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Pushover Analysis for Steel Frame Structure with Bracing

Mitesh.Arora[1], Rahul.Gautam[2]
[1]Department of civil engineering, viva institute of technology, India
Email: mitesharora22@gmail.com
[2] Department of civil engineering, viva institute of technology, India
Email: rah991900@gmail.com

Abstract— *In last few periods steel structure has played an essential role in industry of construction. it is necessary to design a structure so that it implement well under seismic loads. The seismic performance of a multi-story steel structure framed building is designed in accordance to the provisions of the Indian standard code (is 800 -2007). The ductility of the structure can be improved by introducing steel bracings in the structural system. Different type of bracings can be used for retrofitting too. performance of frame is studied through nonlinear static analysis (pushover analysis) using a software package e-tabs 2016, diagonally braced, alternative diagonally braced, v-braced, inverted v-braced, k- braced etc. in this study a typical multi-story (g+5) steel frame building is designed with and without different types of bracings. Deformed shapes, hinge results, lateral displacements, modal period and frequencies of the altered building frames and corresponding type shapes are compared for frame with and without bracings. Pushover curves and performance points for the different frames with and without bracing systems are compared to find the relative performances of several frames considered.*

Keywords— steel structure, seismic performances, braced frame, pushover analysis, retrofitting.

I. INTRODUCTION

1.1. General

In last few decades Steel structure have been played an important role in Industry of Construction. It is necessary to design a structure that should be perform well under seismic loads. The ductility of the structure can be increased by introducing Steel bracings in the structural system. Different type of bracings can be used for retrofitting as well. There are many different numbers of ways to arrange Steel bracings such as X-braced, diagonally braced, alternative diagonally braced, V-braced, inverted V-braced, K-braced etc. Frames of such structure should have adequate ductility property to perform well under seismic loading. To estimate the ductility and other properties like lateral displacements modal period and frequencies for each type of bracing considered, push over analysis is performed on E-Tabs 2016. A simple program-based push-over analysis is a technique for performance-based design (non-linear analysis) of building frames subjected to earthquake loadings.

II. PUSHOVER ANALYSIS

Pushover analysis or non-linear analysis an accurate analysis method in which the whole structure is subjected to monotonically increasing lateral load with a varying height distribution of lateral force until a desired displacement is arrived. Pushover Analysis consists of a series of sequential elastic analyses, superimposed approximate the force- displacement curve of the overall structure. A two or three dimensional diagrams of all lateral force resisting elements is first created and gravity loads are applied initially. The structure is subjected to pre-defined lateral loads pattern which are distributed along the building height. The lateral forces are increased until the some members start yield. The structural model is modified account for the reduced stiffness of yielded members and lateral forces are again increased until additional members yield. The process is continued until a control displacement at the top of building reaches to certain level of displacement at the top of building reaches a certain level of deformation or structure becomes unstable. The displacement is plotted with base shear to get the static pushover curve.

III. Literature review

2.1. General

In this chapter we are providing a brief description of the literature review of the modeling of structure would be difficult to

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explain in this chapter. A proper description of previous studies on pushover analysis is presented in this section. This literature review enables us to access the recent contributions related to pushover analysis on steel structures mainly and the past contributions made which nearly matches the present work.

