International Journal of Statistics and Systems
ISSN 0973-2675 Volume 11, Number 2 (2016), pp. 115-127

http://www.ripublication.com

Analysis of Concrete structure vibration performance regarding record dual scale coefficient of earthquakes in temporal background analysis

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Abstract:

To choose a suitable record, there is a preference to plan response spectrum adaptability over seismology parameters. As said before, when analyzing temporal background records are in accordance with intense movement's parameters like PGA, PGV and the time needed to coincide with plan response spectrum. These records should be corrected using plan spectrum. So records are selected from intense movements like: maximum Earth velocity, maximum Earth speed and the time needed to coincide with plan response. Common methods of scaling records in temporal background analysis includes frequency and temporal domain methods. Method used in bylaws is in temporal domain method. Scale value of this method depends on initial resistance and tenacity, process of structure tenacity decline and the type of soil in which earthquake occurs. However; this method of scale has not the ability to change records frequency content and surrender its effect. To further describe the above mentioned problem, it should be said that dynamic analysis of structures using earthquake records needs record choices, number of required records and type of method in scaling records. So in this paper it has been tried to present a new method for different quake dual scaling and the effect it has in comparison to other methods on behavioral quake of concrete frame in temporal background analysis results. Method used for scaling records in performing analysis of temporal background is record revision based on 2 scale coefficients in which public scaling coefficient and temporal scale coefficient are used to scale quake records. This way, effect of applying this method is evaluated looking at the amount of decrease in steel response.

Key words: records, temporal background, concrete structure, scaling

1. Introduction

In the discussion of structure quake performance evaluation, their manner of behavior based on imposed loads in non-linear confine is a very important subject in structural engineering. There are many approximate methods to determine structural nonlinear behavior. One of the most accurate methods in estimating structure response to the quakes occurred in nonlinear behavioral confine is the method of nonlinear temporal record analysis. Gaining accurate and correct outcomes in nonlinear temporal record analysis necessitate using recorders which are nicely scaled. Choosing the type of record and scaling it according to design spectrum is one of components of this method. There are many ways to act upon in this way.

To choose a suitable record, there is a preference in plan response spectrum over seismographic parameters. As said before, in analyzing temporal chronicle records are chosen among intense movement parameters like PGA, PGV and the time needed to coincide with plan response spectrum. These records should be corrected by plan spectrum. [3,4]. So records are chosen based on intense movement parameters like maximum Earth's velocity, maximum Earth's speed and the time needed to coincide with plan response spectrum. Among common methods of scaling records in temporal chronicle analysis are frequency domain (in which content of Earth's registered movement frequency is provided manually to further adjust with the purpose plan) and temporal domain (which has confined themselves manually only to making Earth's registered movement range). Temporal Spectrum velocity values simply and evenly scaled to high and low or elementary equations to coincide with process plan spectrum.

Method used in bylaws is also located in temporal domain method group. Scale value of this method depends on initial resistance and tenacity, process of structure tenacity decline and the type of soil in which earthquakes occur. However; this type of scaling is not able to change the content of records frequency and surrenders its effect. To further explain this problem, it should be said that analyzing structural dynamic needs record choice, required number of records and the type of records scaling methods.

In studies made by Kappos and Kyriakakis, evaluating method of further scaling in natural records of quakes and its effect on analysis results were dealt. Shahrouzi and Sazjini in a search for choosing and scaling quake records in analyzing temporal chronincle made use of extra heuristic optimization algorithms. Martinez-Rueda in a survey studied 2 general approaches for synchronized scaling of records maximum domain and records temporal scale. Fahja and Ozdemir in a survey presented a simple method for choosing and scaling records on structures, moreover; they used equivalent frame of one freedom degree instead of nonlinear analysis of cutting frame. Watson and Abrahamson in their study using a suggested process depending on largeness, distance and type of quake area confined temporal period of records for scaling quake records in analysis of temporal chronicles. In a survey done by Azari Rahimzade investigation of the performance of method in scaling presented in FEMA440 in estimating concrete structure parameters to compare the method of records in bylaw in Iran 2008 and UBC are evaluated. Mehrabian and Saffari investigated different methods of Iran quake records scaling for farther distances and near fault for 4 types of soil.

