# Nonlinear (Pushover) Analysis of Steel frame with External Bracing

**N.T. Bhagat, A. H. Deshmukh**

***Abstract*— *Steel is by far most useful material for building construction in the world and in last decades steel structure has played an important role in construction industry. Providing strength, stability and ductility are major purposes of seismic design. It is necessary to design a structure to perform well under seismic loads. In this paper nonlinear pushover analysis is carried out for high rise building steel frame with different pattern of External bracing. The shear capacity of the structure can be increased by introducing steel bracing in structural. There is 'n' number of possibilities to arrange steel bracing for Ex. Diagonal, X, K, V Inverted V. A typica12th- story regular steel frame having 'V' zone building is designed for various types of concentric bracings like Diagonal, V, X, and Exterior X in that 'X' Bracing are more effective. So result shows effective bracing only using STAAD PRO for bracing using different types of material sections i.e. ISMB, ISMC and ISA or any tubular or hollow sections are used to compare for same patterns of bracin.***

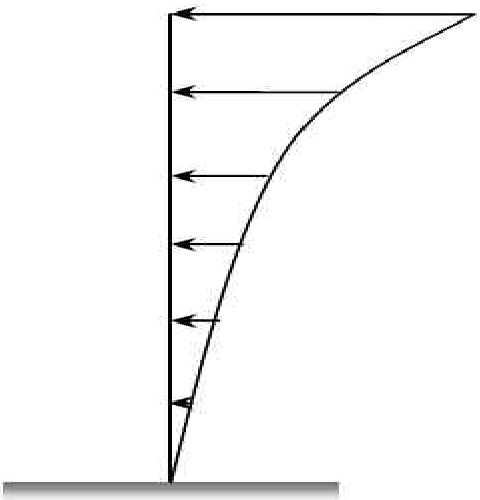
***Keywords: - Typical steel frame, exterior bracing Tube or ISMB or ISA or ISMC, Pushover Curve.***

## I. INTRODUCTION

Earthquake is a natural phenomenon, which is generated in earth's crust. Duration of earthquake is usually rather short, lasting from few seconds to more than a minute or so. But thousands of people lose their lives due to earthquakes in different parts of the world. Building collapse or damages are the major loss due to earthquake ground motion. In an earthquake, the building base experiences high-frequency movements, which results in inertial forces on the building and its components. The force is created by the building's tendency to remain at rest, and in its original position, even though the ground beneath it is moving. The use of the nonlinear static analysis (pushover analysis) came in to practice in 1970‟s but the potential of the pushover analysis has been recognized for last two decades years. This procedure is mainly used to estimate the strength and drift capacity of existing structure and the seismic demand for this structure subjected to selected earthquake. This procedure can be used for checking the adequacy of new structural design as well. Pushover analysis is a static, nonlinear procedure in which the magnitude of the structural loading is incrementally increased in accordance with a certain predefined pattern. With the increase in the magnitude of the loading, weak links and failure modes of the structure are found. Pushover analysis may be classified as displacement controlled pushover analysis when lateral displacement is imposed on the structure and its equilibrium determines the forces. Similarly, when lateral forces are imposed, the analysis is termed as force-controlled pushover analysis. The target displacement or target force is intended to represent the maximum displacement or maximum force likely to be experienced by the structure during the design earthquake. Response of structure beyond maximum strength can be determined only by displacement controlled pushover analysis. Hence, in the present study, displacement-controlled pushover method is used for analysis of structural steel frames with and without bracings. A plot of the total base shear versus top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. Beyond elastic limit, different states such as Immediate Occupancy, Life Safety Collapse prevention and collapse are defines as per ATC 40 and FEMA 356.

Design of Lateral Force (Qi)

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$



**Typical Lateral Load Pattern**

## II. METHODOLOGY

### A. Structural Modeling

For the analysis work, Use high rise steel frame building (12) floors are made to know the realistic behavior of building during earthquake. The length of the building is 21m and width is 16m with each 3.65m floor height. The columns are assumed to be fixed at the ground level. Non Linear static analysis i.e. pushover analysis is used. Use of bracing with different section and different material. Comparing the Steel Framed structure without bracing and Steel Framed structure with different bracing patterns.

