Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 (Spl issue II) 2014 : 323- 330

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

Seismic evaluation of sublime steel structures with E.B.F system according to Base shear Based on performance design

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ABSTRACT

The structures designed Based on the recent regulations show non-elastic deformation behaviors in relation to the intense earthquakes. Most of these regulations have been established based on structures non-elastic behaviors and this behavior achieve in an indirect method such as considering the coefficients of structures behavior, importance coefficient and earthquake coefficient. In relation to the moderate to intense earthquakes, the structures non-elastic behavior lead to intense delivery and bending of structural components and this completely collapses the structure making much expenditure for its repair process. Recently, a new method expanded that it is called the design Based on function in this regard. This method achieves the structural components nonlinear behavior along with defining the deformation of structure as well as functional limit-Based moods. In the end of the present study, the function of short, moderate and long steel structures seismic issues with exterior coordination braces according to the regulation of IBC were investigated in this regard.
Keywords*: non-elastic behavior, behavior coefficient, importance coefficient, seismic coefficient, design Based on function*

INTRODUCTION

The earthquake is one of the most challenging issues of the civil-engineering designers. The intense quakes of the earth in some minutes can lead to large devastations. The catastrophic events happened in Armenia and Sanfransisco and the collapse of 120 steel and concrete structures of buildings in Mexico City in 1985 are subjected to these destructive issues in this case. Among this, not only the whole buildings were destroyed but also the gigantic volume of the apartments and people's life were completely devastated due to the same earthquake. However, the tallest buildings were tolerated against the quake and showed considerable resistance in this regard. This made people hopeful for the application of high tolerating buildings against the earthquakes although there have been seen some damages in the related buildings. Hence, it is necessary to consider the designing and facilitations for resistance against the earthquakes in seismic areas of the world. Our country is also susceptible to these destructing quakes coming along with humanistic and economical damages; thus, the high potential attention to the seismic designing of the buildings is one of the most crucial affairs in this case [3]. Of course in recent years many different studies have been carried out in the field of earthquake engineering; this made some essential changes in the related regulation basically but there is required many various investigations in this field yet. During the earthquake the most important locations such as hospitals, firefighting centers can be susceptible to the huge damages along with death tolls [2]. Hence, the attention to these locations and areas is one of the most essential affairs in constructional issues of the country.

MATERIALS AND METHODS

In this research the functional levels of two steel structures with high importance Based on regulation of IBC 2006 were investigated [3]. For the reason, it was firstly considered the steel building with 15 and 20 floors and they were also analyzed and designed by the use of ETABS Software. Then, the functional levels of the above mentioned steel buildings were also assessed according to the regulation of FEMA (FEMA 356, 2000a) and finally the providence of functional levels and the regulation of IBC 2006 were efficiently evaluated in this study. Also, the software of PERFORM3D was applied to achieve the nonlinear analysis (FEMA 356, 2000a). Also, the statistical (FEMA 356, 2000a) and dynamical analyzes were used to evaluate the structures[4,5,6].

Modeling of under-study frames:
In order to evaluate the suitability of the related regulation in designing the braced frame steel structures, two samples with tall heights and symmetric plans were regularly considered.
In figure 1-4 the plan related Based on the samples was shown.

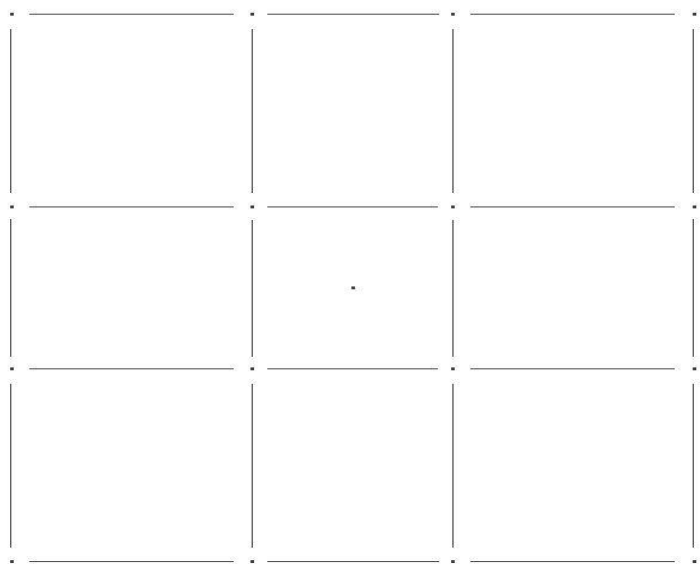

Figure 1: plan of samples Base

As it shown the plan of the whole models was equal and only the number of models floors was different together. For the reason, the number of 15 and 20 floors was considered in this study.
In modeling of the samples, the following cases were considered:

