Comparative Study on Stability of Structure with Regard to Type of Bracings

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Abstract— Most of the RCC buildings fail due to lateral loads. Bracing systems are one of the lateral load resisting systems which have structural importance especially in reinforced concrete buildings. Different bracing systems are found to be efficient for seismic responses. Steel bracing systems have both practical and economic advantages & their application is faster to execute. They are usually installed between existing vertical members. The purpose of the study of seismic response of a building is to design and build a structure in which the damage to the structure and its structural components by earthquake is minimized. This paper is about analysing the stability of the multi storied building with different bracing systems.

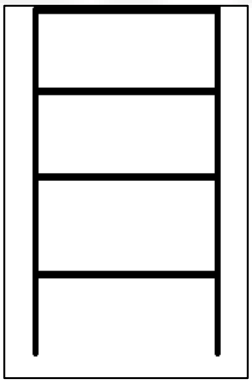
Keywords: RCC Buildings, Bracings

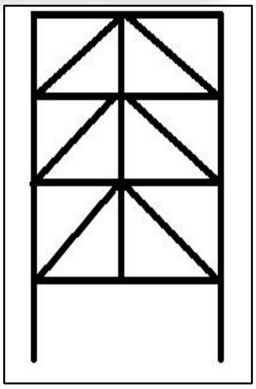
I. INTRODUCTION

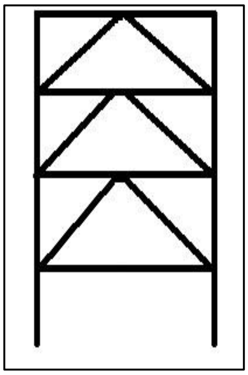
When a tall building is subjected to lateral or torsional deflections under the action of fluctuating seismic loads, the results to oscillatory movement can induce a wide range of responses in the building, occupants inside the building experience mild discomfort. As far as the ultimate limit state is concerned, lateral deflections must be limited to prevent second order p-delta effect due to gravity loading being of such a magnitude which may be sufficient to collapse structure. To satisfy strength and serviceability limit stares, lateral stiffness is a major consideration in the design of tall buildings. The simple parameter that is used to estimate the lateral stiffness of a building is the drift index defined as the ratio of the maximum deflections at the top of the building to the total height. Different types of Bracing configuration are used to improve the lateral stiffness and to reduce the drift index. In this Project the study is conducted for braced frame structures. Bracing is a highly efficient and economical method to laterally stiffen the frame structures against seismic loads. A braced bent consists of usual columns and girders whose primary purpose is to support the gravity loading, and diagonal bracing members that are connected so that total set of members forms a vertical cantilever truss to resist the horizontal forces. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing the stiffness and strength against horizontal shear.

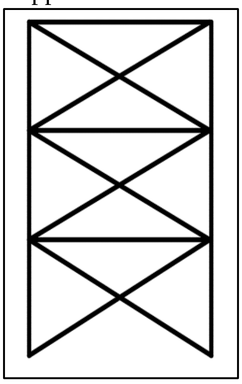
A. *Conventional Braced Frames*

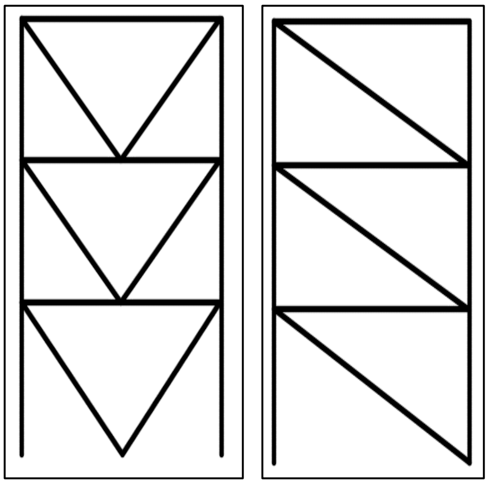
In current United States practice, concentrically braced frames are typically designed using elastic analyses. In such analyses, the behaviour of these frames follows that of a vertical truss for any concentrically braced frame configuration V Bracing, Eccen Back bracings, chevron, cross-braced, or zipper frames (Khatib, 1988). However, the post elastic behaviour of braced frames is integrally linked to the configuration of braces. This influence is effected either directly, such as in the post-buckling change in deformation mode of chevron-braced frames (Khatib, 1988), or indirectly, by the selection of brace size and its influence on brace fracture life (Lee, 1987). Current United States building codes treat these various configurations as one system (AISC, 1997, ICBO, 1997). These codes recognize issues specific to one configuration, chevron bracing, and provisions exist to minimize the deviation of its post elastic performance from that of other configurations; chevron-braced frames designed to those provisions are treated by the codes as equivalent to other configurations. Because lateral loading on a building is reversible, braces will be subjected in turn to both tension and compression, consequently, they are usually designed for the more stringent case of compression. For this reason, bracing systems with shorter braces, for example V bracing, may be preferred to the full diagonal types. As an exception to designing braces for compression, the braces in the double diagonal is designed to carry in tension the full shear in panel. A significant advantage of the fully triangulated bracing types is that the girders moments and shears are independent of the lateral loading on the structure. Consequently, the floor framing, which in this case, is designed for gravity loading only, can be repetitive throughout the height of the structure with obvious economy in the design and construction. The role of web members in resisting shear can be demonstrated by following the path of the horizontal shear down the braced bent as shown in Figure.


