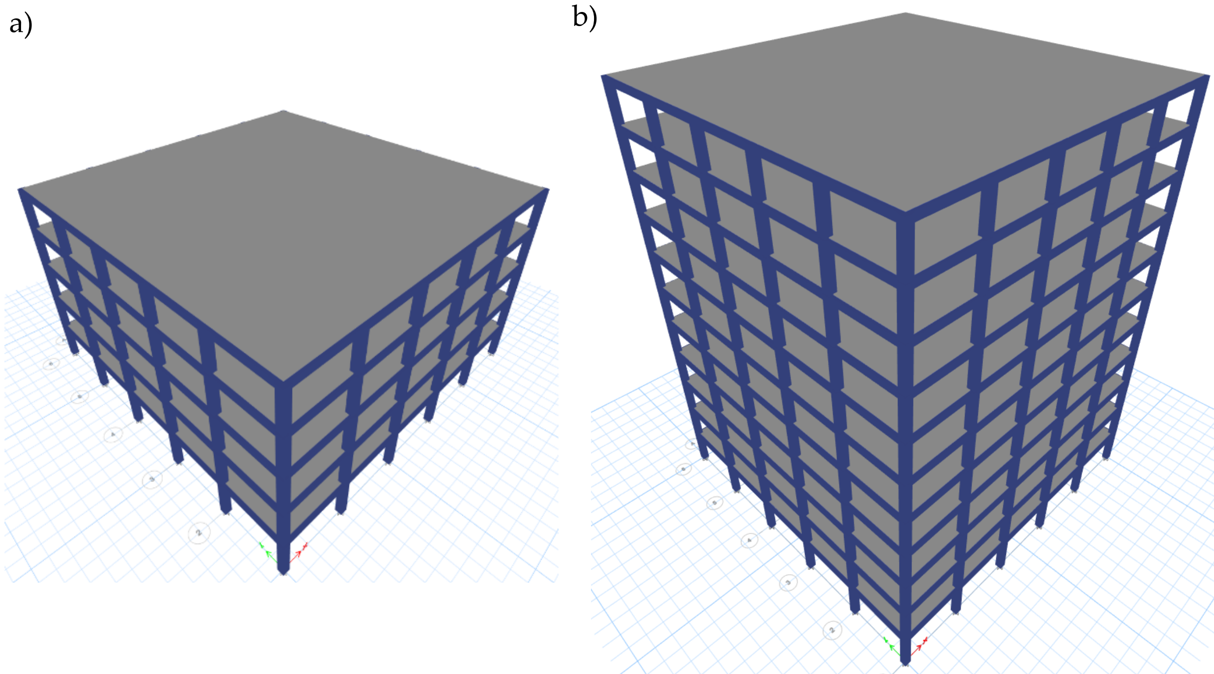

Figure 1: 3D-plan view of the Building A (a) and Building B (b)

Table 1: Properties of the design spectrum

https://doi.org/10.56038/oprd.v5i1.526

Site location	Turkey - Muğla
Soil Type	Stiff soil
Soil Description	Tight sand, gravel, hard clay layers
Latitude	37.030278°
Longitude	28.506389°
Earthquake level	DD-2 (10% of exceedance in 50 years – Recurrence period of 475 years)
S_{DS}	1.206
S_{D1}	0.376

4. Selecting of Earthquake Data

For the selection process, the magnitude, site distance from source, and the fault mechanisms are considered. The site is chosen to be stiff soil with a shear velocity in the upper 30 meters varying from 180 to 760 m/s. The real earthquake records are downloaded from the PEER database.

The selection criteria of earthquake data are as: The magnitude range: 5 - 9; The distance range for near field: 0 - 15 km; The distance range for far field: 15 - 100 km.