1- The structural design was considered as optimized members
2- In the whole models, the height of floors was 3.5m considered
3- In the whole models, the dimensions of the lateral opening were 6m and the dimensions of the middle openings were 5m considered
4- The roof of the whole models were considered block beam
5- In the whole structures, a steel frame with convergent brace was considered
6- The type of soil was considered as C area
7- The importance coefficient was achieved 1.25 in the whole models
8- ETABS Software was applied to design the models
9- The software of PERFORM3D VER5.0.0 was applied to analyze the structures nonlinearity

1-3: applied materials specifications:
In designing of structures by the help of designing regulations, the type of used tolerance was considered as the tolerance of the expected materials; hence, the expected resistance of the materials was matched with the design of models and analysis of nonlinear issue in table 1-4 as following:

Table 1: specifications of the expected materials

Fye: expected delivery resistance of steel	**2400 kg/cm2**
Fue: expected delivery tension of steel	**3700 kg/cm2**

As it mentioned in the regulation of FEMA273 and FEMA365 (FEMA 356, 2000a), the components of the building and the internal struggles during the earthquake were divided into two sections as following [4]:

1- Controlling components of the force
2- Controlling components of deformation

There is a need to the material lower beam for calculating the resistance of the force controlling component (magazine 360, 2006). Hence, according to the seismic optimization regulation and FEMA 273, this resistance can be considered as the expected resistance of the material division on 1/1(FEMA 356, 2000a). As a result, the resistance of the below table has been applied in order to evaluate the force controlling parameters[4,5].

Table 2: specifications of material lower beam

Fylb: resistance of lower beam of steel	**2180 kg/cm2**
Fulb: resistance of lower beam tension of steel	**3363 kg/cm2**

2-3: modeling of nonlinearity of samples:
As it mentioned before, the static and dynamic nonlinear analysis using PERFORM3D Software were applied to analyze the components of the deformation controlling case. The lateral loading patterns used in nonlinear static analysis include the simultaneous load pattern, triangle loading and suitable loading pattern with the obtained lateral forces from the linear dynamic analysis. Three accelerative recording instruments of seismic beating, Victoria and Northridge were applied to evaluate the periodical history in this path.
3-3: construction of models geometry:
The model of column and beam is constructed in order to construct the geometry of models with defining the points (grids) and elements between the grids; finally, it leads to the construction of a three dimensional model of the samples in this regard.
4-3: definition of the elements specifications:
One of the most important and sensitive steps of modeling is subjected to the linear and nonlinear specifications of the elements. It is coming along with high complexities requiring high accuracy in this case. At first, the cross-section of the elements is introduced to the software and it can easily measure and calculate the stiffness of the same cross-section; then, by defining Mu for the positive and negative moment of the steel beam as its capacity as well as defining the curvature of the moment's reaction in relation to the axial force for the columns were introduced for the specifications of the same cross-section in this pavement[2].
5-3: limit state:
After achieving the above-mentioned steps, the model is ready to be utilized that the plastic joints specifications should be firstly defined before its completion in this case. The controlling conditions were defined as two forms as following:

a- DRIFT control
b- Joint turning control [5].

After the completion of the modeling steps for every sample, its analysis is achieved that the results have been given in section four.

RESULTS

1-1-4: diagram of structural Base shear in 15 floors
In figures (1-1) to (1-6) the structural shear Base diagram in a 15 floors has been given under the loading patterns.

