ANALYSYS AND DESIGN OF VARIOUS BRACING SYSTEM IN HIGH RISE STEEL STRUCTURES.

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ABSTRACT

Steel structures can be strengthened in various types, to resist the lateral forces coming on the structure. In steel buildings, the most widely used method of constructing lateral load resisting system is using braced frames. These systems help the structure to reduce the buckling of columns and beams and the stiffness of the structure is increased. Hence, the main concern while analyzing steel structure is to select the appropriate bracing model and to decide the suitable connection type. The steel bracings are also used in retrofitting to give maximum strength to the structure. In this study, the behavior of the bracing system is analyze by using different types of bracing systems e.g. X bracing, V bracing, Inverted V bracings, Knee bracings. These bracings are analyzed and designed by using STAAD. Pro V8i software. For this analysis the G+9 storey building with different bracing system has been analyzed and designed as per Indian Standard Code 800-2007 by using UC and UB (British) sections for the wind, earthquake and gravity loads also their combinations.

Keywords - Bracing System, Steel structures, X bracing, V bracing, Inverted V bracings, Knee bracings.

I INTRODUCTION

The High rise steel structures are now a day's very popular because of the ease of erection and high strength-weight ratio. The stability of the high rise structures from the lateral loads like wind and earthquake is important. The structure can be stabilizing by using the bracing system, moment resisting connections, and also a shear wall. But the mostly favourable type to resist these lateral loads is bracing system in steel structure. The suitability of the bracing system is depends upon the behaviour of the bracing to the lateral loads act on the structure. The IS 1893:2002 is used for the earthquake load calculation. For wind load calculation I.S 875:1984 is used. The structure is designed by using IS 800:2007 for Limit State method of design.

II STEEL BRACING SYSTEM

Bracing is a highly efficient and economical method to laterally stiffen the frame structures against wind and other lateral 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.

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2.1 Types of Bracings

2.1.1 Concentrically Braced Frames (CBFs): Concentrically braced frames (CBFs) (Fig.1) having simple connections, it is assumed that the centroidal axes of the members meet at a common point at each joint and so the members carry essentially axial loads.

2.1.1.1 X-Bracing : This is the most economical and efficient forms of bracing. When the cross bracing (Fig.1 (a)) is used, lateral force from one direction induces tension in one member while the other brace is in tension when the force is reversed. Therefore, if two diagonals are used, in the form of cross-bracing, they only need to resist tension. When one brace is in tension, compression is induced in the other.

2.1.1.2 Diagonal Bracing; In diagonal only a single diagonal member is used. This member is designed to resist both, tension as well as compression caused by lateral forces acting in both directions on the frame. Single bays of diagonal braces (Fig. 1(b) and (c)) respond differently according to the direction of loading. Configuration (b) may be much weaker and flexible in the direction causing compression in the braces, while configuration (c) will be weaker and more flexible in the storeys with compression braces, leading to the possibility of soft-storey formation.

2.1.1.3 V Bracing: The V-braced arrangements of Fig. 1(d) and (e) suffer from the fact that the buckling capacity of the compression brace is likely to be significantly less than the tension yield capacity of the tension brace. Thus there is inevitably an out-of balance load on the horizontal beam when the braces reach their capacity, which must be resisted in bending of the horizontal member. This restricts the amount of yielding that the braces can develop, and hence the overall ductility.

2.1.1.4 K Bracing: The same out-of-balance force applies to K-braces (Fig. 1(f)) when the braces reach their capacity, but this time it is a much more dangerous horizontal force applied to a column – dangerous because column failure can trigger a general collapse. For this reason, K-braces are not permitted in seismic regions by the code because of the inelastic deformation and buckling of K bracing member may produce lateral deflection of connected columns, causing collapse of structure.

The K bracing and diagonal bracings is not considered in this study due to its instability for given load conditions and geometry.

