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Examine the Effect Height on Changing Intermediate Flexural Frames Performance Level after Adding Outward-Oriented Vestibule Braces

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ABSTRACT: Considering the inability to design techniques based on force the predicted nonlinear behavior of members, arising from the non-linear properties of materials and the importance of design resistant structure against dynamic loads, such as earthquake force, in-in recent years the tendency of engineers and designers are increasing the use of design methods, based on the displacement and behaviour (design based on performance). Speed and a lot of materials and task force, has led to the construction of steel structures in the countries to expand. Moreover, the presence Iran on the seismic belt ALpayd, more need to study the behaviour of these structures and them resistant design becomes more apparent. On the other hand, construction special flexural frames, recommended by most regulations for use in high seismic zones, it may not, by Non-specialist workforce; Thus, flexural frame, mostly, are constructed from median flexural that using it alone is not suitable in high seismic zones. Therefore, for ease of implementation, often, the first proposals for strengthening these frames is to add brace to them. Also, the urban development and housing demand, shortage of suitable land for urban development alters the pattern of buildings to the high-rise building construction. In this study, with regarding architectural considerations, the effect height at changing flexural steel frames performance level after adding outward-oriented vestibule braces under nonlinear static loading is examined. Capacity spectrum method (CSM) in ATC-40 to obtain performance level was used. SAP2000 software was used for modeling and analysis.

Keywords: Flexural Frame, Nonlinear Behavior , Nonlinear Static, Outward-Oriented Brace

INTRODUCTION

Due to the construction of buildings, is expensive and requires a lot of time, and retrofit it directly affects the safety and tranquility of human resources, as the largest, supporter a country that is building part of the capital of each country. Iran's presence on the earthquake belt ALpayd will increase the need for retrofitting buildings in the country. On one hand, hot weather and dry and temperate area, and there are sufficient resources in metals, and the pace of implementation, ease of construction, and on the other hand, price of steel frames, is to stimulate the use of frame system steel in the construction industry.

Frame construction; have suffered displacement, under the effect of lateral loads, such as earthquakes. The most common method of controlling the stick displacement in metal frames, are BRACED FRAMES, the general configuration, it is a time-driven, or driven out. Coaxial bracing greatly increases the stiffness of the structure, rather than, equal flexural frames, and limits, the lateral displacement of the structure, But the cause buckling inhibitory members, and inappropriate behavior in past earthquakes, it is not recommended to use this system in areas of high seismicity. In contrast, the compliance with, the architectural considerations, and appropriate behavior, and predicting when an earthquake has increased the public tendency to use the system, bracing, external axis. However, the use of the system structures, is associated with a particular delicacy, so, lack of attention to good design, and to determine the optimal configuration, the interaction of wind bands, and moment frame, the role of different parameters on the performance systems, and the implementation of specific points, can easily undermine the validity of this system, therefore, seems to items within it, should be done in this area, further discussion.

This study was conducted to evaluate the level of performance medium frames of steel , with outward-oriented vestibule braces , first using the software SAP2000,medium frames of steel, is model, the number of spans, and different heights are analyzed under load nonlinear static and has studied the effect of adding, outward-oriented vestibule braces on performance level of flexural frames.

Introduce rigid flexural frames

The main feature of this system is to connect its members, which effectively, is involved in structural behavior, and system stability.

Benefits:

- No interference, the architectural considerations.
- Relatively ductile behavior.
- High energy dissipation capability

Defects:

- Low hardness, which can lead to displacement a lot.
- Large sections of the tall buildings

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Finally, the non-economic

Behavior of flexural frame against lateral loads

Behavior of flexural frames against seismic loads, the truth is, the rotation of the nodes, and generates deformation in beams and columns. These deformation are produced at work on two major factors.