Bare frame


Zipper braced frame


Chevron bracing


X- Braced frame



V- braced frame   Eccen back frame

II. OBJECTIVES

The objectives of the study are:

1) To obtain the most effective structure to resist the lateral loads.
2) To identify the most vulnerable building among the models considered for seismic action.
3) To understand the efficiency of steel structures with different types of bracings with respect the story shear, story displacement, drift and time period for all zones in India.
4) To study effect on behavior of steel structure.
5) To obtain most stable structure for the considered bracing types.

III. METHODOLOGY

Following methodology is adopted for analyses.

1) Steel structure is considered for the study having 10 stories of height 30 m with each floors is considered as 3 m height.
2) The regular steel moment resisting frame of square plan is considered as base or reference model.
3) With reference to base model, all the bare frame structures of different zones are studied and compared with structures included bracings for all the models with zones.
4) In order to get consistent results, the floor height is kept constant for all geometric configurations.
5) To understand the behaviour under lateral loads applied as per IS 1893: 2002 are used respectively.
6) Based on the results and responses from earthquake loads applied, conclusion are made.

A. Analysis Considerations

The entire analysis has been done for all the 3D models using ETABS 2016 version software. The results are tabulated in order to focus the parameters such as lateral displacements, storey drift and storey shearing linear analysis. In nonlinear analysis, the identification of plastic hinges at various performance levels, performance point and capacity of various models were studied.

B. Equivalent Static Method

The natural period of the building is calculated by the expressions T=0.075h0.75 for bare frame as given in IS 1893 (Part 1) 2002, where h is the height of the building in the considered direction of vibration. The lateral load calculation and its distribution along the height are done as per IS 1893 (Part 1) 2002 which was mentioned in the chapter 5. The seismic weight is calculated using full dead load plus 25% of live load. For the equivalent static load analysis the earthquake load is considered in both X and Y directions.

C. Response Spectrum Method

Dynamic analysis of the building models is performed using ETABS 2016. The lateral loads generated by ETABS correspond to the seismic zone V and 5% damped response spectrum given in IS 1893 (Part 1) 2002. The fundamental natural period values are calculated by ETABS, by solving the Eigen value problem of the model. Thus, the total earthquake load generated and its distribution along the height corresponds to the mass and stiffness distribution as modelled by the software. Here, as in the equivalent static analysis, the seismic mass is calculated using full dead load plus 25% of live load. The 5% damped response spectrum is considered for all modes of the building. For the modal combination Complete Quadratic Combination (CQC) method is considered, because in this method of modal combination coupling of the modes take place. For each displacement and force in the structure, the modal combinations produce a single positive results for each direction of acceleration, these directional value for a given response quantity have to be combined to produce a single positive result, and for this directional combination, square root of sum of squares (SRSS) method is adopted. After defining the response spectrum case, analysis is carried out.

D. Modelling

1) Framed steel structure without bracings.
2) Steel structure with zipper braced frames.
3) Steel structure with invert v bracings.
4) Steel structure with Chevron bracings.
5) Steel structure with Eccen Backward bracings.
6) Steel structure with X-bracings.