In this paper we tried to evaluate different methods of scaling records in analyzing temporal chronicle and then a new method for record dual scaling of different quakes

are presented and the effect of using this method on quake behavior concrete frames in result analysis of temporal chronicle are studied and investigated. Method used in scaling records for performing temporal chronicle analysis is discussed in this paper, record correction is based on 2 scaling coefficients in which apart from public scaling coefficient (PGA), a temporal scaling coefficient is also used in scaling quake records in order to compare and evaluate the effect of use of this method in decreasing response of steel frames.
To compare results taken from dynamic analysis of temporal chronicle with methods of spectrum analysis, it is necessary that apart from scaling actions needed to correct quake records. There are many methods presented in record scaling in this paper. Effect of this method will be studied in analyzing temporal chronicle of concrete bending frame structures.

2. Plan and analysis of concrete frames being studied

2.1 static analysis

In this study 2 concrete structures with average bending frame system in 5 and 8 floors are modeled and studied. Plan of all considered structures are presented and is obvious in figure 1. Structures are located in areas of high danger. Plan base velocity is A=0.35 and earth type of II and building importance coefficient is I=1. Concrete resistance is 250 kg/cm^2 and fittings are of type AIII. Floor heights in models equals to 3.2 and opening length is between 4 to 5.5 meters and dead load, floor live load and live load of roof are 480, 200 and 150 kg/cm^2 respectively. System of model structures are of average concrete bending frame and structure period is T, reflex coefficient is B and other parameters are presented in table 1.

Table 1: plan of modeled structures

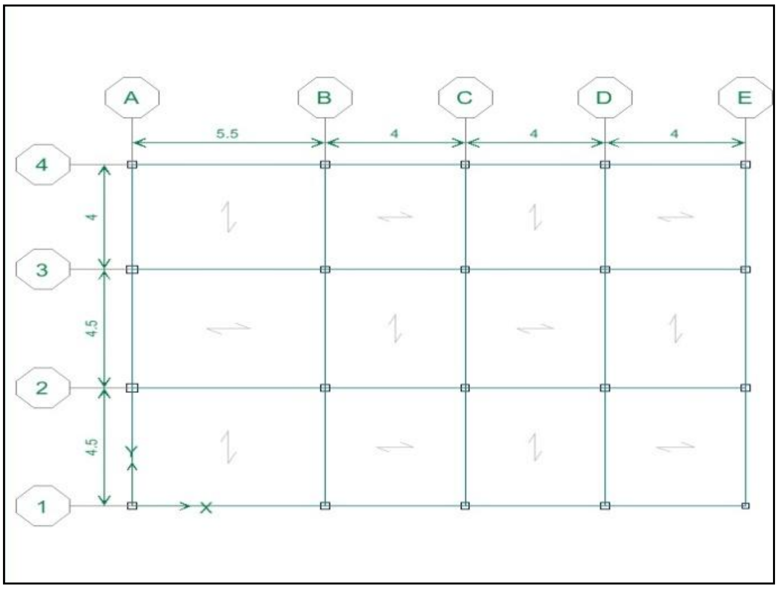
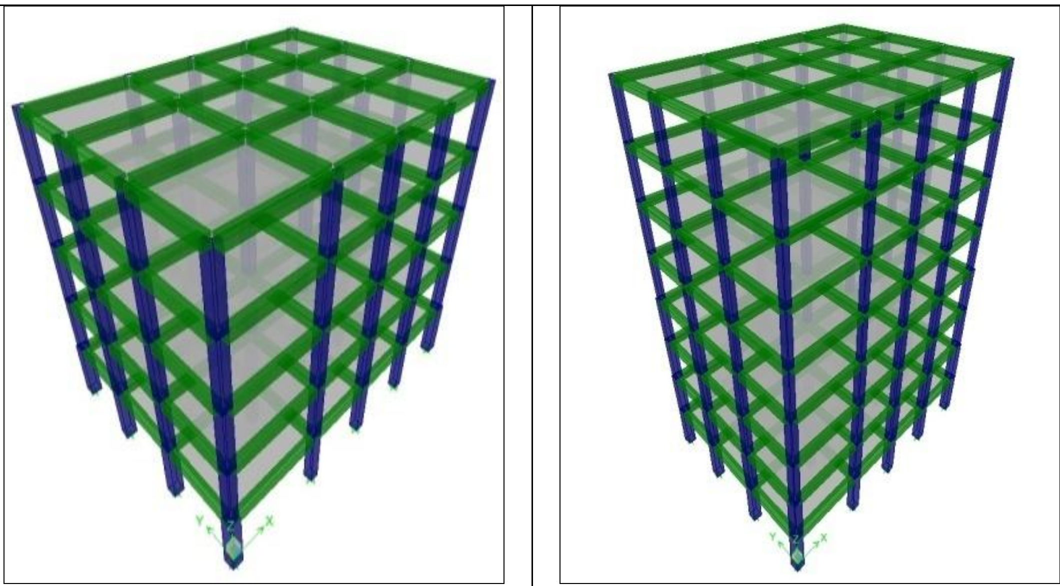


