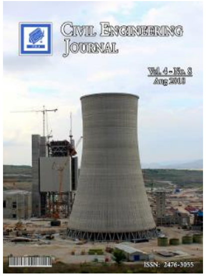
Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 4, No. 8, August, 2018



The Consideration of Response Modification Factor of L-Shaped Structures by Using Adaptive Pushover Analysis Method and Comparison with Traditional Pushover Method

Azin Akbari [a*], Erfan Ordookhani [b], Mohammad Reza Pasaeian [b]

[a] *Department of Civil Engineering, Qazvin branch, Islamic Azad University, Qazvin, Iran.*

[b] *Department of Civil Engineering, Sharif University of Technology, Tehran, Iran.*

Received 12 May 2018; Accepted 21 July 2018

Abstract

In the most of regulations, reduction factor of seismic force depends only on the kind of lateral loading system, but research has shown that this factor is a function of many factors such as period and modal characteristics of the structure, the height and especially form of plan in the building. Due to the complexity of nonlinear dynamic analysis method, today, nonlinear static analysis method called pushover, as a practical appropriate tool has developed in field of earthquake engineering based on function frequently. But traditional pushover analysis method have defects that can be noted Including the stability of lateral load pattern form, did not consider the impact of higher modes or impact of more efficient modes and lack of consideration of the stiffness matrix of member or the entire of structure changes in step of analysis. In recent years a number of researchers have proposed using adaptive load pattern, in this methods, lateral load pattern have changed and adapting in during analysis based on momentary stiffness matrix of structures. In this paper we investigate the response modification factor in L-shaped geometric asymmetry by using SAP software, Pushover analysis used in this study is divided into two categories pushover with constant load pattern (traditional method) and pushover with the adaptive load pattern (adaptive). So, it is studied building with L-shaped asymmetrical plan, with moment frame double structural system - bracing and number of floors 5, 10, 15 and 20, with four different bracing plan types at considering frames, and the end were compared obtained response modification factor from the two methods for these buildings.

Keywords: Geometric Asymmetry; L-Shaped Plan; Response Modification Factor; Adaptive Pushover; Adaptive Load Pattern.

1. Introduction

Structures in during of earthquakes have non-linear behavior, and therefore a considerable amount of input earthquakes energy waste in the form of damping energy and solid waste. In order to reduce the performing force of the earthquake due to the nonlinear behavior of structures caused by factors such as ductility, add resistance, damping, etc., calculated linear force from linear spectrum of plan, is reduced by using of the factor which called response modification factor of structure (R) [1]. Response modification factor known in of different regulations with different names and numeric amounts. In American codes and regulations, such as uniform building regulation (UBC 1997 NEHRP 2000 or 1997 regulations and FEMA 273) to (R) correction factor of response, in the National Building regulation of Canada as a correction factor for the force, in the SEAOC 1988 regulation called the functional factor of the system (R_w), in the European Regulation called the response modification factor (q), in loading standard of the New Zealand as ductility

* Corresponding author: skyinvader2007@gmail.com

http://dx.doi.org/10.28991/cej-03091130

factor of location change (μ) and the function structural factor (S_p), in the Building standard law of Japan called the ductility factor (1 / Ds) and is known in 2800 standard of Iran called the response modification factor (R) [2].

Bagheri and Tayari did a research at Tabriz university in 2017 titled response modification factor and displacement amplification factor (DAF) incriminate moment steel frame which it's response modification factor and its effective factors and also used displacement amplification factor in fourth edition of 2800 of Iran's Standard for medium moment steel frame were evaluated, and in this study the researcher had used FEM-P645 approach. After analyzing the date, the results form push over analyses, based on bilinear 2800 standard, the average factor Ω0 was 1.80 and 2.37 respectively. And it is noteworthy that the value of response modification factor with these above-mentioned methods was 3.96 and 5.26 respectively, while the suggested response modification factor in 2800 standard of Iran are 3 and 5. Thus, the suggested methods in FEM-P645 for evaluating structural performance parameters had better correlation with above-mentioned modification factor in 2800 standard for medium moment frames.

In 2016 Zahrayi and Alayi carried out a research about modification factor for double system of moment frame with medium plasticity and convertible x bracing with pall friction damper. In this research, the role of pall friction damper in convertible x bracing is shown. Frame two-dimensional 3, 6 and 2 floor had 3, 5 and 7 mouths which were designed based on Iran's standard, using pushover analysis the results showed that with existence of pall friction damper in dual system steel structures with convertible bracing, the response modification factor value was improved up to 100%.

According to 2800 regulation, response modification factor includes the effects of factors such as the ductility, uncertainties amount and add resistance available in the structure. This factor with regarding to the porter systems type of building determined by the aforesaid regulation. The aims of 2800 standard to determine minimum standards and regulations for the design and implementation of buildings against earthquake effects, so that with its respecting expecting to maintain the stability of buildings in against of intensive earthquakes, be minimized casualties, and enable to resist also building against mild and moderate earthquakes without structural major damage [3].

Nonlinear dynamic analysis methods are very time consuming and perform them need to consider a set of mappings is earthmoving acceleration during different earthquakes. In addition, logic simulation of nonlinear waste behavior of structural elements in this type of analysis adds its complexity. In contrast, non-linear static analysis methods can be a good choice for performance evaluation of non-linear the structures, during an earthquake [4]. In this paper, will be pay to the response modification factor in L-shaped geometric asymmetry. Also, in this research, examine building with L-shaped asymmetrical plan, in the number of floors 5, 10, 15 and 20. One of the used valid methods for analysis, is pushover analysis. Used assumptions in this article include:

- Type of analysis the non-linear static analysis – is or pushover or linear progressive load.
- It is considered the rigid floors diaphragm.
- Buildings with residential use and in an area with high seismic intensity has placed on ground of soil in type Π according to 2800's regulation. Also, it is considered floors height of the building, 3.2 meters.
- studied models are steel frame structures with dual system of moment frames with convergent braces in two directions that are its design has been done in accordance with section 10 of national building regulations and based on the of limited moods method.
- The long beams Span is assumed 4m in two directions.
- Used steel is type St37and concrete C25 is used with zero weight in the roof.

2. Theoretical Approach

Classification the pushover analysis methods:

From one view point, it can be classified pushover methods into two categories that is following:

- Traditional or conventional pushover methods.
- Advanced pushover methods.

Traditional pushover methods are said ways that be determined theirs load pattern according to a supposed modi form case in which is constant in during the analysis and responding of freedom few degrees structure to responding of freedom a single degree system linked as known hysteresis characteristics. In capacity spectrum methods (1998) ATC40, the modification of factors method in FEMA356, seismic improvement instruction of Iran are including traditional methods.

Advanced pushover methods are methods that try to consider such as effects of higher modes in terms of how determining to load pattern. For this reason, in most of cases used the concepts of modal analysis in structural dynamics and combined modi techniques. How to use these concepts in different ways are different. Some of the advanced pushover methods that is altered during the action loading pattern analysis based on instantaneous stiffness matrix of the structure, are called adaptive Pushover methods.

2.1. Traditional Pushover Method

Generally, in the traditional pushover analysis methods posed material characteristics and non-elastic material enter in the structural model directly. Then, this structural model under effecting of a lateral load pattern effect has been pushed incrementally until reaching a target position change and are determined the mounts of internal and forces deformations and occurrences of fractures layout, plastic joints during the process can be displayed easily. This process continues until the displacement of structures exceeding from the displacement of target and or structures falling. In this way, it is trying to shift the target equal to the possible displacement maximum under impact expected earthquake. Actually in the pushover analysis method to assessing of structural performance, the structural capacity spectrum compared with seismic demand spectrum. The ruling mode shape ($\emptyset$) in during of analysis time is assumed regardless of the deformations of result in lodging of permanent members. Assuming of specification the vector $\{\emptyset\}$, lateral load pattern based on ruling assumption mode shape by using Equation (1) is determined [5].

$$\{\mathrm{f}\} = [\mathrm{m}] \times \{\emptyset\} \tag{1}$$

Where [m] mass matrix of multi-degree freedom system, $\{\emptyset\}$ ruling assumption mode shape vector and $\{f\}$ is a pattern of lateral load shape vector. By applying increasing pattern of lateral load on the structure, pushover curve (base shear - removable of roof curve) resulting for a multi- degrees freedom structures by using modal analysis concepts in structures dynamics to the force curve- a degree of freedom system displacement to spectrum curve of the a degree freedom system capacity, a degree freedom system displacement maximum, D_1 is determined under effects of expected earthquake by using range of equivalent elastic or non-elastic range. The expected roof displacement maximum of multi-degree freedom system displacement U_{ro}, is estimated by using Equation 2 [6].

$$\mathrm{U_{ro}} = \mathrm{D_1} \times \Gamma\Phi_\mathrm{r} \tag{2}$$

If the structure is designed so that it can in places where is occur the most strain, and show sufficient ductility to stable hysteresis behavior, then, unable to will be bear with intended amount non-linear deformation. The concept of this sentence becomes clear that the difference between the dynamic and static force of the earthquake be understood equivalently and to transferring of ground motion to the mass of the structure, to be required members with lateral stiffness. In other words, if the lateral stiffness of vertical members (means of transmission of seismic waves into floors) is equal to zero, then it will not be transferred acceleration (motion) of land to the structure and therefore the base shear is equal to zero. Conversely, if the stiffness of the structure is suppose infinite structures (rigid structures), then will be transferred the same acceleration (motion) of land to the structure. Or it could be assumed that structure is part of the earths and in recent mode of base shear will be accelerated equal to multiplication of the structures mass [6].

In practice, what happens during an earthquake in conventional structures, is in-between state in above scenarios. The point that must be taken into consideration carefully is that if reduced lateral stiffness of the structure, the base shear will be reduced. In accordance with the present definitions, the following terms shall be determined in accordance with the Relations 3 and 4.

$$c = \frac{\text{base shear}}{\text{non} - \text{removable weight}} \tag{3}$$

Therefore, the required elastic resistance with base rate C_{eu} is expressed as follows:

$$\mathrm{C_{eu}} = \frac{\mathrm{V_e}}{\mathrm{W}} \tag{4}$$

Where W is weight the immobile masses of structures and V_e maximum created base shear in the structure about elastic. Because the existence of ductility in the structures, an economic structure can be designed so that to have the maximum amount of real resistance of C_yW and in this state, it express maximum displacement of the frame by Δ_{max} [7]. Curve diagram of the capacity is a conventional structure with Figure 1.

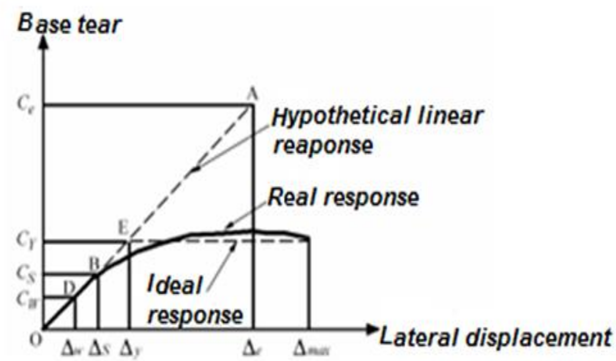


Figure 1. The curve diagram of the capacity in a conventional structure [26]

2.1.1. The Combination of Gravity Loading

In combination of gravity and lateral loading of high and low line of gravity load impacts, G, should be calculated from the following relationship:

$$G_1 = 1.1\ QD + QL \tag{5}$$

$$G_2 = 0.9QD \tag{6}$$

2.2. Adaptive Pushover Method

The first adaptive techniques can be attributed Einhorn, and Brexit and et al. Then, research has continued on the adaptive method now that can be named some of these authors Gupta and Kunnuth, Elnashai, Antoniou and Ferracuti.