2.2.Literature review on pushover analysis

- **DR. P.Eswaranoorthi et.al.(2014)[1]** studied the thorough investigation of the pushover analysis of steel frames such as bare frame that is by not using bracings, Braced frame are done by them. The pushover analysis is done by using ANSYS and through experiment under the lateral loading has been carried out with the intention to note the percentage of strength achieved. After analysis the result shows that the yield load of steel braced frame is 1.22 times greater than the yield load of bare frame in the analytical investigation and the yield load of steel braced frame is 1.32 times greater than the yield load of bare frame in the experimental method. Similarly the ultimate load of the steel braced frame 1.07 times greater than the ultimate load of bare frame in the experimental investigation. At the ultimate load, Deflection of the braced frame Is reduced 3.09 times compared to bare frame in the experimental investigation. The deflection value range through ANSYS is also validated by Stiffness method.
- **Kurapati Nikhila et.al.(2017)[2]** base shear and displacement capacity of the braced steel space frame with considering uniformly collapse case is decreased by 89.47% and 89.38%when compared to regular space frame without considering uniform collapse case at Seismic zone 2. Base shear and displacement capacity of the braced steel space frame with considering progressive collapse case is declined by 89.7% and 89.7% when compared to regular space frame not taking in to account the uniform collapse case at seismic zone 3.
- **Mayank Chouhan and Dr. Savita Maru et.al.(2017)[4]** Many recommend are studied for linear and non-linear analysis and the seismic evaluation of the structure are discussed. Most of the researchers have reviewed that the steel structure were assumed to be placed in various zones of India are carried out the investigation on the non-linear pushover analysis and associated the performance of the steel components, maximum base shear capacity and displacements of the structure located I the various zones. The software used for the analysis are described in numbers SAP2000, ETABS are mainly the software used to find out the seismic estimation and performance of the structure. All these studies require further research not based on assumption, but in real terms it is necessary to think through existing steel structures under seismic evaluation.
- **Prince kaley and Mirza aamir baig et.al.(2014)[6]**The performance point is to study the steel structure with and without bracing, the steel structure in performance point of view with bracing has less susceptible damage states than the steel structure without bracing. Comparing the results of structure with and without bracings, base shear vs. displacement curve indicates that the braced structure are far most better than the steel structure without bracing. It also indicates that the capacity curve is far more linear therefore steel structures with bracing. Study of hinges formed during pushover analysis for structure without bracing. The severe and collapsed state of damage is observed more in structure without bracing than in structure with bracing. Therefore bracing reduces the plastic hinge state and consequences less damage. Study of storey wise lateral displacements, modal period and frequencies shows the lateral displacement is reduced significantly in case of braced frame. Also modal period for different modes of braced steel frames is comparatively less than that of unbraced steel structures or frames. Further frequencies of braced steel frames is comparatively higher than that of unbraced frame. When the storey wise displacements were compared and the modal with ‘single diagonal bracings’ was found to give better results for non-linear static analysis where compared to other models. Also, model with the X bracing was found to giving better results in terms of modal periods and frequencies for non-linear static analysis.
- **Jayram Nayak B et.al.(2018)[5]** From the pushover analysis results it can be observed that, the braced frame have enhanced base shear capacity compared to bare frame. One storey for all configurations have higher seismic performance compared to two storey bracing and three storey bracing. Also, X bracing with one storey bracing and diamond bracing with two and three storey bracings shows highest seismic performance. Aspect ratio of one has shown better performance foe all the structural models considering.

IV. MATERIAL AND METHOD

Covering various levels of irregularity in plan and elevation, structural ductility and directional effects, using pushover analysis a

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characteristics non-linear force displacement relationship can be determined

Fig no 3.1 Pushover methodology

3.2.Pushover analysis

Pushover or non-linear analysis is defined as an analysis in the mathematical model directlyIncluding the nonlinear load-deformation characteristics of individual components and elements of the building shall be subjected to monotonically increasing lateral loadsrepresenting inertia forces in an earthquake until a target displacement is exceeded from target Target displacement (elastic plus inelastic) is the maximum in the building at roofexpected under selected earthquake ground motion. The structural Pushover analysis assessesperformance by estimating the force and deformation capacity and seismic demand using a non-linear static analysis algorithm.

