Design and Structural Analysis of Steel Building by Using Etabs

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Abstract - *Structures situated in seismically active areas are generally more vulnerable to serious damage. When compared to reinforced concrete structures, steel possesses a few key physical characteristics, such as great strength and ductility. When building a structure that is seismically resistant, steel properties must be taken into account. The examination of steel-framed buildings with various bracings is explained in this study. The ETABS software is used to analyze steel-framed structures. Base shear, storey shear, and storey drift for zone IV are the primary parameters assessed in this work. In accordance with IS 1893:2002, the models are examined using equivalent static analysis.*

Key Words: Seismic response1, Steel framed buliding2, bracing system3, ETABS4, Storey drift5, Storey displacement6, Equivalent static analysis7

1. INTRODUCTION

Earthquakes are one of the many natural disasters that might happen in this globe. When subterranean rock unexpectedly fractures, the ground trembles as a result of the earthquake, causing high-frequency motions in the building. Steel constructions have a lot of potential in the construction business right now. Previous earthquakes in India have demonstrated the need for both engineered and non-engineered structures to be designed to withstand seismic loading. Steel bracings can be utilized to withstand soil loads while building multi-story structures.

Assessing how braced and unbraced structures react to seismic stresses and comparing the percentage decrease in storey drift for braced and unbraced frames are the primary goals. to determine the best bracing for steel structures that effectively withstand seismic loads, as well as to compare base shear, storey shear, and storey drift for various bracing methods.

2. LITERATURE REVIEW

Dr D. Brindha and Adarsh Paul (2017), they have analyzed G+5 storey steel structure for the seismic zone IV as per IS 1893: 2000 by using ANSYS software. They examined usefulness of a variety of type of the steel bracing. They observed that the steel braced frame is one of the structural system used to counter earthquake load in multistoried steel framed building. They observed that the G+5 steel structure undergoes least deflection while using the V braced structure. They concluded that the strain energy released in the V braced frame varies greatly, releasing more than twice the energy, when compared with the unbraced frames.

Muhammed Tahir Khaleel, Dileep Kumar U (2016), concluded that the bracing in the building reduces the storey displacement in both regular and irregular building as compared to the building without bracings for lateral loads, Cross bracings has more base shear and Knee bracing has the least amount of base shear and use of bracing system increases the stiffness of the structure. They have analyzed a G+9 building for the seismic zone V as per IS 1893: 2000 by using ETABS software. They used Equivalent Static Method and Response Spectrum Method for the analysis.

Manish S. Takey and Prof. S.S.Vidhale, In this study the author have used G+9 storey building and seismic zone III as per IS 1893: 2000. They used response spectrum method for the analysis of building models using the software SAP 2000. They concluded that the X braced building is better than other types of braced building and as the size of the bracing section increases the displacements and storey drifts decreases for the braced buildings.

Shachindra Kumar Chadhar, Dr. Abhay Sharma, they have analyzed G+15 storey building for the seismic zone IV as per IS 1893: 2000 by using StaadproV8i software and linear static method is used for the analysis. They used V type and inverted V type bracing for the building. They concluded that an arrangement of bracing systems has considerable effect on seismic performance of the building. Inverted V bracing system significantly reduces the bending moment and shear force than V type bracing system.

3. METHODOLOGY

For this study, a G+5 building with lift room, it has storey height of 3.5 meters each. Different types of steel bracing are provided on various positions of the building. The structural models of the structure are modeled using ETABS software. The dead load and live load are considered as per IS 875, and earthquake analysis is done as per IS 1893 for zone-IV.