Algorithm Pushover adaptive method based on force

1. Determination of the nominal load vector p_0.
2. Calculation of the load factor λ.
3. Calculation of the normalized modal vector F_t.
4. Update the loading vector.

The first stage once is done in beginning of the analysis, the remaining three stages, are repeated in each step alternately.

The pattern of lateral forces distribution is independent of response spectrum and just, is considered the system modal characteristics.

$$F_{ij} = \Gamma_j \varphi_{ij} M_i S_a\ (j) \tag{7}$$

Where

i; Floor number, j mode number, Γj participation factor of j-th mode, Φij component of mode shape vector j-th in i-th class I and Sa (j) spectral acceleration in j-th mode and Mi mass of the i-th floor.

Step 3: The formula for calculating the normalized modal vector:

$$F_i = \sqrt{\sum_{j=1}^{N} F_{ij}^2} \tag{8}$$

Lateral forces the result of each vibrated mode by using:

The square root the sum of squares:

$$F_i = \sqrt{\sum_{j=1}^{N} \sum_{k=1}^{N} (F_{ij} \rho_{jk} F_{ik}} \tag{9}$$

Squares method

$$\rho_{jk} = \frac{\delta.\xi^2.(1+r)r^{1.5}}{(1-r^2)^2 + 4\xi^2 r(1+r)^2} \tag{10}$$

$$r = \frac{\omega_k}{\omega_j} \tag{11}$$

Normalized modal vector formula in each loading stage:

$$\overline{F_i} = \frac{F_i}{\sum F_i} \tag{12}$$

Algorithm of pushover adaptive method based on displacement

1. Determine the nominal displacement vector U_0
2. Calculate the load factor λ
3. Calculation of Normalized modal vector
4. Updating the load vector

Di calculation method based on displacement

$$D_i = \sqrt{\sum_{j=1}^{N} D_{ij}^2} = \sqrt{\sum_{j=1}^{N} \left(\Gamma_j \varphi_{ij} S_d(j)\right)^2} \tag{13}$$

Where

i as Floor number, j as mode number, Γj participation factor of j-th mode, Φij component the vector of mode shape j-th in i-th floor and Sd (j) is the spectral displacement in j-th mode.

Algorithm of adaptive pushover method based on the relative displacement between floors

This algorithm is similar to DAP method with the difference that Di will be achieved of total relative displacement of the lower floors classes

Di calculation method based on the relative displacement between floors.

$$\Delta_i = \sqrt{\sum_{j=1}^{N} \Delta_{ij}^2} = \sqrt{\sum_{j=1}^{N} \left[\Gamma_j \left(\varphi_{ij} - \varphi_{i-1,j}\right).S_d(j)\right]^2} \qquad D_i = \sum_{k=1}^{i} \Delta_k \tag{14}$$

Di Vector by using following equation convert to normalized vector

$$\bar{D}_i = \frac{D_i}{\max D_i} \tag{15}$$

Overall adaptive $U_t = \lambda_t.\bar{D}_t.U_0$

Cumulative adaptive method $U_t = U_{t-1} + \Delta\lambda_t.\bar{D}_t.U_0$

Two methods to updating of the load and displacement vector

Overall adaption

In the below figure, the load distribution shown as an example for FAP procedure

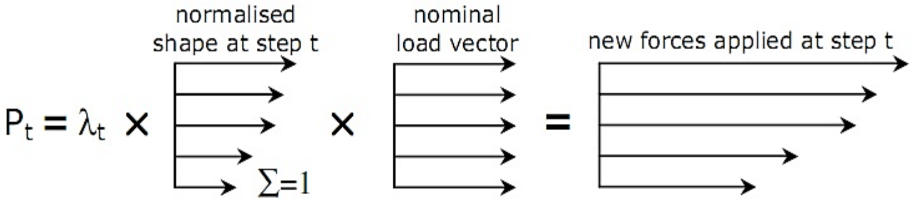


Figure 2. The load distribution

$$P_t = \lambda_t.\overline{F}_t.P_0 \tag{16}$$

Vector P_t load in t step from analysis is the equal to new vector the overall factor multiplying λt, normalized modal vector $\overline{F}_t$ and nominal load vector P_0.

Cumulative adaption

$$P_t = P_{t-1} + \Delta\lambda_t.\overline{F}_t.P_0 \tag{17}$$

P_t load vector in t step of analysis is by adding obtained new vector from multiplying the increase in load factor $\Delta\lambda_t$, normalized modal vector $\overline{F}_t$ and P_0 nominal load vector.

2.3. Method the Determination of Response Modification Factor

The response modification factor have depends on parameters such, ductility, main periodicity time of structures, damping factor of structure, characteristics of soil, characteristics of earthquake, load behavior- deformation of materials, increasing resistance factor, participation of high modes and confidence factor of the design [8]. The main factor influencing on the response modification factor, is ductility capacity of structure. In fact, if there is no ductility capacity in a structure, it cannot be considered the response modification factor for them.

Main periodicity time of structures as the factor that will be causes changes in the elastic and non-elastic response of structure, will effect on response modification factor. It is very more intuitive Periodicity time impacts on the amount of response modification factor in hard structures (with the periodicity time). Attenuation as a mechanism of energy dissipation alters the response of the structure when is elasticity and elasticity state and thus will be effect in amounts of the response modification factor. Also, the characteristics of caused earthquake on structure include maximum of acceleration, duration and frequency content will effects on factor behavior. Material that have load behavior- are different deformation which selecting each them will be effect on amount of response modification factor. Load model-deformation of materials that have resistance and hardness reduction, will have lowest factor behavior. Considering the participation of higher -vibrational modes in calculation the earthquake force, will be treated reduction of response modification factor. [8].

Increasing resistance factor is as the main factor in increase of response modification factor on multi-degrees freedom systems. Also, because of acceptance of lack performance of confident margin in loading regulations of structures against of earthquake and existence the current confident margin factor in design regulations of structures, response modification factor according with amount of confident factor [9]. ductility factor (μ),fundamental periodicity of the structure (T), load response modification – the deformation of materials, increasing resistance factor ($R\Omega$) and design confident factor (Y), are the most important factors in determining the response modification factor that considered in this research, based on Yang method for calculating their response modification factor.

2.3.1. The Method Ductility Factor of Yang

One of the most reliable methods is presented for calculating response modification factor by Professor Yang (Uang). In this method, the first, the maximum base shear of structures is calculated when the structure remains in linear range. Reduction factor due to ductility (R_μ) is defined than the base shear of structure in elastic state to base shear at disruptive level. Also, proportion of base shear at disruptive level in during the foundation of first plastic joint called increasing resistance factor (Ω) by respecting to the general behavior of a conventional structure (Figure 1), required elastic resistance amount that is defined according to base shear factor, include [10].

$$\Omega = \frac{C_y}{C_s} \tag{18}$$

$$R_\mu = \frac{C_{eu}}{C_y} \tag{19}$$

$$R_{u=}\Omega \times R_\mu \tag{20}$$

$$R_{w=}\Omega \times R_\mu \times Y \tag{21}$$

Usually "correct design of a structure acceptable lead to it ductility. In this case, the structure can be reached self-resistance maximize (C_yW). As Figure 1 shows, the maximum the lateral relative location change in the floor is equal to. Since the calculation of amount (C_yW) with plastic limit or final resistance of structure corresponded when creating the disruption mechanism and requires to nonlinear analysis, its amount has not been mentioned by specific relationship [10]. For design purposes, some regulations reduce the C_y to C_s amount that represents the first plastic hinge establishment at complex structure. This amount of force, is a balance that overall responding of structure going out remarkably from elastic situation. The balance of force in the way the treatment of regulations with design are depends on the resistance. In design of sections for this amount of lateral force, it can be noted ways such as method of final load state and load factor method- resistance. The difference of entered force amount between C_y and C_s to so-called increasing resistance, since is common in some design regulations using the tension method, regulations reducing CS to C_w amount, and allowable tension factor Y consider equals 1.4 [11].

Reduction factor of the force due to ductility , of the structures, has depreciated a significant amount of earthquake energy in the form of waste energy, reducing the entered force amount and associated with effecting force reduction factor. The amount of energy dissipation depends on the overall ductility amount of the structure. According to done studies, it specified that force reduction factor not only to system characteristics, but also depend on properties the movements of earth.

For movements of the earth, is a function of fluctuation period of structure, Attenuation, type of waste treatment and deformation nonlinear amount of structures (ductility factor), which the impact of fluctuation period and deformation nonlinear amount is more than the other two cases. Also in the high ranges of period, this factor is almost independent of the period and is almost equal with ductility of structure; in a low range of period, also this factor strongly depends on the period. For very rigid structures ( ) that is impossible the force reduction in ductility, this factor is equal to 1 [12].

3. Methodology

The firs, will be discussed response modification factor in L-shaped geometric asymmetry in two mode with equal and unequal wing with 5, 10, 15 and 20 floors numbers according to triangular and uniform load pattern with combination of G1 and G2 gravity load of traditional pushover analysis (CPA). Then it will be examine unequal wing L-shape plan becomes to a square plan and response modification factor in this two mode. Combining used load in the pushover analysis to gravity loading (G1) which its continuation done the loading to form of triangular load is to form of (D + L) 1.1, that the D and L are respectively dead and live load based on sixth issue of National building regulations that participation factor of live load is equal 2.0. Intended Steel is according to ST 37 properties. Intended load according to Kg/cm^2 in the analysis are as follows: loading on the roof should be omitted: dead and live load respectively 600, 150 and loading on the other floors: dead and live load are 600 and 200 and loading on firstly floor should be omitted: dead and live load are 600 and 500. Intended plans and types are evaluated according to Figures 3 to 9.

Figure 3 is related to L-shaped structural plan with equal wing and Figure 4 is related to L-shaped structural plan with unequal wing which shows direction of the beams of the roof. The distance between span of the frame is 4 meter.