**Building Description:-**

1) Building Type = Bare Frame
2) Size of Building = 21m X 16m

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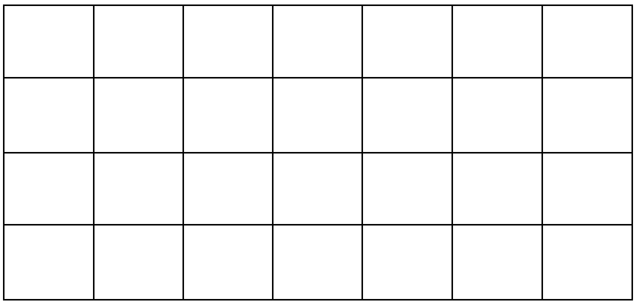
3) Each Floor Height = 3.65m
4) Total Height of Building =43.8 m
5) Slab Thickness = 125mm
6) Zone of Building = V
7) Steel Section (ISMB) Beam and Column Used
8) Steel (ISA) or Tubular Pipe ,ISMB or ISMCBracing Used
9) Grade of Steel = Fe250
10) Live Load = 3KN/m
11) Floor Finish Load = 1KN/m

**B. Plan of Building**



**Bay@3minX-direction and 4m in Z-direction (21mX16m)**

**C. Static Load Calculation**

Static Load for without bracing of steel frame having 12th floor steel building. Calculate the total gravity and lateral load acting at each nodal point on the building structure. The total load can be calculated are as follows.
Total Load Due to Dead Load = 4713 KN
Total Load Due to Live load = 8388 KN
Total Load on structure = 13101 KN
Load on each floor = 1091.75KN
Building Properties:-

1) The Building can design V zone class Z=0.36
2) The Response Reduction Factor R = 4
3) The importance factor I = 1
4) Medium soil Type II

The time period in X direction & Z direction can be calculated as

$$T = 0.09\,h/\sqrt{d}$$

For X direction T = 0.09*43.8 /4.58 = 0.86Sec so Sa/g = 1.36/T = 1.582

For Z direction T = 0.09*43.8/ 4 = 0.985 so Sa/g = 1.36/T = 1.380

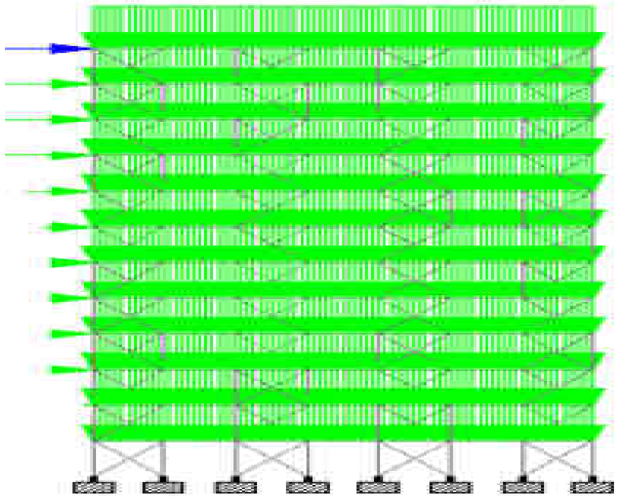
For X direction Ah = Z*I*Sa / 2Rg
= (0.36*1*1.582) / 2*5
$A_h$ = 0.0712

For Z direction $A_h$ = 0.0621
Lateral Load = Ah*Wi

**Lateral load in X direction = 0.0712 X 13101= 932.790KN**

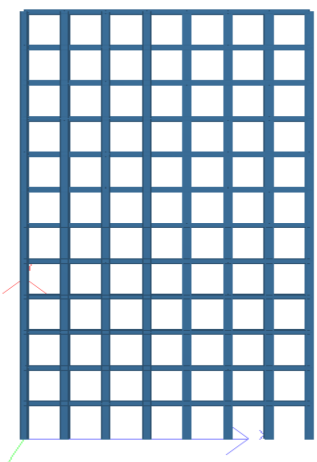
**Lateral load in Z direction = 0.0621 X 13101 = 813.572KN**