According to the earthquake building codes, the following requirements are considered:

1- Sets of eleven earthquake records are to be selected considering site conditions, fault mechanism, magnitude and distance.
2- Maximum three records are allowed from the same earthquake.
3- The period of interest along the response spectrum is 0.2 Tn to 1.5 Tn. The square root of the sum of squares should be used for the two horizontal records. SDS and SD1 values are multiplied by 1.3 to account for the increase that is resulted from using the SRSS method in the PEER database.
4- Scaling of the two horizontal records then is scaled with the same factor

Fig. 2 shows the flowchart of the research where 3 types of fault mechanisms are chosen namely: Normal fault, reverse fault and strike-slip fault. For each of these faults, earthquake records from near field and far field are selected. Then, each set of earthquake records is scaled or matched according to three different modification methods: Time domain scaling (TDS), Spectral matching in the frequency domain (SMFD), and Spectral matching in the time domain (SMTD).

https://doi.org/10.56038/oprd.v5i1.526

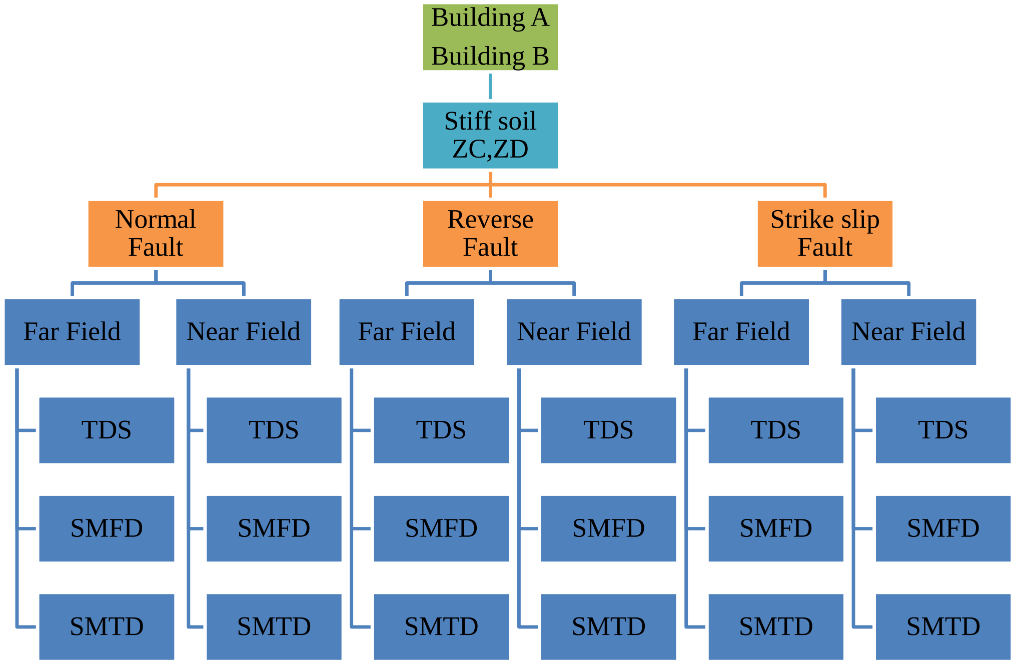

Figure 2: Flowchart of this study. Time domain scaling (TDS), Spectral matching in the frequency domain (SMFD), and Spectral matching in the time domain (SMTD)

Table 2-Table 7 contain the earthquake records taken from the PEER database for the normal fault - far field, normal fault – near field, reverse fault - far field, reverse fault – near field, and strike-slip fault - far field, strike-slip fault – near field, respectively.

Table 2: Earthquake records for normal fault - far field.