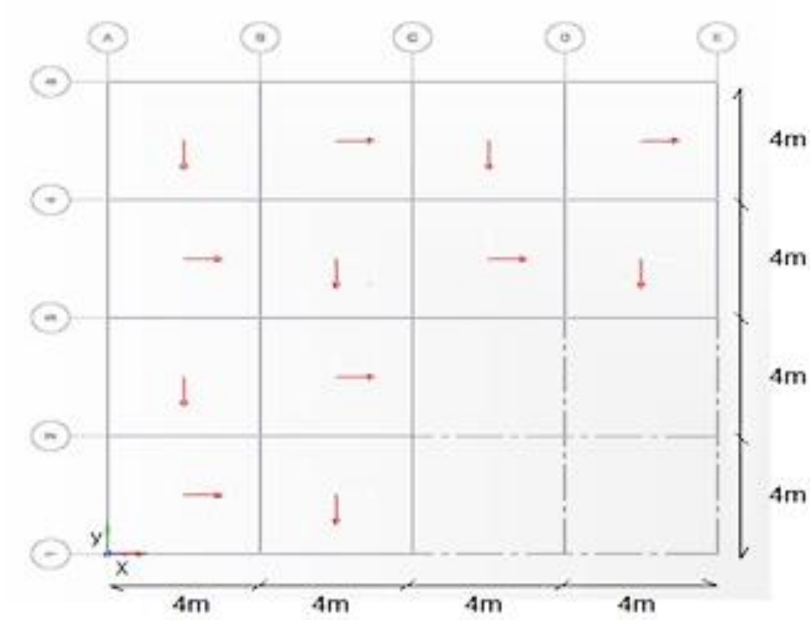


Figure 3. L-shaped plan with equal wing

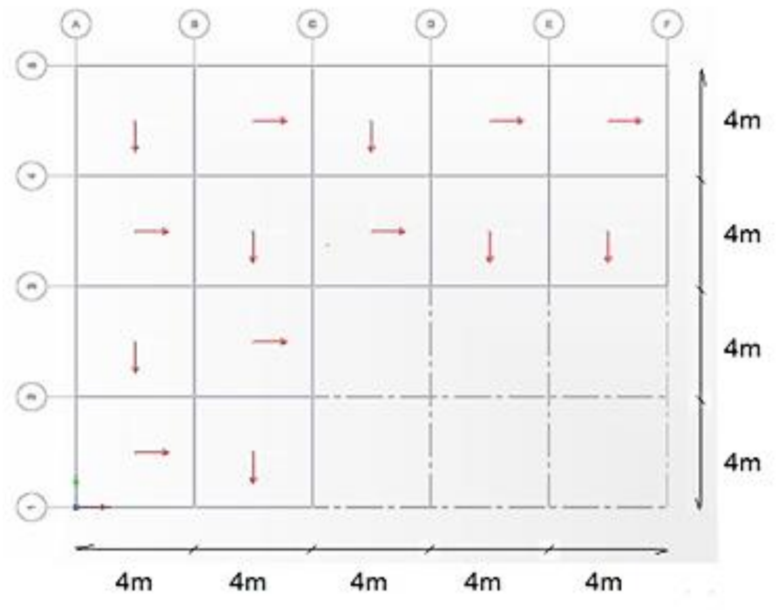


Figure 4. L-shaped plan with unequal wings

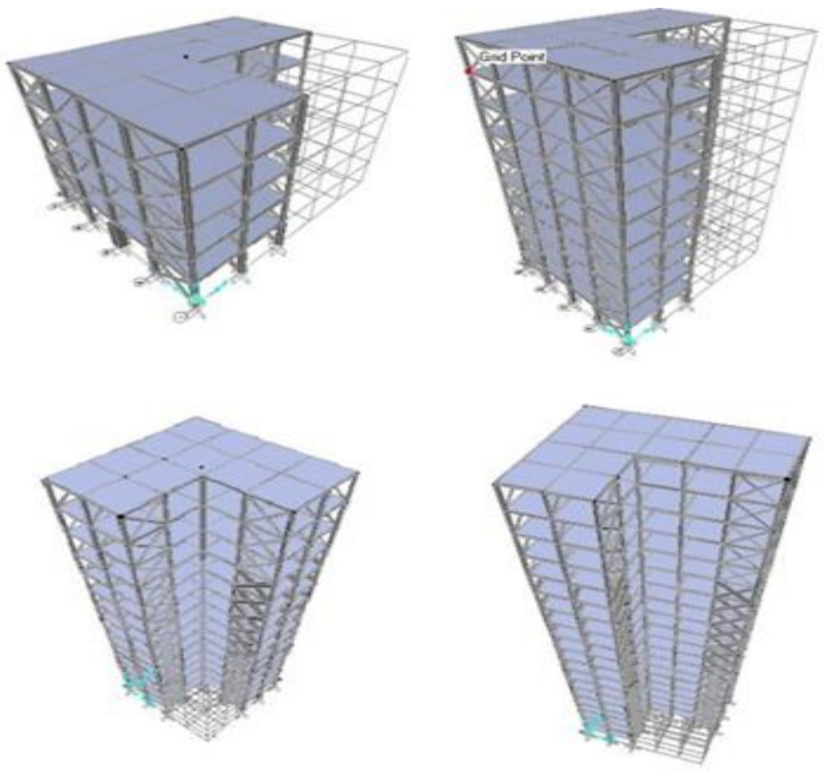


Figure 5. The three-dimensional view of the L-shaped asymmetrical structure

In Figure 5, the three-dimensional l-shaped asymmetric structures shown.

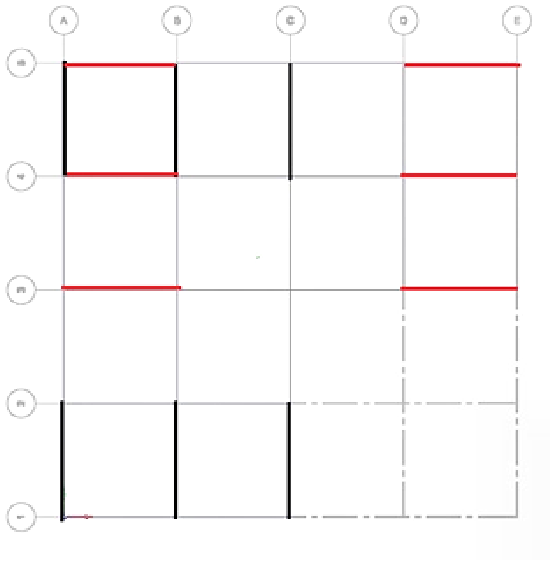


Figure 6. Type 0 bracing plan of L-shaped

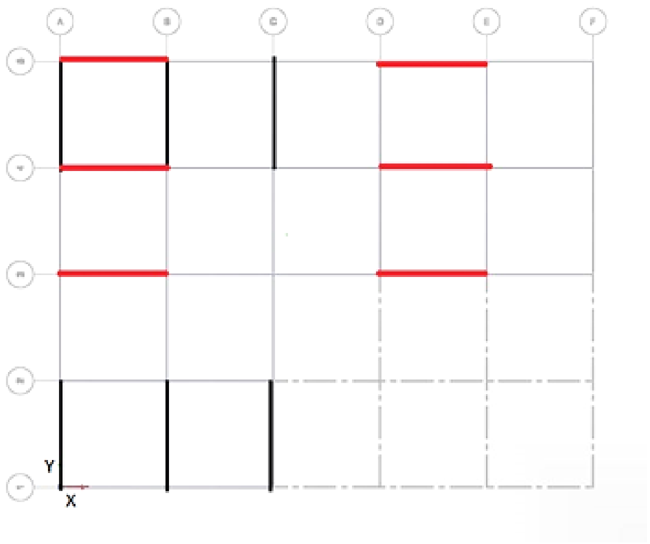


Figure 7. Type 1 bracing Plan of L-shaped

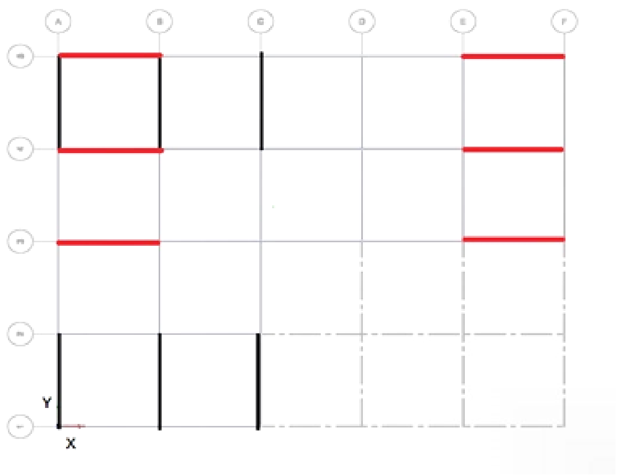


Figure 8. Type 2 bracing Plan of L-shaped

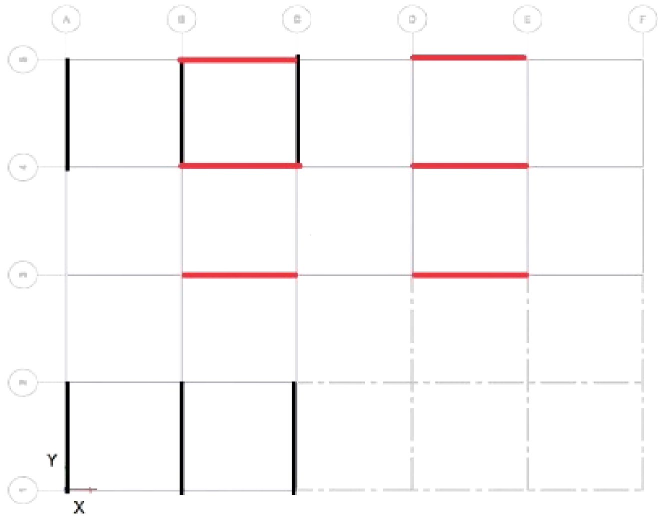


Figure 9. Type 3 bracing Plan of L-shaped

In Figures 6, 7, 8 and 9 respectively, the bracing method in analyzing the span of frame 1, 2 and 3 is shown, which the bracing positions are shown with red. In frames A, B and C, the bracing which are shown in black are fixed in all condition and their position does not change. It is noteworthy that this structure has a dual system steel frame.

Figure 6 is related to a structure with equal wing and Figures 7, 8 and 9 are related to L-shaped structure with unequal wing.

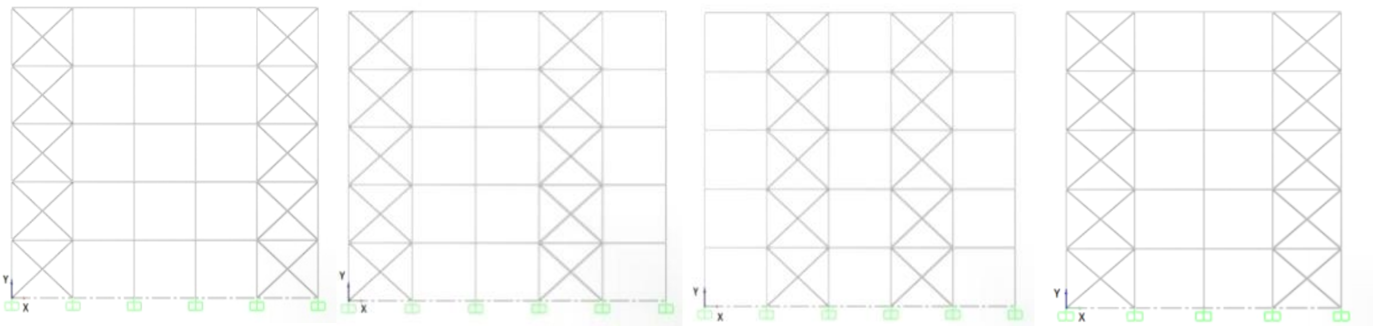


Figure 10. How bracing of opening in frame-sheet X- Z respectively from left to right, type 0, 1, 2 and 3

- The design carried out according to the Iran's Building National Regulations and (issue 10) and according the method of limit states.
- Roof system is Steel deck and the loaded level of beams is assumed 4 meters. Building with residential use and in an area with high seismic intensity and on soil land established with soil of Π type according to 2800's regulation. Also, the height of the building floors is considered 3.2 meters,
- The other aspect of the building in the y-direction which is in perpendicular direction on studied frame, is considered equal to four spans each with 4 meters.

The gravity center of L-shaped plan with equal wing is:

X=6.8571, Y=9.1428

The gravity center of L-shaped plan with unequal wings is:

X=8.5, Y=9.5

To calculate the force of the earthquake and design of these structures, because intend structures intensively have asymmetrical geometric in plan, static design equivalent with over 18 meters have not credit, thus, to the design should use of spectral dynamic analysis and calculation is performed accordance with in the 2800 regulation (edition 3), and is used with assuming response modification factor regarding to steel average moment frame system in addition steel coaxial bracing.

