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The Effect of Vertical Irregularities on the Seismic Behavior of the Moment Steel Frames

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Abstract: *The behavior of irregular buildings in the past earthquakes shows that they had an improper behavior in relation to regular buildings. In this regard, in the present research, the seismic behavior of the special moment-resisting steel frames with irregular distribution of mass in the height has been investigated. This assessment has been performed using linear and nonlinear structural analysis such as the modal linear, static, and dynamic analysis and the history nonlinear, static, and dynamic analysis and with the help of Etabs9, and Sap2000 version 14.2.2 software. In this research, the distribution parameters of the plastic joints and the relative displacement, basic cutting-roof displacement and seismic behavior of the structure which has a special importance in the calculation of the amount of the structure vulnerability have been investigated. So, 14 frames (in which parameters of the floors numbers (6, 18) and situation of the irregular floor (below and middle), weight ratio of the irregular floor to the adjacent classes (50%, 100%) have been have varied) have been investigated in the form of a two-dimensional model. In this regard, to investigate nonlinear behavior of the above structures, nonlinear behavior model of the FEMA356 and nonlinear dynamic analysis with the help of the Bam earthquake records and nonlinear static analysis with two kinds of load distribution have been used. Result of this research shows that the increase of the floors mass has led to the increase of the relative displacement of the floors and increase of the plastic joints in the irregular floor specially in the irregularity of the last floor and for this reason, the reinforcement of the beams and columns of irregular floor and its around floors must be done and the increase of the roof floor mass must be avoided.*

Keywords: *Special Steel Moment-Resisting Frame, Mass Irregularity in the Height, Nonlinear Static Analysis, Nonlinear Dynamic Analysis*

INTRODUCTION

Today in the world, a large number of buildings face change of the use in the time of exploitation. For example, offices or storerooms may be used in the topper floors so that following these changes in the land uses, the floors mass will change. So, there is the possibility of mass irregularity in the plan and floors of the building.

To investigate the above structures, their seismic behavior must be considered. Since conventional methods of analysis and designing of the structure are based on the power criterion, they create a main weakness in the seismic calculation of the structure that is in the range in which the structure behaves linearly. That is the behavioral model of power- displacement is for linear structures. The power criterion can be used to control the members. But since most of the structures enter the nonlinear range during an earthquake due to economic considerations, in this range, the power changes (resistance) are insignificant and create many change of forms (displacements). So, the criterion of displacement is prosed as the most appropriate behavioral index. So, the instructions consider control of the lateral displacement and the relative displacement of the floors as necessary for such investigations.

Humar did an analytical investigation on the participation amount of high modals in the subsidence structures (Humar, 1990). Shahrooz investigated the effect of subsidence using the trembling table and compared with the rules of the UBC regulation and resulted that these rules are too strict (Shahrooz, Pantazopoulou and Moehle, 1988). Delus and Simonini studied the effects of difficulty changes in the height on the buildings with 4, 8, and 16 floors and resulted that there is no difference between static methods with modal methods (Dolce and Simonini, 1986). Hidalgo in similar studies considered the UBC rules for Chilean buildings as inappropriate because these buildings in addition to relative irregularity and that they are designed in a static method, they acted well in the March 1995 Chile earthquake (Hidalgo et al., 2002). Tesu showed that in the vertical side of the subsidence, the static analysis for existence of the twisting effect is inadequate. Hutchinson investigated the effect of the mass and difficulty irregular distribution in the height on the dynamic outer axial of multi-storey and calculated coefficients for the floors outer axial. Young and Tesu investigated the effect of subsidence in the height on the alternation and presented a relation for calculation of the subsidence building alternation (Moghaddam, 2003).

The two two-dimensional 6 and 18 floors structures which have special steel moment-resisting frame system and assuming the mass irregularity effects of 50% and 100% in the height and in the first, middle, and last floors are considered to investigate the irregularity effects and the used steel is of types of St-37, Fy=2400kg/cm^2, and E=2.110$^6 kg/cm^2$. To investigate the behavior of an irregular structure in the height before the earthquake, nonlinear analysis must be done and in this research, using nonlinear analysis, it is tried to investigate the mass irregular special steel moment-resisting frame structures in the height.

Introducing the structures and explaining their mathematical model

To perform analytical studies in this research totally 14 two-dimensional steel frame, six floors, and 18 floors which are symbol of short and average buildings with below structural features have been used.

1. Frames are modeled in two-dimensions.
2. Number of openings in all the frames is fixed and equals 3 and the length of every opening is 4 meters.
3. The opening of the beams landing is considered as 5 meters.
4. The general height of every floor is similar (relative height) and equals 3 meters.
5. Ceiling of the floors is made of beam and block and is hard.
6. Structural system of all the frames is of special steel moment-resisting frame.
7. To load earthquakes, the 2800 regulation and version 3 [1] has been used (linear conditions).
8. All the mentioned frames columns are in the shape of a can.
9. All the beams of the mentioned frames are in the shape of I and a sheet beam.
10. Connection of the frame is rigid.
11. Modeling is done with Etabs9 and Sap2000 version 14.2.2 software.
12. Location of the structure is in Tehran and its use is hospital.

For the regular structure in the height, the dead load has been considered as 500kg/m^2 and the live load as 200kg/m^2. For irregular structure in the height with irregularity of 50%, the related irregularity dead load has been considered as 750kg/m and the live load as 300kg/m and for the irregularity of 100%, the dead load has been considered as 1000kg/m^2 and the live load as 400kg/m^2.

For the steel moment frame structures two types of joints is introduced:

[1] The regulation of the building's design before the earthquake-standard 2800-(version 3)

1. The plastic joints of the beams which are achieved of the required number of the existing beams in the structure and the behavioral curve of the beams (the curve M-θ) and number of the M33 plastic joints (American Institute of Steel Construction, 1989).
2. The plastic joints of the columns which are of the required number of the existing columns types with attention to the ratio of $\frac{p}{p_{cl}}$ in every kind of column, the number of the PMM plastic joints for columns are achieved.

Two types of lateral distributions have been used in this research to the structure model. In the distribution of the first type, the distribution proportionate to the static power of the earthquake is used and in the second type distribution, the monotonous distribution (in which the lateral load proportionate to weight of every floor is calculated) is used. In this research, the FEMA356 has been used to achieve the aimed displacement.
In this research, the design spectrum has been obtained from multiplication of values, reflection coefficient of the building (B) and the design basis acceleration (A). To do dynamic-nonlinear analysis of the structures, Sap2000 version 14.2.2 has been used[2]. In this research, the Bam earthquake record is only introduced for one component of the earthquake with the time steps of 0.02 seconds for Bam earthquake record. In this research, the Bam earthquake mapping acceleration has been used. Moreover, the structures are modeled in two dimensions so, only one of the horizontal components of each of the earthquakes has been used. To scale the mappings acceleration, the seismic amelioration instruction method and in the time range of .2 T to 1.5 T has been used to scale the related earthquake method and also the design spectrum of the 2800 rule with the rank 3 soil has been used.