1. Deformation caused by bending of a cantilevered
2. Deformation caused by bending beams and columns
3.

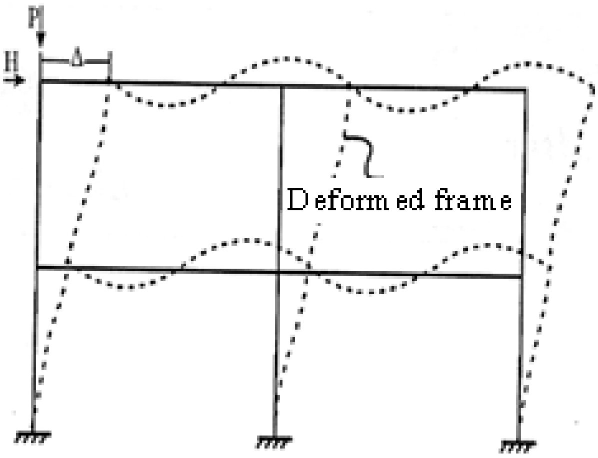

Figure 1. Deformation of flextural fram

Nonlinear deformation, flexural frame, occurs in certain areas of the structure. The elastic strain, these areas can, into the joint, the joint that tolerance period with a constant force. These areas usually are at the bottom of the beams, and the fountain area connection. Should be discouraged, the hinges in columns, because, it is possible, will lead to the creation, construction and destruction mechanisms, which in this case is obtained by consuming less energy. (Niknam et al., 2002)

Introduce divergent Bracing System

The idea of using, the divergent braced frame, was first raised by Professor Popov and colleagues, and was known, the unique advantages of the system, and in 1980, were the first building constructed with this system. The structure, 19-storey building, the Bank of America in San Diego, California. After the construction of a 44 storey building, was constructed in San Francisco, with this system, and good Behavior of, self-revealed on October 17, 1989 Loma Partia earthquake.

Then, quickly spread application EBF, and was inserted, and the design criteria detailed in regulations. First, the rules of this system was introduced in version 1988 regulations SEAOC, with slight variations, the version of the new regulations NEHRP (1996), system of regulations concerning the EBF, was transferred from the annexes to the original law letter, and the AISC regulations, introduced in 1992, this system, as a system downtime in earthquake prone areas.

In this system, a portion of the length of the beam, where between the bracing, and columns, or placed between two bracing, is called the link beam. Beam graft acts like a fuse plasticity, and absorbs a lot of energy, caused by the earthquake (Niknam et al., 2002).

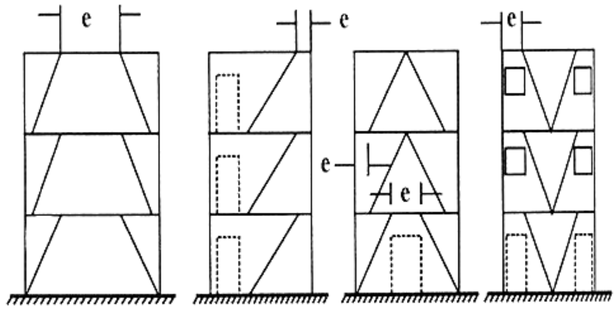

Figure 2. Samples of eccentric frames

The benefits of non-linear analysis methods

Nonlinear methods are introduced to calculate more realistic, seismic demands of buildings, because, thereby, the behavior and performance of the structure, was studied after entering the non-linear region during an earthquake. Overall, the benefits of non-linear analysis, comparison, linear analysis, the reference FEMA-273/274, are summarized as follows:

1. Estimate more realistic labor demand, in the components that are most susceptible to potential, i.e., the axial force in the columns, and the bending moment in Beam and column connections.
2. Estimating realistic, demand the transformation of the components to be to withstand the ground motion caused by earthquakes can undergo inelastic deformation.
3. A more realistic estimate of the effect of reducing hardness, and resistance components, the behavior of the structural system.
4. Knowing the critical areas in which there is a possibility of happening, large deformations.
5. Identification of strength discontinuities

In the nonlinear static analysis method, lateral load, will gradually increase, so far, displacement, beyond a certain point, the level desired. Deformations and internal forces, while increasing lateral load, be monitored continuously.

This approach is similar to the linear static analysis procedure, with the exception that:

1. Enters the analysis of nonlinear behavior of individual members, and structural components.
2. The earthquake is estimated, rather than a specific load, in terms of deformation.

One of the main results of this analysis is to determine the chart, load - displacement or capacity curve. To draw the graph, commonly used, the base shear values, in the contrast, lateral displacement, alignment reference point roof. This diagram can be used to help capacity spectrum method for moving target. In addition, this analysis is one of the oldest methods in determining the structural behavior factor (R) (Noshadravan, 2002).