**Lateral Load Applied to each floor by STAAD PRO V8i**

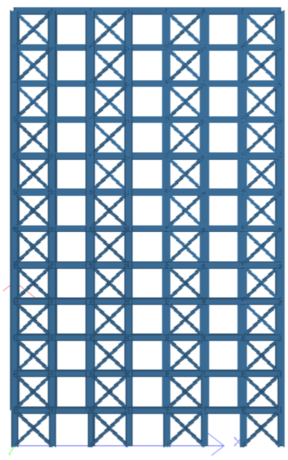


| Sr. No. | Typeof structure | Lateral Load in-X direction(KN) | Increment Percentage | Failure of member |
|---|---|---|---|---|
| 1 | Without Bracing | 932.790 | 5% | No failure |
| 2 | Without Bracing | 932.790 | 10% | Failure in Beam |
| 3 | Without Bracing | 932.790 | 15% | Failure in Beam & Column |

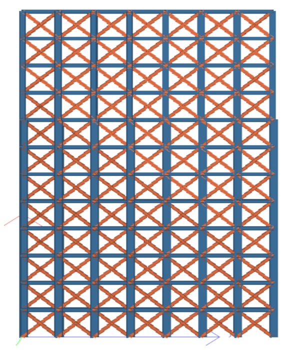
**D. Different Types of Bracing (External Side Only)**



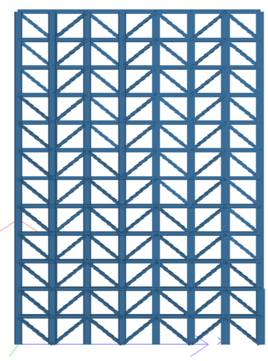
**Without Bracing**



**Exterior Alternate X Bracing**



**Exterior Bracing**



**Exterior Diagonal Bracing**



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## III. RESULT

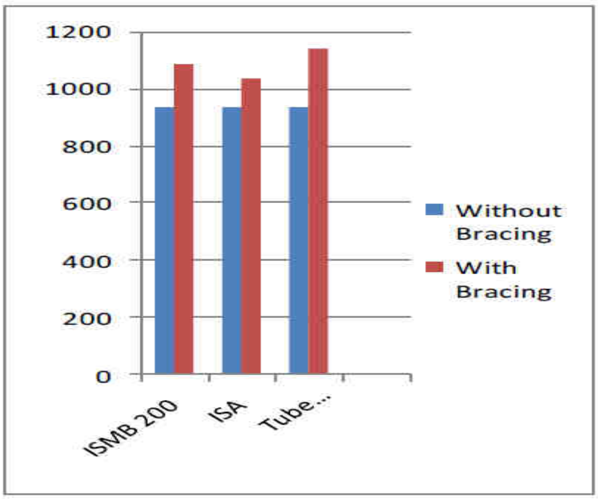
### A) Base Shear for Without & With Bracing

| Base Shear in ( KN ) Z Direction | | | |
|---|---|---|---|
| **X Bracing (Alternate)** | | | |
| ISMB 400 | 813.572 | 901.195 | 9.72 |
| Tube(Hollow Section) 150x150x6mm | 813.572 | 850.335 | 4.32 |
| ISA (200X200X15) | 813.572 | 882.752 | 7.84 |
| ISMC300 & ISMC350 | 813.572 | 861.723 | 5.61 |

