IJBPAS, December, 2015, 4(12), Special Issue: 20-29

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

EVALUATING THE APPROPRIATE RANGE OF PUSH OVER METHODS IN THE ESTIMATION OF TWO DIMENSIONAL CONCRETE FRAME'S SEISMIC RESPONSE WITH CBF

HOSSEIN NASERI[1], MOHAMMAD MOAVI[2]

1. Department of Civil Engineering, Deylam Branch, Islamic Azad University, Deylam, Iran.(Hosnaseri@yahoo.com)
2. Department of Civil Engineering, Omidiyeh Branch, Islamic Azad University, Omidiyeh, Iran.(Mohammad.Moavi@gmail.com)

ABSTRACT

In comparison with the nonlinear dynamic analysis, methods of nonlinear static analysis (pushover), due to the simplicity, speed and ease of interpretation, have developed rapidly and have been well received as the most accurate method in seismic analysis. In this study, three models of 3, 6 and 9 story buildings with concentric bracing frame (CBF) were selected; also, adaptive pushover methods SSAP, DAP and traditional pushover method MODE1 were evaluated as well. Then the accuracy of any of the pushover methods in shear and relative displacement based on the exact nonlinear dynamic method is determined. The accuracy of SSAP method in the estimation of shear and drift of the structure in all three models and the accuracy of DAP method in the estimation of shear and drift of the 9 story structure are confirmed reviewing charts.

Keywords: Adaptive pushover analysis, mixed modes, concrete structure

INTRODUCTION

The design method of most current regulations are based on the resistance factor; however, the researches and the behavior of buildings in the recent earth quakes showed that considering resistance as the only factor in the designing process is not appropriate and increasing the resistance does not necessarily result in the increase in safety. So the new regulations regard replacing the resistance factor by behavior factor when designing a structure. The implementation of behavior factor means that in addition to the resistance factor, the distribution of resistance and the deformation of structural components are also considered. This method of design being based on the behavior of the structure is also called performance based design. Performance in this method is determined by the expected damage and crash in the structural and non-structural components. Considering the fact that the damage to the structural components result in the nonlinear behavior, common methods of analysis and design (linear methods) approximately estimate the performance of the structure; however, the purpose of seismic analysis is to determine the accurate amount of deformation. In other words, linear methods are reliable if in a certain balance of ground motion, the structure remained in the linear range and the distribution of nonlinear response is steady in the structure. In this case, the uncertainty in the results of linear analysis is relatively low. But if the performance goals demand greater nonlinear needs in the structure, the use of linear methods increases uncertainty. Yet non-linear analysis causes an increase in the reliability, safety and cost reduction. Non-linear steps are similar to the common linear methods. First, a model of the structure is prepared then, under the influence of the earthquake, performance of the structure is determined. Engineering required parameters include displacement (roof displacement or any reference point), inter-story drift, deformation, and component force.

As stated, in performance-based seismic design, different levels of earthquake are designed for different levels of expected performance. An important step in performance based seismic design is the estimation of non-linear seismic response of structures. In this regard, two methods are purposed:

A.Nonlinear time history analysis

This method may be the most accurate method for determining the seismic response of the structure in which the analysis of nonlinear dynamic properties of the structure are determined by certain acceleration records.

B.Nonlinear static analysis (pushover)

The best and the most accurate way to evaluate the seismic behavior of the structures is the implementation of nonlinear time history analysis; however, due to the simple implementation and interpretation, nonlinear static analysis is recommended by authentic guidelines and regulations. The simple interpretation and fast analysis of nonlinear static analysis methods as the basis of performance-based design approaches has caused the design engineers to choose this method over the nonlinear dynamic analysis methods.

The foundation of the non-linear static analysis (pushover) is based on relating the multi degree of freedom structures with single degree of freedom structures. In this method, the two concepts of seismic demand and structural capacity turn the structure into the single degree of freedom model and are compared with each other. First the gravity loads are applied on the structure. Then a certain lateral pattern load which is distributed in the height of the building is employed in the structure. At each stage of the process of analysis, the lateral force is increased at a constant rate. Accordingly, the structural model modifies to apply a reduction of harness for yield components. Again at the next stage the lateral force is increased to yield some other components. This process continues until the displacement in the control point (such as the mass center of the roof) has reached a certain level or the building has become unstable. The overall capacity curve of the building is usually obtained through the base shear-displacement of the roof chart. In this method, it is assumed that the first mode is the dominant mode.