MATERIAL AND METHODS

The method of obtaining the performance point

Design and retrofit of structures, based on the performance of the structure, to be drawn by a series of lateral forces. Increasing the resettlement side, increase the forces in the structural members, to the extent that, in the some parts of the structures transcend the forces of the extreme forces surrendered, and are created by plastic

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joints in the structures. Given the level of performance that is chosen for the building, must be able to tolerate a certain amount of resettlement accessories without changing the shape of the curves Force-Deformation, Member exceeds a limit.

If some members of the force or stress are more than this, these members should be reinforced. The amount of displacement is determined for a given performance level. The displacement is called, in FEMA-356, and in the upgrade instructions Target Displacement, and in ATC-40 demand displacement (FEMA356, 2000). The method of obtaining the performance point, in the ATC-40, is based on the capacity spectrum method, CSM (Capacity Spectrum Method). In the ATC-40, the curve of intersection of the capacity spectrum and the demand spectrum, in the coordinates of the displacement spectrum-accelerate, is called a spectral point performance (Performance Point) (ATC-40, 1996). Using this relationship, each point of the spectrum curve, the elastic response, with coordinates (Ti, Sai), is converted to the point, the demand spectrum curve, with coordinates (Sdi, Sai), in the format ADRS.

$$Sd_i = \frac{T_i^{\ 2}}{4\pi} Sa_i g \qquad (1)$$

Using these relationships, each point of the capacity curve (pushover) with coordinates (δ_i, ν_i) becomes the demand spectrum curve with coordinates (sd_i, sa_i) in the format ADRS.

$$Sa_i = \frac{V_i / W}{a_1}$$
$$Sd_i = \frac{\Delta_{roof}}{(PF_1 \times \varphi_{1,roof})} \qquad (2)$$

$$a_1 = \frac{\left[\sum_{i=1}^{N} (w_i \varphi_{i1})/g\right]}{\left[\sum_{i=1}^{N} w_i / g\right]\left[\sum_{i=1}^{N} (w_i \varphi_{i1}^2)/g\right]} \qquad (3)$$
$$PF_1 = \frac{\sum_{i=1}^{N} (w_i \varphi_{i1})/g}{\sum_{i=1}^{N} (w_i \varphi_{i1}^2)/g}$$

Elastic demand spectrum curve, reduced with dampin β_{eff}, Will interfere with the capacity curve (Taghi nejad, 2009).

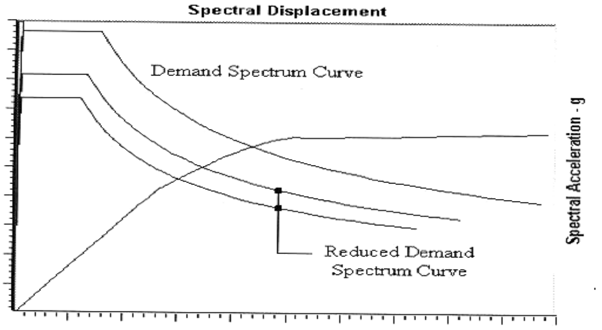

Figure 3. Spectral curves of reduced demand after applying Reduction of spectral coefficients in each stage (Taghi nejad, 2009).

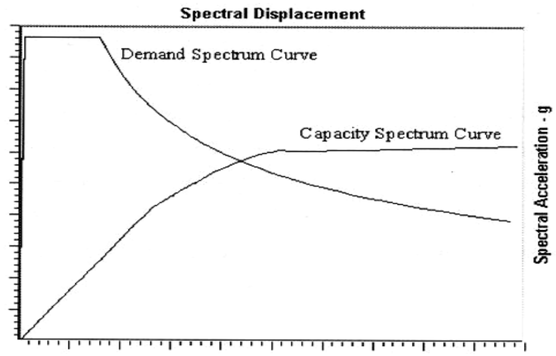

Figure 4. capacity spectrum and spectral response curves associated with each format ADRS (Taghinejad, 2009).

Models and analyzed samples

in the this study, to compare the effectiveness, drive axle braces vestibule formed on the surface, moderate frames, are considered, the next two frames, the number of spans, and the number of different classes, in the both cases, this is the first analysis and design of the frames, the frames, intermediate moment, according to the bylaws of designing buildings against earthquakes, Iran, 2800, third edition, topics, sixth and tenth issue of Iran's National Building Regulations, And after the introduction of the relevant parameters, the analysis of the cap binding, and allocation plastic hinges located under the non-linear static analysis, and has achieved the level of performance, then, with the addition of a porch braces, extra axis is calculated, the new frames.

Geometric characteristics of the samples and their nomenclature

Samples are the frames 4, 7 and 15, floor 3 and 5 span considered is the class with the same height of 3 m, and intended to include the mouth, the same length of 4 m, the position of the harness dams, are considered in the frame symmetrical. Sections, beams, columns and braces, based on linear analysis, and stress ratio obtained is close to one.

For brevity, called frames, the following notation is used:

R: frame bending

RE: frame bending + braces EBF

Characteristics of materials

Steel consumption in frames examined is the type St37 with $F_U = 3700 \, {}^{kg}/_{cm^2}$

in the linear behavior of structural modeling, is used, the specifications, the lower bound on strength of materials, (Lower-Bound Strength) and in modeling nonlinear behavior, in the members controlled by deformation is applied, the resistance profile expected (Expected Strength). Based on recipe development, are expected material properties for the steel equivalent:

Table 1. of steel materials

Characteristic	Amount	Unit
Weight per unit volume	2.1×10^6	kgf/cm^3
The elastic modulus	2.1×10^6	kg/cm^2
Poisson coefficient	0.3	-
Yield stress	2400	kg/cm^2

$$ST\ 37:\begin{Bmatrix} F_{ue} = 1.1F_u = 1.1\times 3700 = 4070\ kg/cm^2 \\ F_{ye} = 1.1F_y = 1.1\times 2400 = 2640\ kg/cm^2 \end{Bmatrix}$$

Location of soil profile

Samples, on the ground of four, according to the law of 2800, the relative risk is very high, depending on soil type, and location of the building, the parameters, the reflection coefficient of the building is equal to: T0 = 0.15, TS = 1, S = 1.75. (Regulations for seismic design of buildings - 2800, 2005)

Profile of applied loads

Frames of the buildings for residential use, and ceiling joists block is assumed, the dead load of 600 kilograms per square meter, and it is assumed, live load of 200 kg. Frames are downloaded within 3 meters. In linear static analysis, seismic force is calculated using the relation. According to Table 1, the law of 2800, the effective weight of the building during an earthquake, a flat roof, it is equal to the total dead load plus 20% live load. For moment frames of mean R = 7, and for residential buildings, is I = 1.

Loading combination, the linear static analysis, it is assumed conforms issue the tenth National Building Regulations, and to combine this analysis, nonlinear static, based on recipes seismic retrofit, combined times two is presented, for consideration, Gravitational effects of dead and live load. These compounds are:

$$Q_G = 1.1(Q_D + Q_L) \quad (4)$$

$$Q_G = 0.9Q_D \quad (5)$$

Based on recipe development is the Q_D, dead load, and is Q_L, live load, based on the sixth issue of Iran National Building Regulations. In this model, first introduced gravity load combinations, then, is done, nonlinear static analysis, the effect of lateral load pattern, the more the case load. (Recipe seismic rehabilitation of existing buildings, 2007)

Lateral load distribution pattern

Based on recipe development, patterns of loading, lateral load pattern proportional to the static method, the model fits, the first mode of vibration, and uniform distribution pattern should be considered, at least two lateral load patterns, to assess the structural. Lateral load patterns should be applied to both positive and negative, separately, to the structures.

Parameters of nonlinear static analysis

As previously mentioned, the working methods, nonlinear static analysis, which thus must first be applied to construct gravity load, gravity load combinations, recipes improvement is only for review, the effect of both gravity loads and lateral loads due to earthquakes, and cannot be used to assess the gravity bearing structures.

In general, the non-linear analysis, we consider two types of non-linear effects. These effects include: geometric analysis, which is related to the effects and large deformation, and the other is non-linear effects of the materials, the effect is shown in models, definition, specifications joints. Behavior of structural members under earthquake loads, in vitro, by the forces reciprocating, to be modeled, and are assessed using a diagram, hysteresis, is to show that the graph load - displacement. Most of Regulations, and computer software, in order to simplify the behavior of members, loads, earthquake, use of a linear model to model.