Table 1: The maximum acceleration of the earthquake in proportion to g before and after scale

Maximum earthquake acceleration of Tabas		Maximum earthquake acceleration of Bam		Maximum earthquake acceleration of El Centro		Building
The scaled record	The main record	The scaled record	The main record	The scaled record	The main record	
0.66 g	1.07 g	0.81 g	0.6565 g	0.44 g	0.3188 g	6
0.88 g		0.97 g		0.54 g		12
1.8 g		1.18 g		0.61 g		18
1.95 g		1.44 g		0.65 g		24

In the nonlinear static method, the lateral load of the earthquake is used statically, gradually and increasingly to the structure to the extent that displacement from a certain point (central point of the roof mass) reaches to change of the aimed place or the structure falls.
Weight loading is calculated from the relation 1.

$$Q_G = 1.1Q_t + 1.1Q_D \qquad (1)$$

According to the instruction, two types of lateral distribution is used for the structure model in this research. In the distribution of the first type, the distribution proportionate to the static power of the earthquake is used and in the second type distribution, the monotonous distribution (in which the lateral load proportionate to weight of every floor is calculated) is used.
Also, the FEMA356 method has been used to gain the aimed displacement.in the table 9-3 the values of the aimed displacement have been shown. In this research, the design spectrum has been obtained from multiplication of values, reflection coefficient of the building (B) and the design basis acceleration (A) (figure 1

[2] User Guide Sap2000 Version 10.0.7, (1976-2006)

Standard2800). For the design basis acceleration in the risk level 1, the number 0.35 has been used and the value of B for the rank 3 soil was obtained as 3.

Table 2: the aimed displacement

Δ t m	T_e	$C_{.}$	
0.253	1.02344	1.30378	600000
0.267	1.02905	1.36426	6.01.050
0.279	1.03031	1.42046	6.01.100
0.257	1.05213	1.27389	6.03.050
0.258	1.07475	1.24378	6.03.100
0.294	1.13273	1.31926	6.06.050
0.327	1.22328	1.3245	6.06.100
0.698	2.10208	1.37552	18.00.000
0.714	2.10216	1.40647	18.01.050
0.73	2.10224	1.43885	18.01.100
0.699	2.11948	1.3624	18.09.050
0.701	2.13994	1.34771	18.09.100
0.744	2.18452	1.39276	18.18.050
0.796	2.28154	1.40647	18.18.100

Results

Linear static analysis

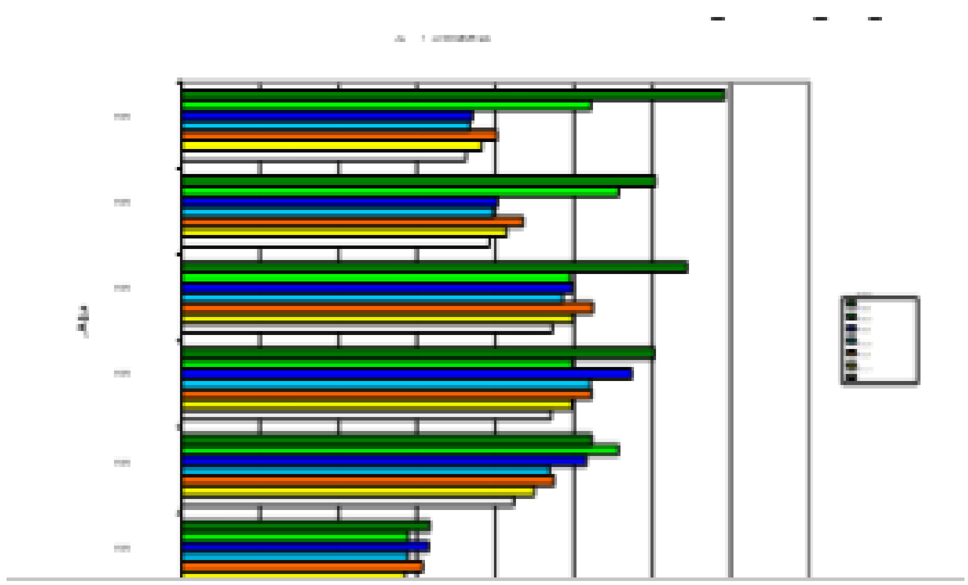


Figure 1: Linear static analysis drift for the mass regular and irregular 6 floors structures

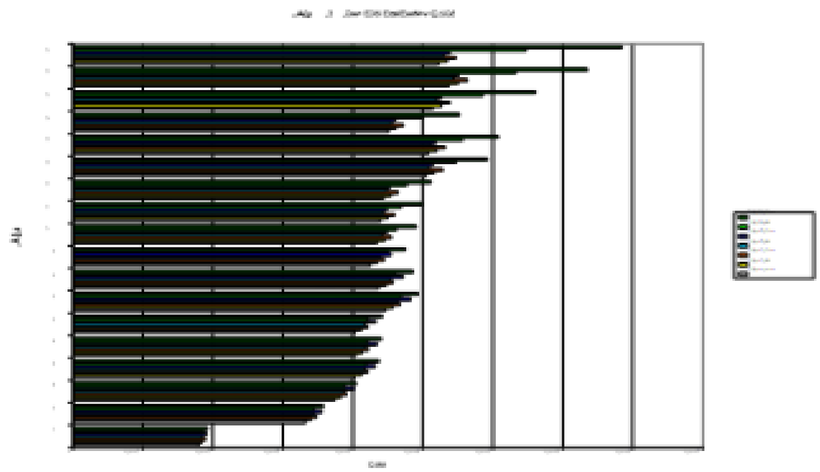


Figure 2: Linear static analysis drift for the mass irregular 18 floors structures

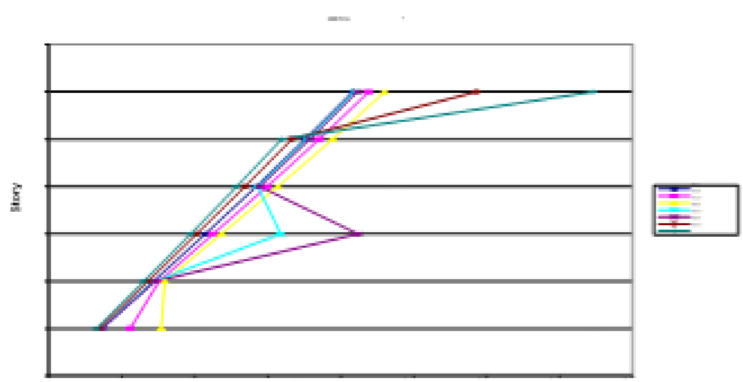


Figure 3: Linear static power distribution of the earthquake for the mass regular and irregular 6 floors structures in the height

