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Comparative Study of Concentrically V Braced system and Eccentrically V Braced system for Steel Building

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Abstract - *A Bracing is a system that is provided to minimize the lateral deflection of structure. The members of a braced frame are subjected to tension and compression, so that they are provided to take these forces similar to a truss. One of the alternatives to reduce the damage caused due to the earthquake is adopting structural steel bracings in the structure. These members can be utilized in the building as a horizontal load resisting system to improve the stiffness of the frame for seismic forces. Steel bracing is economical, simple to erect, involves less space and has adaptability to plan for meeting the required strength and stiffness. For understanding the behaviour of bracings, in this paper two types of bracing systems, concentrically v-braced and eccentrically v-braced systems for steel buildings are analysed. The structures were modelled and analysed using ETABS software. Dynamic analysis used for the analysis is response spectrum method. The comparative analysis was carried out for different load cases and load combinations. The results shows that eccentrically v-braced systems was found to be more efficient than concentrically v-braced system*.

Key Words – Etabs, Floating Column, Bracing Systems, Dynamic Analysis, V bracings.

1. INTRODUCTION

Most of the multistory structures are constructed using RCC frame so it's great significance given to build the structure safe in case of lateral load produced due to wind and earthquake. Nowadays, high rise steel frame building is well established in metro cities. Steel frame habitually refers to a building practice with a "skeleton frame" of vertical steel columns and horizontal I-beams, constructed in a rectangular mesh to support the floors, roof and walls of a building which are all attached to the frame. The evolution of this action made the construction of the skyscraper possible. In recent years, studies have been carried out to use steel bracing instead of retrofit R.C. structures; where majority of the studies deal with equipping of concentric steel bracing throughout the structure. Due to their high strength, stiffness and lateral load capacity, steel bracing are an perfect solution for lateral load resisting arrangement in a reinforced concrete structures.

1.2 Braced Frames

Braced frames are known to be efficient structural systems for buildings under high lateral loads such as seismic or wind loadings. Braced frame systems are employed both in RC as well as in steel buildings. The beams and columns that form the frame carry vertical loads, and the bracing system carries the lateral loads.

On a universal basis of resisting earthquake loads, shear walls are frequently used in RC framed buildings, whereas, bracing is most often used in steel structures. Braced frames reduce lateral displacement, as well as the bending moment in columns. Steel bracing is economical, easy to erect, occupies less space and has flexibility to design for meeting the required strength and stiffness. The main advantage of using braces is that they dissipate the energy without damaging the building and also it can be replaced without any difficulty when it gets damaged.

1.3 Types of Bracings

There are two types of braced frames which are concentrically braced frames and eccentrically braced frames.

1.4 Concentrically braced frames

CBFs are traditionally designed braced frames in which the centre lines of the bracing projections cross at the main joints in the structure, thus reducing surplus moments in the frame.

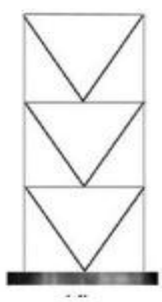

Fig-1 Concentrically V braced frame

1.5 Eccentrically braced frames

In EBFs, some of the bracing members are arranged so that their ends do not meet concentrically on a main member, but are separated to meet eccentrically.

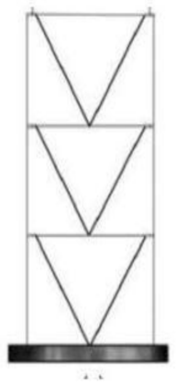

Fig-2 Ecentrically V braced frame

2. Objectives

1. Comparison of concentrically braced V type and eccentrically based V type for Base Shear.
2. Comparison of concentrically braced V type and eccentrically based V type for Story Drift.
3. Comparison of concentrically braced V type and eccentrically based V type for Story Displacement.
4. Comparison of concentrically braced V type and eccentrically based V type for Story Shear.
5. Comparison of concentrically braced V type and eccentrically based V type for Bending Moment for various load combinations.
6. Comparison of concentrically braced V type and eccentrically based V type for Shear Force for various load combinations.
7. Comparison of concentrically braced V ype and eccentrically based V type for Axial Force for various load combinations.

3. Methodology

G+15 Story structure was considered for the analysis. Various parameters used to evaluate the effect of floating column are given in the table below.