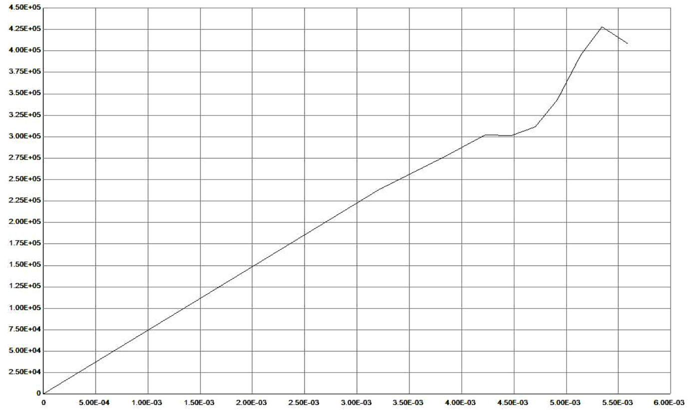

Figure 2: Base shear under uniform loading pattern

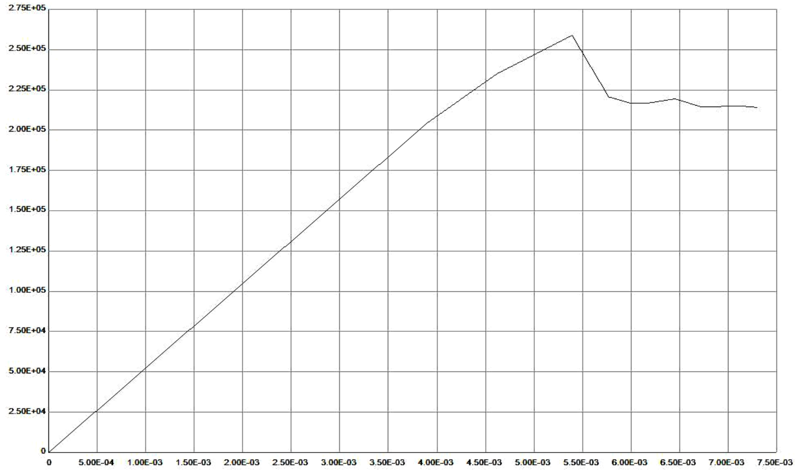

Figure 3: Base shear under triangle loading pattern

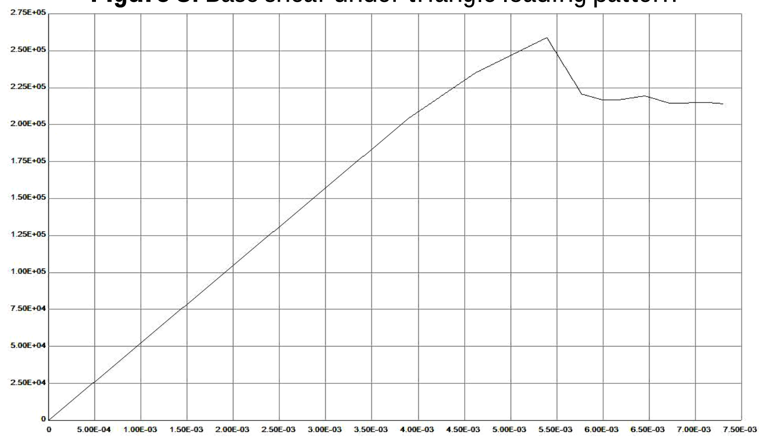

Figure 3: Base shear under suitable loading pattern with lateral forces

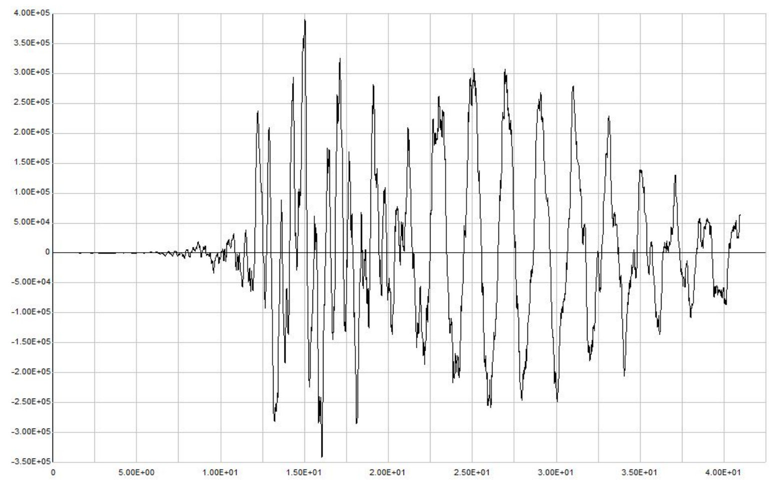

Figure 4: Base shear under kobe earthquake loading pattern

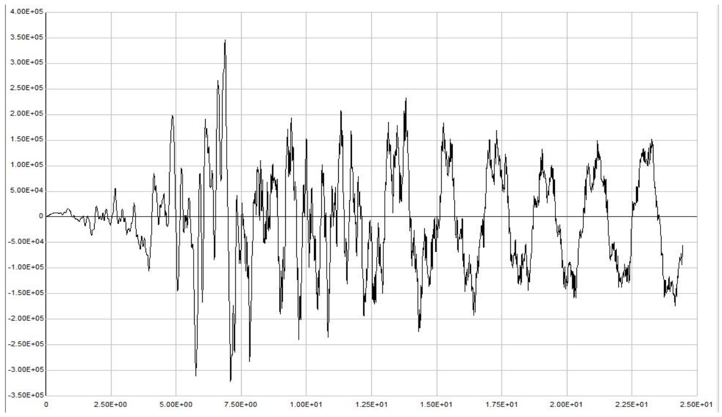

Figure 5: Base shear under Victoria loading pattern

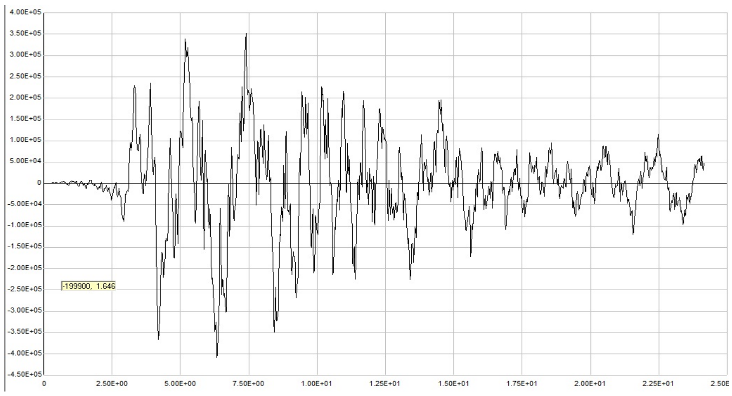

Figure 6: Base shear under Northridge loading pattern

The diagrams of Base shear for a 15 floors structure are given in figures 1 and 6. Three first cases are subjected to static loading and other three cases are related to beating earthquake, Victoria and Northridge. In relation to a 15 floors structure, it can be stated that the degree of Base shear under three lateral loading patterns is different together so that there is no Base shear failure under the simultaneous loading pattern and the related diagram is inaugurating or fixed while the structure the reversed triangle loading is considered in the range of 5.3E-3 to 7.00E-3 from the reference drift as a failure and it also becomes failure under the suitable lateral forces in the area of plastic in relation to the degree of shear. The maximum degree of Base under simultaneous loading is 4.25E5; triangle loading 2.5E5 and suitable lateral forces is 3.3E5 in this case. It is observed that the digits have long-distance together in relation to the middle-ranking structural issue. But the same structure having three patterns of beating earthquake, Victoria and Northridge as convergent Base shear is about 3.5E5.

DISCUSSION

As it mentioned before, if a sublime structure is being established under simultaneous static loading, the maximum degree of the Base shear will be experienced but it is better to design the structure Based on this type of loading due to three patterns of the earthquakes and the convergence of Base shear in this case.

2-3-4: diagram of 20 floors structure Base shear:

In figures (1-7) to (1-30), the diagram of Base shear is shown for a 20 floors structure Base shear under the whole loading patterns.