NORMAL FAULT - FAR FIELD										
Number of EQ	EQ name	Station Name	Year	Record sequence number	Mean Squared Error	Scale Factor	Magnitude	Rjb (km)	Vs30 (m/sec)	Lowest usable frequency (Hz)
1	"Irpinia_ Italy-01"	"Bisaccia"	1980	286	0.4061	2.7312	6.9	17.51	496.46	0.15
2	"Irpinia_ Italy-01"	"Brienza"	1980	288	0.4219	3.1587	6.9	22.54	561.04	0.2875
3	"Irpinia_ Italy-01"	"Rionero In Vulture"	1980	291	0.4246	4.9985	6.9	27.49	574.88	0.375
4	"Irpinia_ Italy-02"	"Rionero In Vulture"	1980	302	0.1378	3.4906	6.2	22.68	574.88	0.25
5	"New Zealand-02"	"Matahina Dam"	1987	587	0.1463	1.4825	6.6	16.09	551.3	0.25
6	"Northwest China-02"	"Jiashi"	1997	1750	0.4635	4.2461	5.93	17.9	240.09	0.3
7	"Lazio-Abruzzo_ Italy"	"Cassino-Sant' Elia"	1984	3605	0.8175	5.206	5.8	19.97	436.79	0.375
8	"Umbria Marche_ Italy"	"Gubbio-Piana"	1997	4350	0.4025	2.9062	6	35.79	492	0.0625
9	"Umbria Marche_ Italy"	"Matelica"	1997	4351	0.2402	5.3676	6	22.75	437	0.125
10	"Umbria Marche (aftershock 2)_ Italy"	"Norcia-Altavilla"	1997	4391	0.6925	4.4963	5.6	16.11	218	0.15
11	"L'Aquila_ Italy"	"Avezzano"	2009	4462	0.2709	4.7312	6.3	23.67	199	0.05

Table 3: Earthquake records for normal fault - near field

NORMAL FAULT - NEAR FIELD										
Number of EQ	EQ name	Station Name	Year	Record sequence number	Mean Squared Error	Scale Factor	Magnitude	Rjb (km)	Vs30 (m/sec)	Lowest usable frequency (Hz)
1	"Norcia_ Italy"	"Cascia"	1979	156	0.4143	4.3392	5.9	1.41	585.04	0.4125
2	"Mammoth Lakes-01"	"Convict Creek"	1980	230	0.5014	1.6683	6.06	1.1	382.12	0.25
3	"Mammoth Lakes-01"	"Long Valley Dam (Upr L	1980	231	0.2641	2.1782	6.06	12.56	537.16	0.1375
4	"Irpinia_ Italy-01"	"Bagnoli Irpinio"	1980	285	0.2108	1.934	6.9	8.14	649.67	0.1125
5	"Irpinia_ Italy-01"	"Calitri"	1980	289	0.364	2.2795	6.9	13.34	455.93	0.25
6	"Irpinia_ Italy-02"	"Bisaccia"	1980	297	0.369	3.6566	6.2	14.73	496.46	0.1625
7	"Corinth_ Greece"	"Corinth"	1981	313	0.3624	1.861	6.6	10.27	361.4	0.25
8	"Kalamata_ Greece-01"	"Kalamata (bsmt)"	1986	564	0.3348	1.785	6.2	6.45	382.21	0.1625
9	"Umbria Marche (aftershock 2)_ Italy"	"Borgo-Cerreto Torre"	1997	4383	0.6162	3.9606	5.6	8.3	519	0.1
10	"L'Aquila_ Italy"	"GRAN SASSO	2009	4477	0.3201	4.1508	6.3	6.35	488	0.15
11	"L'Aquila_ Italy"	"L'Aquila - Parking"	2009	4483	0.2963	1.4781	6.3	0	717	0.025