E. Building Data

Type of Structure – Steel Moment Resisting frame, chevron bracing, Zipper bracings, X-bracing, V-bracing, Eccen back bracing.
Number of Stories – 5, 10 and 15 stories
Height of each floor - 3 m
Height of building – 15, 30 and 45 m
Building type- Office Building

F. Material Properties

Grade of concrete for deck - f_{ck} – M25
Grade of steel - f_e 345

G. Gravity Load

Live load - 3 kN/m^2
Floors finish - 1.5 kN/m^2
Wall load - 12.65 kN/m.
Parapet Wall- 2 kN/m.

H. Earthquake inputs as per IS 1893 (Part I):2002

Location of Building-Moderate intensity (Z-II) and (Z-V)
Soil type- Type II
Importance factors- 1.0
Response reduction factors - 5

IV. Introduction to ETABS

The software used in this program is ETABS 2016. ETABS software is a special computer program developed specifically for different building systems. However, the need for special programs like ETABS, has never been more evident for structural engineers to put nonlinear static and dynamic analysis into practice and to use the greater computer power available today to create larger, more complex analytical models.

With ETABS, modelling and modifying a model, analysis, design and optimizing the design are all done through a single interface which is completely integrated within Microsoft Windows. ETABS produces graphical displays of the results more easily. Printed outputs and saving a file for selected elements or for all the elements are also easily available in ETABS.

V. Results and Discussions

The behaviour of each model is captured and the results are tabulated. The variation of systematic parameters like story lateral displacement, story drift, storey shear, natural time period, story shear and overturning moment has been studied for seismic analysis. The results of all the models are observed and the most suitable model is selected by comparing the results of each model.

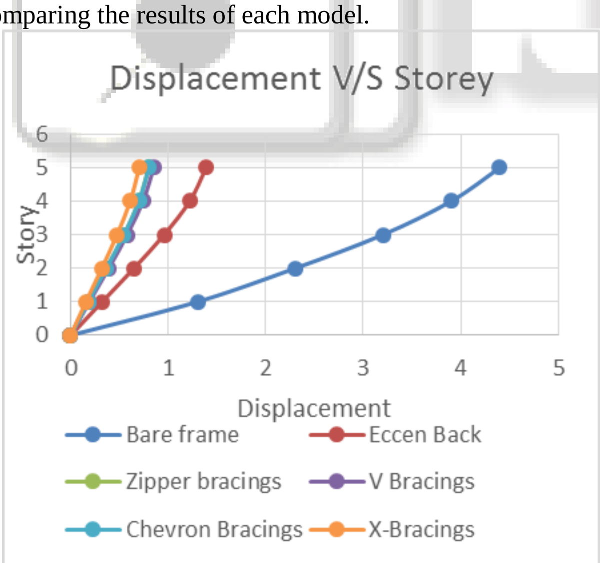


Fig. 1: Storey v/s Displacement Plot for 5 storey structure in x direction (zone-2)

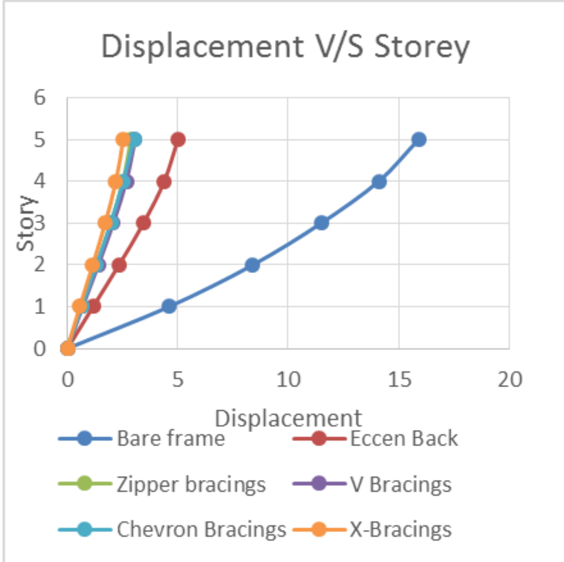


Fig. 2: Storey v/s Displacement Plot for 5 storey structure in x direction (zone-5)