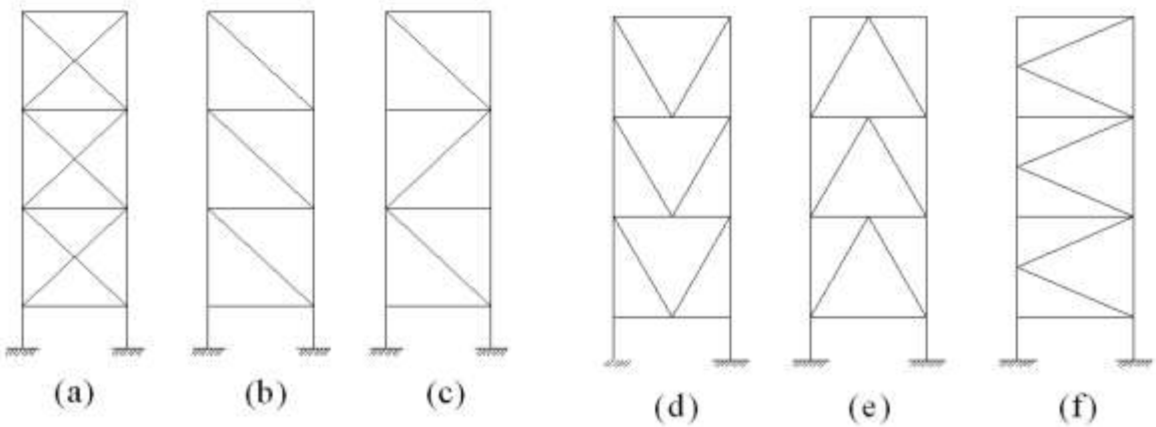

Fig 1: Examples of bracing schemes for concentrically braced frames:
(a) X braced (b) diagonally braced (c) alternative diagonally braced (d) V braced
(e) Inverted V braced and (f) K braced

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2.1.2 Eccentrically Braced frames (EBFS)

In Eccentrically Braced Frames (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. The eccentric link element between the ends of the braces is designed as a weak but ductile link which yields before any of the other frame members. It therefore provides a dependable source of ductility and, by using capacity design principles, it can prevent the shear in the structure from reaching the level at which buckling occurs in any of the members. Arrangements such as (a) and (b) in Fig 2 also have architectural advantages in allowing more space for circulation between bracing members than their concentrically braced equivalent. An alternative arrangement with similar characteristics is the knee-braced frame.

2.1.2.1 Knee-braced frame The yielding element here is the 'knee brace', which remains elastic and stiff during moderate earthquakes, but yields to provide ductility and protection from buckling in extreme events. Unlike the link in the EBF, the knee brace does not form part of the main structural frame, and could be removed and replaced if it is damaged in an earthquake.

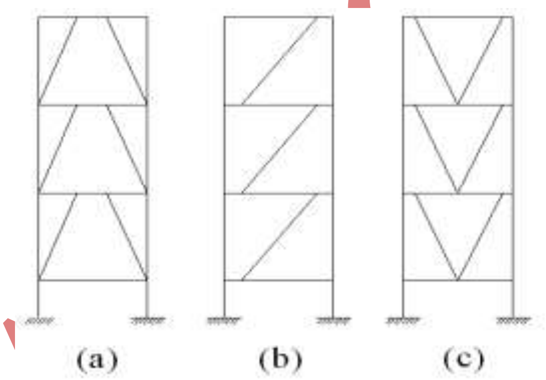

Fig 2: Examples of bracing schemes for eccentrically braced frames: (a) Knee braced ;(b) eccentric diagonal braced; (c) V braced.

. III PROBLEM MODELLING

TABLE 1: Problem Statement for analysis

Parameter	Un-braced Structural System	Braced Structural System
1. Geometry Details		
Plan Dimension	30X12 m	
Height of Structures	35 m	
Number of bays in X direction	5	
Number of bays in Z direction	2	
Width of Bay in X direction	6 m	
Width of Bay in Z direction	6 m	
Height of each Storey	3.5 m	
Type of connection in Main Beam and column in X Direction	Moment Connection	Shear Connection
Type of connection in Main Beam and column in Z Direction	Moment Connection	Shear Connection

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Support Conditions	Fixed Support	Pinned support
Bracing	Not Applicable	Various Types
2. Section Properties Used		
Column	UC sections from British code	
Beam	UB sections from British code	
Bracings	Not applicable	UC sections
3. Primary Load cases		
Dead Load		
a. Self Weight	Applied in Y-1 direction	
b. Cladding load	10 kN/m UDL all over periphery	
c. Floor Load of deck slab	5 kN/m^2 assuming 200 mm thick deck slab	
Live Load		
a. Floor Load for office building	2.5 kN/m^2	
Earthquake Parameters		
a. Earthquake Code	IS 1893: 2002	
b. Seismic Zone	III	
Parameter	**Un-braced Structural System**	**Braced Structural System**
c. Importance Factor	1	
d. Response Reduction	5	4
e. Soil Parameter	Medium Soil	
f. Damping ratio	2 % for steel structure	
Wind Load Parameters		
a. Basic Wind Speed V_b	39 m/s For Pune region.	
b. k_1 = For category 3 Class one.	1	
c. k_2 = terrain, height and structure size factor.	Varies as per floor	
d. k_3= topography factor.	1	