2. Introducing the examined structures

3, 6 and 9 story office buildings having the same plan and 6 meters openings were selected for the evaluation purposes of the study, the height of all stories were 3.2 meters.

The bearing resistance system of the structure is of concentric braced frames. The structure is based on the plan (PGA) 0.428g for acceleration with a probability of exceeding of 10% in 50 years which is designed according to Taiwan regulations.

3. Modeling hypotheses

Modelling the beams and columns is constructed by Displacement-Based Beam-Column Element and Fiber section.

Structural components, connections and supports are assumed to be perfectly rigid.

The effective seismic mass and weight (including dead load and 20% live load) were concentrated and applied on the nodes according to the loading.

The main and link beams are of A36 type and columns and braces of the structure are of A572 steel which were modeled by Steel02 and library of Opensees software (Figure 1):

Modulus of elasticity (MOE): E0= 200000000000 pa

Yield resistance: Fy(A36)=253109300 pa

Yield resistance: Fy(A572)=351534810 pa

Hardening slope b=0.1

4. Examined earth quake records

Records used in this study include 7 records near faults of world's major earthquakes on type C soil and according to the USGS reference represented in table 1.

Each of these records, with the goal of approximate uniformity of target's displacement amount, are measured using the period method compared to the regulation 2800 range (Figure 2).

5. The advanced studied pushover methods

In this study, the following pushover methods were compared with nonlinear time history analysis.

- NTHA
- Adaptive nonlinear static analysis based on story drift (DAP)
- Adaptive nonlinear static analysis based on story shear (SSAP)
- TRIANGULAR

6. Results obtained from the analysis of different methods and records in the 3 story building

After evaluating the performances of pushover methods and investigating the errors of these methods in comparison to the nonlinear dynamic methods in the estimation of story shears in 9 story building, the results obtained which are represented in Table 2 and Figure 3. The results are under the influence of seven records.

After evaluating the performance of pushover methods and reviewing the errors of these methods in comparison to the nonlinear dynamic methods in the estimation of story drift in 9 story building, the results obtained and are represented in Table 3 and Figure 4. The results are under the influence of seven records.

7. Results obtained from the analysis of different methods and records in the 3 story building

After evaluating the performances of pushover methods and investigating the errors of these methods in comparison to the nonlinear dynamic methods in the estimation of story shears in 6 story building, the results obtained which are represented in Table 4 and Figure 5. The results are under the influence of seven records.

After evaluating the performances of pushover methods and investigating the errors of these methods in comparison to the nonlinear dynamic methods in the estimation of story drifts in 6 story building, the results obtained which are represented in Table 5 and Figure 6. The results are under the influence of seven records.

8. Results obtained from the analysis of different methods and records in the 3 story building

After evaluating the performances of pushover methods and investigating the errors of these methods in comparison to the nonlinear dynamic methods in the estimation of story shears in 3 story building, the results obtained which are represented in Table 6 and Figure 7. The results are under the influence of seven records.

After evaluating the performances of pushover methods and investigating the errors of these methods in comparison to the nonlinear dynamic methods in the estimation of story drifts in 3 story building, the results obtained which are represented in Table 7 and Figure 8. The results are under the influence of seven records.

