EFFECTS OF SCALING METHODS AT LINEAR AND NONLINEAR RESPONSE OF THE BUILDINGS

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ABSTRACT

The behavior of a building during an earthquake depends on many factors including the characteristics of the ground motion, the configuration and dynamic characteristics of the structure, the hysteretic behavior of the structural components, the building's non-structural parts, and the local soil behavior. When conducting seismic assessment studies, controlling the first factor involves selecting appropriate earthquake records and Scaling to a specific level of intensity is one of the challenges in non-linear dynamic analysis of structures. This paper presents, how these differences among scaling methods effectthe results of time-history analysis. Three methods had been compared. The Iranian standard No.2800, Spectral correctionand Spectral balance that are the usual scaling methods in Iran. The studied model is 10 story Dual-steel concentrically Braced Frames located in Tehran.The records had been selected with respect to site consideration from BHRC.The results showed that first, the responses of non-linear analysis that consisted of base shear, inter story drift and lateral displacement is more than linear analysis. And second, the Iranian standard No.2800 method had largest response among three methods. Based on results, it is obvious that the Iranian standard No.2800 procedure is conservative than the others.

INTRODUCTION

The structures behaviour in earthquake, depend on many factors such as earthquake characteristics, dynamic behavior of structure, structural partsproperty. One of the important challenges in dynamic analysis of the structures is ground motion selection and modification (GMSM) to a specific level of intensity.many ground motion selection and modification methods have been proposed. It can be pointed such as to equal of the severity of spectrum, to equal on the basis of the geometric mean of the acceleration, to equal on the basis of the peak ground acceleration, velocity ,displacement (Moghaddam, 2003), FEMA 440 scaling procedure (FEMA-440,2005),Iranian standard No.2800, spectral balance and Spectral correction methods. All of the characteristics of the structure should be investigated to reach safedesign. Time history analysisindicatesthe response of the structure due to ground motion very well. Nonlinear structural response is often highly sensitive to the selection and modification of input ground motions(PEER, 2009).This paper investigates the effectiveness ofscaling methods at linear and nonlinear response of the structure.

BRIEF SUMMARIES OF GROUND MOTION SCALING METHODS THAT USE IN THIS STUDY

SPECTRAL CORRECTIONPROCEDURE(BEHNAMFARET AL., 2005)

In this method it has been recommended that if nonlinear spectral accelerations averaging were applied in 0.2 T– 1.5 T periodic ranges, the better results would be obtained from existent methods.
For this purpose, it was applied the squares sum root of spectral ratio acceleration, that was resulted from range of sharing plan divided on the number of assumed points. Accordingly, if n is considered the number of assumed points for each earthquake range acceleration, various stages of spectral correction method consist of determining correction coefficient reform and its actions on the accelerogram is in general as follows:

1-To determine periodic range for every building (0.2T–1.5T) and this range would be divide on n numbers of equal parts
2-To read spectral acceleration corresponding with every considered n periodic point from earthquake acceleration
3-To read spectral acceleration corresponding with every considered n periodic point from acceleration spectrum of Iranian standard No.2800
4-To determine the ratio spectrum of accelerations have been obtained from stage 2 to 1.4 that it equals accelerations spectrum of stage 3
5-To calculate the sum of ratios squares those have been obtained from stage 4
6-To calculate square root of the ratio of numbers that have been obtained from stage 5 divided the number of assumed points
7-To multiple number reverse that has been obtained of stage 6 as correction factor in all of numbers accelerogram that have been equalized
8-To repeat stage 2 to 6 after applying correction factor, and to control new correction factor to equal one.

IRANIAN STANDARD NO.2800 PROCEDURE(STANDARD 2800,2009)

It is recommendedbyIranian standard No.2800that both of the accelerogram which has been selected would be scaled by this procedures:

1-All of the accelerograms would be scaled with their peak ground acceleration. It means that the maximum accelerate of all of them equal to g.
2-Accelerate response spectrum of every both of scaled accelerograms would be determined with considering 5% attenuation.
3-The spectrum of responses would be compounded by using of square root of squares sum. It would be resulted one compounded spectrum for every pair of accelerograms
4-The compounded responses spectrum of three pair's accelerograms would be averaged and compared with standard plan in the range of alternative time (0.2T–1.5T).
5-The scaling factor that has been obtained in stage 4, should be multiplied to the scaled accelerogram in stage 1 and would be applied in dynamic analysis

So, briefly, it has been appointed in Iranian standard No.2800 how accelerations amounts should be scaled in accelerograms that the mean of resulted spectrum from accelerogram, in every point would not less than1.4 times of equivalent point in the applied range which has 5% attenuation in periodic range 0.2T – 1.5 T (T is natural period of the building) .

SCALING BY SPECTRAL BALANCE METHOD (KHODAPARASTET AL., 2009)

In spectral balance method, the areain curve 1.4 equals standard spectrum. The accelerationspectrum curve has been considered as balancing accelerationspectrum and has been applied as accelerograms correction factor that equal to the peak ground acceleration. The different stages of the spectral balance method that intends how the correction factor is obtained and to be applied to accelerogram, as follow:

1-It is determined accelerationresponsespectrum of every component of the scaled accelerogramswith considering 5% attenuation.
2-Acceleration response spectrum of every component would be compound with each other with applying

square root of squares sum method and one unique compounded range would be obtained for every component pair

3-The obtained compounded responses spectrum would be compared with site designspectrum. The scaled factor would be determined in such way that the curve area of every acceleration spectrum that is compounded with the area curve 1.4, equals standard spectrum.

4-The determined scaling factor multiplied in the scaled accelerograms in clause 1 and could be applied to dynamic analysis

THE CHARACTERISTICS OF THE SELECTED RECORDS

Ground motion recordsselected with respect to distance, site conditions, and magnitude of the characteristic event expected to dominate the seismic hazard, directivity of the rupture or basin effects contribute to the intensity and frequency content of a ground motion at a site. Also, the failure mechanism would be same in causative fault(PEER, 2009). Site conditions of the three records are in high risk region. As a result, Earthquakes records have been extracted from Building and Housing Research Center of Iran.

Table 1. The characteristics of selected records for dynamic analysis

Earthquake	Station	Distant to Fault (km)	Type of site soil	Failure Mechanism	Non-corrected Acceleration			PGA	PGV	PGD
					L	V	T			
Varzaghan Ahar	Tabriz	۶۰	III	Compressive	۴۵	۲۰	۲۸	0.045g	0.3	2.7136
Sirach	Sirach	۴۰	III	Compressive	۳۶	۳۷	۲۹	0.036g	20.103	4.1313
Zanjireh	Tasooj	۵۰	III	Compressive	۴۴	۳۱	۹۵	0.044g	69.42	7.428

Selected Ground motion records must scaling to design spectrum. According to three methods,scale factors for these methods are shown in Table 2.

Table 2. Scaling Factors of obtained by different methods

Records Scaling Methods	Scale Factors		
	Tabriz	Sirach	Zanjireh
spectral Correction	۱.۱۶۵۶	۱.۲۷۴۲	۱.۱۶۳۶
Iranian Standard ۲۸۰۰	۲.۵۴۷۳	۲.۵۴۷۳	۲.۵۴۷۳
spectral Balance	۱.۳۲۰۵	۱.۲۹۵۴	۱.۰۲۴۱

ANALYTICAL STRUCTURE CONFIGURATION

The model has been applied in this study is 10-story steel building with 4 bay, with center-to-center span length of5 m, and story height of3.5 m. It is applied various section from 2UNP for bracing in the building. Also it is applied BOX sections for columns and IPE for beams. The model has been shown in Figure 1. The model has been located in Tehran and the soil area is classified as type III according to the third edition of Iranian Standard 2800. Load bearing lateral system of the building is Dual-steel concentrically Braced Frames on both sides. Computer software (SAP2000) is used for linear and nonlinear time history analysis.

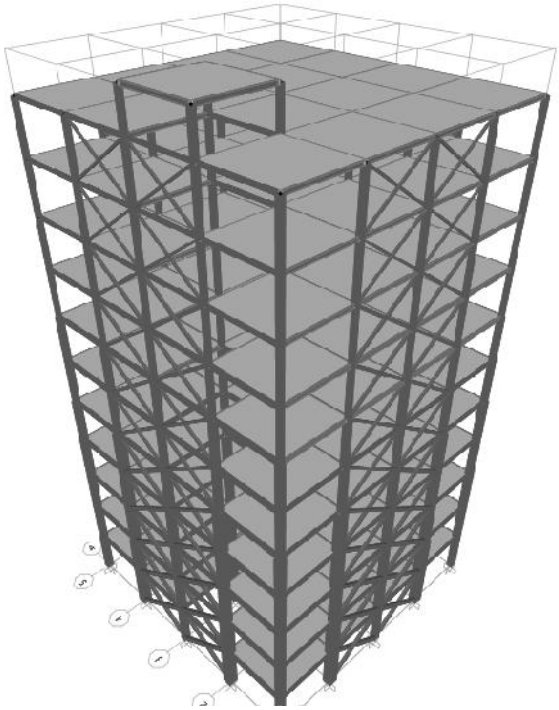

Figure 1. Three-dimensional view of the studied model

THE RESULTS OF LINEAR AND NON-LINEAR TIME HISTORY ANALYSIS:

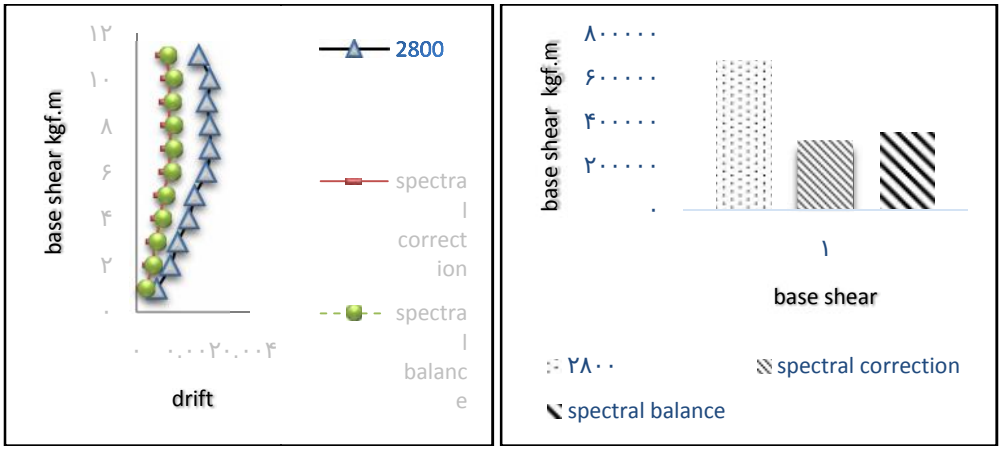

Figure 2. Drift and Base shear of linear dynamic analysis

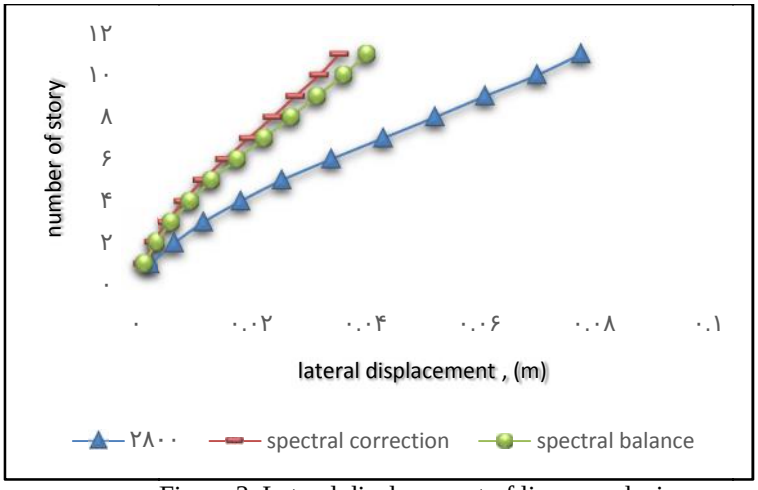

Figure 3. Lateral displacement of linear analysis

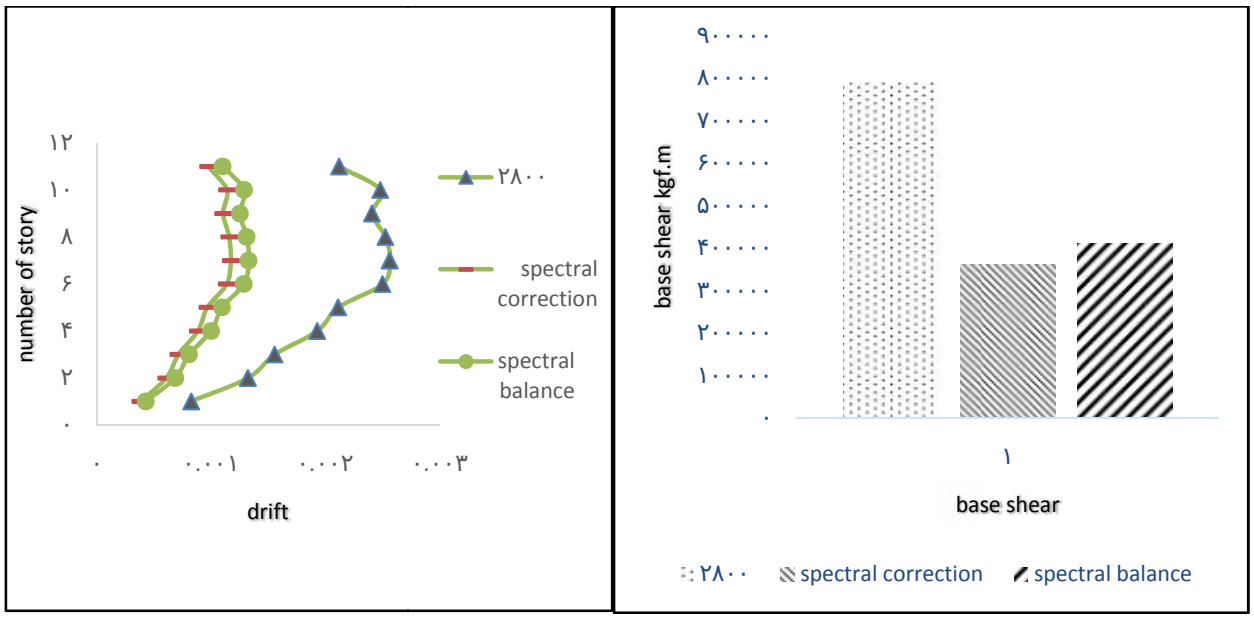

Figure 4.Base shear and Drift of non-linear dynamic analysis

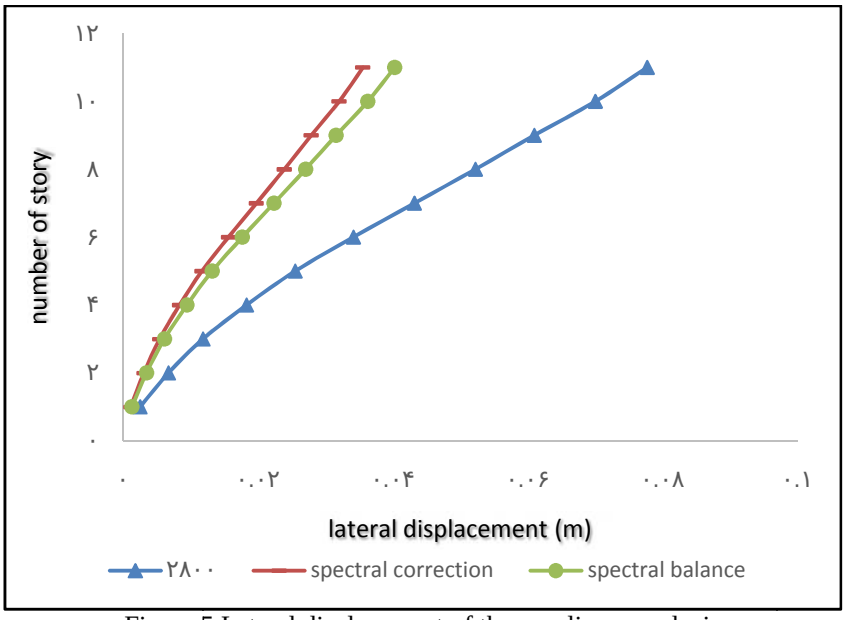

Figure 5.Lateral displacement of the non-linear analysis

CONCLUSIONS

Scaling of earthquake records is one of the most influential items of the structures responses. In this paper, the effects of various methods of records scaling has been investigated on response of steel 10-story building. The results have been obtained as follows:

In linear time history analysis, the values of base shear and lateral displacement in the scaling of Iranian Standard 2800 are more than the method ofspectral correction and spectral balance because the scale factor ofIranian Standard 2800 is twice ofanother. As to be concluded from the results that the value of base shear in non-linear analysis is more than linearin Iranian Standard 2800. Base shear in non-linear analysis shows upper than linearanalysis in spectral balance and spectral correction. But the relative displacements differences are very little. With considering to above, it can be concluded that non-linear time history analysis is closer to the reality. Consequently, value of base shear has been calculated, It is less than reasonable value in linear time history analysis. Based on results, it is obvious that the Iranian standard No.2800procedure is conservative than the others methods.

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