1.1 Type of Bracings used

X bracing, V bracing and Inverted V bracing

1.2 Introduction to ETABS software

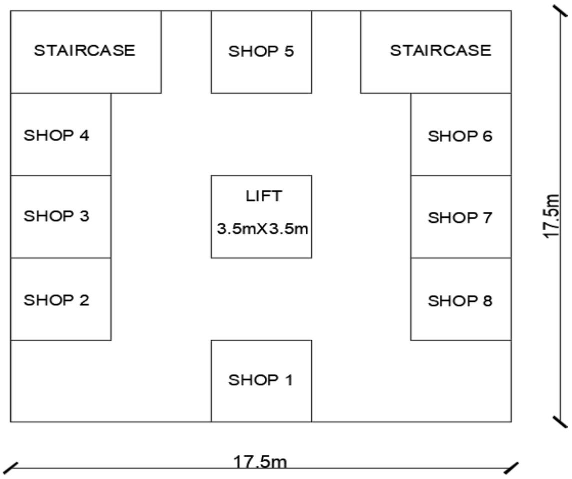
ETABS is Civil Engineering software used in the analysis and design of multistoried building. Software plays an important role in carrying out the seismic calculation of the structural models for the static and dynamic load conditions. ETABS integrates every aspect of the engineering design process. CAD drawings can be exported to ETABS.

1.3 Structural Details

Table -1: Structural details

SI. No.	Description	Parameter
1	No of Storey	G+5
2	Dimension of structure	17.5X17.5m
3	Seismic zone area	IV as per IS 1893-2002
4	Dimension of beam	ISMB300
5	Dimension of column	ISMB400
6	Dimensions of bracings	ISMB200, ISMB450, ISA150X150x150mm, ISMC400
7	Floor to Floor height	3.5m
8	Length of bay	3.5m
9	No of bays	5
10	Base of the structure fixed	

1.4 AutoCAD Plan



1.5 Earthquake load

Table -2: Earthquake load

Earthquake zone	IV
Seismic zone factor	0.24
Silt type	II(Medium)
Eccentricity ratio	0.05

1.6 Load calculations

Time Period:

$$T = \frac{0.09h}{\sqrt{d}}$$

$$= \frac{0.09\times 22.5}{\sqrt{17.5}}$$

= 0.484s along both X and Y directions.

Wall load:

Inside wall = (3.5 – 0.3) × 0.15×19 = 9.12kN/m

Outside wall = (3.5 – 0.3) ×0.012× 24.71

= 0.948kN/m

Parapet wall load:

Load = Density ×Thickness ×Depth

= 25 × 0.15 × 1= 3.75kN/m

Load on lift

Load = (Floor height – beam depth) × wall thickness ×density

= (3.5 – 0.3) × 0.23× 25= 18.4kN/m

Staircase Load

Loads ongoing (on projected plan area)

a. Self-weight of waist-slab

$= 25\times 0.15\times 0.3\times 350.3$

$= 4.1875 kN/m^2$

b. Self-weight of steps

$= 25\times 0.3\times 0.15$

$= 1.125 kN/m^2$

c. Finishes = $1 kN/m^2$

d. Live loads = 0.5 × 5 = $2.5 kN/m^2$

Total load = $8.8125 kN/m^2$

Loads on landing slab

a. Self-weight of landing slab

$= 25\times 0.15 = 3.75 kN/m^2$

b. Finishes = 1kN/m^2

c. Live loads

= 0.5 × 5

= 2.5kN/m^2

Total load = 7.25kN/m^2

1.7 Structural Models

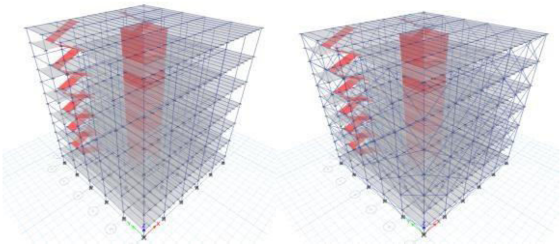


Fig -1: Structural Models

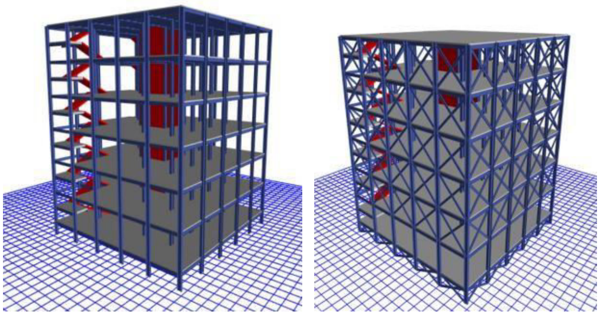


Fig -2: Rendered view

1.7 Analysis

Equivalent Static Analysis

Equivalent Static analysis is the simplest method of analysis. This method is as per IS1893-2002.