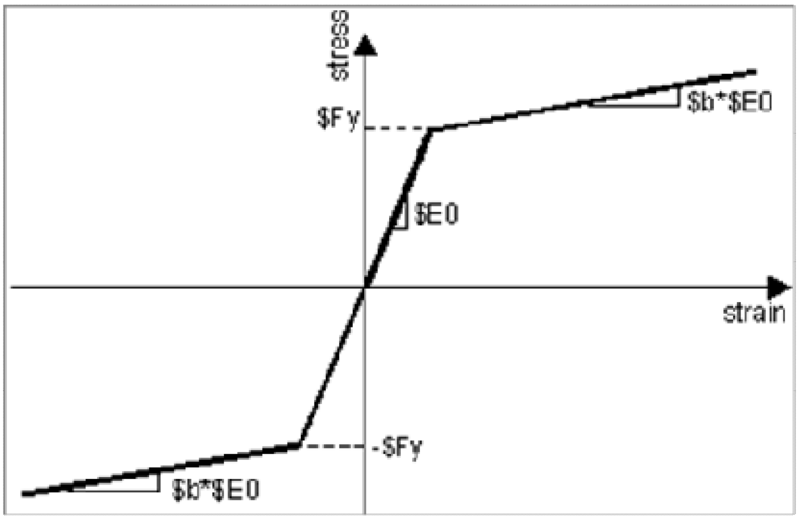

Figure 1: load- steel (steel02) deformation curve

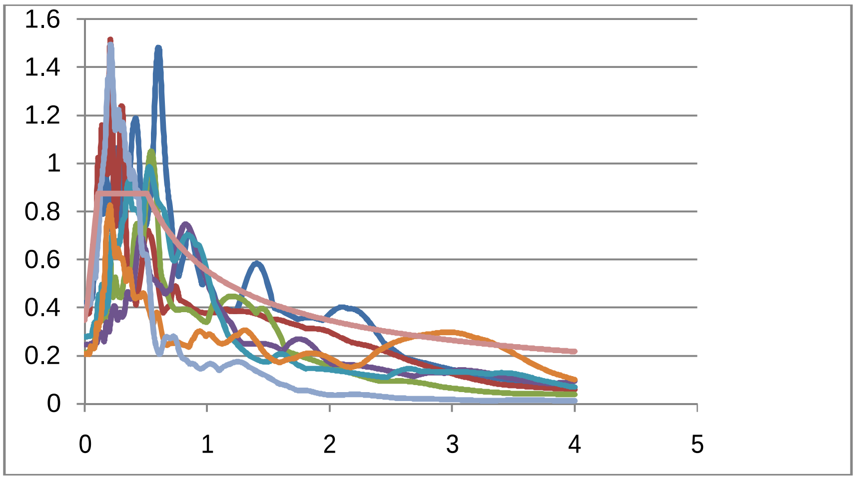

Figure 2: ranges obtained from the earthquake records

Table 1: earthquake Record's Profile [5]

Num Record			Magnitud (M)	Distance (Km)	Scale Factor	DT (sec)	Duration (sec)	PGA (cm/sec2)
LA21	1995	Kobe	6.9	3.4	1.15	0.02	59.98	1258
LA22	1995	Kobe	6.9	3.4	1.15	0.02	59.98	902.75
LA23	1989	LomaPrieta	7	3.5	0.82	0.01	24.99	409.95
LA28	1994	Northridge	6.7	6.4	1.61	0.02	59.98	1304.1
LA29	1974	Tabas	7.4	1.2	1.08	0.02	49.98	793.45
LA30	1974	Tabas	7.4	1.2	1.08	0.02	49.98	972.58
LA27	1994	Northridge	6.7	6.4	1.61	0.02	59.98	908.7

Table 2: the calculation of push over method's errors in comparison with the nonlinear dynamic methods in the estimation of story shear for 9 story structure

Record	CNP196	GO3090	GO4090	HCH090	HDA255	SVL360	WST000	AVERAGE
Dap	6.309354	6.545303	10.40455	7.396632	7.845338	3.073449	10.89548	6.59(%)
Ssap	3.311919	5.532665	10.63894	6.083925	6.438657	3.346273	11.12052	6.63(%)
mode1	4.009067	6.646726	10.54126	7.301346	7.858125	3.395459	11.31925	6.91(%)

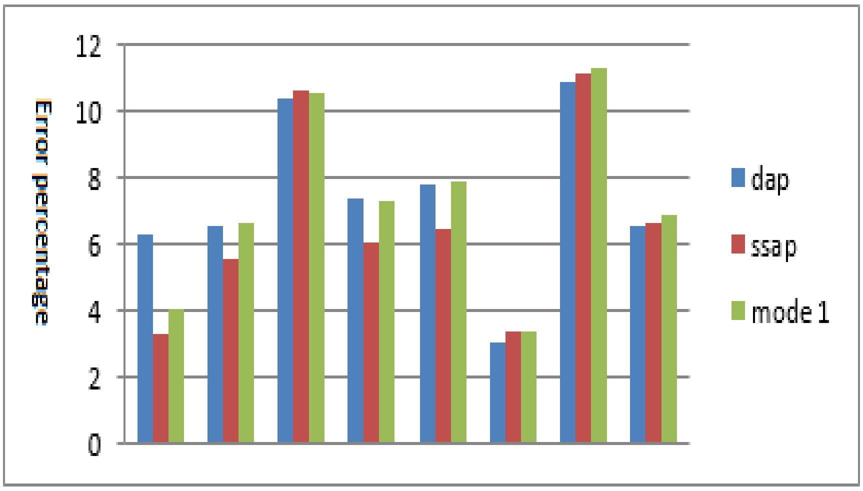

Figure 3: Push over method's error in comparison with the nonlinear dynamic methods in the estimation of story shear for 9 story structure

