Comparative Study of Different Bracing Systems for Irregular High Rise Steel Structure

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Abstract—The civil Engineering industry particularly in India has taken a new mode in construction of high rise structures. High rise structures became a need and new trend to accommodate the people's requirements. As steel structures can be fabricated and erected in no-time compared to R.C.C structures, modern technologies and construction industries are focusing towards the construction of high rise structures using steel. In designing the high rise structures, the effect of lateral loads like wind and earthquake forces are attaining increasing importance and stability against lateral loads because of high height of buildings. For this reason in0recent years wind and earthquake loads have become0determining factors in designing tall structures To attain the resistance against these lateral loads, bracing system is used with different patterns. Bracing system are such structural system which0form an integral part0of frame. The structure has to0be analysed before0arriving the best type0or effective arrangement0of bracing. A 20 storied, irregular 3D framed structure with 3m each story depth is selected for the present study. The columns and beams are designed0to withstand dead load and live load0adequately. The bracings are designed to withstand against lateral load coming in that particular stories. For better results, the various forms of bracing systems are analysed using STAAD Pro software. An attempt has been made to study the behaviour of high rise steel structures for lateral loads by considering Knee and Y bracing systems and also for other bracing systems like X brace, V brace and combination of X and Y braces. Various models thus generated were analysed for different zones, different wind speeds and compared with unbraced0reference model with respect0to criteria's like base shear, axial force, bending moment, shear force, drift index,0inter story drift and also to have maximum0reduction in inter storey0drift and drift index0per unit quantity0of steel consumed for0bracing configuration which0improves the lateral load0resisting capacity of the tall structures.

Key words: Base Shear, Lateral Displacement, Seismic Analysis, Bracing, Story Drift, Drift Index, etc

I. Introduction

As we know in western countries steel structures are widely used because of its high strength ductility properties which reduces the construction time. The lateral stiffness is the main concern about high rise steel structures. The resistance to lateral loads like earthquake and wind forces is the reason for the evolution of various structural systems. The steel is having less weight as compared to reinforced concrete structures so which reduces the dead load coming on the footings. The size of frame members are less as compared to R.C structures which gives more space inside the building. In these days, structural design engineers were finding it difficult to increase the height of the structures while restricting the deflection within limiting value. Using improved technology, advanced materials, and innovative concepts, structural forms have advanced a lot form very basic traditional type of construction. In steel structures we know many type of frames such as rigid and simple frames. In rigid frames, beams and columns are joined together with moment resisting connections and bracing are usually provided in between the beams and columns to increase their resistance against the lateral forces. In these rigid braced structural frames, angle between the members doesn't changes even after the loadings. These rigid connections do not allow any relative rotations at the joints of the members. Design of tall structures requires a consideration of strength to bear the vertical loads and stiffness to resist the lateral loads. When a structure is subjected to natural wind for few minutes to hour then a wind speed would produce a static force on a structure. To provide the stiffness against lateral loads various bracing systems can be used in the structure and the design engineer should analyse all the bracing systems before selecting the suitable one. Thus it is an important priority for a good structural design engineer to select the best and economical bracing system for the high rise steel structures.

II. Objectives

The following objectives were identified for the present study;

1) To review the commonly used bracing systems for high rise steel structure and to summarize the typical best type of bracing system for tall structures.
2) To study the effect of different bracing systems used in high rise steel structures by creating three dimensional finite element model using STAAD Pro software. For the present study, following type of bracing systems are used;
   – X-Bracing systems/Cross-Bracing system.
   – Inverted V-Bracing system.
   – Y-Bracing system.
   – Knee-Bracing system.
   – Combination of X and Y Bracing system.
3) To evaluate the amount of steel consumed for the different bracing patterns to resists the lateral load on the tall structures.
4) To study the variation in axial load, base shear, bending moment and shear force by using different type of bracing systems in high rise steel structures.
5) To evaluate the results from the analysis and comparison is made with unbraced reference model to base shear, drift index, inter story drift and also to have maximum reduction in inter storey drift and drift index per unit quantity of steel consumed for bracing configuration

which improves the lateral load resisting capacity of the tall structures.

III. METHOD OF ANALYSIS

A. The Present Study Done For the Below Mentioned Analysis

- Equivalent static analysis Method
- Wind load analysis method.

IV. PARAMETRIC STUDY

A tall steel structure with 20(G+19) story of dimension 30mx30m has been considered for the present study. Five types of bracings were compared with unbraced reference model. Bracing patterns considered for the study are;

- Model-1 : Knee bracing system.
- Model-2 : Inverted V bracing system.
- Model-3 : X bracing system/cross bracing system.
- Model-4 : Y bracing system.
- Model-5 : