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 brakes 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 brakes , 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.
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

Figure 1. Deformation of flexural frame

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 downright 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).

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
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.

\[
S_d = \frac{T^2}{4\pi} S_a g
\]  

(1)

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

\[
Sc_i = \frac{V_i / W}{\alpha_i}
\]  

(2)

\[
Sc_l = \frac{\Delta_{roof}}{(PF_i \times \phi_{1,roof})}
\]

\[
\alpha_i = \frac{\sum_{i=1}^{N} (w_i \phi_i) / g}{\sum_{i=1}^{N} (w_i \phi_i) / g}
\]  

(3)

\[
PF_i = \frac{\sum_{i=1}^{N} (w_i \phi_i^2) / g}{\sum_{i=1}^{N} (w_i \phi_i^2) / g}
\]

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

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

\[
F_u = 3700 \text{ kg/cm}^2
\]

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>
<thead>
<tr>
<th>Table 1. of steel materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic</td>
</tr>
<tr>
<td>Weight per unit volume</td>
</tr>
<tr>
<td>The elastic modulus</td>
</tr>
<tr>
<td>Poisson coefficient</td>
</tr>
<tr>
<td>Yield stress</td>
</tr>
</tbody>
</table>
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:

\[ Q_{e} = 1.1(Q_{p} + Q_{e}) \]  \hspace{1cm} (4)
\[ Q_{e} = 0.9Q_{e} \]  \hspace{1cm} (5)

Based on recipe development is the Qₚ, dead load, and is Qₑ, 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 (Khaksefid, 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 < (Vₑ/Vₚ) 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 > (Vₑ/Vₚ).

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 < (Vₑ/Vₚ) 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.

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

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

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

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

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

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

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).
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.

REFERENCES

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