Table 3: the calculation of push over method's error in comparison with the nonlinear dynamic methods in the estimation of story drifts for 9 story structure

Record	CNP196	GO3090	GO4090	HCH090	HDA255	SVL360	WST000	AVERAGE
Dap	10.57562	9.660767	11.1433	9.795259	10.4414	4.627667	11.05538	9.61(%)
Ssap	5.721419	6.420357	12.0667	9.753703	10.94296	9.102091	13.36862	9.62(%)
mode1	4.860653	7.248824	11.46588	11.71864	11.58411	8.073	12.96801	9.7(%)

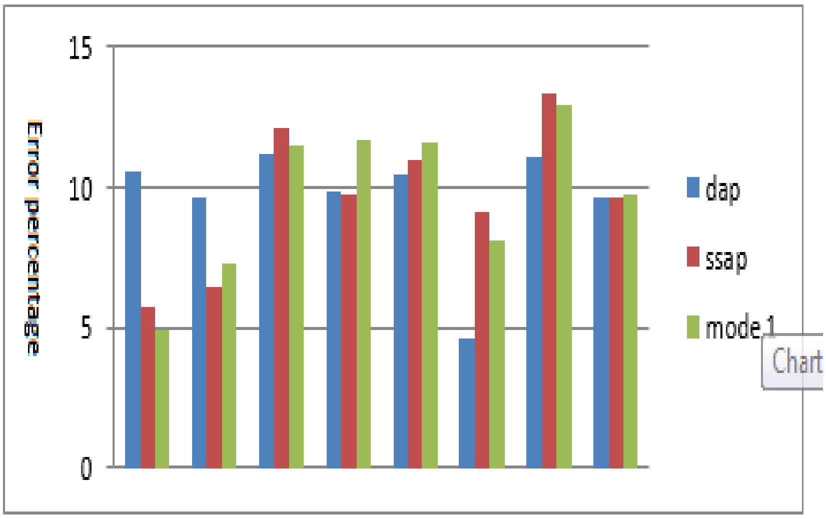

Figure 4: Push over method's error in comparison with the nonlinear dynamic methods in the estimation of story drifts for 9 story structure

Table 4: the calculation of push over method's errors in comparison with the nonlinear dynamic methods in the estimation of story shear for 6 story structure

Record	CNP196	GO3090	GO4090	HCH090	HDA255	SVL360	WST000	AVERAGE
Dap	4.391704	3.051045	4.92353	5.12095	7.793701	3.83194	9.39297	5.5(%)
Ssap	4.391643	2.358436	3.356439	4.966369	6.509224	1.930231	9.085381	4.65(%)
mode1	5.552635	3.055824	4.843382	6.401814	7.697254	3.3513	9.827665	5.92(%)

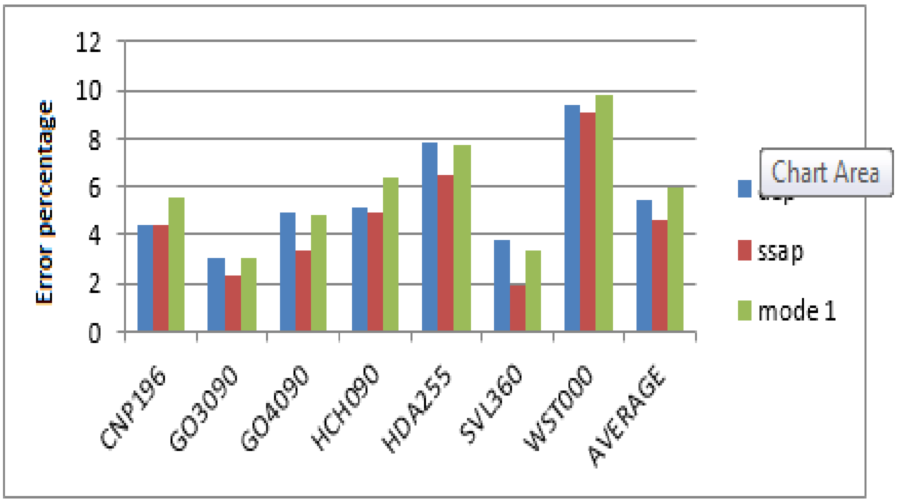

Figure 5: Push over method's error in comparison with the nonlinear dynamic methods in the estimation of story shear for 6 story structure