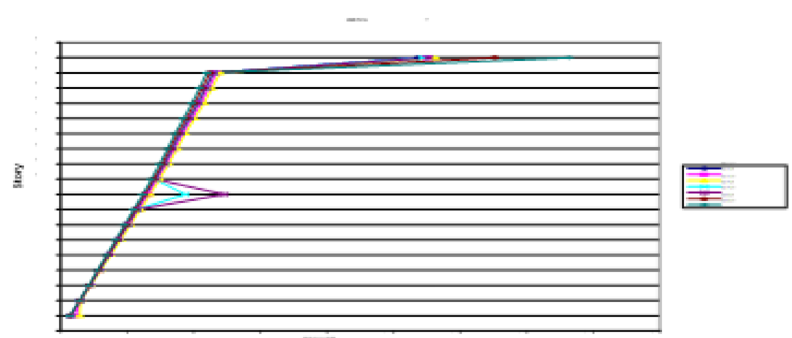


Figure 4: Linear static power distribution of the earthquake for the mass regular and irregular 18 floor structures in the height

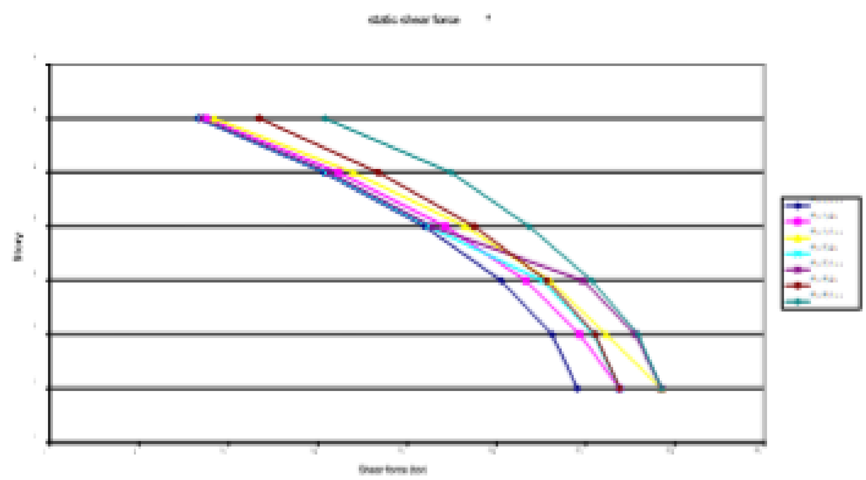


Figure 5: Comparison of the earthquake's cutting of the floors linear static analysis of the mass regular and irregular 6 floors structures

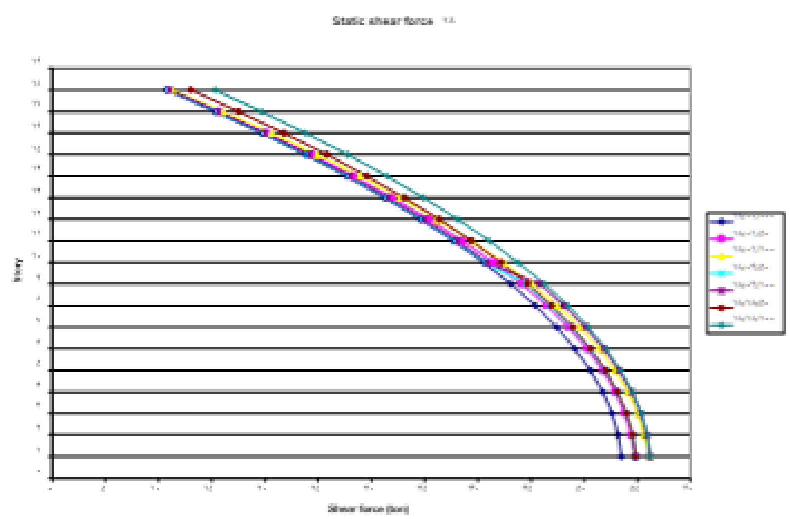


Figure 6: Comparison of the earthquake's cutting of the floors linear static analysis of the mass regular and irregular 6 floors structures

According to the figures (5) and (6), it can be seen that the increase of the floor mass has led to the increase of the base cutting and following that, according to the figures (3) and (4) has led to the increase of the floors' power and floors' cutting especially in the irregular floor. For figures (1) and (2) the floors' drift (relative displacement between the floors), because the relation of the cutting-displacement in the elastic behavior range is a linear relation, so all the results of the floors' cutting for relative displacement of the floors are conformed.

Modal linear dynamic analysis:

Relative displacement between (the ratio of relative displacement on the height) and the floors' cutting

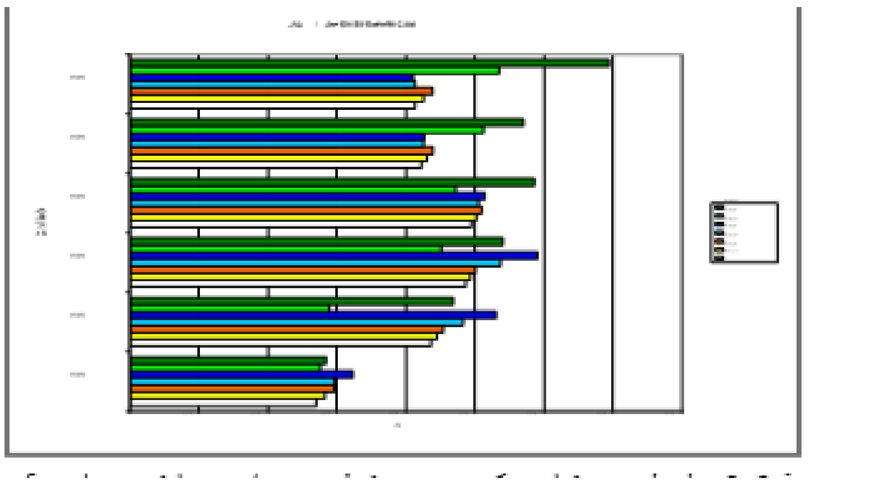


Figure 7: Linear-modal dynamic analysis drift for the mass regular and irregular 6 floors structures