Table 4: Earthquake records for reverse fault - far field

REVERSE FAULT - FAR FIELD										
Number of EQ	EQ name	Station Name	Year	Record sequence number	Mean Squared Error	Scale Factor	Magnitude	Rjb (km)	Vs30 (m/sec)	Lowest usable frequency (Hz)
1	"Kern County"	"Santa Barbara Courthouse"	1952	14	0.5032	3.6722	7.36	81.3	514.99	0.375
2	"Kern County"	"Taft Lincoln	1952	15	0.1351	2.2823	7.36	38.42	385.43	0.125
3	"San Fernando"	"Castaic - Old Ridge	1971	57	0.7319	2.6034	6.61	19.33	450.28	0.375
4	"San Fernando"	"Lake Hughes #1"	1971	70	0.4418	3.8488	6.61	22.23	425.34	0.15
5	"Coalinga-01"	"Parkfield - Fault Zone	1983	340	0.4119	3.453	6.36	26.2	384.26	0.2875
6	"Coalinga-01"	"Parkfield - Gold Hill	1983	352	0.2808	3.9867	6.36	38.1	510.92	0.15
7	"N. Palm Springs"	"San Jacinto - Soboba"	1986	534	1.0194	4.3946	6.06	22.96	447.22	0.25
8	"Taiwan SMART1(45)"	"SMART1 E02"	1986	572	0.149	2.957	7.3	51.35	671.52	0.1
9	"Whittier Narrows-01"	"Studio City - Ventura & Coldwater Cyn Av"	1987	694	1.1414	4.3338	5.99	26.91	400.44	0.3
10	"Loma Prieta"	"APEEL 10 - Skyline"	1989	731	0.492	2.9609	6.93	41.71	391.91	0.1
11	"Loma Prieta"	"Anderson Dam (Downstrea	1989	739	0.1415	1.7978	6.93	19.9	488.77	0.1

Table 5. Earthquake records for reverse fault - near field

REVERSE FAULT - NEAR FIELD										
Number of EQ	EQ name	Station Name	Year	Record sequence number	Mean Squared Error	Scale Factor	Magnitude	Rjb (km)	Vs30 (m/sec)	Lowest usable frequency (Hz)
1	"Tabas_ Iran"	"Dayhook"	1978	139	0.0864	1.453	7.35	0	471.53	0.25
2	"Loma Prieta"	"San Jose - Santa Teresa Hills"	1989	801	0.12	1.839	6.93	14.18	671.77	0.0375
3	"Loma Prieta"	"Saratoga - Aloha Ave"	1989	802	0.0912	1.0767	6.93	7.58	380.89	0.125
4	"Cape Mendocino"	"Cape Mendocino"	1992	825	0.085	0.6084	7.01	0	567.78	0.07
5	"Chi-Chi_ Taiwan"	"TCU071"	1999	1507	0.0811	0.733	7.62	0	624.85	0.25
6	"Chi-Chi_ Taiwan"	"TCU076"	1999	1511	0.1413	0.9542	7.62	2.74	614.98	0.125
7	"San Simeon_ CA"	"Cambria - Hwy 1 Caltrans	2003	3979	0.0946	2.9616	6.52	6.97	362.42	0.1
8	"San Simeon_ CA"	"Templeton - 1-story	2003	4031	0.0785	1.161	6.52	5.07	410.66	0.0875
9	"Niigata_ Japan"	"NIGH11"	2004	4228	0.1602	1.1145	6.63	6.27	375	0.05
10	"Chuetsu-oki_ Japan"	"Yoitamachi Yoita	2007	4864	0.1665	1.4729	6.8	4.69	655.45	0.1
11	"Iwate_ Japan"	"Mizusawaku Interior O	2008	5813	0.1563	1.3097	6.9	7.82	413.04	0.1