Table 1: quake features of analyzed structures

Floor number	(m) height	(sec) period	Reflex B coefficient	Behavior R coefficient	Quake C coefficient
5	16	0.56	2.31	7	0.1159
8	25.6	0.796	1.83	7	0.0917

Based on 2800 standard, structures having a period more than 0.7 seconds experience whip force. To apply whip force resulted from quake power, it is done according to UBC94. Not to mention, variables are applied in such a way that whip force measured by software is applied based on 2800 standard. 2 structures of 5 and 8 floor are modeled and planned to determine their optimization points based on table 2 for bars and floor pillars.



A. 5 floor modeled structure | B. 8 floor modeled structure

Figure 2: modeled structures

Table 2: features of bar segments and modeled structure pillars

MODEL	Story	Columns		Beams
5STORY	5	C40-12F18		B40X40
	4	C50-12F18		B40X40
	3	C50-12F18		B40X50
	2	C50-12F18		B40X50
	1	C60-20F20	C50-12F18	B40X50
8STORY	8	C40-12F18		B40X40
	7	C40-12F18		B40X40
	6	C40-12F18	C40-16F18	B40X40
	5	C40-12F18	C50-12F18	B40X50
	4	C50-12F18		B40X50
	3	C50-16F18	C50-12F18	B40X50
	2	C60-20F20	C50-16F18	B40X50
	1	C60-20F20		B50X50

2.2 analysis of linear temporal (dynamic) chronicle

In this method, structure is analyzed based on many registered or simulated records. Records should be equivalent with quake source procedure, comparable quake largeness, quake place distance to structure, geological and tectonic features, and type of alluvia layers. Their adaptability is provided by maximum plan or quake spectrum. Time needed to a strong shock in records Earth should be 10 seconds or 3 folds of structure main shift time. Time needed for Earth strong shock in records can be determined using valid methods like method of energy aggregation distribution. Forces and form transformations are determined with recessive behavior. Orderly structure analysis with independent peripheral resistant members in 2 ways can be done 2 dimensionally in 2 distinct ways, otherwise; structure should be analyzed in 3 dimensional ways.