Table-1 Structural Specification

Type of Building	Commercial
No. of Storys	G+15
No. of staircase	1 in each floor
Height of each Story	3 m
Thickness of Wall	230 mm
Number of bays in X-Direction	10
Number of bays in Y-Direction	6
Type of Support	Fixed

3.1 Sectional Properties

Table-2 Sectional properties

Sl. No.	Type	Dimensions (mm)	Material
1.	Beam	ISWB 500	FE345
2.	Column	ISWB 600 (1st floor to 5th floor)	FE345
		ISWB 550 (6th floor to 10th floor)	FE345
		ISWB 500 (11th floor to 15th floor)	FE345
3.	Braces	Concentrically Braced, ISHB 450	FE345
		Eccentrically Braced, ISHB 450 (0.8m eccentricity at both ends)	
4.	Slab	200 (Deck)	Deck
4.	Float Glass	50	Glass

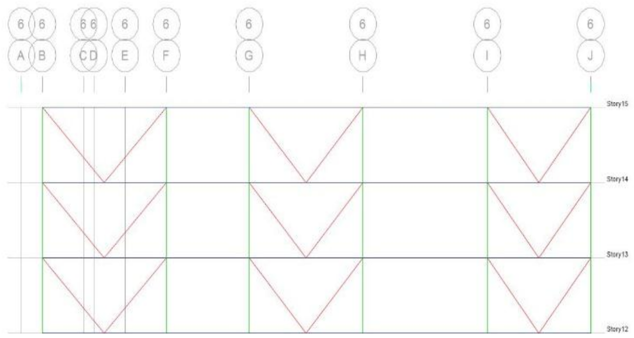

Fig-3 Concentrically V Braced System

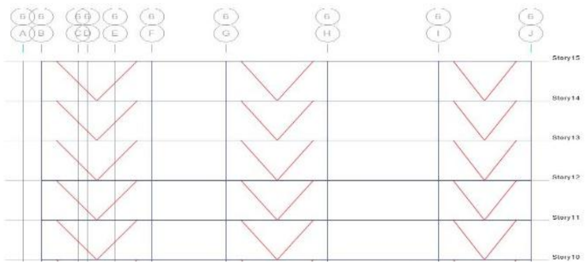

Fig-4 Eccentrically V Braced System (0.8 m eccentricity on both sides)

3.2 Load Patterns

Table-3 Load pattern

Sl. No.	Type of load	Pattern Type	Intensity
1.	Dead	Dead	Programm Determined
2.	Live	Live	2.5 kN/m²
3.	Floor Finish	Super dead	1.5 kN/m²
4.	Wall Load	Super dead	12 kN/m²
4.	Earthquake Loads	Seismic	Zone IV
5.	Wind load	Wind	47 m/s

3.3 Load Combinations

Different types of load combination were considered for the analysis of dome. Load combinations are considered as per IS 875 Part III and IS 1893-2002.

Table-4 Load combinations

Sl. No	Combination	Load combinations for Steel Structure
1.	Combo 1	1.7 (DL+LL)
2.	Combo 2	1.7 (DL+EQ)
3.	Combo 3	1.7 (DL+WL)
4.	Combo 4	1.4 (DL+LL+EQ)
5.	Combo 5	1.4 (DL+LL+WL)

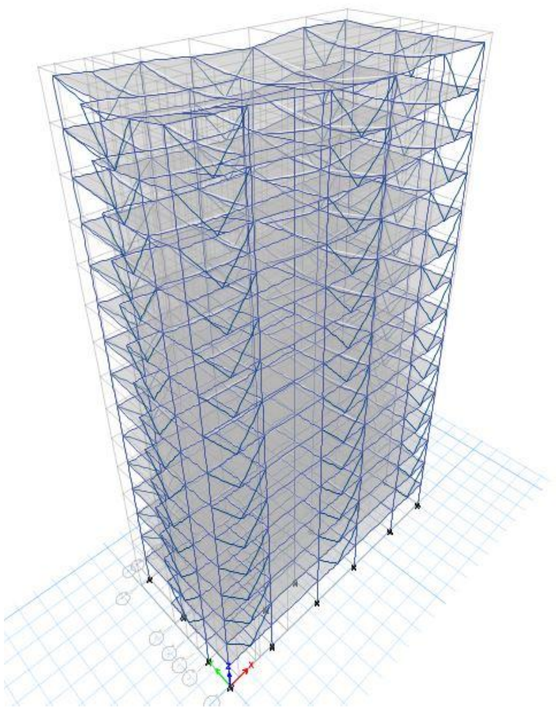

Fig-5 Analysed structure.

4. Results

The results of the analysis of structure with concentrically V braced system and eccentrically V braced system for steel structure are discussed. The results include Base Shear, Story Drift, Story Displacement, Story Shear, Bending Moment, Shear Force and Axial Force.

4.1 Seismic Base Shear

Base shear is an approximate of the maximum awaited lateral force that will transpire due to seismic ground motion at the base of the structure. In a multi-Story building, all vibration systems of the building forward to the base shear.