Calculated theory Period for dual-system: $T=0.05 H^{(3/4)}$

Achieved period in the structure is as follows:

5-storey structures:	T=0.4	h=16 m
10-storey structures:	T=0.672	h=32 m
15-storey structures:	T=0.911	h=48 m
20-storey structures:	T=1.131	h=64 m

4. Analysis of Results

All models are designed for life safety performance level of standard 2800. An example of how plastic hinge formation in the models shown at Figure 12.

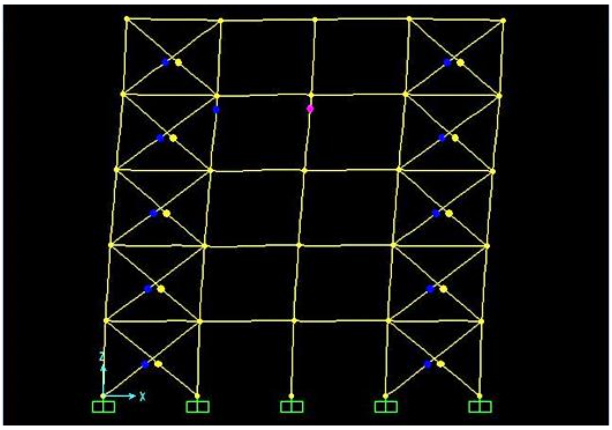


Figure 11. How plastic formation of 5-storey structures in SAP software

For example, diagram of regarding to the load-displacement of the 5-storey model shown under pushover analysis with static triangular lateral load pattern and then uniform lateral load pattern.

The analysis of models under the static triangular lateral load pattern.

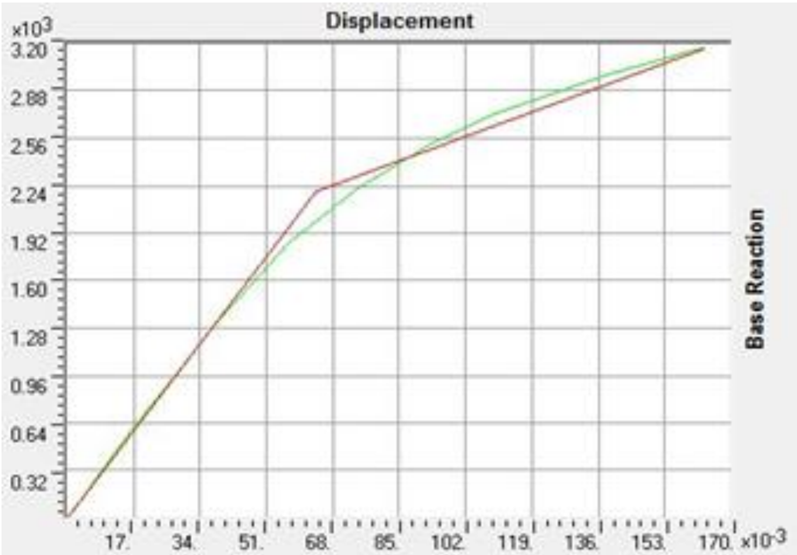


Figure 12. Bar graph- displacement the 5 –story model of zero type

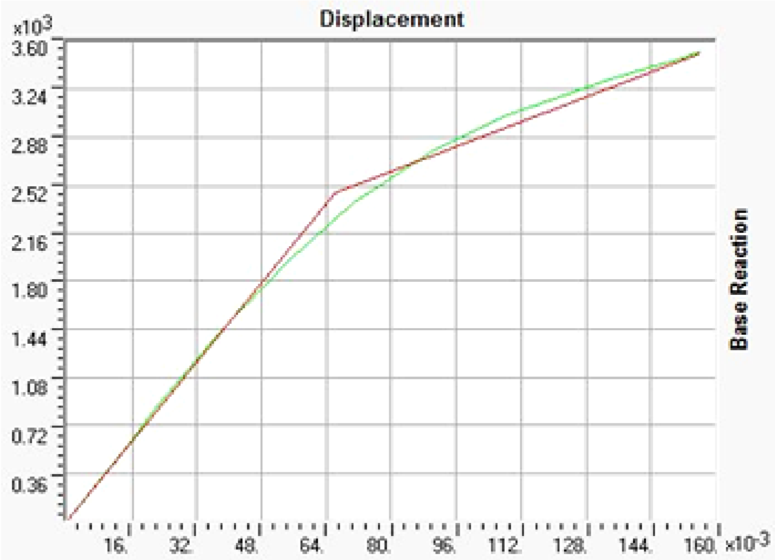


Figure 13. Bar graph-displacement the 5 -story model of 1 type

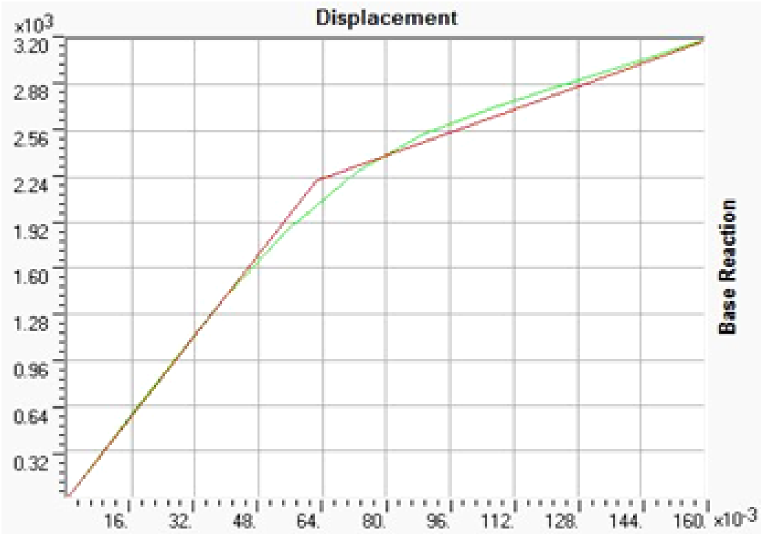


Figure 14. Bar graph-displacement the 5 -story model of 2 type

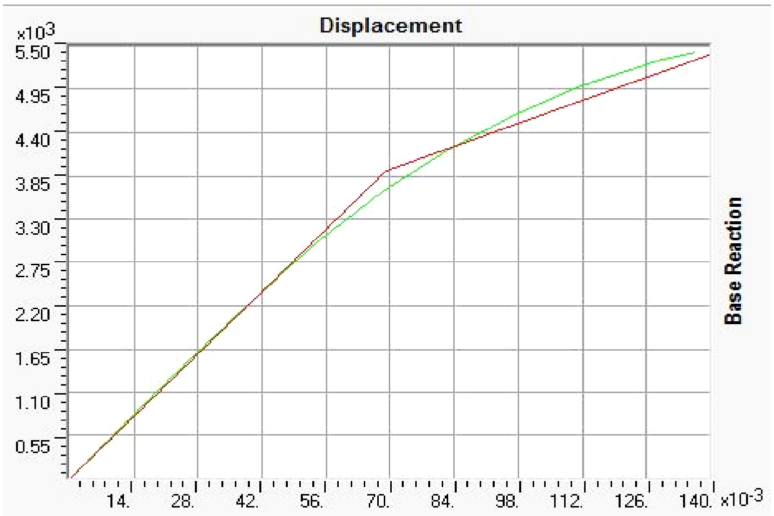


Figure 15. Bar graph-displacement the 5 -story model of 3 type

The analysis of models under uniform lateral load pattern.

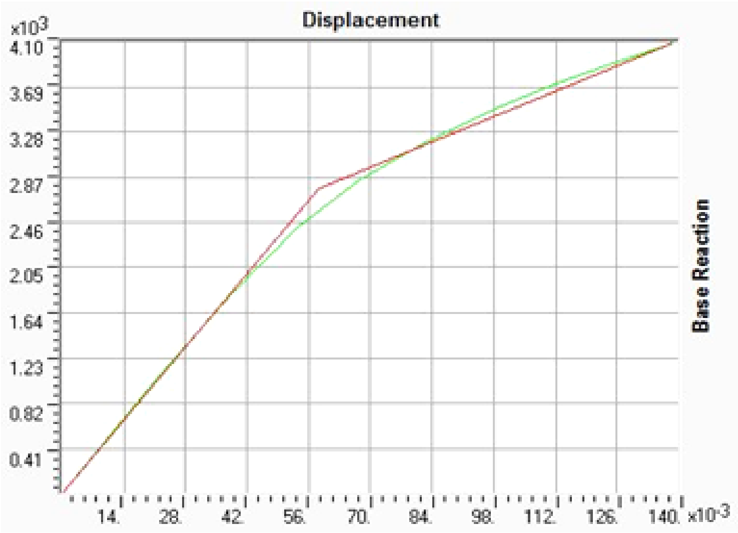


Figure 16. Bar graph-displacement the 5 -story model of zero type

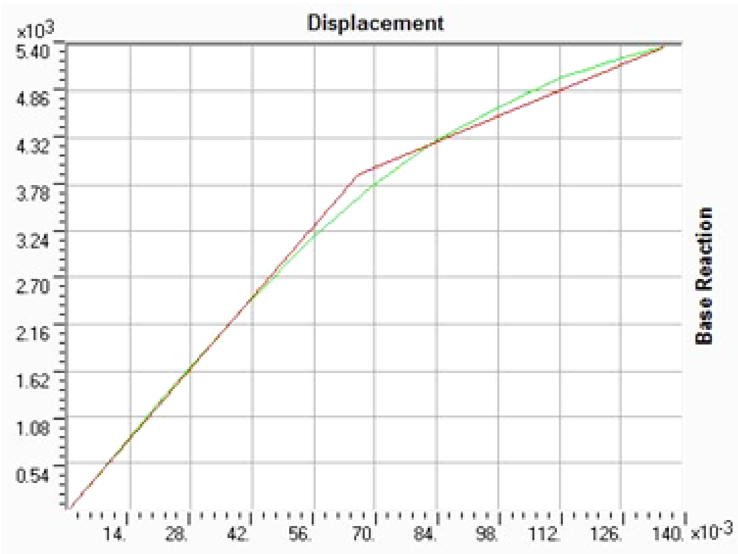


Figure 17. Bar graph-displacement the 5 -story model of 1 type

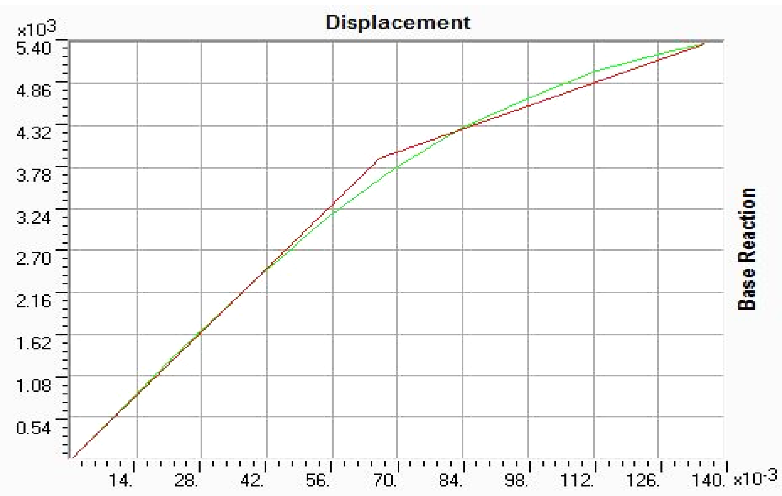


Figure 18. Bar graph-displacement the 5 -story model of 2 type

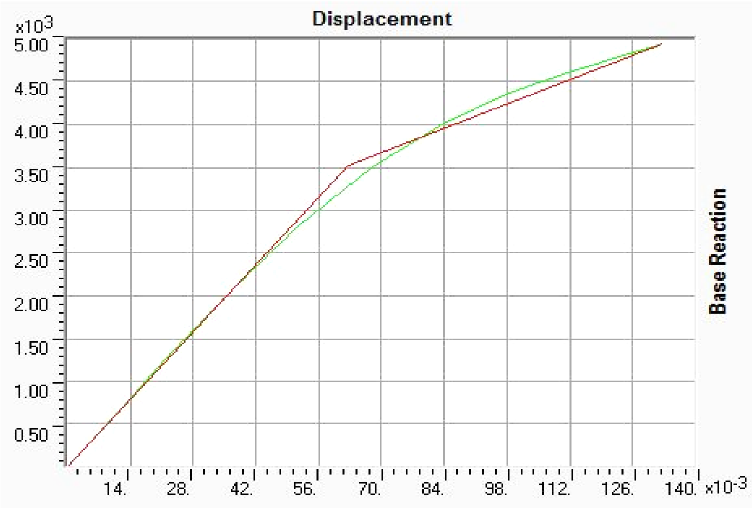


Figure 19. Bar graph-displacement the 5 -story model of 3 type

At first, models under triangular and uniform loading combination of gravity load G1 and G2 be pushover analysis, and parameters and response modification factors amounts in the way charts as follows.