In this method of analysis base shear (V_B) is determined by,

$$VB = A_h \times W$$

$$\text{Therefore, } A_h = \frac{ZISa}{2Rg}$$

Where, A_h = Design acceleration spectrum value, using the approximate fundamental natural time period 'T'.

W = Seismic weight of the building.

4. RESULTS

4.1 Manual Calculations

Seismic Weight

Weight of Shear wall = 1358.438kN

Live load on floor = 6431.25kN

Weight of Parapet wall = 262.5kN

Table -3: Seismic weight calculations

Serial No.	Item	Area (m2)	Volume (m3)	Weight (kN)
1	Beam	0.005	8.137	626.689
2	Column	0.010	8.359	643.776
3	Slab	306.25	321.562	8039.063
4	Inside Wall	61.25	110.25	2094.75
5	Outside Wall	306.25	14.7	360.444

4.2 Base shear

$$T = \frac{0.09h}{\sqrt{d}} = \frac{0.09 \times 22.5}{\sqrt{17.5}} = 0.484\text{sec.}$$

Base shear =AhW

$$Ah = \frac{ZISa}{2Rg} = \frac{0.24 \times 1 \times 2.5}{2 \times 5} = 0.06$$

Base shear =0.06×19816.911= 1189.01Kn

Table -3: Base shear along X and Y direction (EQx and EQy) in kN

Type of Bracings	Seismic weight as per IS 1893-2002	Seismic weight as per ETABS Software	Base shear as per IS 1893-2002	Base shear as per ETABS Software
Conventional	19816.91	19269.80	1189.01	1156.188
X-Bracing	20107.55	19535.10	1206.45	1172.1
V-Bracing	20046.49	19476.03	1202.78	1168.56
Inverted V-Bracing	20046.49	19476.03	1202.78	1168.56

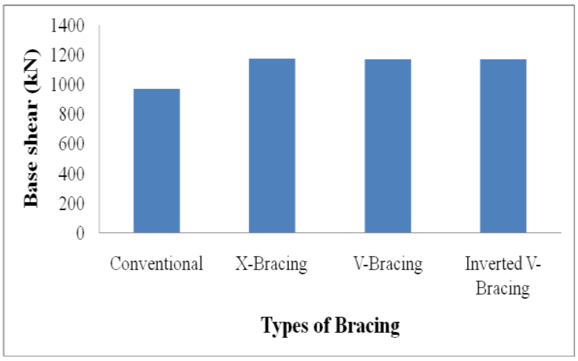


Chart -1: Base shear along X and Y direction (EQx and EQy)

The above graph is plotted based on the results(Table 3) obtained from the ETABS software. As shown in Chart-1

When the seismic weight increases there is an increase in base shear.

4.3 Storey Shear

Table -4: Storey shear along X direction (EQx)in kN

	Conventional	X-Bracing	V-Bracing	Inverted V-Bracing
Base	0	0	0	0
Ground	967.35	1172.08	1168.54	1168.54
Storey1	964.66	1168.85	1165.31	1165.3
Storey2	947.79	1148.50	1145.36	1145.58
Storey3	903.61	1094.67	1092.25	1092.20
Storey4	818.83	991.32	989.94	989.95
Storey5	680.20	822.25	822.28	822.39
Storey6	474.45	571.27	571.55	573.35