Table 6: Earthquake records for strike slip fault - far field

STRIKE SLIP FAULT - FAR FIELD										
Number of EQ	EQ name	Station Name	Year	Record sequence number	Mean Squared Error	Scale Factor	Magnitude	Rjb (km)	Vs30 (m/sec)	Lowest usable frequency (Hz)
1	"Imperial Valley-06"	"Cerro Prieto"	1979	164	0.1053	2.2177	6.53	15.19	471.53	0.1125
2	"Livermore-01"	"Del Valle Dam (Toe)"	1980	212	0.1876	3.6591	5.8	23.92	403.37	0.1625
3	"Landers"	"Fort Irwin"	1992	855	0.1818	3.238	7.28	62.98	367.43	0.07
4	"Kocaeli_ Turkey"	"Fatih"	1999	1160	0.1885	2.6981	7.51	53.34	386.75	0.025
5	"Hector Mine"	"Big Bear Lake - Fire	1999	1770	0.2152	2.7773	7.13	61.85	406.7	0.026
6	"Denali_ Alaska"	"Carlo	2002	2107	0.0679	4.7335	7.9	49.94	399.35	0.078
7	"Chi-Chi_ Taiwan-04"	"CHY028"	1999	2703	0.0969	3.0393	6.2	17.63	542.61	0.0325
8	"Chi-Chi_ Taiwan-04"	"CHY035"	1999	2709	0.2061	3.2067	6.2	25.01	573.04	0.05
9	"Landers"	"Forest Falls Post	1992	3752	0.0971	3.8206	7.28	45.34	436.14	0.125
10	"Landers"	"North Palm Springs Fire	1992	3757	0.1408	2.7545	7.28	26.95	367.84	0.1125
11	"Bam_ Iran"	"Mohammad Abad-e-	2003	4054	0.0891	4.4452	6.6	46.2	574.88	0.0375

https://doi.org/10.56038/oprd.v5i1.526

Table 7. Earthquake records for strike slip fault - near field

STRIKE SLIP FAULT - NEAR FIELD										
Number of EQ	EQ name	Station Name	Year	Record sequence number	Mean Squared Error	Scale Factor	Magnitude	Rjb (km)	Vs30 (m/sec)	Lowest usable frequency (Hz)
1	"Kobe_Japan"	"Nishi-Akashi"	1995	1111	0.2394	1.1131	6.9	7.08	609	0.125
2	"Kocaeli_Turkey"	"Arcelik"	1999	1148	0.3017	2.31	7.51	10.56	523	0.0875
3	"Duzce_Turkey"	"Lamont 1059"	1999	1612	0.1553	3.5294	7.14	4.17	551.3	0.075
4	"Duzce_Turkey"	"Lamont 1061"	1999	1614	0.1557	3.6521	7.14	11.46	481	0.0875
5	"Manjil_Iran"	"Abbar"	1990	1633	0.0527	0.7647	7.37	12.55	723.95	0.13
6	"Hector Mine"	"Hector"	1999	1787	0.1614	1.3832	7.13	10.35	726	0.0375
7	"Chi-Chi_Taiwan-04"	"CHY074"	1999	2734	0.2306	1.1634	6.2	6.02	553.43	0.08
8	"Tottori_Japan"	"SMN015"	2000	3943	0.0702	2.3484	6.61	9.1	616.55	0.075
9	"Bam_Iran"	"Bam"	2003	4040	0.2418	0.6464	6.6	0.05	487.4	0.0625
10	"Parkfield-02_CA"	"Bear Valley Ranch_ Parkfield_ CA_USA"	2004	4096	0.1752	3.8369	6	3.38	527.95	0.125
11	"Parkfield-02_CA"	"Parkfield - Vineyard Cany 1E"	2004	4130	0.2735	1.7384	6	1.59	381.27	0.1125

5. Result

The results of the different scaling and matching methods by using the time history analysis on 12 sets of eleven earthquakes in the near field and far field on the low-rise and mid-rise buildings are discussed. The discussion is carried out based on the results of base shear.

The highest predicted lateral force on the base of the system due to seismic is calculated based on the different scaling methods. Table 8 shows the maximum base shear values for Building A (5 floors).

Table 8. Base shear results for normal fault – far field – Building A

Building A - normal fault - far field			
	Max base shear (KN)		
EQ	TDS	SMFD	SMTD
286	1347.3664	3437.3545	2730.1566
288	2353.4518	4942.3514	3081.8834
587	2457.1023	4575.1078	2722.2108
3605	2806.7295	3973.4453	2576.564
4351	2638.5854	3732.6005	2555.3541
302	1987.4824	3827.3814	3043.3488
4350	1740.5627	3807.6012	2659.7678
1750	2377.3495	3651.0641	2424.1627
4462	2225.9826	3819.9558	2555.4949
4391	5337.0458	4273.893	2749.5357
291	2706.732	4285.4176	2720.702
AVG	**2543**	**4030**	**2711**

https://doi.org/10.56038/oprd.v5i1.526

Fig. 3 and fig. 4 represent the base shear values for Building A (5 floors) and Building B (11 floors) achieved by three different scaling methods, respectively. It can be noticed that the SMFD produced higher results across all sets of earthquakes. There are fluctuations in the results for the TDS and SMTD.