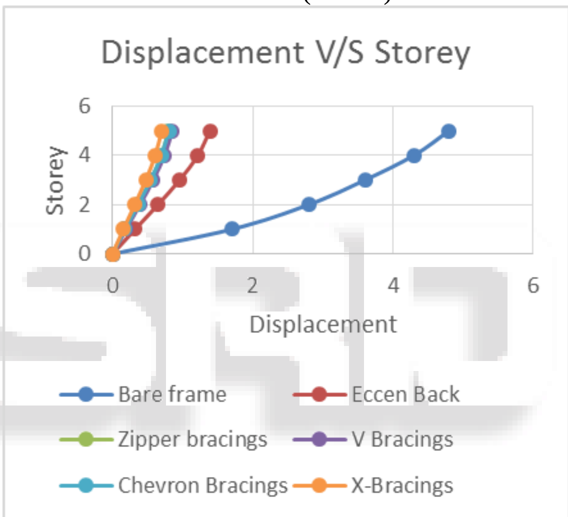


Fig. 3: Storey v/s Displacement Plot for 5 storey structure in Y direction (zone-2)

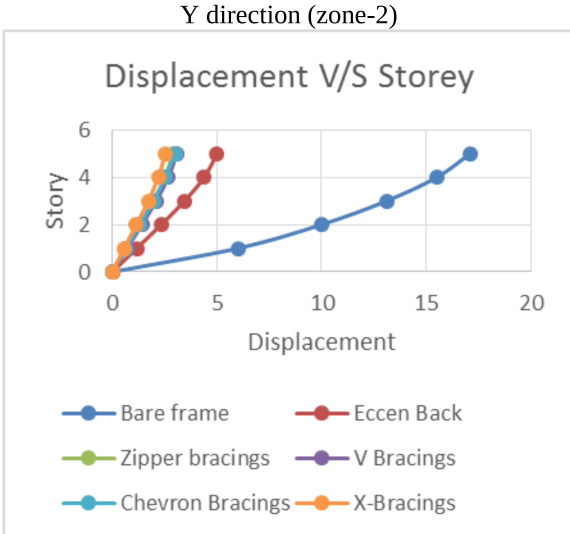


Fig. 4: Storey v/s Displacement Plot for 5 storey structure in Y direction (zone-5)

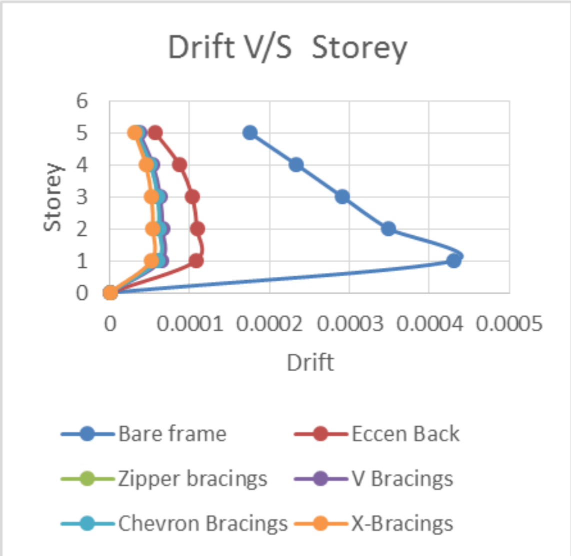


Fig. 5: Storey v/s Drift Plot for 5 storey structure in x direction (zone-2)

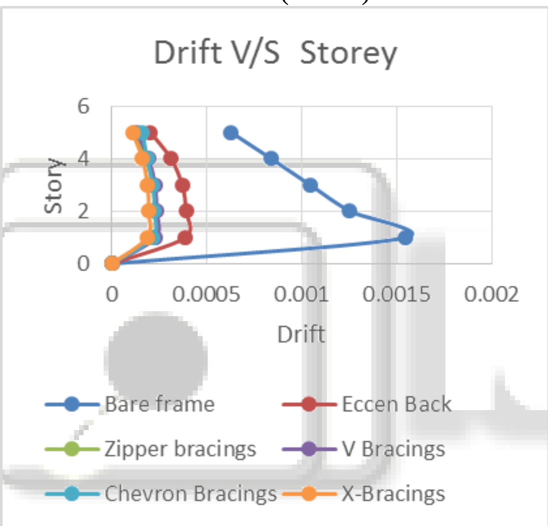


Fig. 6: Storey v/s Drift Plot for 5 storey structure in x direction (zone-5)