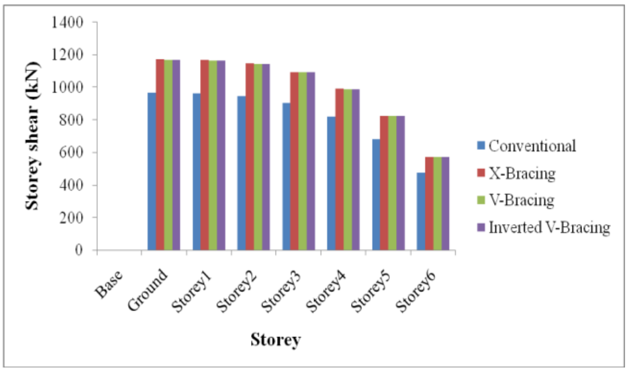


Chart -2: Storey shear along X (EQx) in kN

The above graph is plotted based on the results (Table 4) obtained from the ETABS software. As shown in Chart-2. storey shear decreases with increase in storey height. For X-braced, V-braced and Inverted V-braced structural sysstem, storey shear along X direction increased up to 15% against the conventional structural system.

Table -5: Storey shear along Y direction (EQy)in kN

	Conventional	**X-Bracing**	**V-Bracing**	**Inverted V-Bracing**
Base	0	0	0	0
Ground	812.24	1172.07	1168.53	1168.53
Storey1	809.98	1168.84	1165.31	1165.30
Storey2	795.82	1148.49	1145.36	1145.58
Storey3	758.72	1094.66	1092.25	1092.19
Storey4	687.54	991.32	989.94	989.95
Storey5	571.14	822.25	822.28	822.39
Storey6	398.37	571.27	571.55	573.35

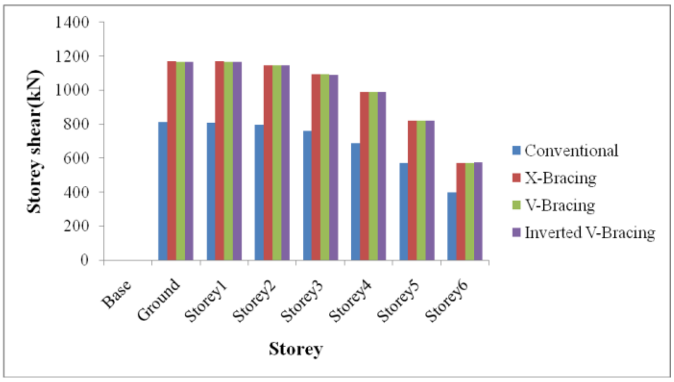


Chart -3: Storey shear Y direction (EQy) in kN

The above graph is plotted based on the results (Table 5) obtained from the ETABS software. As shown in Chart-3. storey shear decreases with increase in storey height. For X-braced, V-braced and Inverted V-braced structural sysstem, storey shear along X direction increased up to 26% against the conventional structural system.

4.3 Storey drift

Table -4: Storey drift along X direction (EQx) in mm

	Conventional	X-Bracing	V-Bracing	Inverted V-Bracing
Base	0	0	0	0
Ground	0.00026	0.0001	0.00013	0.00013
Storey1	0.00077	0.0005	0.00058	0.00057
Storey2	0.00109	0.0002	0.00032	0.00031
Storey3	0.001233	0.0002	0.000345	0.000336
Storey4	0.001242	0.0002	0.000352	0.000341
Storey5	0.001158	0.0002	0.000344	0.000337
Storey6	0000964	0.0002	0.000328	0.000314

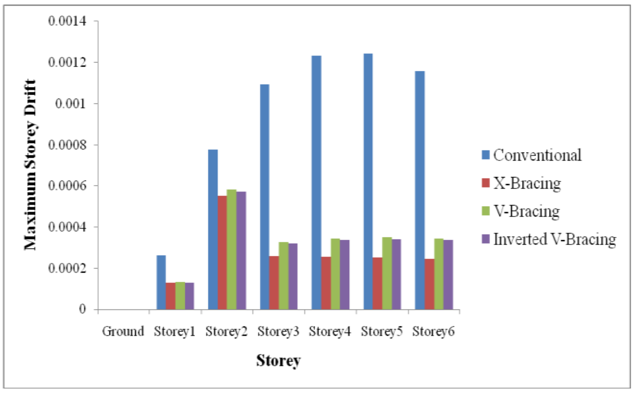


Chart -4: Storey drift along X direction (EQx) in mm

The above graph is plotted based on the results(Table V) obtained from the ETABS software. As shown in Chart-4 storey drift increases with increase in storey height. For X-braced structural sysstem, storey drift along X direction, reduced up to 58% against the conventional structural system.