2.3 choosing records and methods of scaling them in linear dynamic analysis

As said before, response of temporal chronicle analysis depends heavily on used record features and slightest changes in these records results in huge discrepancy in responses. One important subjects related to response chronicle analysis is choosing suitable shocks. Records used should belong to shocks having features (hugeness, distance from stimulant fault and conditions of place soil) similar to plan shock conditions in place. Every shock consists of 2 horizontal components and 1 vertical component which in 3 dimensional analyses, 2 horizontal components of shock simultaneously put structures under pressure based on what will be discussed in the next chapter. In this study, 7 pairs of real records are chosen to carefully analyze linear response chronicle.

2.4 methods of record tantamount

7 pairs of records are used for dynamic analysis according to standard

recommendation 2800. 3 following methods are used to do the act of Tanta mounting:

2.4.1 method of standard tantamount 2800

Based on mentioned discussions, records used for linear dynamic analysis are provided in table 3. Graph of pair records used are provided in figure 3. After choosing records by Seism signal software, their response spectrum is shown to be of %5 damping ratio, one sample of a measured spectrum is provided in figure 4.

Table 3: features of records being used

record	(sec) time	PGA (g)	
		Y component	X component
Parkfield	30.32	0.357	0.272
Avaj	32.46	0.431	0.494
Chalan	32.48	0.347	0.431
Tabas	23.8	0.406	0.327
Northridge	39.98	0.514	0.568
Kooshk	32.28	0.394	0.328
Italy	32.74	0.342	0.333

This way for each pair of records according to standard 2800 there was one distinct synthetic spectrum which is being averaged. In the next step, based on 2800 standard, average obtained is compared to multiplication of reflex spectrum in 1.3 velocity of plan base. In bylaw ASCE, average of response spectrum of 7 records in 0.2T to 1.5 T confine should be % 10 more of 1.3 times multiplication reflex spectrum in plan base velocity. In bylaw 2800 there is not a value dedicated to it and there is only an evidence of focus on a high average value. This way above corrections are made. In figure 5 the graph obtained is shown. Then; scale coefficient is measured for initial records according to 2800 standard. Coefficient of obtained scales is shown in table 4.

Table 4: values of scale coefficient for records according to 2800 method

Seismograph	Parkfield	Avaj	Chalan	Tabas	Northridge	Koshk	Italy
Scale Factor	2.00	1.43	1.10	1.45	0.72	4.26	1.50

2.4.2 compound scaling (2800 compound and dual scaling)

Another method for measuring scale factor for seismographs is the compound method. At first, seismograph times are normalized in this method and will be multiplied in time scale factor, then; new seismographs of the obtained spectrums together with spectrum average comparison to scaling factor value are measured. Steps in doing this process are as follows:

1- Spectrum division PGA to normalize them

2- Measuring value of T_{atp} seismograph from response spectrum (T_{atp}: time needed for response spectrum to reach the value of 1.)
3- Gaining T_{atp} of reflex spectrum of the soil
4- Gaining factor of time scale according to $SF_t = T_{atp(Mean)} / T_{atp(accel.)}$ relation.
5- Applying time scale factor to normalized seismographs of time axis.
6- SRSS and act of averaging
7- Comparison with reflex spectrum in the desired confine and measuring scale factor.

After calculating so-called factors, they are applied to seismographs and after SRSS operations and comparing average values with standard plan spectrum, values of seismograph scale factors are calculated according to table 6. After calculating scaling factors, these factors will be applied to seismographs and structures with respect to measured seismographs will be dynamically analyzed. Calculated force values are presented later.

2.4.3 Dual Scaling

In this new method, both velocity and time axis are being scaled. Velocity axis is scaled based on Heosner stress of seismograph and time axis is scaled according to T_{atp} factor. This is a practical engineering method to simplify dynamic calculations. To use dual scaling method, Martinez Article is considered a reference for application analysis of practical engineering in guiding dual tantamount of shock movements in order to analyze non-linear chronicle.