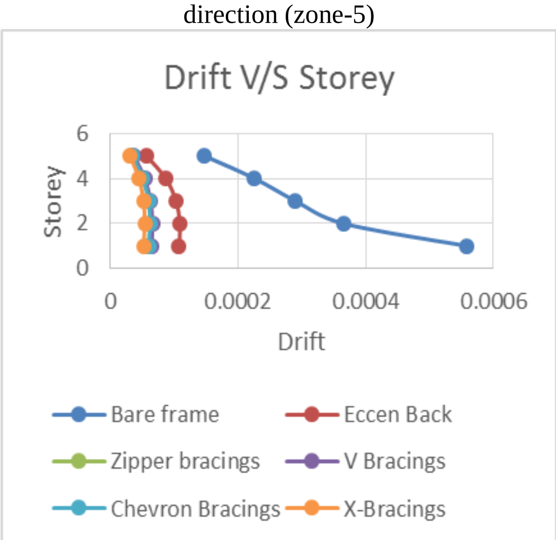


Fig. 7: Storey v/s Drift Plot for 5 storey structure in Y direction (zone-2)

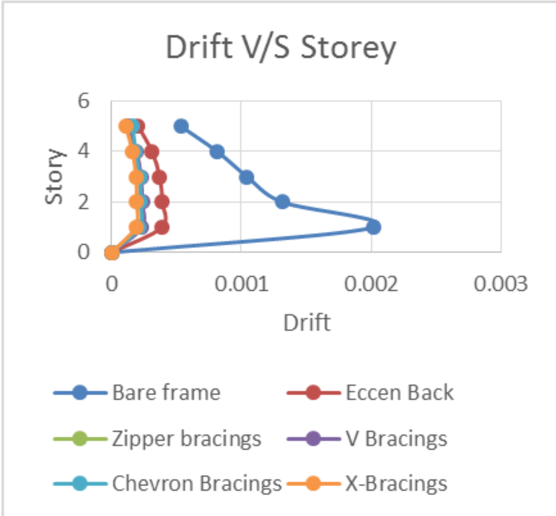


Fig. 8: Storey v/s Drift Plot for 5 storey structure in Y direction (zone-5)

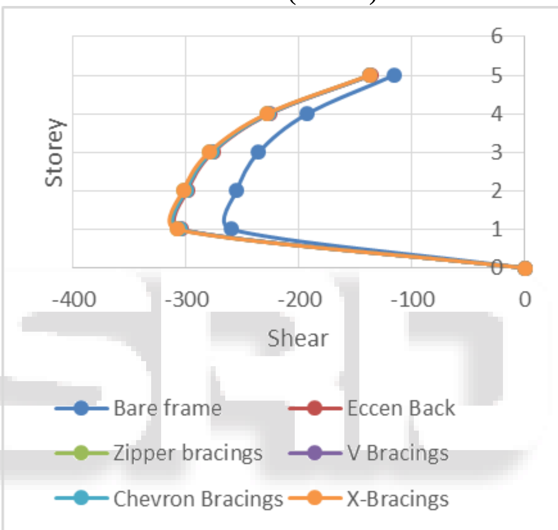


Fig. 9: Storey v/s storey shear Plot for 5 storey structure in x direction (zone-2)

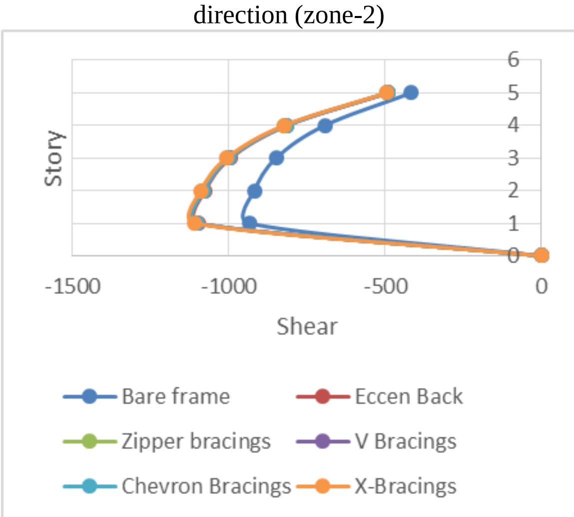


Fig. 10: Storey v/s storey shear Plot for 5 storey structure in X direction (zone-5)