Table-5 Base shear foe Seismic loads

Sl. No	Seismic Load	Conc. V Bracing (kN)	Ecc. V Bracing (kN)
1.	EQ – X	1676.9733	1632.269
2.	EQ - Y	1151.9965	1121.4302

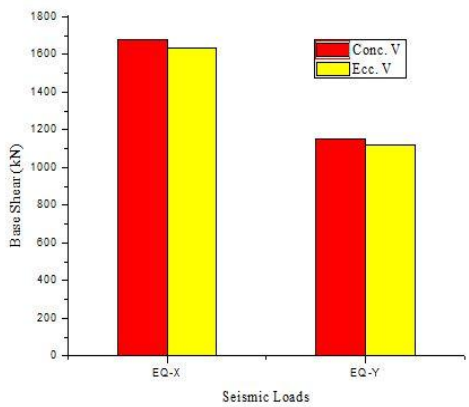

Chart-1 Base shear for seismic loads

4.2 Story Drift

Story Drift is generally defined as the lateral displacement of one floor relative to the floor below. The greater the drift, greater the damage. Values larger than 0.025 indicates serious issue to cause damage to human life.

Table-6 Story drift for EQ - X

Story	Seismic Load	Conc. V Bracing (mm)	Ecc. V Bracing (mm)
15		0.000956	0.000932
14		0.001191	0.001159

13		0.00136	0.001324
12		0.001456	0.001417
11		0.001508	0.001468
10		0.001389	0.001352
9		0.001363	0.001327
8		0.001331	0.001296
7		0.001287	0.001253
6		0.001236	0.001203
5		0.001039	0.001012
4		0.000981	0.000956
3		0.000959	0.000934
2		0.000977	0.000951
1		0.001263	0.001237

Table-7 Story drift for EQ - Y

Story	Seismic Load	Conc. V Bracing (mm)	Ecc. V Bracing (mm)
15		0.001118	0.001088
14		0.001171	0.001141
13		0.001402	0.001365
12		0.001632	0.001588
11		0.001805	0.001757
10		0.001798	0.00175
9		0.001865	0.001815
8		0.001907	0.001856
7		0.001921	0.00187
6		0.001905	0.001854
5		0.001737	0.00169
4	EQ - Y	0.001685	0.00164
3		0.001605	0.001562
2		0.001406	0.001369
1		0.001571	0.00153

4.3 Story Displacement

Displacements, the expansion to which a structural element progresses or bends under strain is the main serviceability anxiety in the structures. The value of maximum roof displacement is a straight and logical measure used to valuate the overall displacement response of a building. If the value of the inter-story displacement for each story is the same as the value of the roof displacement divided by the number of stories, the structure deforms uniformly.

Table-8 Story displacement for EQ - X

Story	Seismic Load	Conc. V Bracing (mm)	Ecc. V Bracing (mm)
15		50.01	48.682
14		47.744	46.475
13		44.544	43.36
12		40.753	39.672
11		36.629	35.659
10		32.339	31.481
9		28.361	27.611
8		24.405	23.76
7		20.516	19.974
6		16.745	16.303
5		13.207	12.858
4		10.205	9.936
3		7.356	7.162
2		5.281	5.144
1		3.808	3.711

Table-9 Story displacement for EQ - Y

Story	Seismic Load	Conc. V Bracing (mm)	Ecc. V Bracing (mm)
15		70.001	68.124
14		67.628	68.815
13		64.282	62.559
12		60.075	58.465
11		55.179	53.702
10	EQ – Y	49.772	48.44
9		44.381	43.193
8		38.785	37.748
7		33.065	32.181
6		27.305	26.575
5		21.61	21.033
4		16.404	15.966
3		11.395	11.091
2		7.189	7.000
1		4.935	4.805

4.4 Story Shear

It is defined as the ratio of story collapse to the story shear force when total collapse transpires. Through a string of dynamic analyses, effortless equations are prepared to calculate the necessary story shear safety factor that can be used to avert collapse of building.