Also, given that the frames were examined, were not considered in the modeling, the effect of the frames, and other non-structural components, and only the beams and columns are modeled, specifications, plastic joints, and admission criteria, Due to the limitations of thin wing sections and die based on column members, table 5-3, is harvested, recipes seismic rehabilitation. For beams, is considered the joints, the strength, and the columns are considered, the interaction of axial and bending. Also, after adding curb sections, output shaft, the porch, is defined according to the length of link beam shear joint, click on the link beam. The effects of strain hardening, is intended, in accordance with Instruction seismic rehabilitation, taking into account the slope, the slope is equal to 3% elastic. Also, all members are defined as controlled by deformation.

RESULT AND DISCUSSION

Evaluation of results

Analysis covers the study is shown in Tables 2, 3 and 4, and criteria have been related to the outcomes, appropriate bracing systems, and critical lateral load distribution. Also, the relative displacement, the first displacement is greater than the target place (Khaksefidi, 2010). The survey frames, with three spans, the results indicate that, in all cases, the outward-oriented vestibule braces, it seems appropriate system to strengthen. Is lower, the reduction in roof displacement at the 15-story frames is lower than frames 4 and 7 stories, but, not much difference.

In the frame with four spans, the results indicate that, in all cases, the outward-oriented vestibule braces, it seems appropriate system to strengthen. In all frames criteria $0.8 < (V_P/V_y)$ is supplied.

In the frame with five spans, strengthening systems, with EBF, Frameworks, with lower elevation, indicating better performance. Only reinforced the frame with seven floors, with EBF, is not supplied, the lateral resistance, $0.8 > (V_P/V_y)$.

Investigation on the tables indicate that, in all frames with fixed span, with increase at height frame performance level of flexural frames is improved. Also the rate of Δ/h is reduced and almost in all frames criteria $0.8 < (V_P/V_y)$ is supplied.

After reviewing the relative displacement, is obtained, the following classes:

- The three-span reinforced frames, the relative displacement of the roof, for any of the classes is to not exceed the 1 percent above the floor.
- The four-span reinforced frames, the relative displacement of the roof, for any of the classes is to not exceed the 1 percent above the floor.
- The five-span reinforced frames, the relative displacement of the roof, for any of the classes is to not exceed the 2% floor height. The relative displacement of the roof, in the third and fourth floors, is exceeded, the 1 percent above the floor.

Table 2. Parameter control, general admission criteria structure for frames 3 spans

Row	Name Frame	height Frame (cm)	Lateral displacement of the roof	$\frac{V_P}{V_y}$	$\frac{\Delta}{h}$	Frame performance level
1	R3D-4T	1200	31.308	1.0722	0.0261	CP
2	RE3D-4T	1200	4.856	1.1889	0.0040	IO
3	R3D-7T	2100	43.025	1.1186	0.0205	CP
4	RE3D-7T	2100	12.364	1.3744	0.0059	IO
5	R3D-15T	4500	76.451	1.0822	0.0170	LS
6	RE3D-15T	4500	8.370	1.0573	0.0019	IO

Table 3. Parameter control, general admission criteria structure for frames 4spans

Row	Name Frame	height Frame (cm)	Lateral displacement of the roof	$\frac{V_P}{V_y}$	$\frac{\Delta}{h}$	Frame performance level
1	R4D-4T	1200	32.222	1.0623	0.0269	CP
2	RE4D-4T	1200	2.739	1.0130	0.0023	IO
3	R4D-7T	2100	43.461	1.1075	0.0207	CP
4	RE4D-7T	2100	3.009	0.9134	0.0014	IO
5	R4D-15T	4500	76.052	1.0819	0.0169	LS
6	RE5D-15T	4500	5.653	0.8514	0.0013	IO

Table 4. Parameter control, general admission criteria structure for frames 5 spans