Figure 3: Used pair seismographs for dynamic analysis

Figure 4: sample of a calculated seismograph

Figure 5: axis of response spectrum

Average and corrected standard spectrum

Table 5: scaling factor values of seismographs according to compound scaling method

Seismograpgh	**Parkfield**		**Avaj**		**Chalan**		**Tabas**		**Northridge**		**Koshk**		**Italy**	
	x	y	x	y	x	y	x	y	x	y	x	y	x	Y
T_{amp}	0.5	0.6	0.6	0.5	1	0.9	0.7	0.7	1	1.2	0.2	0.4	1	1
SF_t	0.26	0.28	0.28	0.23	0.48	0.44	0.36	0.36	0.50	0.63	0.11	0.20	0.50	0.50

Table 6: values of scaling factor for seismographs based on compound method

Seismograph	Parkfield	Avaj	Chalan	Tabas	Northridge	Koshk	Italy
Scale Factor	1.01	0.95	1.50	1.20	1.65	0.88	1.26

Since parameters like: type of faults, distance to shock center, type of structure, shock largeness have an influence on shock forces imposed on structures, this is a general method used for different structures of shocks of each seismograph type. In dual scaling method presented in Martinez article, shocks occurred in normal faults and stone structures are used. After above explanations, way of dual scaling is done step by step as follows:

1- Division of seismographs to PGA for normalizing them
2- Calculating T_{atp} values of seismographs through response spectrum
3- Gaining T_{atp} of reflex spectrum of alleged soil according to the above relation.
4- Gaining time scale factor
5- Applying time scale coefficient to time axis of normalized seismographs.
6- Calculating Heosner for each seismograph (using seism signal software)
7- Obtaining average from Heosner intensity based on the relation:
$SF_a = HI_{Mean} / HI_{Accel.}$
8- Calculating factor of intensity scale
9- Applying intensity scale factor to velocity axis, scaling seismographs to time scale factor
10- SRSS and averaging
11- Comparison to reflex spectrum in the relevant domain and calculating scaling factor

Mentioned factors are presented in table 7. A dual scaling sample is presented for Chalan Quake seismograph.
They are applied to seismograph only after calculating mentioned factors. After SRSS operations and comparing average values with standard plan spectrum, values of seismograph scaling factors were calculated according to table 8.
Now that all of scaling factors are calculated using mentioned method, these factors were applied to seismographs and structures are laid based on dynamic analysis. Analysis results are presented later. Values of forces and movements like floor cuttings, anchor, swing, change of place and floor drift is compared to analyze the methods. Based on 2800 standard, results from dynamic analysis should be multiplied in I/R. Raw Results from analysis should be multiplied in 0/142857 and are shown in axis.

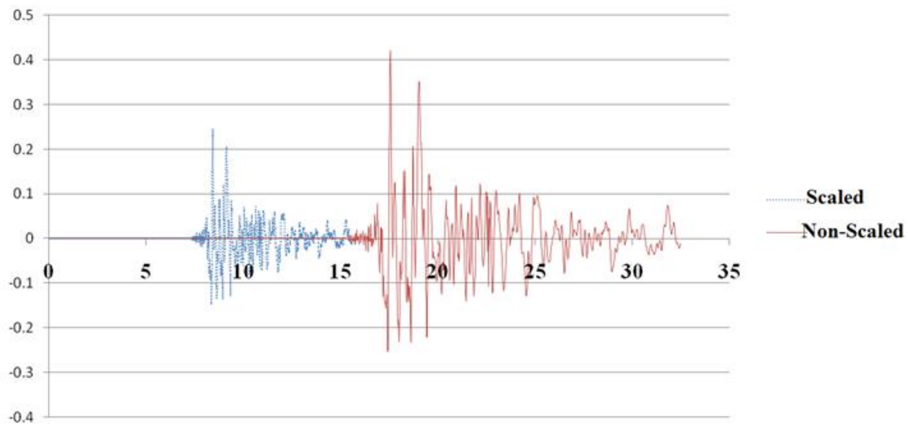


Figure 6: scaled and non-scaled seismograph axis of horizontal compound in Chalan quake