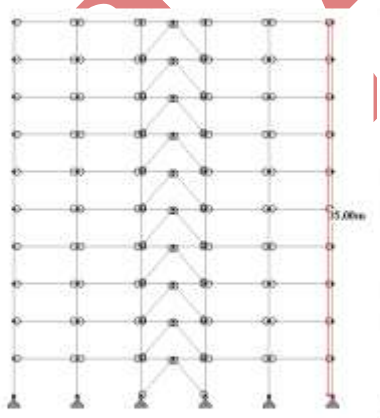
Fig.4.1 Inverted V bracing.

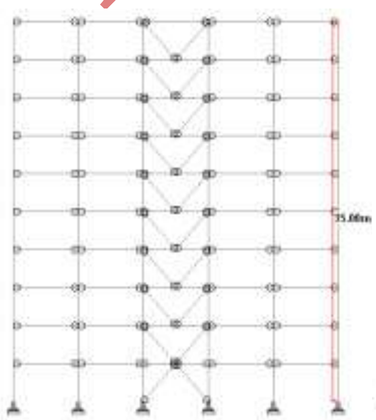
Fig.4.2 V bracing.

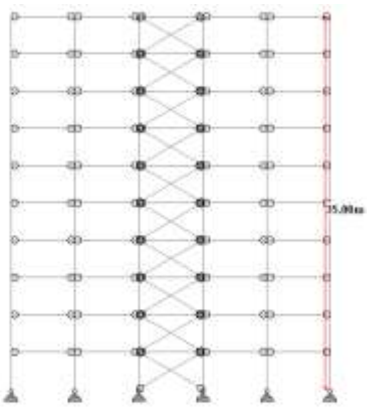
Fig.4.3 X bracing.

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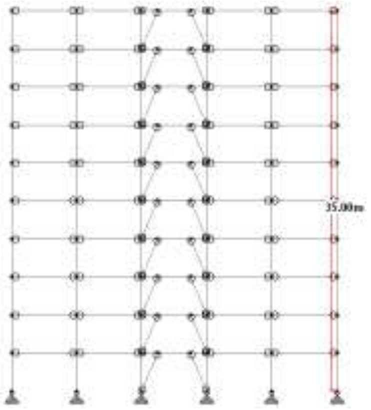


Fig.4.4 Knee bracing.

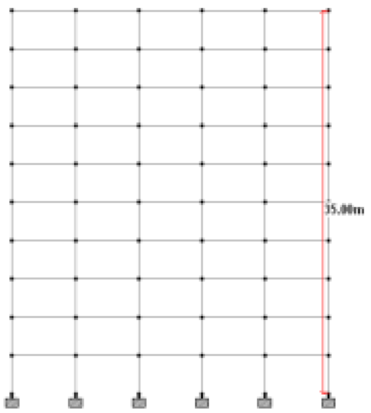


Fig.4.5 Moment resisting frame

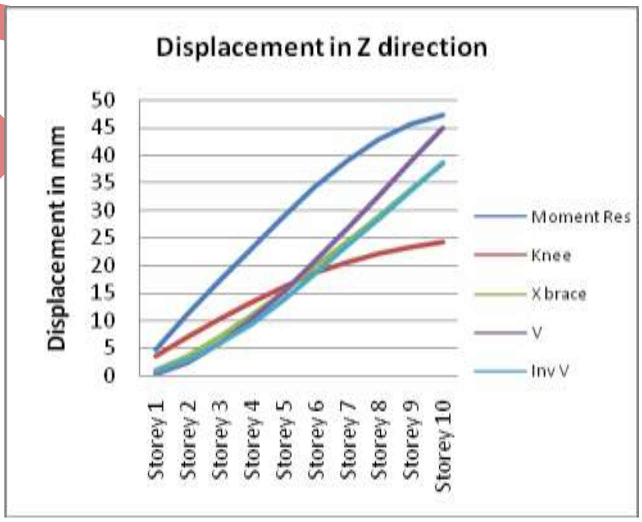
Fig .4: Models of Various structures

IV RESULT AND DISCUSSIONS

The results for the storey displacement and total weight analysis are based on the loads and their combinations as per IS 800 – 2007.The results are taken from output file of STAAD Pro. V8i software.