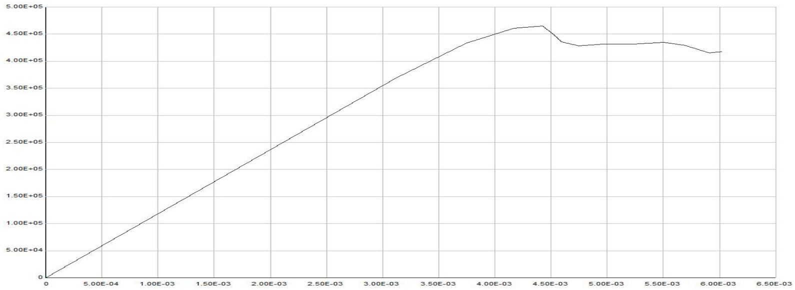

Figure 7: Base shear under uniform loading pattern

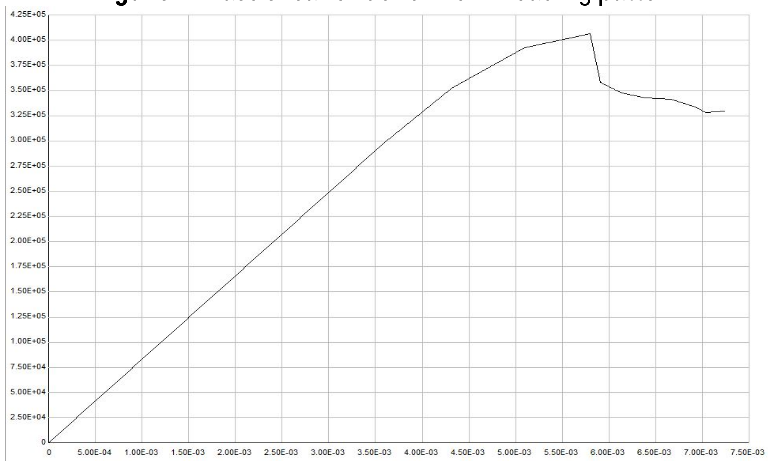

Figure 8: Base shear under triangle loading pattern

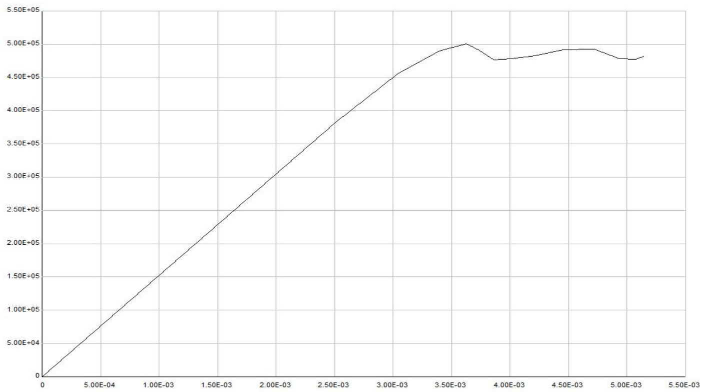

Figure 9: Base shear under suitable loading pattern with lateral forces

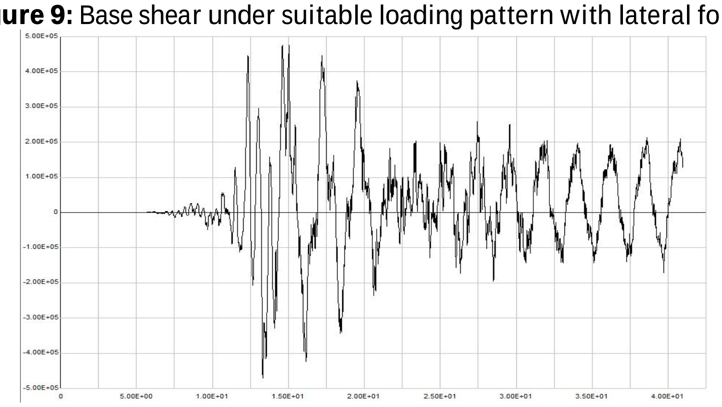

Figure 10: Base shear under kobe earthquake loading pattern

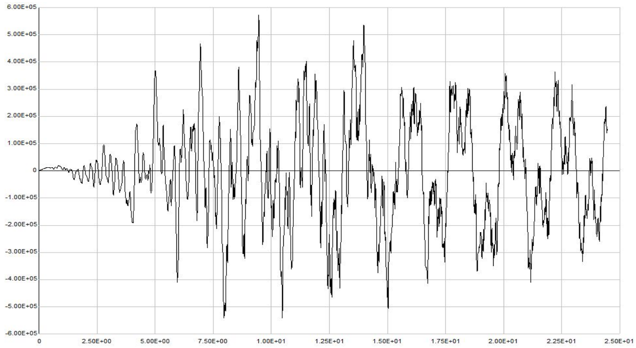

Figure 11: Base shear under Victoria loading pattern

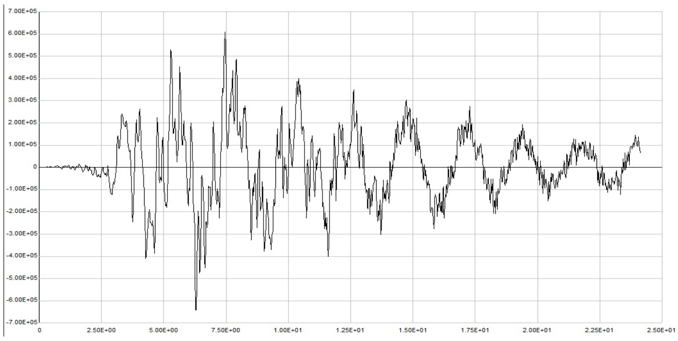

Figure 12: Base shear under Northridge loading pattern

The diagrams of Base shear for a 20 floors structure are given in figures (1-7) and (1-12). Three first cases are subjected to static loading and other three cases are related to beating earthquake, Victoria and Northridge. Due to the comparisons between the 20 and 15 floors structures Base shear, it is observed that the degree of Base shear in 20 floors is two times higher than the 15 floors structure. This difference is seen in static loading; of course, it can be observed in beating, Victoria and Northridge earthquake loadings. Hence, it can be concluded that the increase of floors numbers does not change the behavior of structure components capacity but it plays a key role in the degree of structure Base shear. In table 1-5 the whole levels of the performance for three structures have been given in relation to the static lateral forces[2,6].

Table (1-5) levels of structures performance	Fifteen floors				Twenty floors			
	Performance	IO	LS	CP	Performance	IO	LS	CP
Rectangular loading X	Column	26	5	3	Column	19	0	0
	Beam	59	6	2	Beam	94	8	8
	Brace	8	8	6	Brace	14	14	10
Rectangular loading Y	Column	27	4	3	Column	15	0	0
	Beam	49	6	2	Beam	83	8	8
	Brace	8	8	6	Brace	14	14	8
Triangle loading X	Column	27	1	0	Column	25	0	0
	Beam	92	6	6	Beam	135	10	8
	Brace	12	12	8	Brace	17	15	10
Triangle loading Y	Column	28	1	0	Column	26	0	0
	Beam	87	6	6	Beam	124	10	10
	Brace	12	12	8	Brace	18	14	10
Range loading X	Column	21	1	0	Column	17	0	0
	Beam	51	4	4	Beam	75	8	6
	Brace	10	10	6	Brace	12	12	8
Range loading Y	Column	21	0	0	Column	15	0	0
	Beam	50	6	4	Beam	71	6	6
	Brace	10	10	6	Brace	12	12	8
Beating earthquake	Column	98	4	0	Column	84	0	0
	Beam	228	4	4	Beam	259	6	4
	Brace	59	42	14	Brace	67	44	8
Victoria earthquake	Column	85	3	3	Column	79	0	0
	Beam	64	47	12	Beam	227	0	0