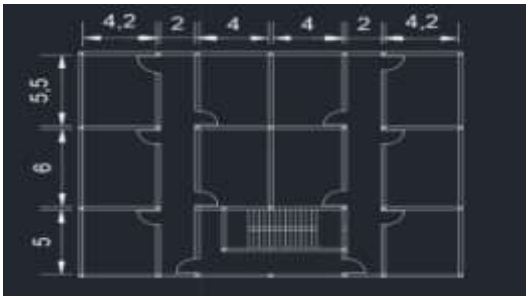
- **a)** A thorough literature review to understand the seismic behavior of building structures and application of pushover analysis.
- **b)** Seismic behavior of steel frames with various types of eccentric bracings geometrical and their structural details
- **c)** Model the selected in seismic behavior of steel frames with various eccentric bracings computer software ETABS (2016).
- **d)** Carry out pushover analysis or non-linear analysis of seismic behavior of steel frames with various types of bracings and arrive at a conclusion.

Response characteristics that can be obtained from the pushover analysis are summarized as follows:

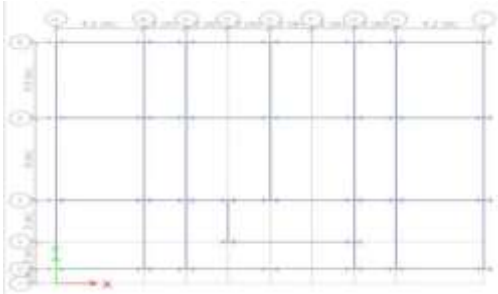
- **a)** Estimates of force and displacement capacities of the structure.
- **b)** Estimates of all force (axial, shear and moment) demands on likely brittle elements and deformation demands on ductile elements.
- **c)** Sequences of the failure of elements and the consequent effect on the overall structural stability.

3.3. PUSHOVER ANALYSIS PROCEDURE

1) A two or three dimensional model that represents the overall structural is created.



Developed plan in AutoCAD



Centre line plan in Etabs

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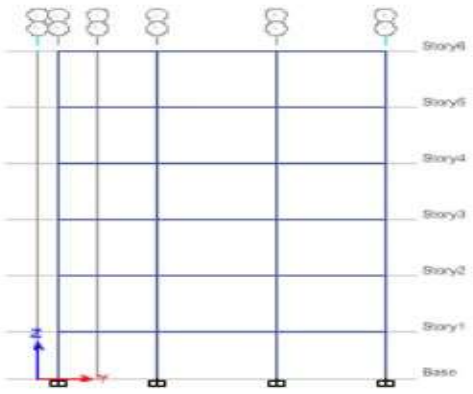
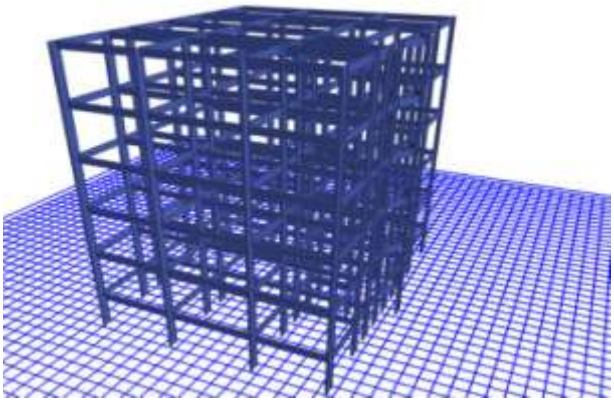
2) Assigning the member properties



Elevation view in Etabs



Render view of model

3) Gravity loads combine of dead load, live loads and lateral loads are applied to the structural model initially

Description of model

Sr.No.	Particular	Details
1.	Live load	5 kN/m²
2.	Earthquake load	As per IS 1893 (Part 1)-2016
3.	Slab thickness	150 mm
4.	Depth of foundation below ground	4 m
5.	Type of soil	Type Ⅱ, medium as per IS:1893-2016
6.	Storey height	4.2 m
7.	Grade of steel	Fe410 structural steel
8.	Column size	ISWB 600
9.	Beam size	ISMB 550
10.	Bracing size	ISMB 400
11.	Building importance factor	1
12.	Height of building	24.5 m

4) Lateral loads are increased until some member(s) yield under the combine effects of gravity and lateral loads.