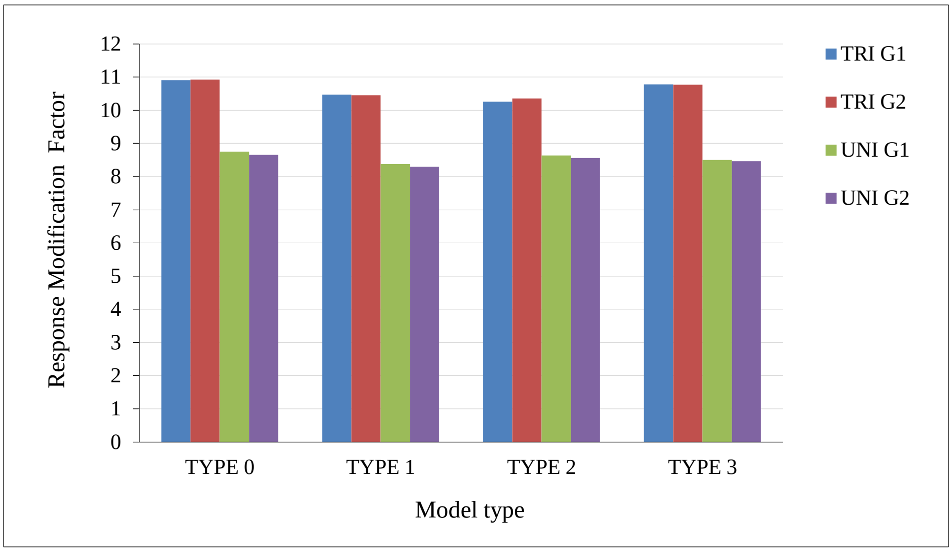


Figure 20. Comparing the response modification factor of 5-storey model with different bracings type and load pattern

Over strength factor and ductility reduction factor for buildings with five floors with different types of bracing, along with consistent load and triangular is as follow:

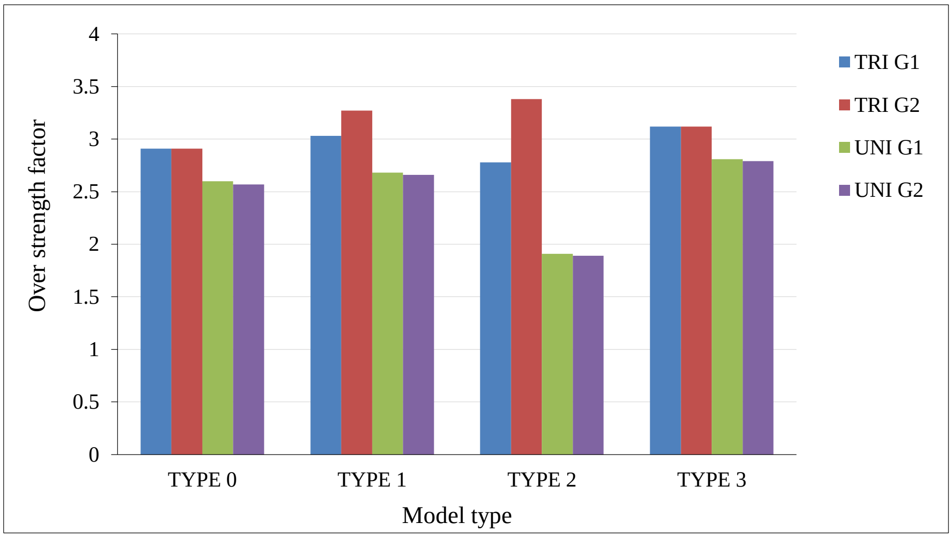


Figure 21. Add resistance factor of 5-story model

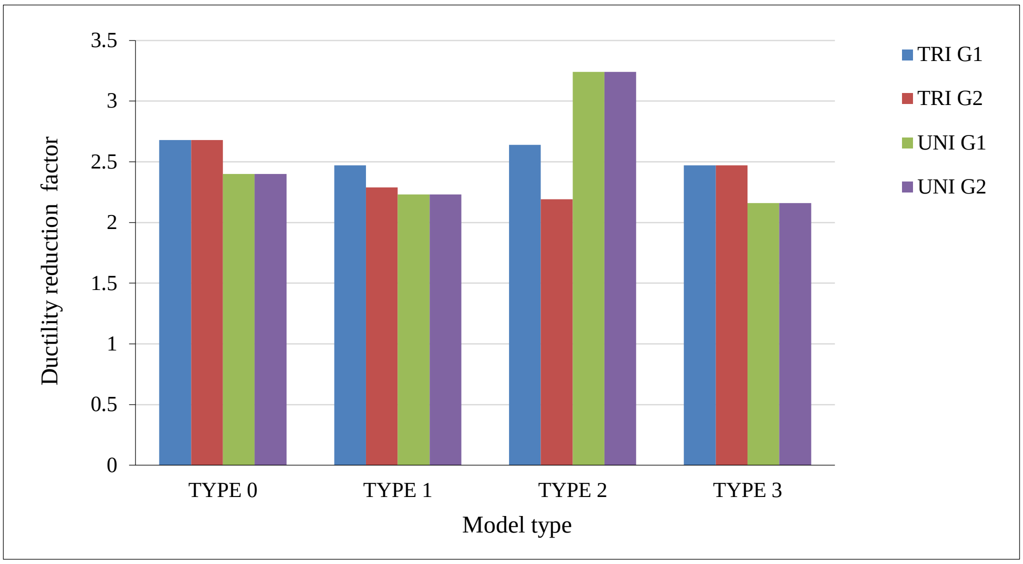


Figure 22. Ductility reduction factor 5-story model

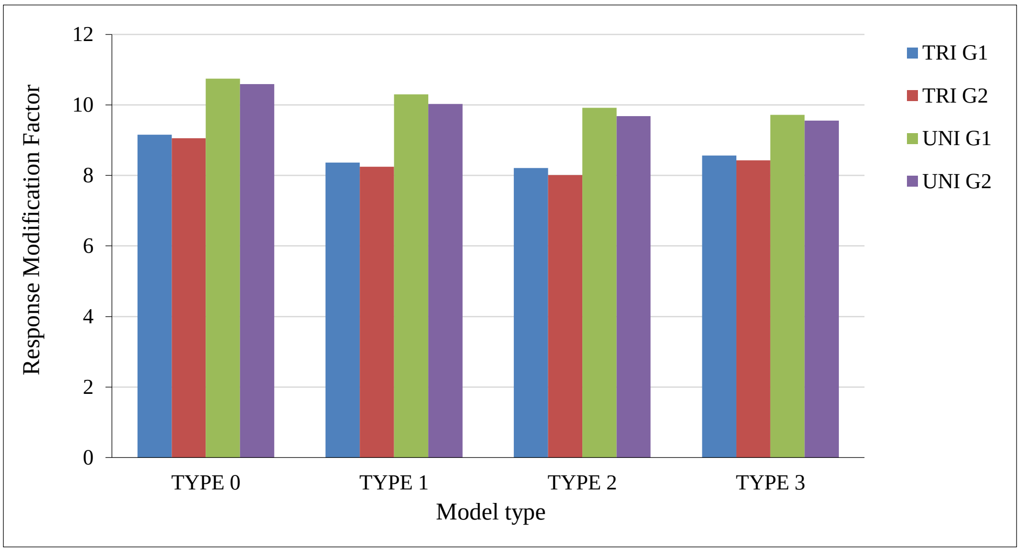


Figure 23. Comparing the response modification factor of 10-story model with different bracings type and load pattern

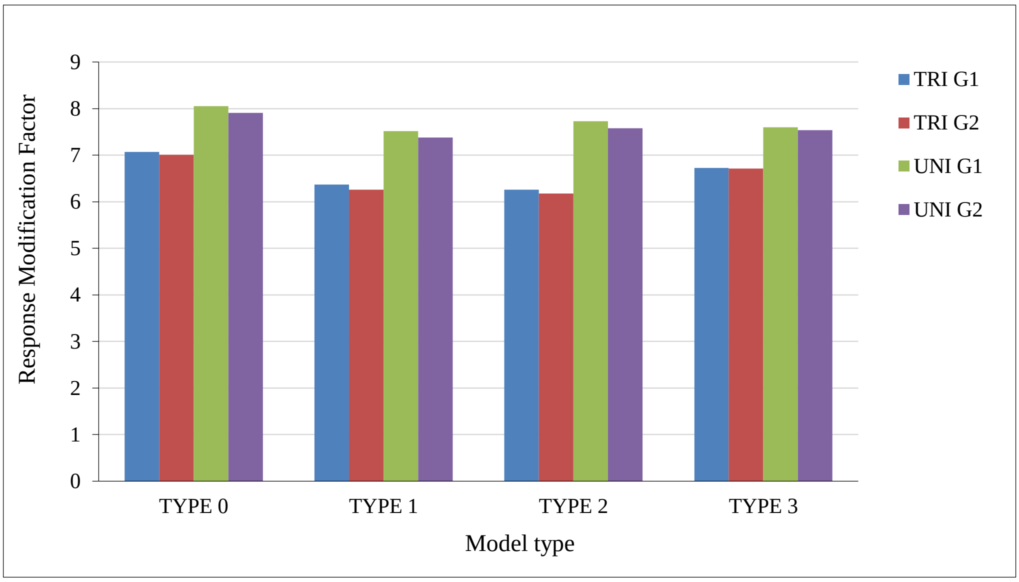


Figure 24. Comparing the response modification factor of 15-story model with different bracings type and load pattern