Table 7: values of seismograph required factors based on dual scaling method

		Housner Intensity	T_{amp}	SF_a	SF_t
Parkfield	x	0.47	0.51	2.13	0.26
	y	0.512	0.55	1.95	0.28
Avaj	x	0.589	0.55	1.70	0.28
	y	0.415	0.45	2.41	0.23
Chalan	x	1.76	0.95	0.57	0.48
	y	1.14	0.88	0.88	0.44
Tabas	x	0.75	0.71	1.33	0.36
	y	1.06	0.72	0.94	0.36
Northridge	x	1.84	0.98	0.54	0.50
	y	2.29	1.23	0.44	0.63
Koshk	x	0.184	0.22	5.43	0.11
	y	0.184	0.35	5.43	0.20
Italy	x	1.22	0.99	0.82	0.50
	y	1.65	0.98	0.61	0.50

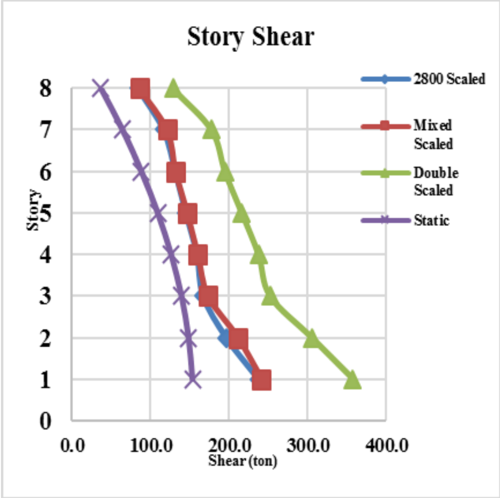
Table 8: values of scaling factor for seismographs based on dual scaling

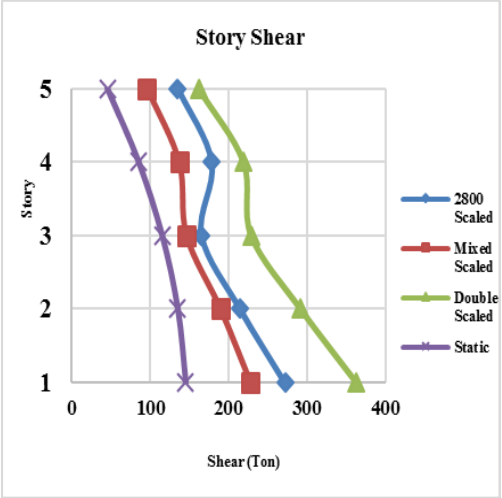
Seismograph	Parkfield	Avaj	Chalan	Tabas	Northridge	Koshk	Italy
Scale Factor	1.66	2.24	1.99	2.13	1.76	3.21	2.09

3. Analysis results in concrete frames

3.1 comparison of floor cutting

As there are 7 seismographs used in analysis, based on 2800 standard average values of forces and change of places in different seismographs are calculated for each floor and are considered as output values. As cutting compound is applied to structures simultaneously, 2 cutting compounds will be transformed to one general cutting and they are used in axis. In figure 7 values of floor cutting is presented in modeled structures.