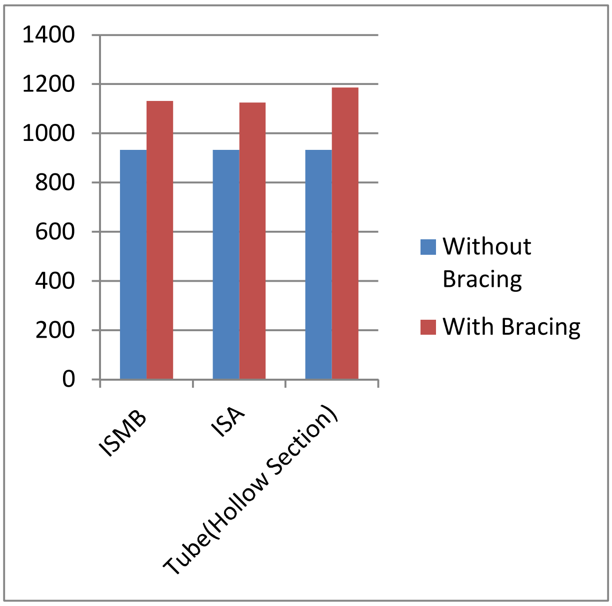
| Base Shear in ( KN ) X Direction | | | |
|---|---|---|---|
| **Type of Bracing** | **Without Bracing** | **With Bracing** | **% Increment** |
| **Diagonal Bracing** | | | |
| TC ISMB 200 | 932.79 | 1083.949 | 15.31 |
| ISA (200X200X18) | 932.79 | 1036.955 | 10.10 |
| Tube(Hollow Section) 130x130x4.85mm | 932.79 | 1139.685 | 18.15 |
| **X Bracing (Alternate)** | | | |
| ISMB 200 | 932.79 | 1132.152 | 17.72 |
| Tube(Hollow Section) 130x130x4.85mm | 932.79 | 1125.458 | 17.12 |
| ISA (200X200X18) | 932.79 | 1186.478 | 21.38 |
| **Exterior X Bracing (All Side)** | | | |
| ISMB 250 | 932.79 | 1449.205 | 35.63 |
| ISMC 350 | 932.79 | 1446.499 | 35.44 |
| ISA (200X200X12) | 932.79 | 1447.425 | 35.51 |

### B) Base Shear for With Bracing & Without Bracing

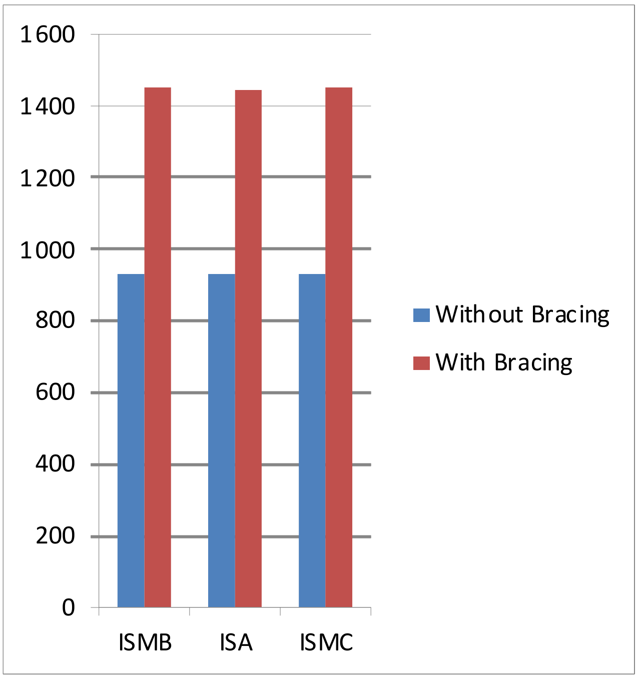
#### 1) Diagonal Bracing (X Direction)