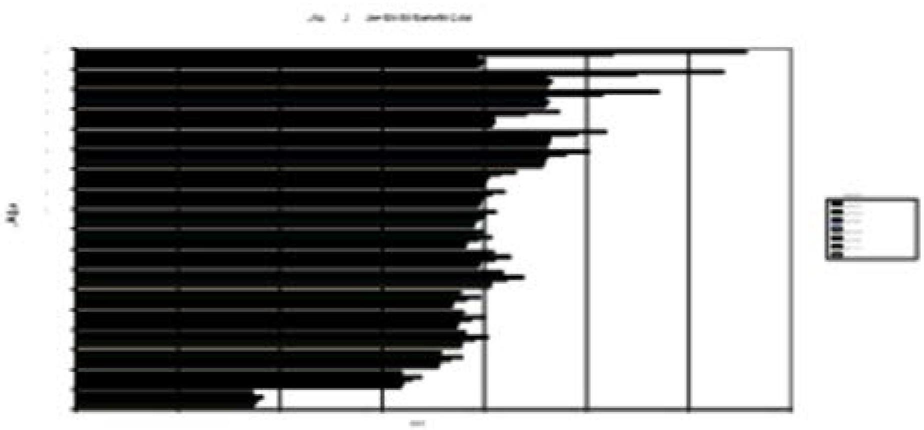


Figure 8: Linear-modal dynamic analysis drift for the mass regular and irregular 18 floors structures

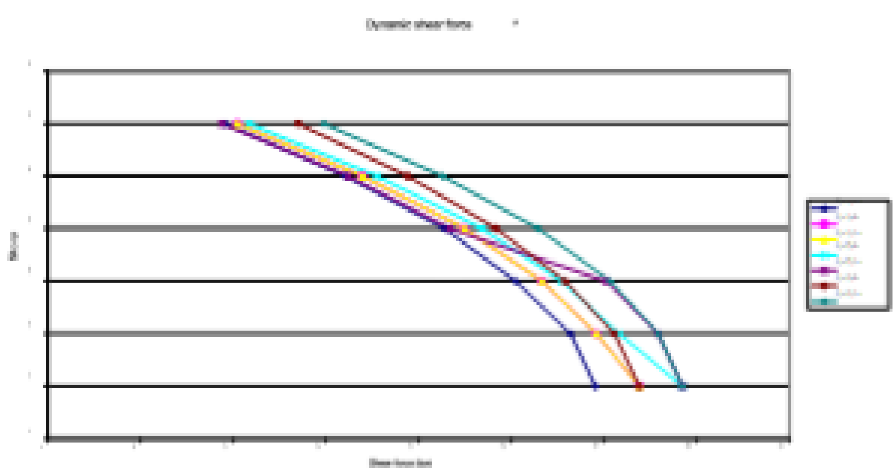


Figure 9: Comparison of the earthquake's cutting of the linear dynamic analysis floors for the mass regular and irregular 6 floors structures

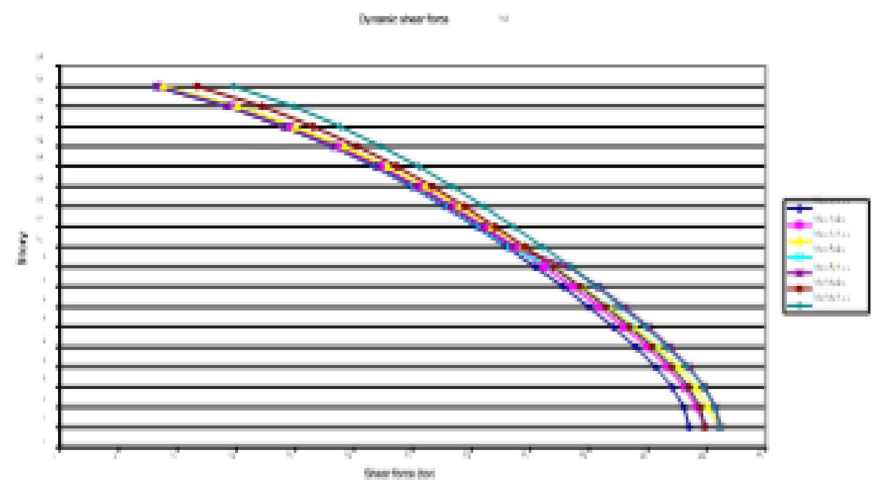


Figure 10: Comparison of the earthquake's cutting of the linear dynamic analysis floors for the mass regular and irregular 18 floors structures

According to the figures (9) and (10), it can be seen that the increase of the floor mass has led to the increase of the base cutting and following that, has led to the increase of the floors' cutting especially in the irregular floor. For figures (7) and (8), the relative displacement between the floors, because the relation of the cutting-displacement in the elastic behavior range is a linear relation, so all the results of the floors cutting are conformed to the floors relative displacement.

2-2- The alternation time:

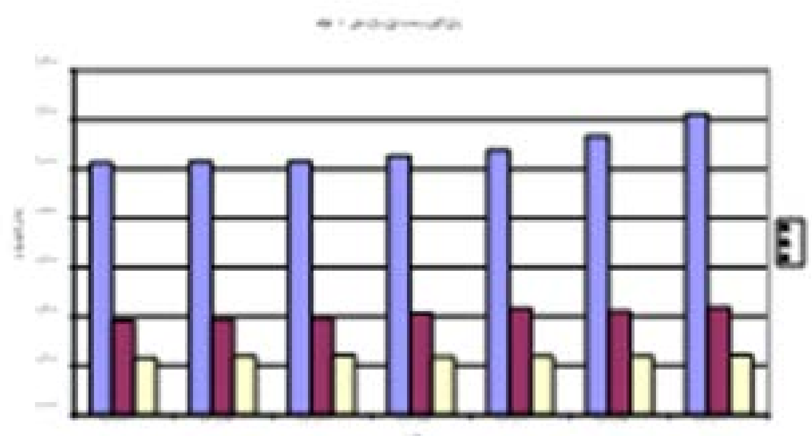


Figure 11: The alternation time of the first three models of regular and irregular 6 floors structures

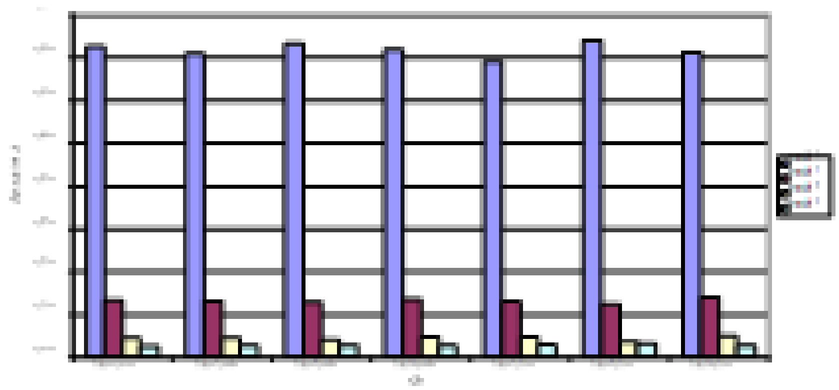


Figure 12: The effective mass percentage in the first three models of irregular and regular 18 floors structures