Table-10 Story shear for EQ - X

Story	Seismic Load	Conc. V Bracing (kN)	Ecc. V Bracing (kN)
15		302.00	276.00
14		567.00	518.00
13		796.00	728.00
12		991.00	906.00
11		1155.00	1056.00
10		1290.00	1180.00
9		1400.00	1280.00

8		1487.00	1359.00
7		1553.00	1420.00
6		1602.00	1465.00
5		1636.00	1496.00
4		1658.00	1516.00
3		1670.00	1527.00
2		1676.00	1532.00
1		1677.00	1533.00

Table-11 Story shear for EQ - Y

Story	Seismic Load	Conc. V Bracing (kN)	Ecc. V Bracing (kN)
15	EQ - Y	207.00	202.00
14		389.00	380.00
13		547.00	534.00
12		681.00	665.00
11		793.00	775.00
10		886.00	866.00
9		962.00	939.00
8		1021.00	998.00
7		1067.00	1042.00
6		1101.00	1075.00
5		1124.00	1098.00
4		1139.00	1113.00
3		1147.00	1121.00
2		1151.00	1124.00
1		1152.00	1125.00

4.5 Bending Moment

The results of analysis for maximum bending moments are tabulated in below tables and their variations are plotted in figures below.

Table-12 Maximum bending moment for conc. and ecc. V braced structure

Sl.No	Load Combination	Maximum bending moment for conc. V, Mz (kN-m)	Maximum Bending Moment for ecc.V, Mz (kN-mm)
1.	Combo 1	581.6424	554.1562
2.	Combo 2	483.1679	456.1638
3.	Combo 3	501.0045	473.5189
4.	Combo 4	464.3106	442.0715
5.	Combo 5	478.9996	456.364

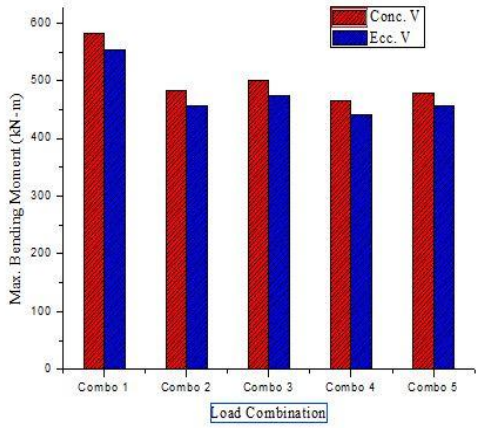

Chart-2 Maximum bending moment for Conc. V and Ecc. V.

4.6 Shear Force

The results of analysis for maximum shear forces are tabulated in below tables and their variations are plotted in figures below.

Table-13 Maximum shear force for conc. V and ecc. V braced structure

Sl.No	Load Combination	Maximum Shear Force for conc. V, Fy (kN)	Maximum Shear Force for ecc. V, Fy (kN)
1.	Combo 1	711.308	677.7207
2.	Combo 2	641.8101	607.5974
3.	Combo 3	612.7652	579.1782
4.	Combo 4	608.9763	580.8009
5.	Combo 5	585.783	558.1229

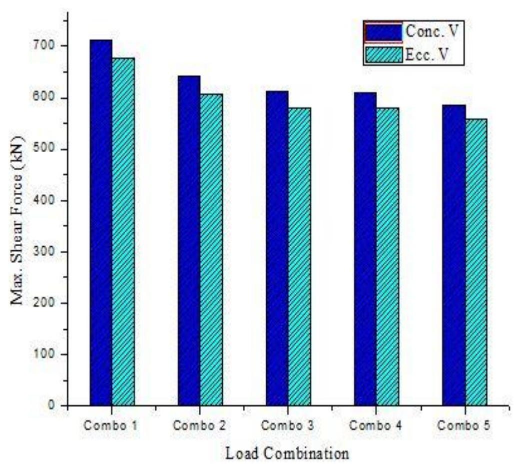

Chart-3 Maximum shear force for Conc. V and Ecc. V.

4.7 Axial Force

The results of analysis for maximum axial forces are tabulated in below tables and their variations are plotted in figures below.

Table-14 Maximum axial force for conc. V and ecc. V braced structure

Sl.No	Load Combination	Maximum Aial Force for conc. V, Fx (kN)	Maximum Axial Force for ecc. V, Fx (kN)
1.	Combo 1	15770	15038
2.	Combo 2	13740	13004
3.	Combo 3	13621	12888
4.	Combo 4	13086	12480
5.	Combo 5	12988	12384

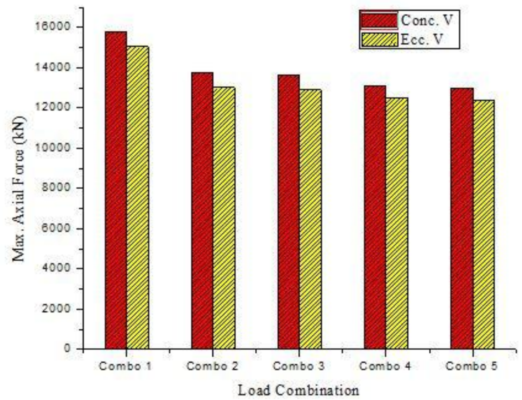

Chart-4 Maximum axial force for Conc. V and Ecc. V.