Table -4: Storey drift along Y direction (EQy)in mm

	Conventional	X-Bracing	V-Bracing	Inverted V-Bracing
Base	0	0	0	0
Ground	0.00023	0.00011	0.00012	0.00011
Storey1	0.00061	0.00042	0.00044	0.00044
Storey2	0.00094	0.00026	0.00035	0.00042
Storey3	0.00116	0.00028	0.00041	0.00048
Storey4	0.00128	0.00028	0.00043	0.00055
Storey5	0.00134	0.00028	0.00042	0.00061
Storey6	0.0013	0.00026	0.0004	0.00042

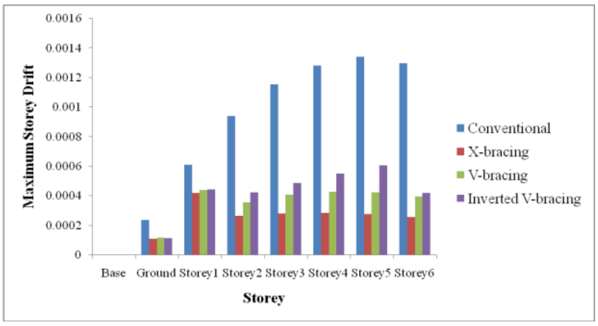


Chart -5: Storey drift along Y direction (EQy) in mm

The above graph is plotted based on the results(Table VI) obtained from the ETABS software. As shown in Chart-5 storey drift increases with increase in storey height. It is observed that the storey drift along Y-direction for X-braced system is reduced up to 58% against the conventional structural system.

The graphs of storey drift, storey shear, base shear are plotted for different bracing sections of X-bracing are as follows

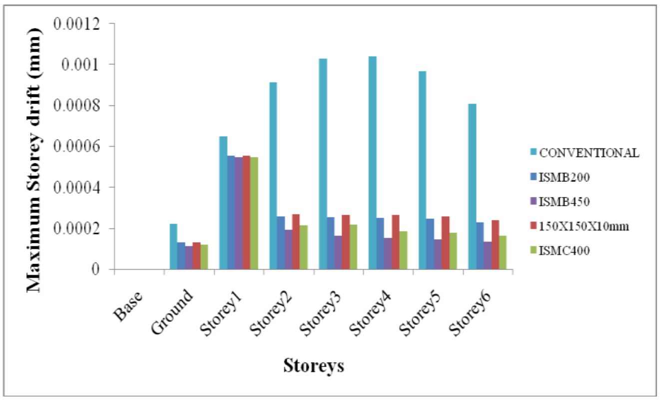


Chart -6: Storey drift along X direction (EQx) in mm

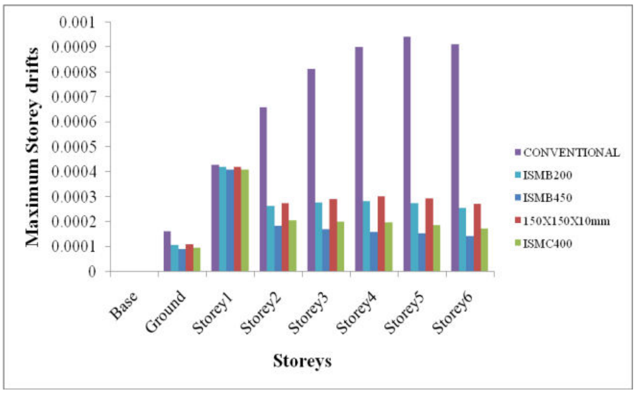


Chart -7: Storey drift along Y direction (EQy) in mm

From chart-6 and chart-7 it is observed that the storey drift for steel structure with ISMB450 is less as compared to that of ISMB200, 150X150X10mm and ISMC400. The Storey drift for X braced building with ISMB450 in X and Y direction is reduced up to 64% and 56% respectively as compared to that of conventional structural system.