4.1Storey displacement

Graph 2 : Storey displacement in X direction



Graph 3 : Storey displacement in Z direction

TABLE 2 : Storey displacement in X

	Moment Res.	Knee brace	X brace	V brace	Inv V brace
Storey 1	4.777	6.01	2.433	1.124	1.524
Storey 2	11.146	12.944	5.508	3.838	3.932
Storey 3	17.512	20.693	9.451	8.417	7.22
Storey 4	24.375	28.938	14.173	14.369	11.289

TABLE 3 : Storey displacement in Z

	Moment Res	Knee brace	X brace	V brace	Inv V brace
Storey 1	4.779	3.535	0.942	0.237	0.743
Storey 2	11.194	7.016	3.606	2.278	2.885
Storey 3	17.303	10.313	7.062	5.897	5.91
Storey 4	23.147	13.373	10.997	10.258	9.463

Storey 5	30.992	37.5	19.549	21.129	16.305
Storey 6	37.158	46.736	25.41	28.4	21.806
Storey 7	42.813	55.552	31.568	36.054	27.56
Storey 8	50.029	63.357	37.824	43.814	33.612
Storey 9	55.517	69.854	43.977	51.387	39.437
Storey 10	58.884	74.332	49.858	58.56	**44.764**

Storey 5	28.859	16.132	15.277	15.232	13.814
Storey 6	34.269	18.55	19.749	20.657	18.548
Storey 7	38.819	20.589	24.322	26.509	23.498
Storey 8	42.933	22.205	28.989	32.629	28.542
Storey 9	45.665	23.377	33.763	38.84	33.623
Storey 10	47.233	**24.22**	38.512	44.995	38.693

From the above results it is clear that the displacement in X direction (longer dimention) is maximum for the Knee bracing and minimum for the Inverted V bracing as shown in graph 2 and table 2. In Zdirection (shorter dimention) the displacement in knee bracing is less than other and moment resisting structure have more displacement as shown in graph 3 and table 3.All displacements are within permissible limits.

Weight of Structure

The TABLE. 4 shows the total weight of the structure after design of the members.

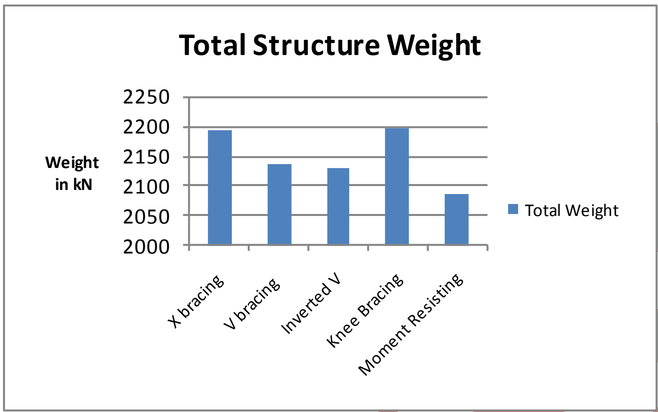


TABLE 4 : Total weight of structure

Type of structure	Total Weight in (kN)
X bracing	2191.9
V bracing	2137.3
Inverted V	2131.4
Knee Bracing	2196.9
Moment Resisting	2086.0

Graph 5 : Graph showing total weight of structure in kN.

As shown in above graph 5 the total weight of the members in the moment resisting structure is less.The moment resisting structures are not prefferd for the high rise building [11].In the case of bracing system the Inverted V braced frame have less weight as compare to other braced frame

V CONCLUSION

1. The resultant storey displacement of Inverted V bracing frame is less as compare to other bracing systems hence it is Inverted V bracing better in the stiffness than other.
2. The weight of the Inverted V bracing is also less than others, hence it is economical.
3. By using the Inverted V bracing it possible to accommodate required openings such as for windows and doors which are very difficult in some other bracing system like X bracing, because X-bracings run across the entire wall area.

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