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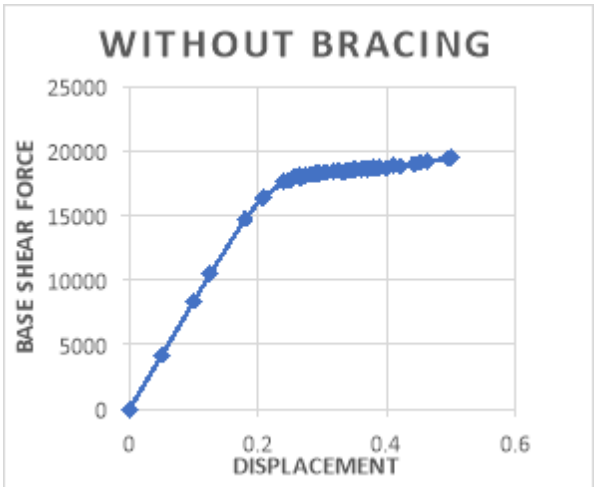
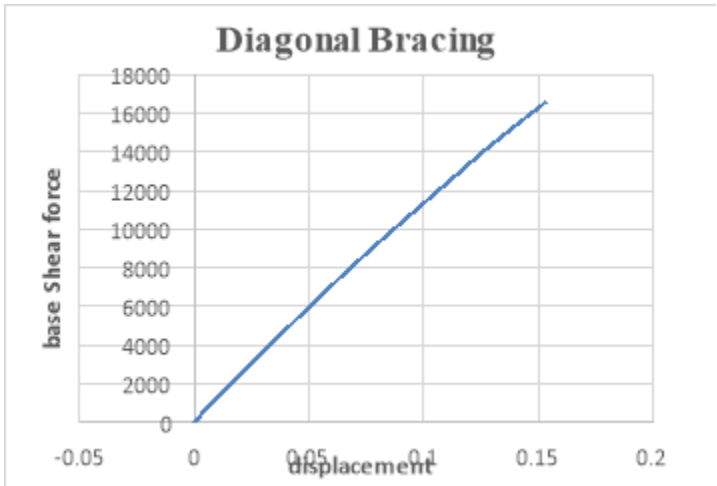
5) Base shear and roof displacement are recorded to yield first.