Row	Name Frame	height Frame (cm)	Lateral displacement of the roof	$\frac{V_P}{V_y}$	$\frac{\Delta}{h}$	Frame performance level
1	R5D-4T	1200	32.97	1.0576	0.0275	CP
2	RE5D-4T	1200	3.046	1.0768	0.0025	IO
3	R5D-7T	2100	42.817	1.0873	0.0204	CP
4	RE5D-7T	2100	2.572	0.6070	0.0012	IO
5	R5D-15T	4500	75.742	1.0797	0.0168	LS
6	RE5D-15T	4500	7.071	0.9824	0.0016	IO

Control of the members in the performance point:

For these structures may meet the desired performance level should at target displacement, treated, none of the structural joints, the range of deformations beyond, admission criteria selected functional level. Otherwise, must be strengthened, members, is formed in the joints, deformation beyond the selected range of acceptance criteria, performance levels. For example, two frames are shown in the following figure (Khaksefidi, 2010).

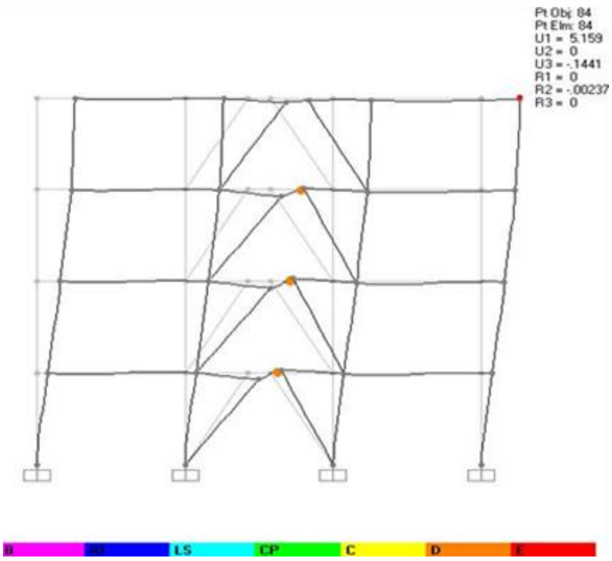

Figure 5. Joint consisting of a 4stories - 3 spans REframe

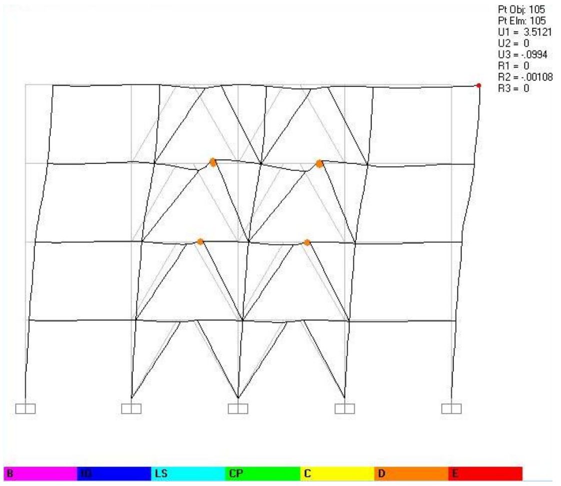

Figure 6. Joint consisting of a 4stories - 4 spans REframe

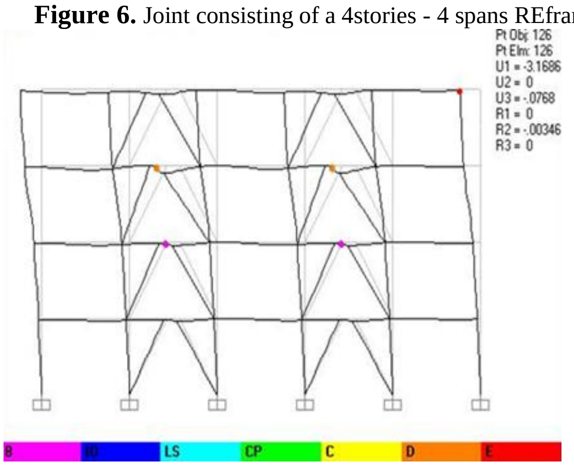

Figure 7. Joint consisting of a 4stories - 5 spans REframe

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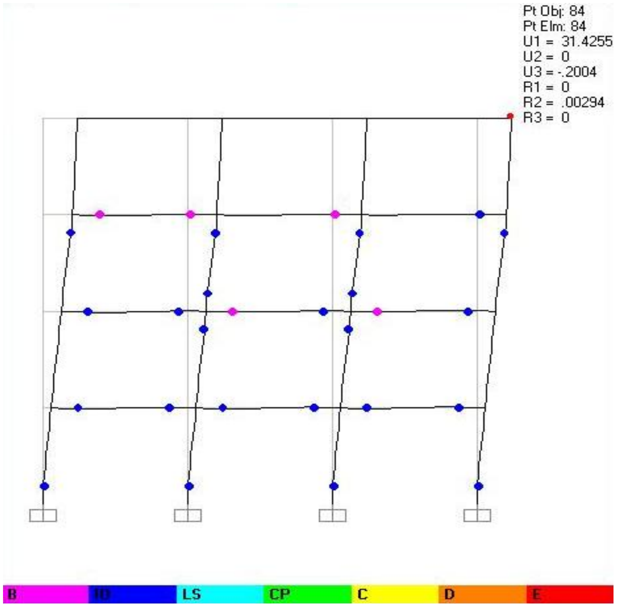

Figure 8. Joint consisting of a 4stories - 3 spans Rframe

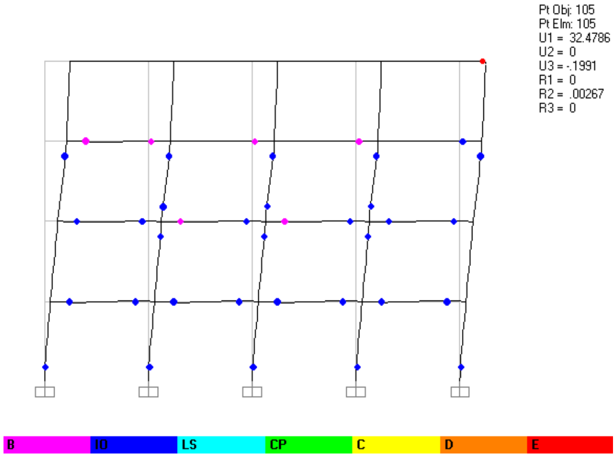

Figure 9. Joint consisting of a 4stories - 4 spans Rframe

The location and number of joints formed within larger area of the performance level frame, in the first displacement larger than target displacement, are shown in Table 5,6.

Table 5 - Number of formed joints, the range is greater than performance level the frame for RE-frames