According to the figures (11) and (12), it can be seen that:

1. The alternation time of the first three structure modals has increased by the increase of the irregular floor mass according to the relations T= 2π $\sqrt{\frac{m}{k}}$ and $|k - m\omega^2| = 0$
2. The alternation time in the first modal: since the first modal figure is in the form of a tress, so by the increase of the mass in the topper floor level, total difficulty of the structure has decreased and according to the relation T=2π$\sqrt{\frac{m}{k}}$ the alternation time increases.

Modal figure:

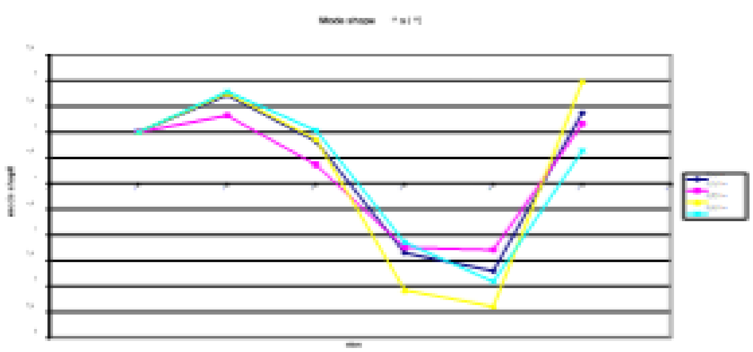


Figure 13: The first modal of the 100% mass irregular and regular 6 floors structures

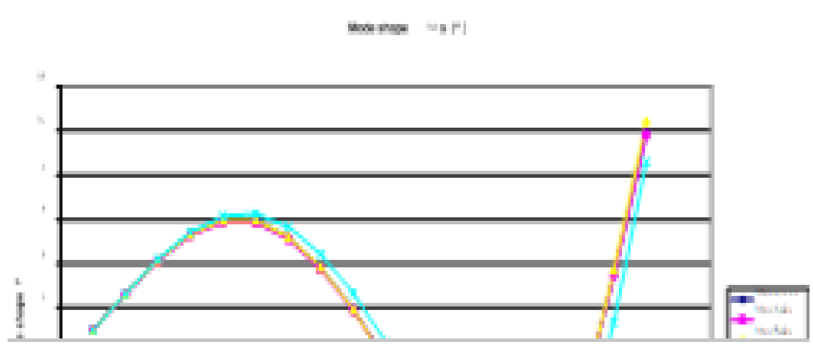


Figure 14: The first modal of the 100% mass irregular and regular 18 floors structures

According to the figures (13) to (14) for the modal figure of all the structures based on the relation $[k - m\omega^2] \times [\varphi] = 0$:in the irregularity of the first floor, the third modal figure is almost equal. In the irregularity of the middle floor, the third modal figure is almost equal. In the irregularity of the last floor, the third modal figure has increased in the lower floors and decreased in the higher floors.

Mass participation coefficient:

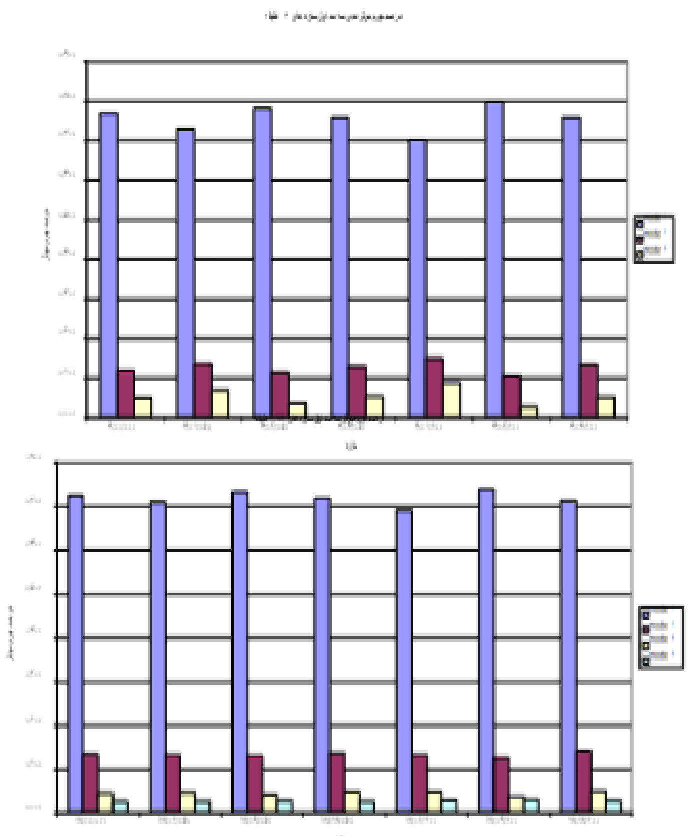


Figure 16: The effective mass percentage in the first three modal of the structure

According to the figures (15) to (16):

In the first modal, the most mass participation coefficient has happened in the irregularity of the middle floor in relation to the regular condition and has decreased in the irregularity of the first floor and in the irregularity of the last floor. In the second modal, the modal participation coefficient in the irregularity of the middle floor has decreased in relation to the regular condition and has increased in the irregularity of the first floor and in the irregularity of the last floor. In the third modal, the modal participation coefficient in the middle floor irregularity has increased in relation to the regular condition and has increased in the irregularity of the first floor and has decreased in the irregularity of the last floor.