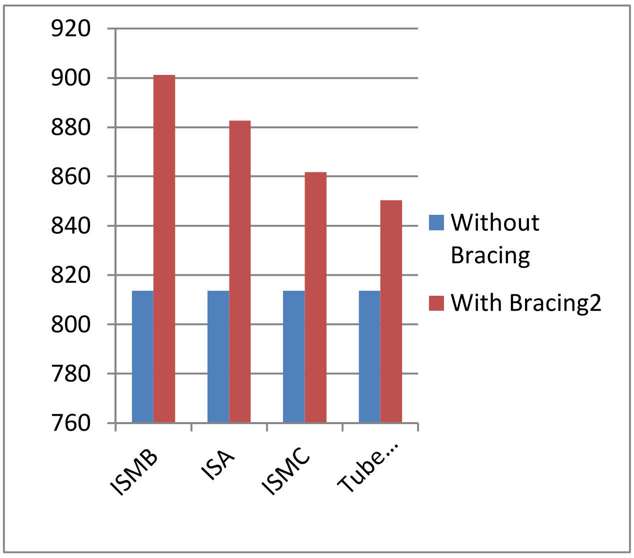

#### 2) Alternate X Bracing(X Direction)




#### 3) Exterior X Bracing (All Side in X Direction)




#### 4) Alternate X Bracing (Z Direction)



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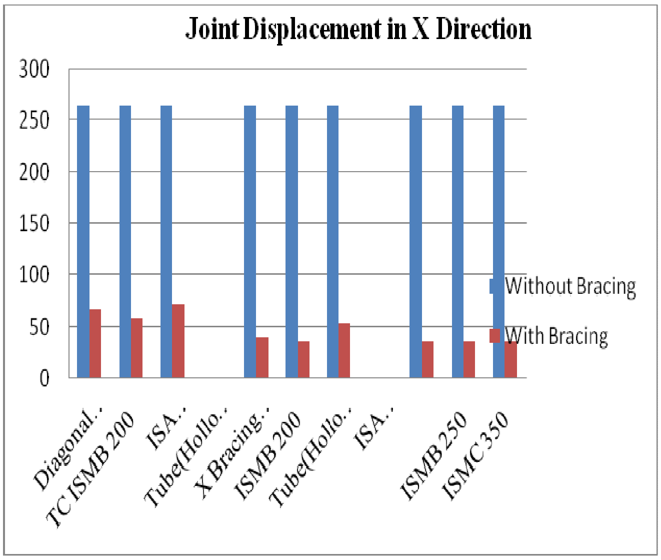
### C) Displacement *in X Direction*

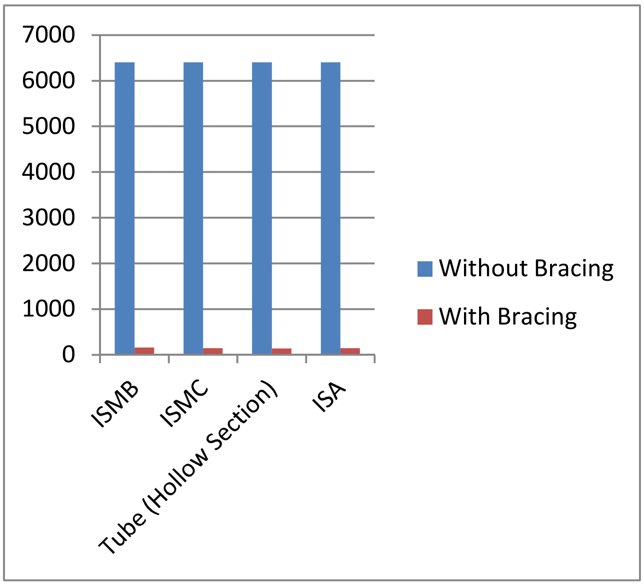
| Type of Bracing | Without Bracing (mm) | With Bracing (mm) |
|---|---|---|
| **Diagonal Bracing** | | |
| TC ISMB 200 | **264** | **68** |
| ISA (200X200X18) | **264** | **58** |
| Tube(Hollow Section) 130x130x4.85mm | **264** | **73** |
| **X Bracing (Alternate)** | | |
| ISMB 200 | **264** | **40** |
| Tube(Hollow Section) 130x130x4.85mm | **264** | **36** |
| ISA (200X200X18) | **264** | **54** |
| **Exterior X Bracing (All Side)** | | |
| ISMB 250 | **264** | **35** |
| ISMC 350 | **264** | **36** |
| ISA (200X200X12) | **264** | **35** |

### D) Displacement in Z Direction

| X Bracing (Alternate) | Without Bracing (mm) | With Bracing (mm) |
|---|---|---|
| ISMB 400 | **6400** | **16** |
| Tube(Hollow Section)150x150x6mm | **6400** | **14** |
| ISA (200X200X15) | **6400** | **15** |
| ISMC300 & ISMC350 | **6400** | **15** |