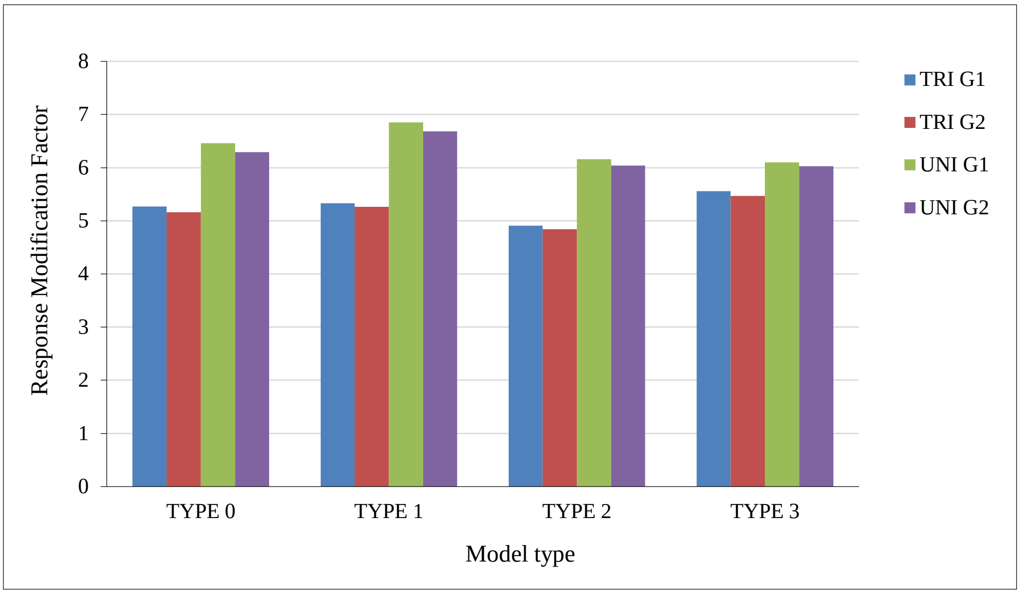
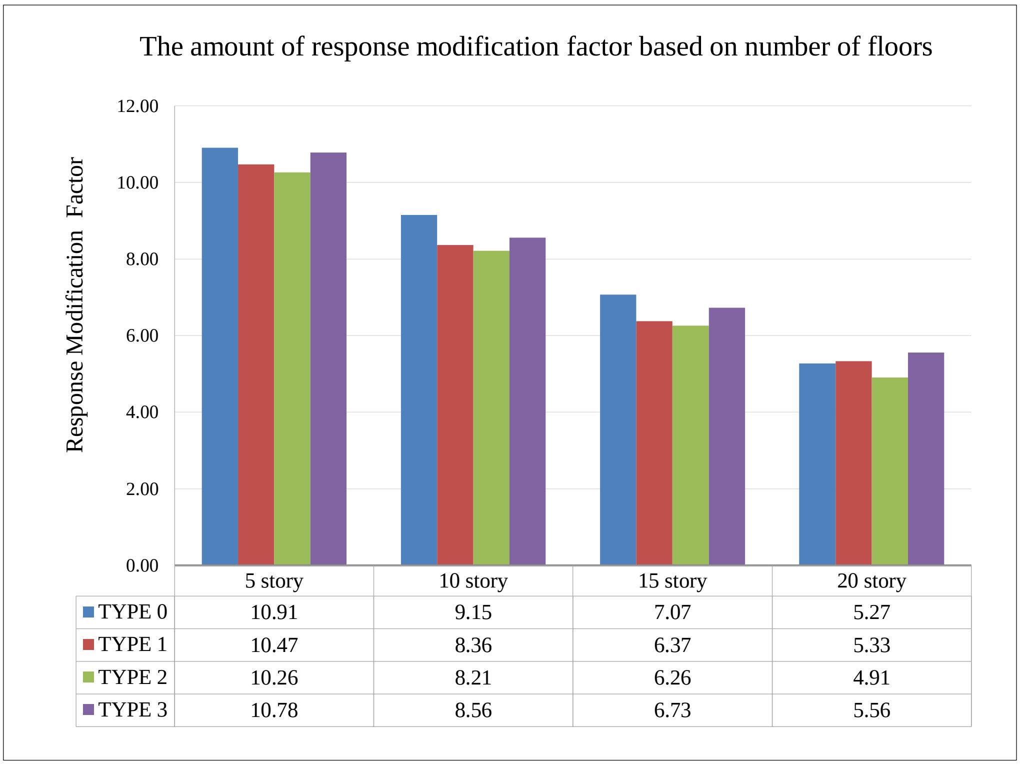


Figure 25. Comparing the response modification factor of 20-story model with different bracings type and load pattern

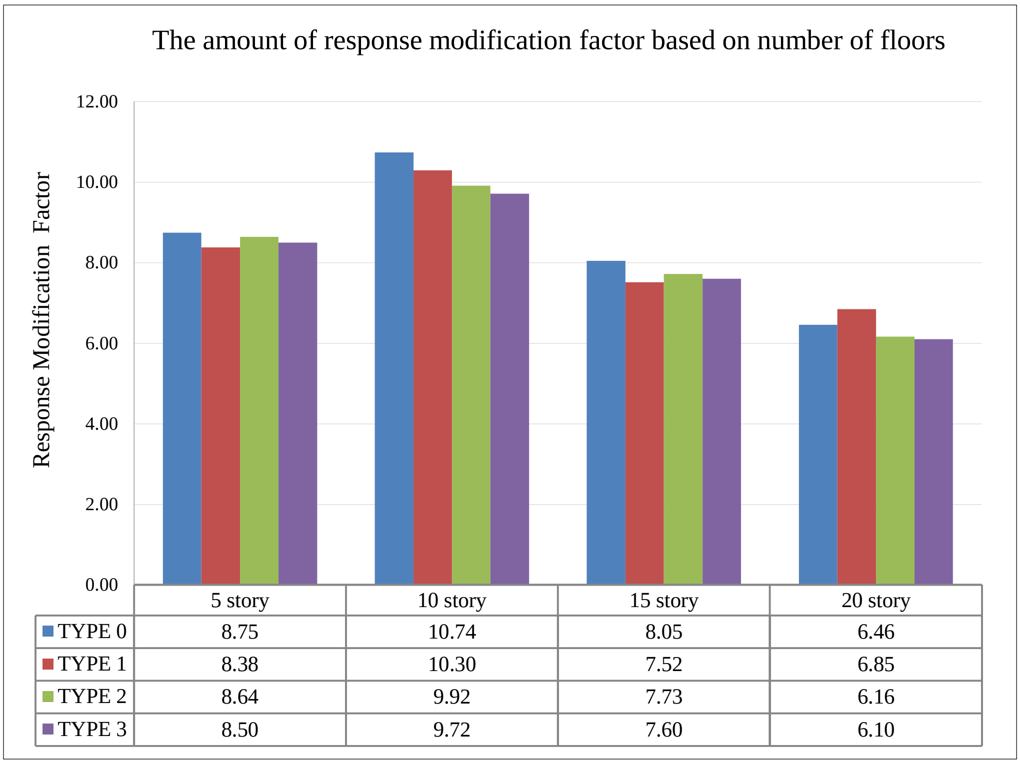
As it is seen, response modification factor in the buildings with 5, 10 and 15 floors, with triangular lateral load which is more than modification factor, is along with the used uniform load pattern in pushover analysis. In cases of buildings with 20 floors, this issue is reversed, consistent load pattern is prevailing.

The response modification factor for buildings with variety of floors and the type of various bracing which have been conducted by pushover analysis with consistent load patterns and triangular load patterns, has been shown in In Figure 26 and 27.



	5 story	10 story	15 story	20 story
TYPE 0	10.91	9.15	7.07	5.27
TYPE 1	10.47	8.36	6.37	5.33
TYPE 2	10.26	8.21	6.26	4.91
TYPE 3	10.78	8.56	6.73	5.56

Figure 26. The amounts of response modification factor of L-shaped models with static triangular load pattern



	5 story	10 story	15 story	20 story
TYPE 0	8.75	10.74	8.05	6.46
TYPE 1	8.38	10.30	7.52	6.85
TYPE 2	8.64	9.92	7.73	6.16
TYPE 3	8.50	9.72	7.60	6.10

Figure 27. The amounts of response modification factor of L-shaped models with uniform load pattern

Now, we looking about consideration and comparing the response modification factor and other factors in regular symmetric and L-shaped model that well visible in below diagram.

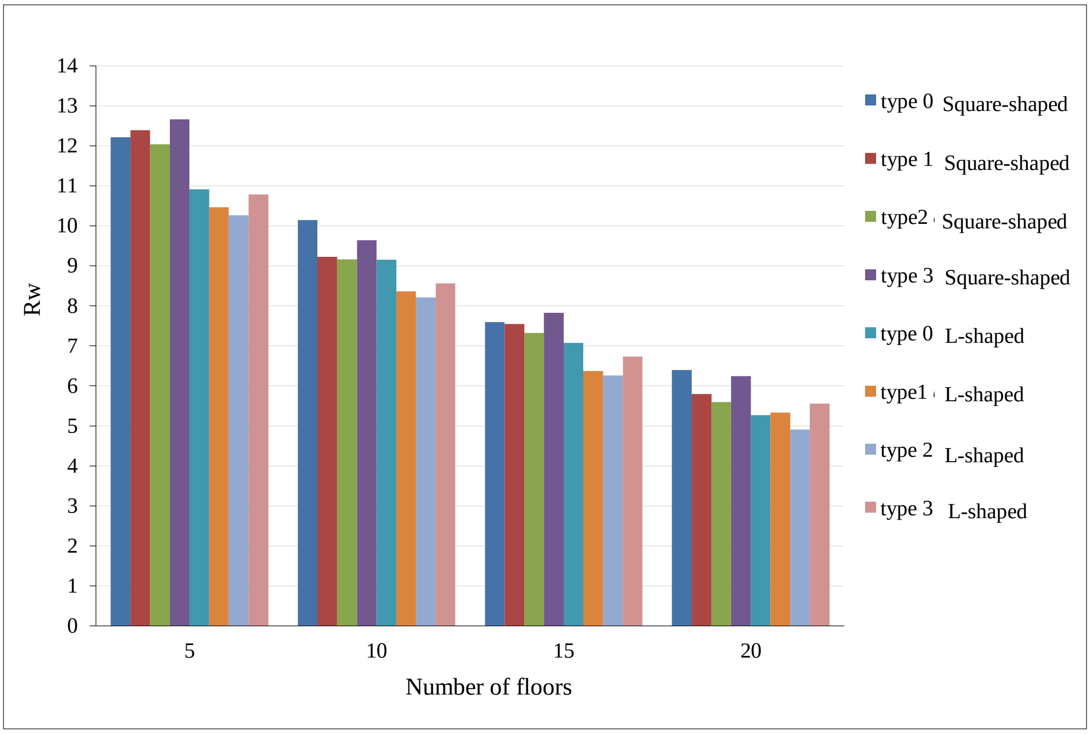


Figure 28. The amounts of response modification factor of L-shaped and regular symmetric models under impact of triangular load pattern