5 floor structure	8 floor structure

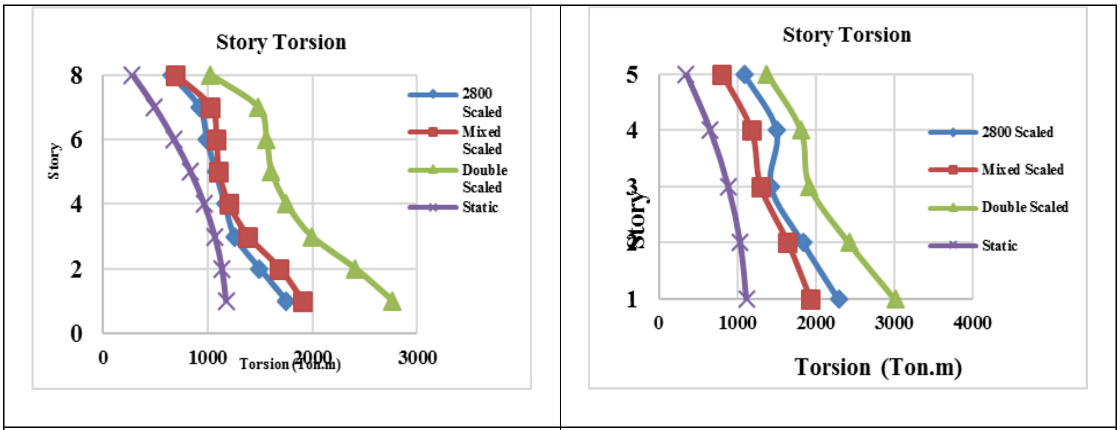
Figure 7: comparison of floor cutting in structures with different methods

Examining above graphs we can say that all 3 dynamic methods are cutting values more than static way. Since plan of modeled structures is orderly and their maximum height is 35.2 meters, we can design them using static method. This means that results from static analysis is acceptable for these structures.

3.2 comparison of floor torsion

Torsion in each structure is created because of difference in mass center and structure tenacity center and it is an extra peripheral force that should be applied in plans especially those of disorderly structures. In this part torsion created from static and linear dynamic analysis will be compared using different scaling. In figure 8 axis related to structure torsion is introduced. Since plans are the same, we can say that distance of mass and tenacity center are mostly the same for models.

Values of torsion in structures is in accordance with floor cutting value, mass center distance and tenacity center. Here, it should be noted that a random torsion of %5 should be applied in static analysis for applying peripheral forces. This causes a huge increase in torsion values. In graphs 8 it is seen that process of floor cutting holds true for different phases of analysis. It is seen that as height increases, torsion also increases and it is continuously getting closer to values of dynamic analysis. As torsion results from cutting, it was expected that values resulted from different analysis are behaving like cutting values and this is obvious in axis. Increase in 2800 scaling method height and compound method both calculated similar torsion values.