	Brace	226	0	0	Brace	77	39	0
Northridge earthquake	Column	234	38	16	Column	213	8	0
	Beam	291	17	11	Beam	0	0	0
	Brace	70	54	26	Brace	110	54	11

CONCLUSION

After modeling and analyzing the 15 and 20 floors structures in the software of ETABS and their designing Based on regulation IBC 2006, the related structures were redesigned in the software of PERFORM3D and they were established under the static nonlinear and dynamic analysis to evaluate the buildings performance Based on IBC 2006 according to FEMA instructions. In nonlinear static analysis of structures under simultaneous, triangle and suitable lateral forces loading patterns, they were established under the lateral loading pattern as well as in dynamic analysis, they were considered under three beating, Northridge and Victoria structures patterns; for the related structures, the diagram of capacity, relative deformation and Base shear diagrams were designed in this study. Also the limit status of the performance was specified and by reviewing and comparing them, we concluded the subject that we point them in continue of the study. In structures 15 and 20 floors due to the Base shear force diagram and relative deformation as well as limit status for nonlinear static analysis only two patterns of simultaneous and suitable lateral force are requires. In addition to this, there have been specified many different differences between the nonlinear static loading and dynamic loading of these structures. It can be stated that for tall structures, both nonlinear static and dynamic analyzes are required in this case[3,4,5].
As it mentioned in the chapter, the main aim of the present study was to evaluate the function of designed buildings Based on regulation IBC 2006 according to instructions of FEMA. Due to the point, although the entire structures were designed Based on IBC regulation but the estimation of the LS performance level, the whole lateral loading patterns made most floor beams susceptible to problematic issue in relation to the bracing area; In tall structures, there have been specified many various differences between nonlinear static loading and dynamic loading in the related structures. It can be stated that for tall structures both nonlinear static and dynamic analyzes are required in this regard.

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