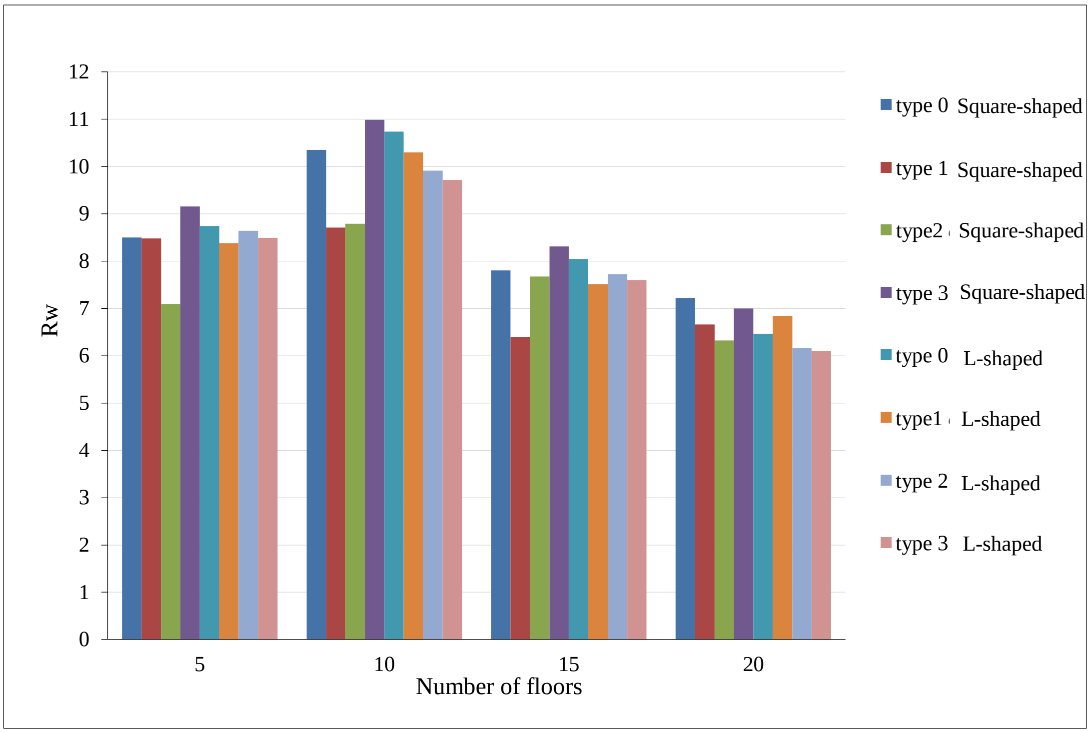


Figure 29. The amounts of response modification factor of L-shaped and regular symmetric models under impact of uniform load pattern

It is observed, both in models with L-shaped plan, and the model with symmetric plan, amount of response modification of bracing type 3, be more than response modification factor and amount of response modification factor in 2 type is less than other types.

Ductility reduction factor show should be omitted less impact than the height.

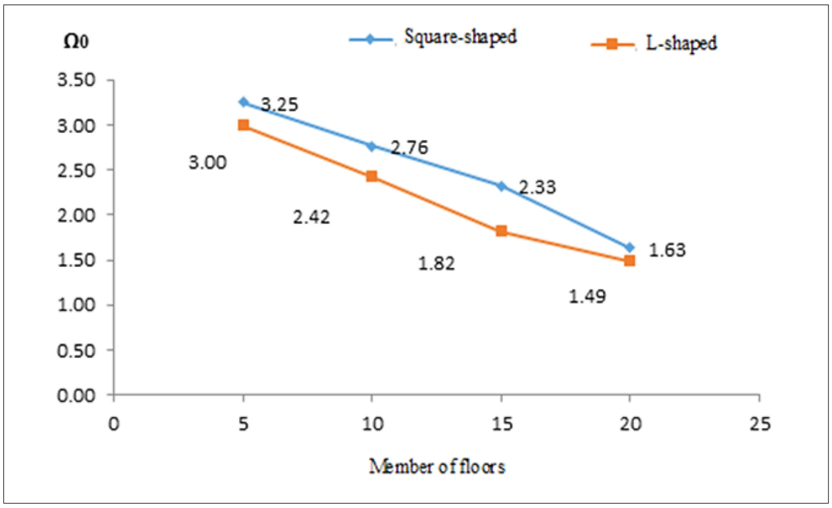


Figure 30. Add resistance factor according to the number of floors in the zero type (square and L-shaped plan)

Add resistance and response modification the factor have much more in the square and symmetrical plans. Also shown which have much more in square plans. It should be avoided from any geometric irregular in plan, because it cause the twisting in the structure and reduction of response modification factor.

5. Results Related to Adaptive Pushover Analysis

Selection the earthquake record for achieving the acceleration spectrum Sa, displacement spectrum Sd.

In order to performance of analysis by adaptive method for each method, require to acceleration spectrum and displacement spectrum. Selecting the acceleration of mappings has been done from table F-6 regarding to FEMA-440 regulation because analysis are 3-dimension, thus, it require to 2 horizontal components of the earthquake. Since, it shown in table 11 which number of records are relating to the common earthquake, in total achieved 9pairs acceleration that other records has been downloaded from Pacific Earthquake Engineering Research Center (PEER).

Get the acceleration spectrum Sa and the displacement spectrum Sd

The acceleration and displacement spectrum have been obtained as follows:

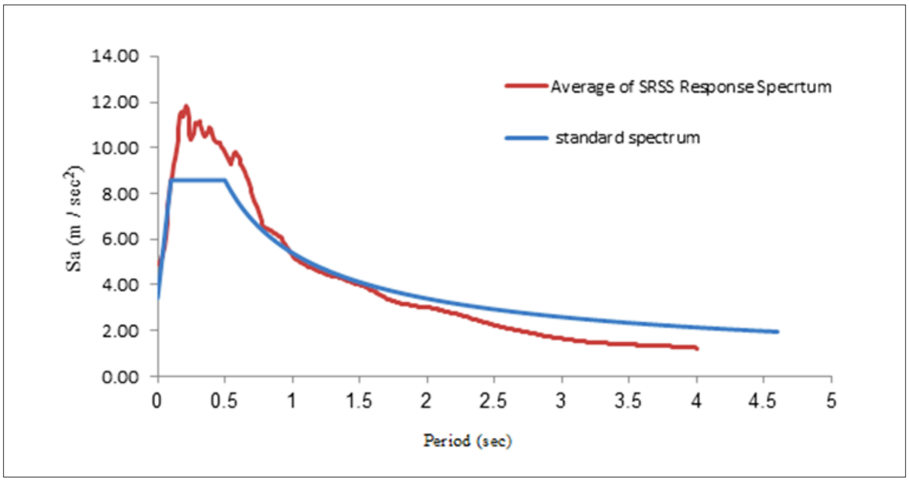


Figure 31. Standard spectrum and obtained acceleration spectrum graph spectrum to 5 –story

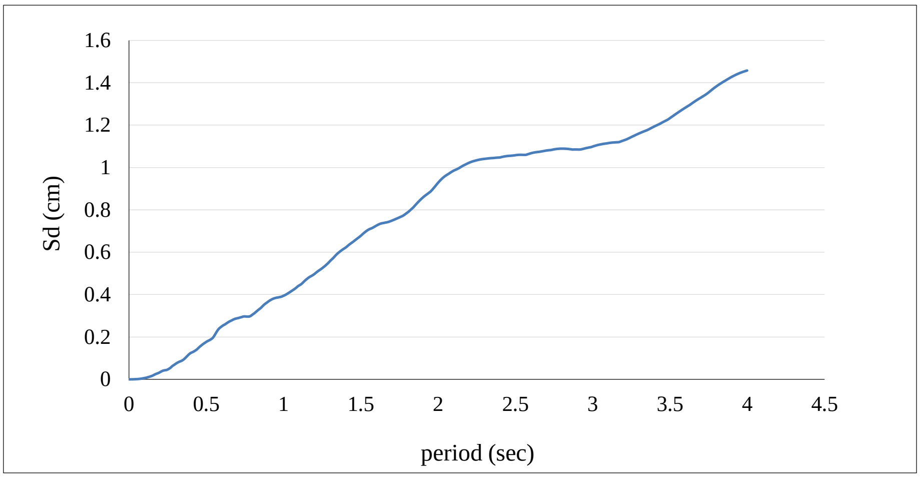


Figure 32. Obtained displacement spectrum graph for all models

For example, many graph regarding to load-displacement of 5-storey model with zero type obtained from pushover analysis method has been shown with 3 methods, as following:

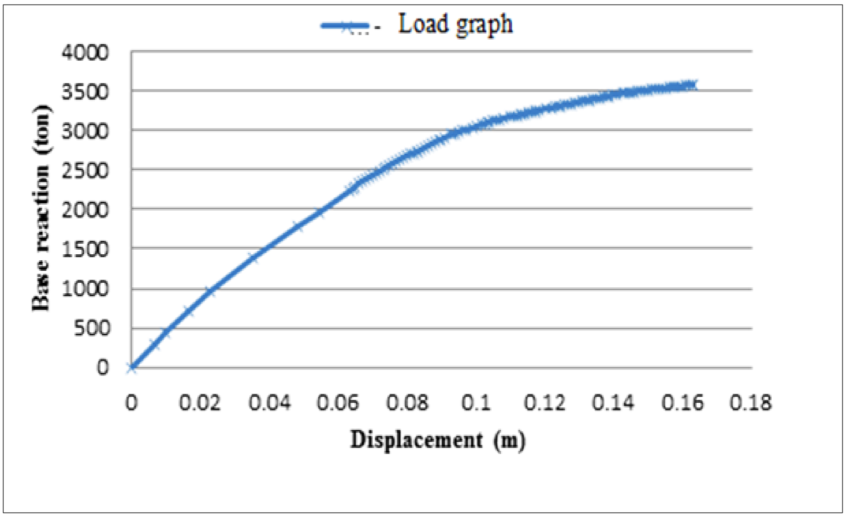


Figure 33. Load - displacement curve of 5-story model with zero type obtained from the DAP analysis

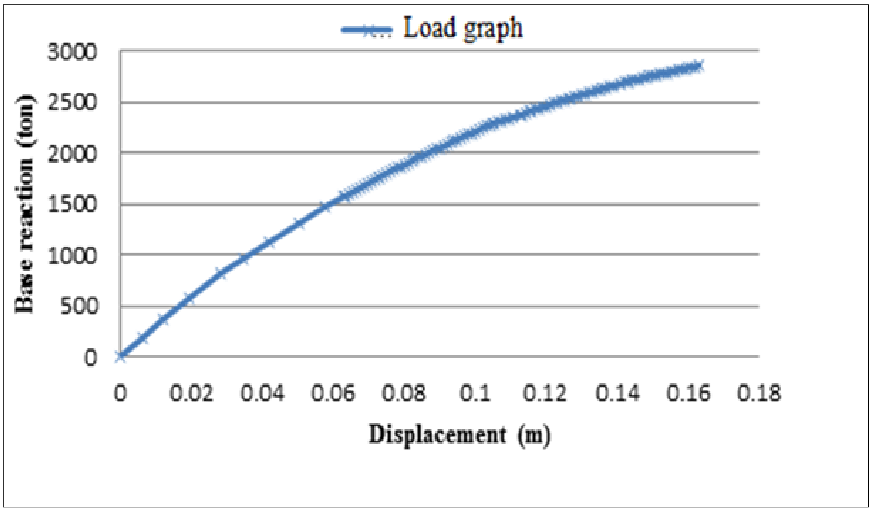


Figure 34. Load - displacement curve of 5-story model with zero type obtained from the DRAP analysis