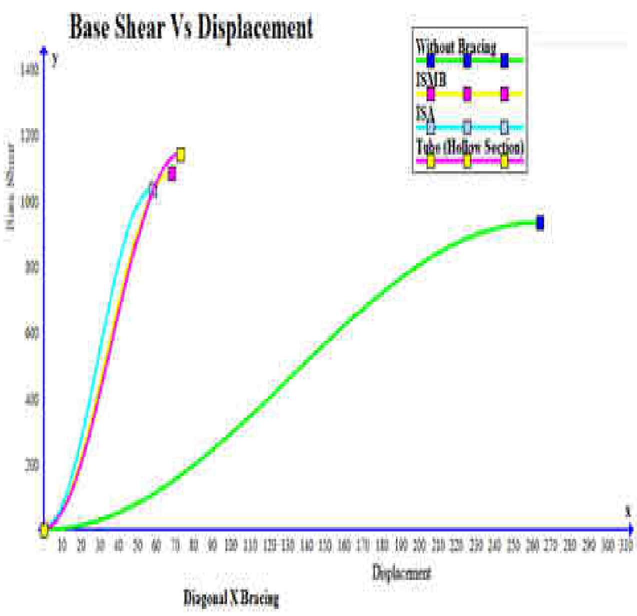



**Joint Displacement in Z Direction**




**Pushover (Capacity) Curve of Different Types of Bracing**

**1) Diagonal X Bracing (In X Direction)**



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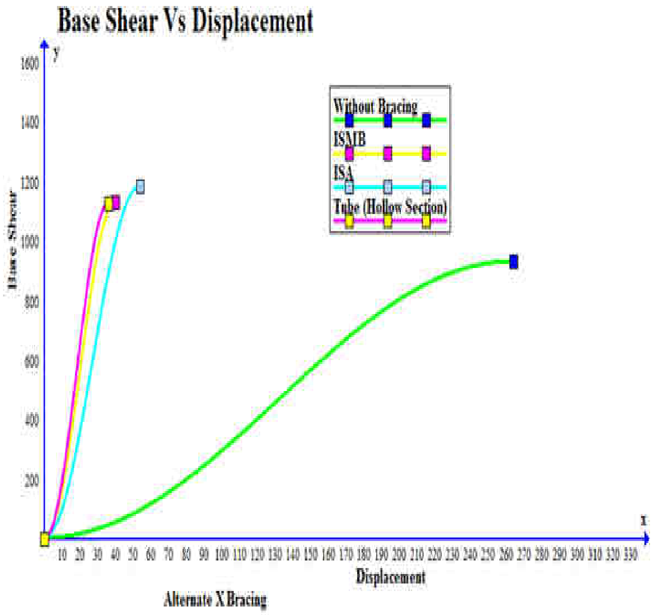
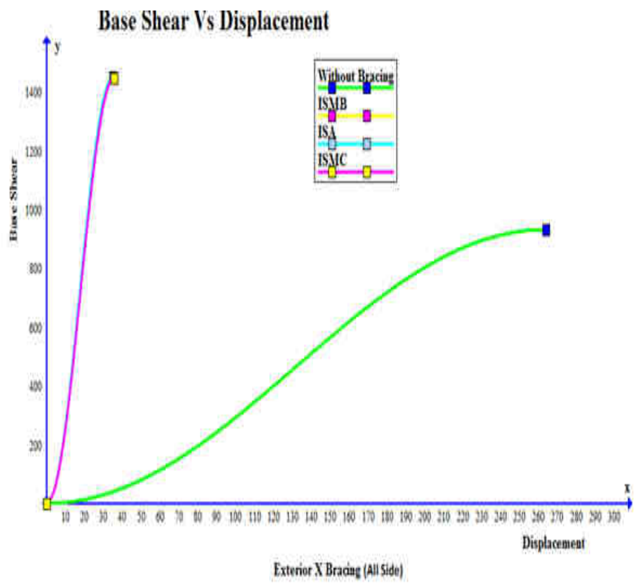
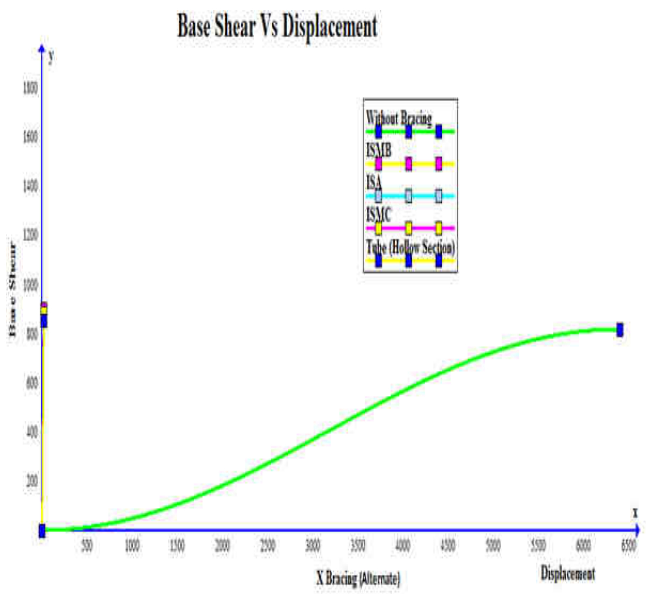
2) **Alternate X Bracing (In X Direction)**