Row	Name Frame	Frame performance level	Number of formed joints, the range is greater than performance level the frame	Place the joint formation
1	RE3D-4T	IO	3	beam
2	RE3D-7T	IO	4	beam
3	RE3D-15T	IO	1	beam
4	RE4D-4T	IO	4	beam
5	RE4D-7T	IO	0	beam
6	RE4D-15T	IO	0	beam
7	RE5D-4T	IO	2	beam
8	RE5D-7T	IO	0	beam
9	RE5D-15T	IO	0	beam

Table 6 - Number of formed joints, the range is greater than performance level the frame for R-frames

Row	Name Frame	Frame performance level	Number of formed joints, the range is greater than performance level the frame	Place the joint formation
1	R3D-4T	CP	0	beam
2	R3D-7T	CP	0	beam
3	R3D-15T	LS	0	beam
4	R4D-4T	CP	0	beam
5	R4D-7T	CP	0	beam
6	R4D-15T	LS	0	beam
7	R5D-4T	CP	0	beam
8	R5D-7T	CP	0	beam
9	R5D-15T	LS	0	beam

CONCLUSION

According to previous seasons, we can mention the following points as a wrap.

1. With increase at height frame performance level of flexural frames is improved.
2. Using the outward-oriented braces systems, it seems appropriate to strengthen flexural frames, the short and medium-height buildings. However, the formed joints at the members, shall be controlled and if necessary, should be reinforced members, that condition of the joints it is located in a larger range of performance level of the entire building.
3. In all cases, after adding braces to the frame increases the lateral stiffness of the system and will result in reducing the lateral displacement of the frame.
4. According to the diagrams, custom shirts, for distribution in various lateral loads, as well as the lateral load distribution assumption, the triangle, the majority of regulations, the approval is in place, the lateral load distribution, and the first mode structures.

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