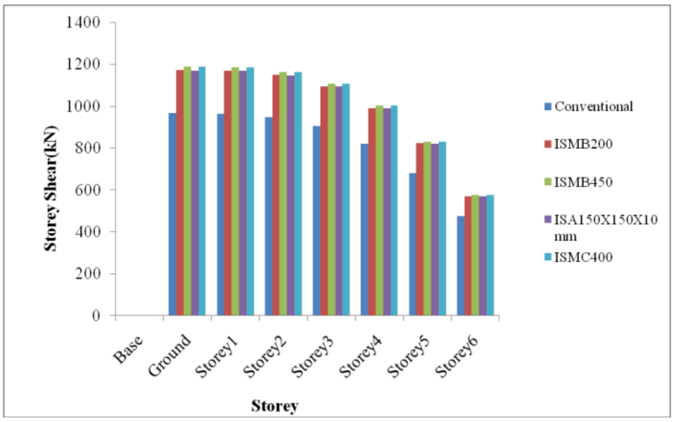


Chart -8: Storey shear along X direction (EQx) in mm

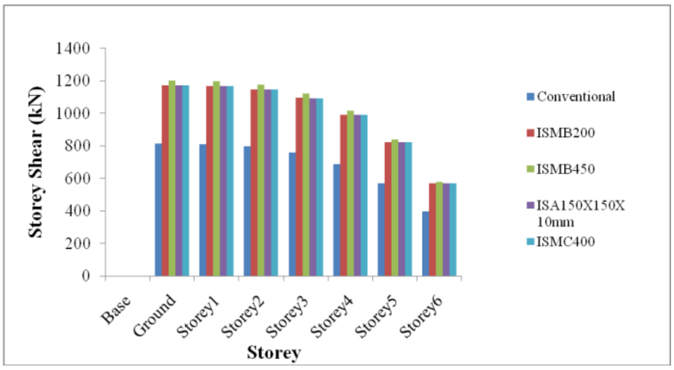


Chart -9: Storey shear along Y direction (EQy) in mm

From chart-8 and chart-9 it is observed that the storey shear for steel structure with ISMB450 is more as compared to that of ISMB200, 150X150X10mm and ISMC400. The Storey shear for X braced building with ISMB450 in X and Y direction is increased up to 16% and 28% respectively as compared to that of conventional structural system.

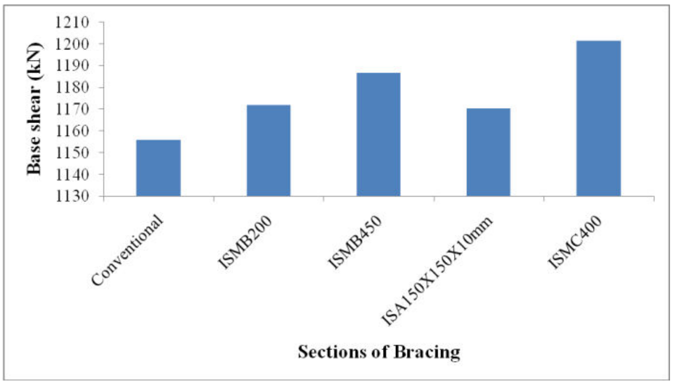


Chart -10: Base shear along X and Y direction (EQx and EQy)

As shown in Chart-10, the base shear value for ISMC400 is more as compared to that of ISMB200, 150X150X10mm and ISMC400 sections.

3. CONCLUSIONS

- Storey drift for the system with X-bracing is reduced by 58.8% in both X and Y direction as compared to that of unbraced system.
- Base shear of the braced frame increases as compared to unbraced system, because the seismic weight of the structure increases.
- The values of storey shear for conventional system is increased up to 15% in X direction and 26 % in Y direction.
- Section ISMB450 is providing good response compare to other sections.

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