3) **Exterior X Bracing (In X Direction)**




4) **Alternate X Bracing (In Z Direction)**




## IV. CONCLUSION

The provision of Only Exterior bracing shear capacity of frame increases by 30% to 40% by using different types of section with optimum dead load.Increasing size of section or Bracing in the Building, the base shear capacity will be increased by 70% to 80% also.The Displacement can reduces or to be neglected by using bracing with increasing small sectional dead load.Using different types of exterior bracing such as V, K, Y, X, Diagonal, in that X Bracing is more effective for increasing base shear capacity & decreasing displacement of structure. Increasing Base shear & decreasing displacement, the life of structure increases. The pushover analysis is very good approach to assess the adequacy of a structure to seismic loading.

## REFERANCS

1. Mr. Praveen Thakur, Dr.SureshKushwaha &PrabhatSoni October2014 International Journal of Innovative Research & Development )"Analysis of Nodal Displacement and Beam EndForces for Multistoried Framed Structure"
2. Mr. VaseemInamdar&Mr.Arun Kumar August 08 August 2014(International Journal of Innovative Research & Development Volume No.03, Issue No. 08 August 2014)"Seismic Analysis Of Steel Frame With Bracings Using Pushover Analysis Using ETAB"
3. Mr. Mohammed Idrees Khan & Mr. Khalid Nayaz Khan July 2014**(**International Journal of Advanced Technology in Engineering and Science Volume No.02, Issue No. 07, July 2014**)** "Seismic Analysis of Steel Frame with Bracing Using Pushover Analysis"
4. Cinitha A, Umesha P&, Nagesh R . Iyer**(** Scientist, CSIR- Structural Engineering Research Centre, Taramani, Chennai) "Evaluation of Seismic Performance of an Existing Steel Building- Pushover Analysis Approach"
5. Vijay&K.Vijayakumar**(**International Journal of Engineering Research and Development) "Performance of Steel Frame by Pushover Analysis for Solid and Hollow Sections".
6. K.K.Sangle,K.M.Bajori,V.Mhalungkar.,2012, "Seismic Analysis Of High Rise Steel Frame Building With And With Out Bracing"
7. M.D. Kevadkar, P.B. Kodag,(2013), "Lateral Load Analysis Of RCC Building"
8. Haroon Rasheed Tamboli (2012) :-Performed seismic analysis using Equivalent Lateral Force Method for different reinforced concrete (RC) frame building models that included bare frame, in filled frame and open first story frame
9. NarenderBodige, Pradeep Kumar Ramancharla (2012)"modeled a 1 x 1 bay 2D four storied building using AEM (applied element method"
10. Srikhanta Prasad (2009) "Analytical Study to Evaluate Nonlinear Seismic Performance of One Bay and Two Bay RC Frames at Different Storey Levels".
11. Syed Ahamed, Dr. Jagadish G. Kori (2013) "Performance Based Seismic Analysis Of An Unsymmetrical Building Using Pushover Analysis**".**
12. Indian IS Code IS800-2007 & IS1893-2002 (Part 1)
13. Indian IS Code IS800-1984 Design of Steel Structure



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