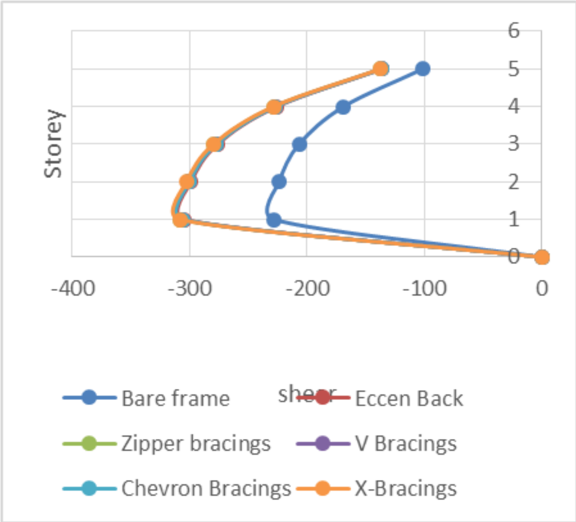


Fig. 11: Storey v/s storey shear Plot for 5 storey structure in Y direction (zone-2)

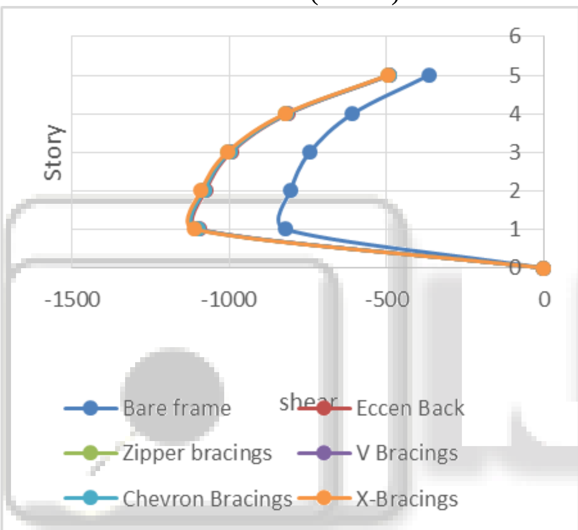


Fig. 12: Storey v/s storey shear Plot for 5 storey structure in Y direction (zone-5)

VI. CONCLUSIONS AND SCOPE FOR FUTURE STUDIES

The present work is to compare structure with its behaviour when it is subjected to lateral loads to due earthquake. Three different Building heights are considered for the study as 5, 10 and 15 storey structures and bare frame structure is modeled and compared with adding bracing to the structures subjected to lateral loads. The various parameters is considered for the study are determining the good configuration of bracings to resist lateral loads they are lateral storey displacement, storey drift, storey shear, natural time period and Overturning moment,

Following conclusion are given for different thickness of structures.

1) From the seismic analysis results obtained for storey displacement, it shows that we got maximum values for the bare frame structure, when we added invert v bracings there is small reduction in the displacement and for X-bracing and zipper bracing system .we found that maximum reduction in the storey displacement.
2) From the results obtained we concluded that the steel structure with x-bracings can control the lateral displacement due to earthquake.
3) From drift parametric study we can say that the obtained value is within the limit that is less then the value of h/250 (h=total height of the structure)
4) The drift value is maximum at the center and minimum at the top and bottom here the steel structure without bracings gives maximum drift value compared to inverted v bracing and zipper bracings.
5) From the analysis from Storey shear parametric study the shear is maximum at the base and its goes on decreases with the story height it's depending on story weight, here the structure with zipper bracing structure gives maximum storey shear.
6) Story shear parametric study base shear is maximum for the zipper braced frame structure compared to bare frame and other structure.
7) Time period is maximum for the 15 storey bare frame structure and minimum for the zipper frame structure in 5 storey structure.
8) From over all consideration of study we can see that the 5 story structure gives minimum results compared to 10 storey and 15 storey structure so the parameters considered for the study is depends on number of storeys.
9) In the study the zonal comparison is done for all models from zone 2 to zone 5 we can see that maximum results for zone 5 compared to zone 2 due to zone factor.
10) Here equivalent static analysis and response spectrum analysis got almost same results due to the scale factor.
11) From over all consideration zipper bracings will gives better performance for the lateral loads.

A. Scope for Future Work

The work presented in this dissertation may use as basics for future work suggested as below

1) A high rise building of higher stories can be studied for different seismic zones in India.
2) The present study is based on the equivalent static analysis analysis results can be verified with Time history analysis and push over analysis.
3) The study can be further carried out on the varying configuration of the bracing systems.
4) Experimental work can be done to verify analytically obtained results.
5) Soil structure interaction can be considered for present analysis.
6) Different types of lateral resisting system can be adopted to structures to increase stiffness.

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