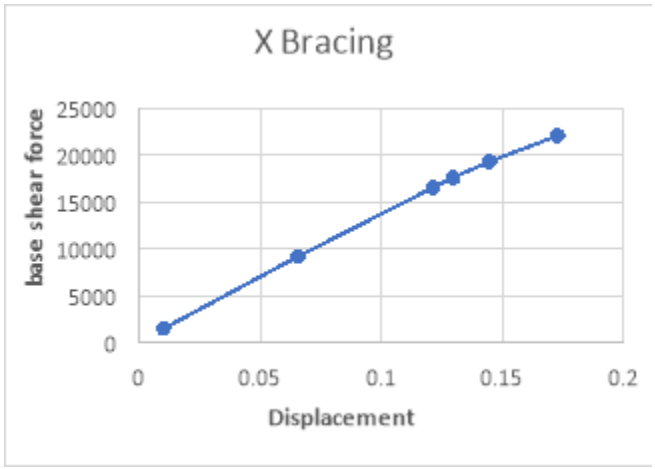
3.4.Location of bracing

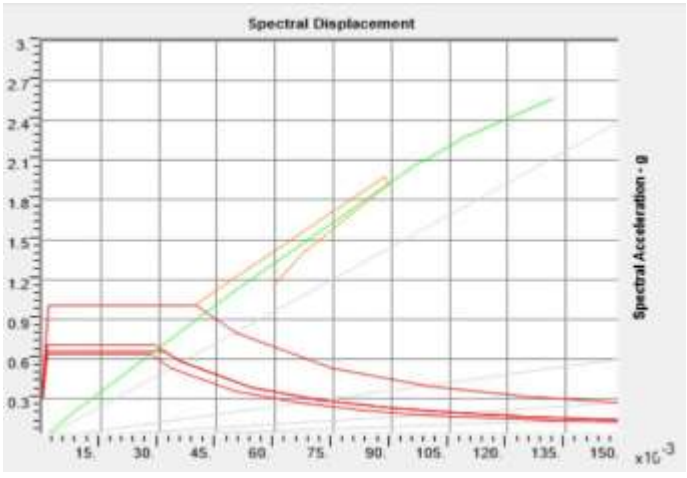
1. Bracing in vertical planes (between lines of columns) provides load to transfer horizontal forces to ground level and provide lateral stability
2. Horizontal bracing At each floor level the bracing in horizontal plane where generally provided by floor plate action and also provides a load path to transfer the horizontal forces to the planes of vertical bracing.
3. The location of the bracing is placed such that, where plastic hinge condition is established.
4. It is provided to the failing member so as to decrease the seismic activity.

V. RESULT OUTPUT:- BASE SHEAR FORCE VS DISPLACEMENT









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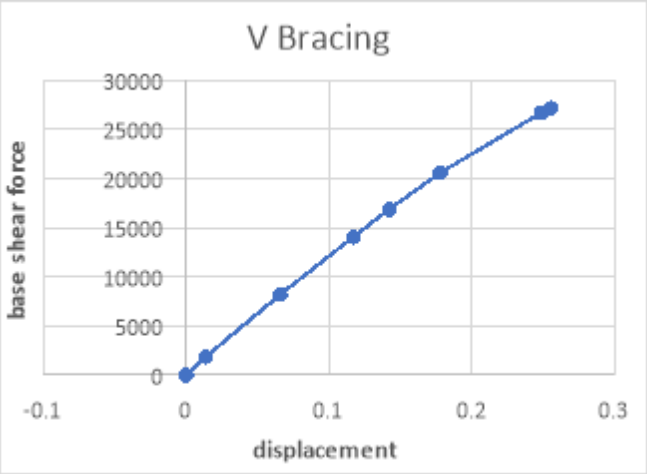

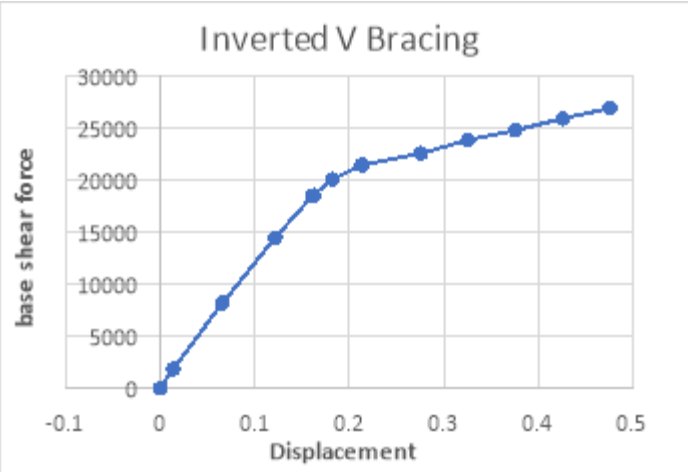

VI. CONCLUSION

The models structure frame are analyzed using pushover analysis. The seismic performance of a multi-story steel structure frame building is designed according to the provisions of Indian code (IS 800-2007). Shear capacity of the structure can be increased by introducing Steel bracings in the structural frame system. Bracings can be used as retrofit as well. There are „n" numbers of possibilities to arrange Steel bracings such as cross (X), inverted V (**/**), and diagonal (\) type eccentric bracings. A typical six-story steel structure frame building is designed with various types of eccentric bracings as per the IS 800- 2007. cross bracing (X), inverted V (**/**), and diagonal (\) are the different types of eccentric bracings considered for the present study. Performance of the each frame structure is studied through non-linear static analysis. Fundamental period of the Building frames and corresponding mode shapes are calculated. Pushover curves and behavior factors for the different eccentric steel frames are compared to find the relative performances of various frames considered.

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