Nonlinear dynamic analysis

The 6 floors structure

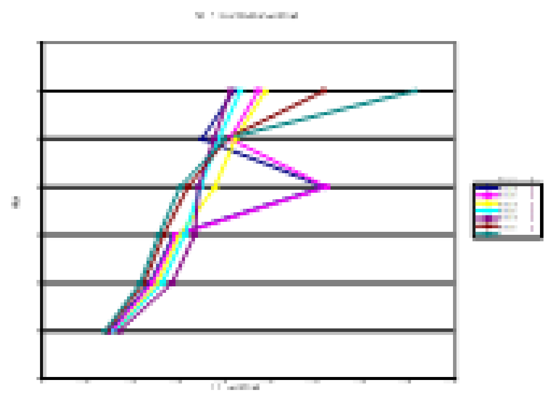


Figure 17: Nonlinear relative displacement of the Bam earthquake on the 6 structures

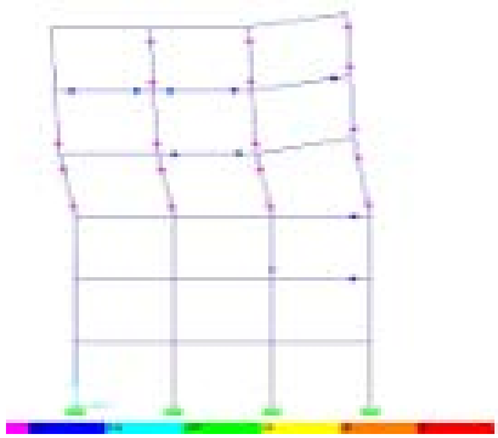


Figure 18: Plastic joint's distribution in the 6 structure of the regular floor for the Bam earthquake

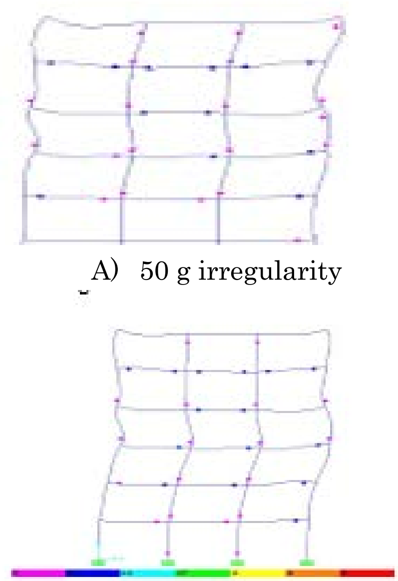


Figure 19: Plastic joint's distribution for the 6 irregular floors in the sixth floor for the Bam earthquake

A) Irregularity 50-6 g B) Irregularity 100-6 g

Irregularity in the last floor with value of 50 g:

According to the figures (17) and (18), the plastic joints' distribution and the relative displacement of the floors for the Bam earthquake is as below:

The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the frequency content and the spectrum acceleration, have become more nonlinear in the fifth floor beams and in the sixth floor columns in relation to the irregular condition. Relative displacement of the floors in the 5th and 6th floors has the most increase in relation to the regular condition due to more nonlinearity of the plastic joints in relation to the regular condition.

Irregularity in the last floor with the value of 100 g:

According to the figure (19), the plastic joints' distribution and the relative displacement of the floors for the Bam earthquake is as below:

The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the frequency content and the spectrum acceleration have become more nonlinear in the fifth and sixth floor beams and in the sixth floor columns in relation to the irregular condition. Relative displacement of the floors in the 5th and 6th floors has the most increase in relation to the regular condition due to more nonlinearity of the plastic joints in relation to the regular condition.

The 18 floor structure:

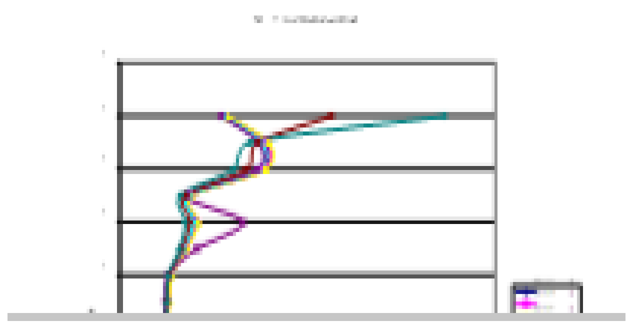


Figure 20: Nonlinear relative displacement of the Bam earthquake on the 18 floors structures

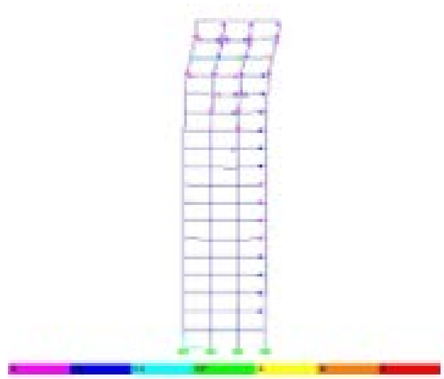


Figure 21: The plastic joints' distribution in the regular 18 floors structure for the Bam earthquake

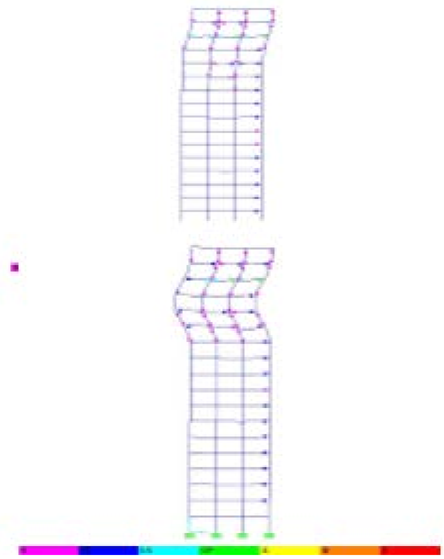


Figure 22: The plastic joints' distribution for the irregular 18 floors structure in the 9th floor for the Bam earthquake

A) Irregularity 50-9 g B) Irregularity 100-9 g

Irregularity in the middle floor with the value of 50 g:

According to the figures (20) to (22), the plastic joints' distribution and the relative displacement of the floors for the Bam earthquake:

The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the frequency content and the spectrum acceleration have become more nonlinear in the 6th, 7th, 15th, 16th floor beams in relation to the irregular condition. Relative displacement of the floors in the 6th and 7th floors has the most increase in relation to the regular condition due to more nonlinearity of the plastic joints in relation to the regular condition.