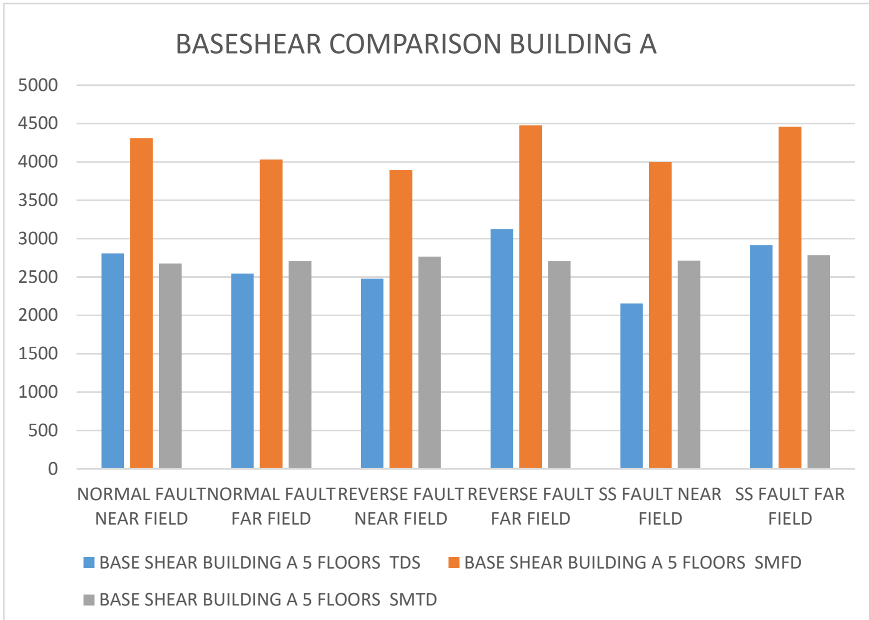

Figure 3: Comparison of base shear values among different scaling methods and fault mechanism - Building A

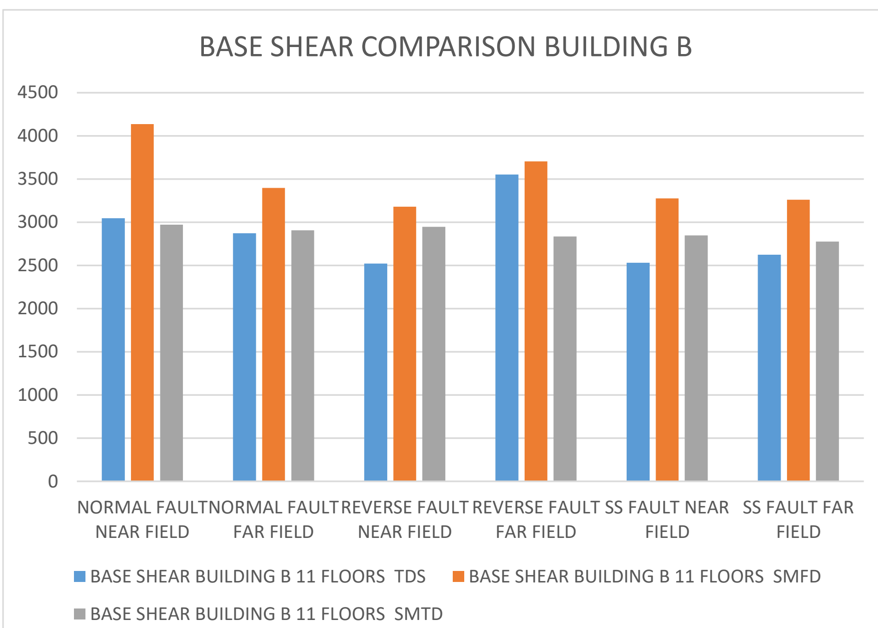

Fig. 4: Comparison of base shear values among different scaling methods and fault mechanism - Building B