Table 5: The calculation of push over method's errors in comparison with the nonlinear dynamic methods in the estimation of story drifts for 6 story structure

Record	CNP196	GO3090	GO4090	HCH090	HDA255	SVL360	WST000	AVERAGE
Dap	15.41981	11.24681	11.45157	19.78662	10.40372	10.79913	10.41147	12.78(%)
Ssap	10.29647	4.188484	5.953901	11.33088	6.240543	4.445021	9.575502	7.43(%)
mode1	11.6219	5.441425	7.112312	12.93908	7.663074	5.070899	9.796599	8.52(%)

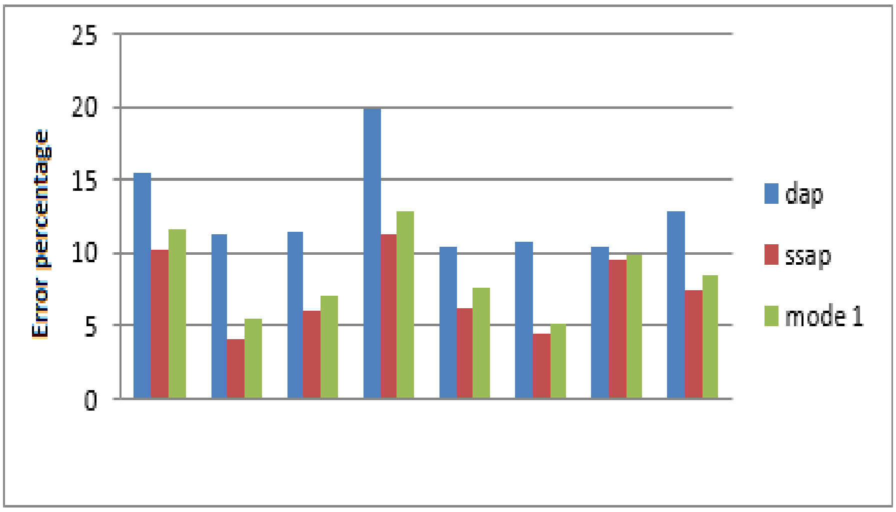

Figure 6: Push over method's error in comparison with the nonlinear dynamic methods in the estimation of story drifts for 6 story structure

Table 6: the calculation of push over method's errors in comparison with the nonlinear dynamic methods in the estimation of story shear for 3 story structure

Record	CNP196	GO3090	GO4090	HCH090	HDA255	SVL360	WST000	AVERAGE
Dap	8.544121	7.966603	6.091043	4.47272	10.89613	6.990814	11.09775	8(%)
Ssap	4.695137	5.566628	1.422592	1.597098	7.0624	6.449958	10.45344	5.32(%)
mode1	8.859669	7.94162	6.616668	4.941267	10.03523	6.662969	11.92517	8.14(%)

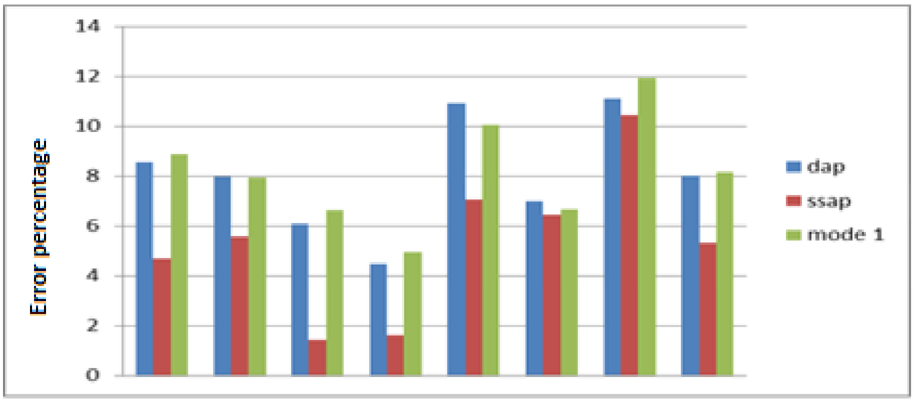

Figure 7: Push over method's error in comparison with the nonlinear dynamic methods in the estimation of story shear for 3 story structure