Irregularity in the middle floor with the value of 100g:

According to the figures (20) to (22), the plastic joints' distribution and the relative displacement of the floors for the Bam earthquake:

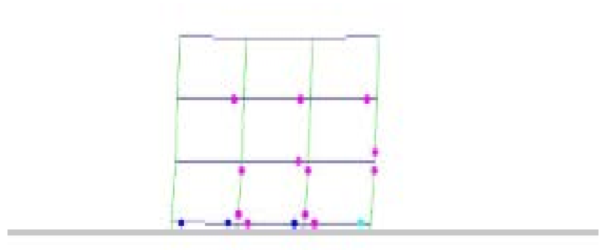
The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the frequency content and the spectrum acceleration have become more nonlinear in the 6th, 7th, 8th floors beams and in the 12th and 13th floors columns in relation to the irregular condition. Relative displacement of the floors in the 7th, 8th, 13th, and 14th floors has the most increase in relation to the regular condition due to more nonlinearity of the plastic joints in relation to the regular condition.

the average relative displacement of all the structures:

1. Irregularity in the first floor: in the 6 floor structure the maximum increase of the average relative displacement has happened in the roof floor and in the first floor we have had little increase. In the 18 floor structure, the maximum increase of the average relative displacement has happened in the last floors and in the first floor, we have had little increase.
2. Irregularity in the middle floor: in the 6 floor structure, the maximum increase of the average relative displacement has happened in the middle floor. In the 18 floor structure, the maximum increase of the average relative displacement has happened in the floor is 4 for 50% irregularity and 3 for 100% irregularity and in the 9th floor, we have had a little increase.
3. Irregularity in the last floor: in the 6 floor structure, the maximum increase of the average relative displacement has happened in the roof floor. In the 18 floor structure, the maximum increase of the average relative displacement has happened in the roof floor.

Nonlinear static analysis:

the plastic joints' distribution and the distribution proportionate to the mass ratio:
1-The 6 floor structure



A) 50 g irregularity

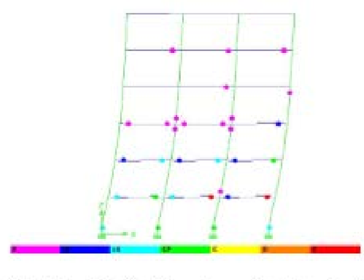


Figure 23: The plastic joints' distribution for the irregular 6 floors structure in the first floor based on the static distribution

A) 50-1 g irregularity B) 100-1 g irregularity

According to the figure (23) and results of the plastic joints' distribution research:

Irregularity in the first floor with the value of 50 g, the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration and the static power have become more nonlinear in the 1st, 2nd, and 3rd floors' beams and in the 3 floor columns in relation to the irregular condition.

Irregularity in the first floor with the value of 100 g, the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration and the static power have become more nonlinear in the first floor beams in relation to the irregular condition.

Irregularity in the middle floor with the value of 50g, the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration and the static power have become more nonlinear in the 2nd and 3rd floors beams and in the 2nd and 3rd floors columns in relation to the irregular condition.

Irregularity in the middle floor with the value of 100g, the plastic joints distribution: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration and the static power, have become more nonlinear in the 2nd and 3rd floors beams and in the 2nd floor columns in relation to the irregular condition.

Irregularity in the last floor with the value of 50g; the plastic joints distribution: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration and the static power, have become more nonlinear in the 1st, 2nd, 3rd, 4th, and 5th floors beams and in the 2nd floor columns in relation to the irregular condition.

Irregularity in the last floor with the value of 100g; the plastic joints distribution: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration and the static power have become more nonlinear in the 2nd, 3rd, 4th, and 5th floors beams and in the 2nd, 3rd, 4th, 5th, and 6th floors columns in relation to the irregular condition.

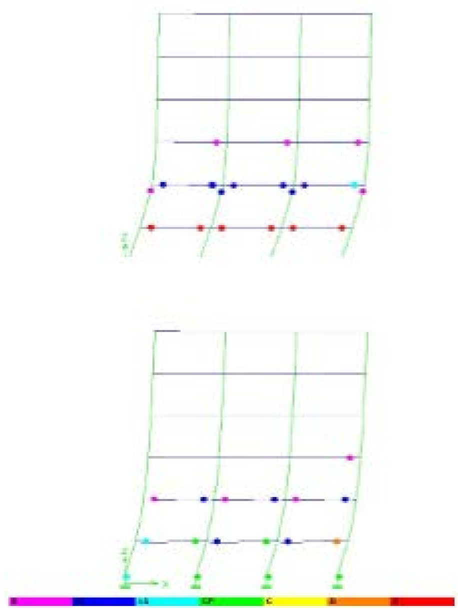


Figure 24: the plastic joints' distribution for the irregular 6 floors structure in the first floor based on the mass proportionate distribution

A) 50-1g irregularity B) 100-1g irregularity

According to the figure (24) and results of the plastic joints' distribution research of the irregularity in the first floor with the value of 50g; the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration have become more nonlinear in the 2nd floor beams and in the 1st and 2nd floors columns in relation to the irregular condition.

Irregularity in the first floor with the value of 100g; the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration have decreased in the floor beams and in the floor columns in relation to the irregular condition.

Irregularity in the middle floor with the value of 50g; the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration have become more nonlinear in the 1st floor beams and in the 1st and 3rd floors columns in relation to the irregular condition.

Irregularity in the middle floor with the value of 100g; the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration have become more nonlinear in the 2nd and 3rd floor beams and in the 2nd and 3rd floors columns in relation to the irregular condition.

Irregularity in the last floor with the value of 50g; the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration have become more nonlinear in the 2nd and 3rd floor beams and in the 1st and 3rd floors columns in relation to the irregular condition.

Irregularity in the last floor with the value of 100g: the plastic joints distribution: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration have become more nonlinear in the 1st, 2nd, 3rd and 5th floors beams and in the 1st, 2nd, 3rd, and 4th floors columns in relation to the irregular condition.

The 18 floor structure:

The plastic joints distribution:

Irregularity in the first floor with the value of 50g: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration and the static power, have decreases in the floor beams and in the floor columns in relation to the irregular condition of the nonlinear effects.

Irregularity in the first floor with the value of 100g: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration and the static power, have decreases in the 1st floor beams and in the floor columns in relation to the irregular condition of the nonlinear effects.

Irregularity in the middle floor with the value of 50g: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration and the static power have become more nonlinear in the 7th floor columns in relation to the irregular condition.

Irregularity in the middle floor with the value of 100g: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration and the static power, have become more nonlinear in the 4th, 7th, and 9th floor columns in relation to the irregular condition.

Irregularity in the last floor with the value of 50g: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration and the static power, have become more nonlinear in the 12th, 13th, 14th, 16th, and 17th floors beams and in the 13th, 14th, 16th, and 18th floors columns in relation to the irregular condition.

Irregularity in the last floor with the value of 100g: The plastic joints in this irregular condition according to the destructive effects of the P-Δ and the spectrum acceleration have become more nonlinear in the 16th, and 17th floors beams and in the 13th, 14th, 16th, and 18th floors columns in relation to the irregular condition.

Distribution proportionate to the mass ratio:

According to the results of the plastic joints' distribution:

Irregularity in the first floor with the value of 50g: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration, have become more nonlinear in the 1st floor beams and in the 1st floor columns in relation to the irregular condition.