The SMFD method gives higher values for base shear in about 83% of the results. The TDS and SMTD methods show similar results for the normal fault. However, there are noticeable differences between the TDS and SMTD methods for the reverse and strike-slip faults.

6. Conclusions

Earthquake records were selected and chosen from the PEER database based on magnitude, fault mechanism, distance from fault and site conditions. The earthquake records were modified to match the target response spectrum. For this, three different modification methods were used: Time domain scaling, spectral matching in the frequency domain and spectral matching in the time domain. Then, the engineering demand parameter (Base shear) were achieved and compared.

- •The SMFD method resulted in higher values for the base shear for all the sets of earthquake records for building A and building B.
- •The TDS and SMTD methods resulted in relatively close results for the engineering demand parameter.
- •There are higher variabilities in the results of base shear between the SMFD and the other two methods (TDS and SMTD) for building A.
- •The SMTD method produce records that are very compatible with the target spectrum along wider range of periods.
- •Spectral matching in time domain produced very compatible scaled spectra to the target spectrum better than the other two scaling methods.
- •In the time domain scaling, it is impossible to match all the spectra to the target spectrum and hence the concentration is on the period range of interest.

7. Acknowledge

This thesis was funded by Muğla Sıtkı Koçman University Scientific Research Project Office (BAP, Project No. 21/120/03/2).

References

[1] Katsanos EI, Sextos AG, Manolis GD: Selection of earthquake ground motion records: A state-of-the-art review from a structural engineering perspective. Soil Dyn Earthq Eng. 2010; 30(4): 157–169.

[2] Bommer JJ, Acevedo AB: The use of real earthquake accelerograms as input to dynamic analysis. J Earthq Eng. 2004; 43–91.

[3] Al Atik L, Abrahamson N: An improved method for nonstationary spectral matching. Earthq Spectra. 2010; 26(3): 601–617.
[4] Fahjan YM: Selection and scaling of real earthquake accelerograms to fit the Turkish design spectra. Teknik Dergi/Technical J Turkish Chamb Civ Eng. 19(SPEC. ISS.); 2008; 1231–1250.
[5] Özdemir Z, Fahjan YM: Comparison of time and frequency domain scaling of real accelerograms to match earthquake design spectra. In: Sixth Natl Conf Earthq Eng; 2007; 435: 446.
[6] Huang YN, Whittaker AS, Luco N, Hamburger RO: Scaling earthquake ground motions for performance-based assessment of buildings. J Structural Eng. 2011; 137(3): 311–321.
[7] Samadzad M, Esmaili O, Epackachi S, Mirghaderi R: Effects of time-domain ground motion scaling method on nonlinear response of tall shear walls and RC structures. In: Ninth Canadian Conference on Engineering; 2007 26-29 June; Ottawa, Ontario, Canada.
[8] Graves RW, Pitarka A, Somerville PG: Ground-motion amplification in the Santa Monica area: Effects of shallow basin-edge structure. Bull Seism Soc Am. 1998; 88 (5): 1224–1242. Doi: https://doi.org/10.1785/BSSA0880051224.
[9] Kaul MK: Spectrum-consistent time-history generation. J Eng Mechanics Division. 1978; 104(4): 781-788.
[10] Lilhanand K, Tseng WS: Generation of synthetic time histories compatible with multiple-damping design response spectra. In: Transactions of the 9th international conference on structural mechanics in reactor technology. 1987, K1.
[11] Abrahamson NA: Non-stationary spectral matching. Seismological Res Letters. 1992; 63.1: 30.