Table 7: the calculation of push over method's errors in comparison with the nonlinear dynamic methods in the estimation of story drifts for 3 story structure

Record	CNP196	GO3090	GO4090	HCH090	HDA255	SVL360	WST000	AVERAGE
Dap	9.117614	9.293599	5.836971	6.183038	7.56195	7.08129	11.81985	8.12
Ssap	5.698703	5.264916	2.904162	2.788504	2.943142	8.55536	11.33652	5.64
mode1	6.257147	6.011762	2.821785	3.036979	3.944342	8.062799	11.98884	6.017

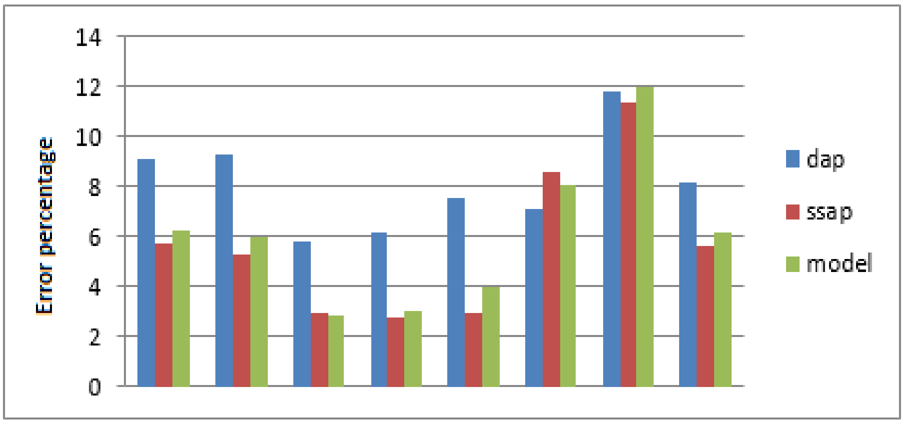

Figure 8: Push over method's error in comparison with the nonlinear dynamic methods in the estimation of story drifts for 3 story structure

SUMMARY AND CONCLUSION

We examined the implementation of the purposed methods in 3, 6 and 9 story buildings with concentric braced frames (CBF) to evaluate the accuracy and efficiency of them. The building were under the influence of seven earthquakes near the faults. The methods in the study were employed using Dynamic analysis to obtain target displacement in braced structures.

The effects of different methods in the estimation of relative displacement between stories

The adaptive pushover method SSAP indicated the least amount of errors in the estimation of relative displacement of all three structures. According to the mode1, the Pushover analysis in three story structure shows an appropriate accuracy. Perhaps, these results indicate that the amount of mode1 participation in midrise buildings is much more than high rise buildings; and the accuracy of traditional pushover methods in low rise buildings is appropriate according to the mode1.

The effects of different methods in story shear estimation

Estimation the amount of story shear in 3, 6 and 9 story structures, the adaptive push over method SSAP indicated the least errors. Pushover analysis method based on the mode1 showed the least accuracy in shear estimation.

General conclusion

According to the results, adaptive pushover method SSAP is the most accurate method in estimating relative displacement and structure shear. Also, DAP method showed a good accuracy in the estimation of relative displacement in high rise buildings. In addition, the traditional pushover method is appropriate in the seismic estimation of low rise buildings.

REFERENCES

1. Sun-Pil Kim , Yahya, C., [2008] ,"*An alternative pushover analysis procedure to estimate seismic displacement demands*" , Journal of Engineering Structures 3793_3807

2. OpenSees, [2009] , "*Open System for Earthquake EngineeringSimulation*",Available from URL**:** (http://opensees.berkeley.edu)

3. U.S. Geological Survey, Available from URL: http://www.seismosoft.com

4. Mehrabian, R., Safari, H., (2008), "Comparison of different methods of scaling acceleration", the fourth National Congress of Civil Engineering, Tehran University, May 2008.

5. Gary,S.P.,[2010]," Using Buckling-Restrained Braces in Eccentric Configurations ", A dissertation submitted to the faculty of Brigham Young University in partial fulfillment of the requirements for the degree of philosophy ,pp.50-59