Irregularity in the first floor with the value of 100g: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration, are similar in the 1st floor beams and in the 1st floor columns in relation to the irregular condition.

Irregularity in the middle floor with the value of 50g: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration, are similar in the floor beams and in the floor columns in relation to the irregular condition.

Irregularity in the middle floor with the value of 100g: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration, have become more nonlinear in the 7th floor beams and in the 1st floor columns in relation to the irregular condition.

Irregularity in the last floor with the value of 50g: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration, have become more nonlinear in the 1st floor beams and in the 1st floor columns in relation to the irregular condition.

Irregularity in the last floor with the value of 100g: The plastic joints in this irregular condition, according to the destructive effects of the P-Δ and the spectrum acceleration, have become more nonlinear in the 8th floor beams in relation to the irregular condition.

The behavior coefficient

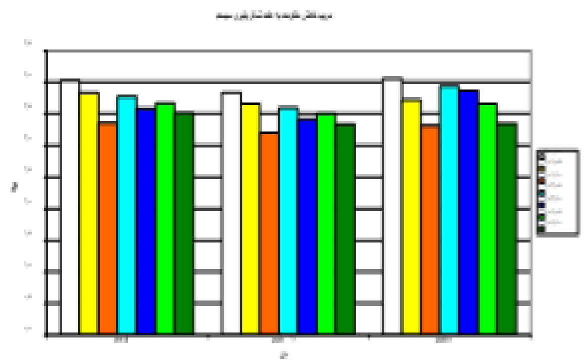


Figure 25: Resistance decrease coefficient due to the plasticity of regular and irregular 6 floors structures

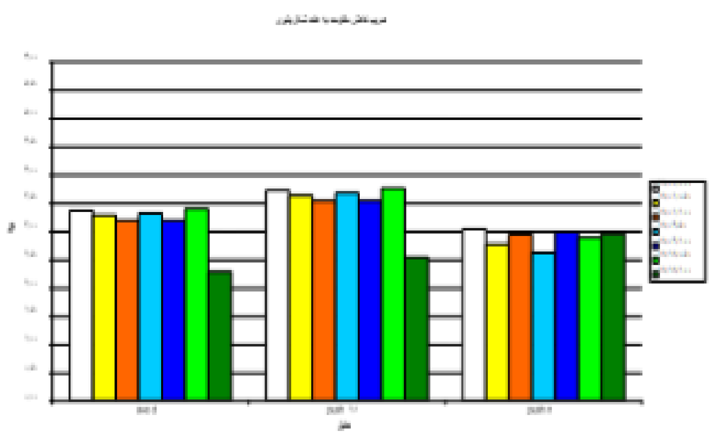


Figure 26: resistance decrease coefficient due to the plasticity of regular and irregular 18 floors structures

Now, the relation below can be used as a quantitative estimation of the R (behavior coefficient).

$R=R_{\mu}\times\Omega\times Y$

Which in the above relations R_{μ}= the reduction coefficient due to plasticity of the system. This coefficient shows the capacity of the energy depreciation in the cyclic behavior. For R_{μ} below relations can be presented for a one degree free structure.

A) For areas with the spectrum fixed displacement speed: (T>0.5sec)

$R_{\mu}=\mu$

B) For areas with the spectrum fixed acceleration (T<0.5sec)

$$R_{\mu} = \sqrt{2\mu - 1}$$

μ is the identified plasticity coefficient

Ω= The resistance additional coefficient that equals resistance of the total destruction mechanism to the resistance of formation of the first plastic joint.

Y= The allowable stress coefficient which is gained through the relation below. (Ratio of the plastic anchor to the exploitation anchor)

$Y=\frac{M_P}{M_W}$

In this research:
Ω=2
Y=1.45
So:

$$R_{\mu} = \frac{R}{\Omega \times Y} = 3.45$$

Conclusion

1. **Irregularity in the first floor:**
   - **Linear static analysis:**

Mass increase of the first floor in all the structures has led to the increase of the relative displacement of the irregular floor and the floors around the irregular floor.

- **Linear dynamic analysis:**

Mass increase of the first floor has led to the relative displacement of the irregular floor and its around floors.

- **Nonlinear dynamic analysis:**

Mass increase in the first floor has led to more nonlinearity of the plastic joints in the irregular floor and its around and following that has led to the increase of the first floor displacement and its higher floors.

- **Nonlinear static analysis:**

Distribution of the plastic joints for loading proportionate to the floors mass has happened in the floors of half-part below.
Mass increase in the first floor has led to more nonlinearity of the plastic joints of the first floor and its higher floors.
Mass increase in the first floor leads to the little increase of the base cutting.
-R_{μ}= Irregularity increase does not have a significant effect on the behavior coefficient.

2. **Irregulatity in the middle floor:**
   - **Linear static analysis:**

Mass increase of the middle floor in all the structures has led to the increase of the relative displacement of the irregular floor and the floors around the irregular floor.

- **Linear dynamic analysis:**

Mass increase of the middle floor has led to the relative displacement of the irregular floor and its around floors.

- **Nonlinear dynamic analysis:**

Mass increase in the middle floor has led to the more nonlinearity of the plastic joints in the irregular floor and its around and following that, has led to the little increase of the middle floor displacement and its higher floors and increase of 20% in the irregular floor of the 6 floors structures.

- **Nonlinear static analysis:**

Distribution of the plastic joints for loading proportionate to the floors mass has happened in the floors of half-part below.
Mass increase in the middle floor has led to the more nonlinearity of the plastic joints of the first floor and its around floors.
Mass increase in the middle floor leads to a little increase of the base cutting.
-R_{μ}= Irregularity increase does not have a significant effect on the behavior coefficient.

3. **Irregularity in the last floor**
   - **Linear static analysis:**

Mass increase of the last floor in all the structures has led to the increase of the relative displacement of the irregular floor and the floors below the irregular floor.

- **Linear dynamic analysis:**

Mass increase of the last floor has led to the relative displacement of the irregular floor and the floors below the irregular floors.

Nonlinear dynamic analysis:

Mass increase in the last floor has led to more nonlinearity of the plastic joints in the irregular floor and its around and following that, has led to the little increase of the last floor displacement and its lower floors.

- **Nonlinear static analysis:**

Distribution of the plastic joints for loading proportionate to the floors mass has happened in the floors of half-part below.

Mass increase in the last floor has led to more nonlinearity of the plastic joints of the last floor and its lower floors.

Mass increase in the last floor leads to the decrease of the structure plasticity.

Mass increase in the last floor leads to the little increase of the base cutting.

-R_{μ}= Irregularity increase does not have a significant effect on the behavior coefficient unless impermanence (mechanism) happens.

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