5. Conclusions

1. Base Shear for Conc. V braced frame is more than Ecc. V braced frame because the weight of the Conc. V braced is more than the Ecc. V braced frame. Base shear gets reduced by 3% for Ecc. V braced.
2. Story drifts for earthquake load both in X-direction and Y-direction are more for Conc. V braced frame when compared to Ecc. V braced frames. Story drift for Conc. V braced structure is 3% more when compared to Ecc. V braced structure.
3. Story displacement was found to be lesser for Ecc. V braced structure when compared to Conc. V braced structure. There was a 3% reduction in Story shear for Ecc. V braced when compared to Conc. V braced structure.
4. Story shear for earthquake load in X-direction and Y-direction are more for Conc. V braced structure. The results were found that for X-direction Conc. V brace has 9% more Story shear and for Y-direction Story shear has 3% more when compared to Ecc. V braced structure.
5. Bending moment for Conc. V braced structure was found to be more than Ecc. V braced structure. Maximum bending for Conc. V braced structure was found to be 5% more and minimum bending moment of 5% when compared with Ecc. V braced structure.
6. Shear force for Conc. V braced structure was found to be more than Ecc. V braced structure. Maximum shear for Conc. V braced structure was found to be 5% more and minimum shear of 5% when compared with Ecc. V braced structure.
7. Axial force for Conc. V braced structure was found to be more than Ecc. V braced structure. Maximum axial Conc. V braced structure was found to be 5% more and minimum axial force of 5% when compared with Ecc. V braced structure.

References

1. **Dhanaraj M. Patil, Keshav K. Sangle,** Seismic Behaviour of Different Bracing Systems in High Rise 2-D Steel Buildings, (ELSEVIER) The Institution of Structural Engineers 8 (2015) 2352-0124.
2. **Somil Khattar, K. Muthumani,** Seismic Performance of Reinforced Concrete Frame with Steel Bracing System, Recent Technology and Engineering 3 (2019) 2277-3878.
3. **Anes Babu, Dr. Chandan Kumar Patnaikuni, Dr. Balaji, K.V.G.D., B.Santhosh Kumar,** Effect of Steel Bracings on RC Framed Structure, Journal of Mechanics and Solids 1 (2017) 0973-1881.
4. **Shih-Ho Chao, Netra B. Karki, Dipti R. Sahoo,** Seismic Behavior of Steel Buildings with Hybrid Braced Frames, Journal of Structural Engineering (ASCE) 139 (2013) 1019-1032.
5. **Md. Ahasan – ul – Haque, Md. Atik Masum, Md. Muhtadi Ratul, Zasiah Tafheem,** Effect of Different Bracing Systems on the Structural Performance of Steel Building, Journal of Engineering and Technology 1 (2018) 2395-0056.
6. **Krishnaraj R. Chavan , H.S.Jadhav,** Seismic Response of R C Building With Different Arrangement of Steel Bracing System, Engineering Research and Applications 7 (2014) 2248-9622.
7. **Anusha K, Raghu K,** Analysis of Braced Frame Multi Storied Structure with Different Angles as Per Indian Standards, Journal of Engineering and Technology 5 (2018) 2395-0056.
8. **S.M. Razak ,T.C. Kong, N.Z. Zainol, A. Adnan, M. Azimi,** A Review of Influence of Various Types of Structural Bracing to the Structural Performance of Buildings, E3S Web of Conferences 34 (2018).
9. **Harshitha M K, Vasudev M V,** Analysis Of Rc Framed Structure With Structural Steel Braces

Using Etabs, Journal of Engineering and Technology 1 (2018) 2395-0056.
10. **M. R. Maheri, A. Sahebi,** Use of steel bracing in reinforced concrete flames, Engineering Structures (ELSEVIER) 12 (2007) 1018-1024.
11. **G.Hymavathi, B. Kranthi Kumar, N.Vidya Sagar Lal,** Performance of High-Rise Steel Building With and Without Bracings, Journal of Engineering Research and Applications 11 (2015) 2248-9622.
12. **Safvana P, Anila S,** Seismic analysis of Braced RCC structures using ETABS software, Journal of Advance Research, Ideas and Innovations in Technology 2 (2018) 2454-132X.
13. **K.K.Sangle, K.M.Bajoria, V.Mhalungkar,** Seismic Analysis of High Rise Steel Frame Building with and without Bracing, WCEE (2012).
14. **IS 1893-2002** Indian standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standard New Delhi.
15. **IS-800-2007** Indian standard code practice for general construction in steel, Bureau of Indian standard New Delhi.

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