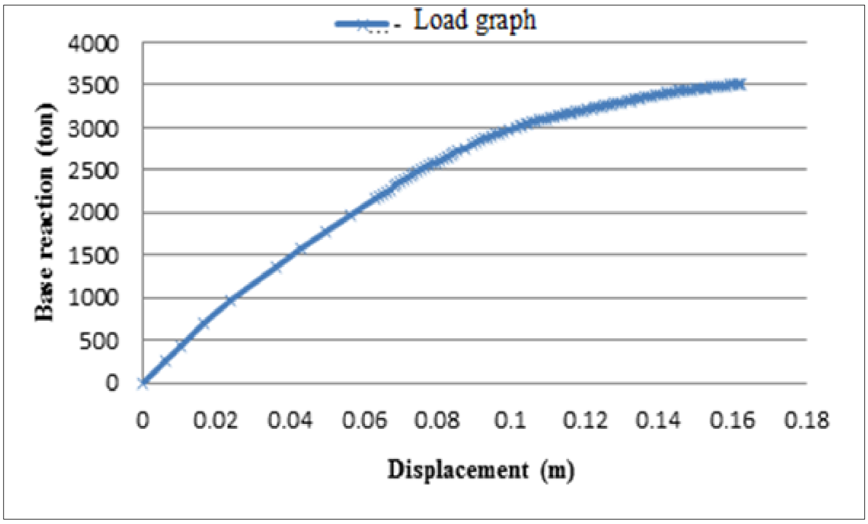
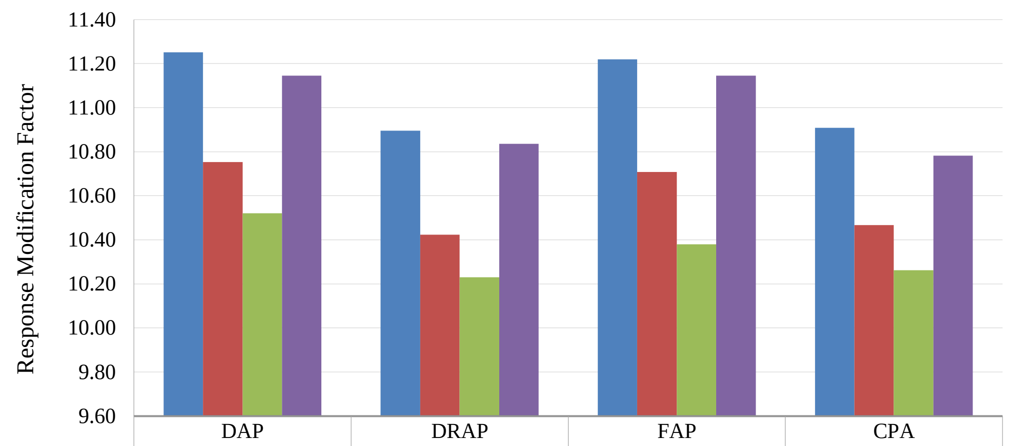


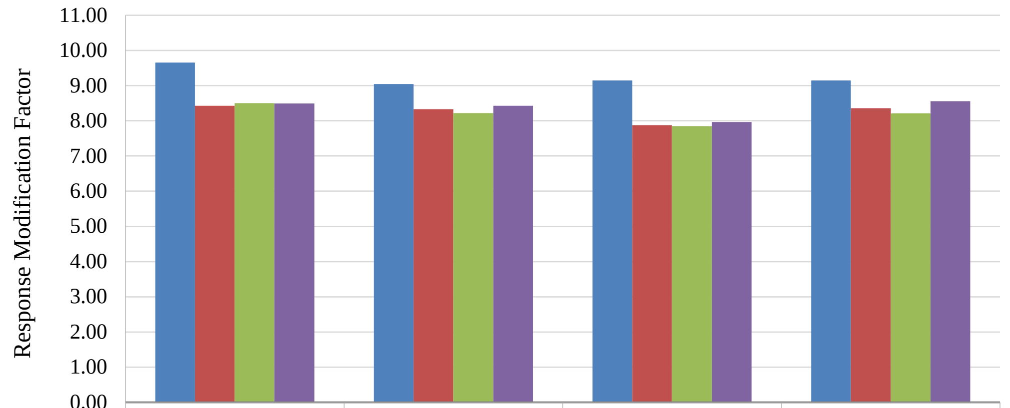
Figure 35. Load - displacement curve of 5-story model with zero type obtained from the FAP analysis

In the following tables compared amounts 3 methods of adaptive with traditional pushover under static triangular load pattern.



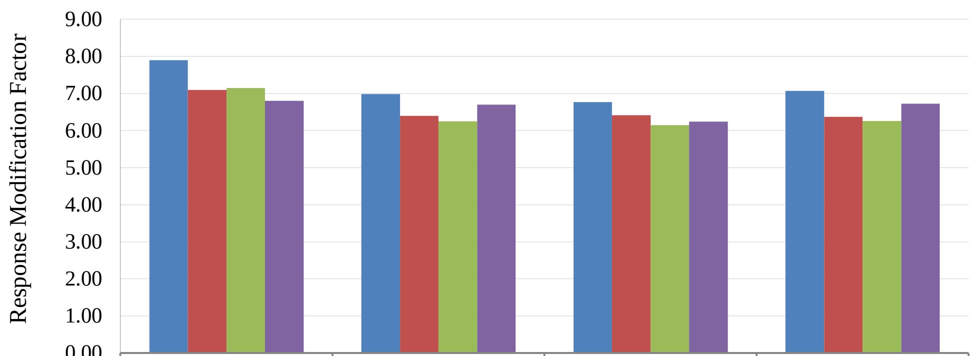
	DAP	DRAP	FAP	CPA
TYPE 0	11.25	10.90	11.22	10.91
TYPE 1	10.75	10.42	10.71	10.47
TYPE 2	10.52	10.23	10.38	10.26
TYPE 3	11.15	10.84	11.15	10.78

Figure 36. Amounts of obtained response modification factor of 5-story building from analysis of four methods



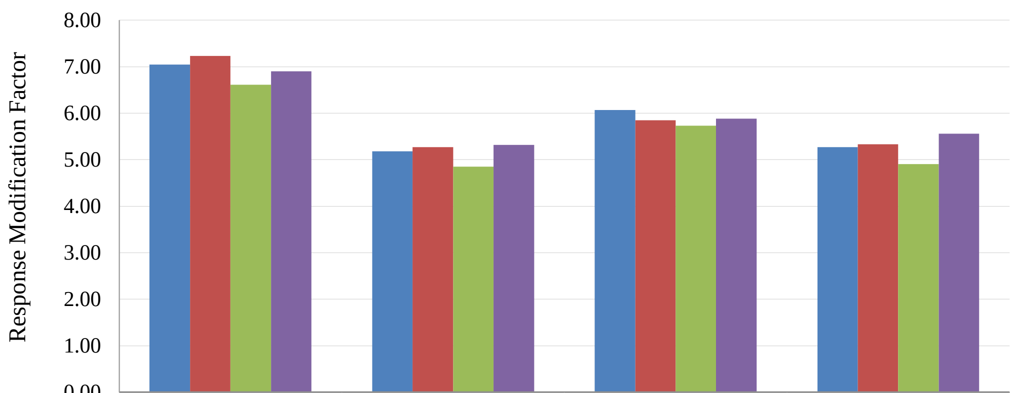
	DAP	DRAP	FAP	CPA
TYPE 0	9.66	9.05	9.15	9.15
TYPE 1	8.43	8.33	7.87	8.36
TYPE 2	8.50	8.22	7.85	8.21
TYPE 3	8.49	8.43	7.96	8.56

Figure 37. Amounts of obtained response modification factor of 10-story building from analysis of four methods



	DAP	DRAP	FAP	CPA
TYPE 0	7.90	6.98	6.77	7.07
TYPE 1	7.09	6.40	6.42	6.37
TYPE 2	7.15	6.25	6.15	6.26
TYPE 3	6.80	6.70	6.24	6.73

Figure 38. Amounts of obtained response modification factor of 15-story building from analysis of four methods



	DAP	DRAP	FAP	CPA
TYPE 0	7.05	5.18	6.07	5.27
TYPE 1	7.23	5.27	5.85	5.33
TYPE 2	6.61	4.85	5.73	4.91
type 3	6.90	5.32	5.88	5.56

Figure 39. Amounts of obtained response modification factor of 20-story building from analysis of four methods

6. Conclusions

- In consideration of the results of this series of graphs proved that L-shaped structural response modification factor of 2-wings is more than the structure with unequal wing that is higher its length of one side.
- DAP method has been more error amount in compared to the other two methods and DRAP method has less error. In other words, response modification factor amounts the DRAP method in all floors is closer to the traditional pushover response modification factor amount. Also, whatever the structure rising above, it be higher error percentage of methods.
- In the short-order structures such as 5-story is very high FAP and DAP error percentage, and differs with obtained response modification factor mount from the pushover, and seen at 20-story clearly that DAP method has more errors rather than response modification factor amount than the other two methods.
- Change the layout of braces in the opening of the frames create little change in structure response modification factor amount , although it may this amount is not much more, but is effective, (about 0.1 to 0.5)
- obtained response modification factor from of all existing analysis methods for type 2 models is lower from other models, it means that, if be conduct to a direct that bracings distance in opening of exist frames is more, it happening.

7. References

[1] Razavizadeh, S.M.B and Etemdi, M. "The impacts geometry form and L- shaped irregular structures architecture structures on its behavior against earthquake. 6th National Congress on Civil Engineering. (2011). https://doi.org/10.1007/978-94-007-5377-8_11.

[2] "Design regulation of the buildings against earthquakes", Standard 84-2800, Edition 3, the nineteenth edition, spring. (2014). https://doi.org/10.1201/9781315273440.

[3] "Building and Housing Research Center", the regulation of, buildings design against earthquakes, Tehran. (1999). https://doi.org/10.6028/nbs.bss.48.

[4] Arab Pour, F. Masoudzadeh, S.A. "The regular and irregular Buildings in plan and height (survey and analysis in during of the earthquake)". 12th Civil Engineering Student Conference. (2005). https://doi.org/10.7712/120115.3659.1317.

[5] Chhopra, A.K and Goel, R.K. "A modal Pushover Procedure to estimate seismic demands for buildings": Summery and evaluation "fifth National conference on Earthquake 26-30 may 2003, Istanbul, Turkey, Keynot Lecture. (2003). https://doi.org/10.1002/eqe.380.

[6] Chiguee, M. "Thesis on studying the response modification factor and seismic behavior of combined steel concrete frames by adaptive pushover analysis method (APA)". (2006) https://doi.org/10.1016/j.jcsr.2012.07.010.

[7] Uang, C. -M., "Establishing R (or RW) and Cd Factors for Building seismic Provisions". J. Of struct. Engrg, ASCE, 117 (1991): 19-28. https://doi.org/10.1061/(asce)0733-9445(1991)117:1(19).

[8] FMEA, "NEHRP Guidelines for the Seismic Rehabilitation of Buildings", FMEA 273, (1997). https://doi.org/10.1007/978-3-663-08408-2_4.

[9] Mohammadi Sahabi, M. "Effect of frequency time and addition to demand seismic- non-elastic resistance reinforced concrete moment frames", thesis phd, University Torbat-e Modarres of Tehran. (1997). https://doi.org/10.1002/tal.1168.

[10] Uang, C. M. "Establishing R (or Rw) and Cd factors for building seismic privisions", Journal of Engineering, ASME 117, (1992): 19-28. https://doi.org/10.1061/(asce)0733-9445(1991)117:1(19).

[11] Zahraei, SM. "The consideration of proposed response modification factor of Regulations in designing the concrete by Fulcrum of thermal expansion (neoprene)" Journal of Transportation, 9, (2012). https://doi.org/10.14359/8547.

[12] Sadegh Azar, M and Ghafouri, M. "calculation factor the steel coaxial braced structures response modification factor". Scientific-Research Sharif Journal. 14, 2007: 22-35. https://doi.org/10.12989/scs.2015.18.1.165.