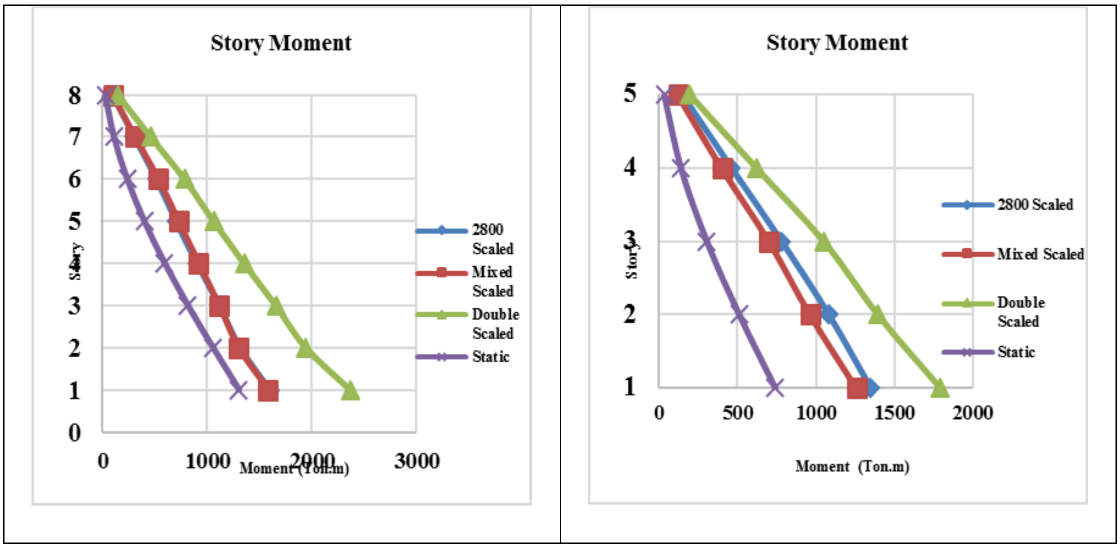


8 story structure	5 story structure

Figure 8: comparison of story torsion in structures with different methods

3.3 comparison of story anchor

Values of anchors in different structures under dynamic analysis are presented using different methods of seismograph scaling. When horizontal force is applied to structure, this force creates an anchor in structure. The main impact of anchor is in structure destruction and it was seen that in some areas with special structures the anchor was so heavy that it destroyed the structure. Values of anchor are presented in here. Since compounds of X and Y of anchor are separate from each other (one around X and the other around Y axis) the bigger ones are chosen for planning.



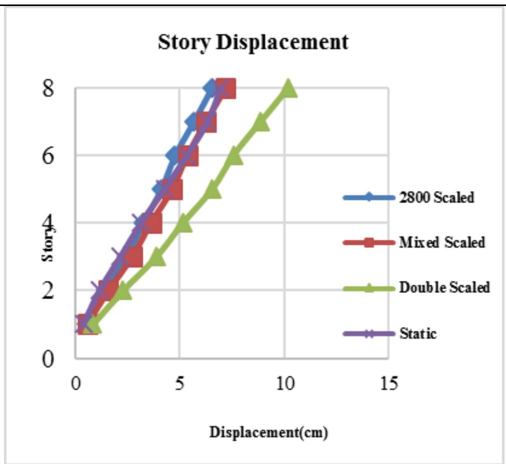
8 story structure	5 story structure

Figure 9: comparison of story anchor in structures with different methods

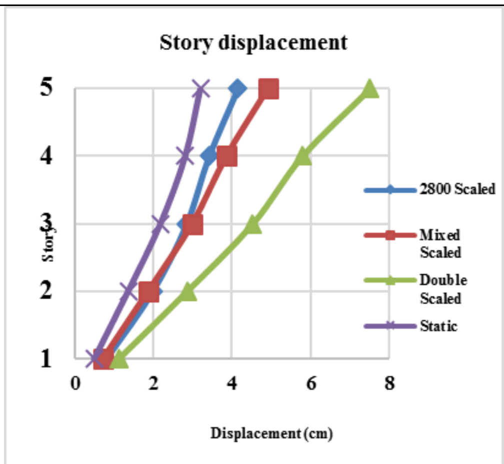
2800 method is a more suitable method for anchor values chosen from different ways of dynamic analysis. According to all axis of peripheral forces, values of calculated forces using dual scaling are more than 2 other methods. So planning with this method yields stronger points. It is better to use these plans in important structures to become safe.

3.4 comparison of story movement

Since movements occur in this step simultaneously in both X and Y axis, 2 above values will be compounded using SRSS method and change into one united value. Then; values of resulted movement are presented in figure 10.



8 story structure



5 story structure

Figure 10: comparison of story movement in structures using different methods.

4. Conclusions

Results of dynamic analysis for structures of different heights show that values resulted from dual scaling are more than other analysis values and use of this type of scaling can be a safe step forward. It should be remembered that using big values of forces results in planning strong segments that can be costly. It is better to use this method in structures of high importance.

Values of calculated forces using 2800 method can be generally much lower than other 2 methods. Since modeled structures were orderly and their maximum height was lower than 50 meters, results of static analysis were valid. Since results of dynamic analysis using 2800 method were higher than that, the former method produces more optimized results to plans in comparison to 2 other methods. Generally speaking, values of calculated forces for concrete structures using dual scaling method were much higher than 2 other methods and they were often 1.7 times higher than calculated forces of 2 other methods. Since dynamic analysis results in 2800 standard should be only corrected if smaller than static analysis. There were no plans for bigger values of dynamic analysis. The more results from dynamic analysis are closer to static analysis, results are better and planning will be optimized better.

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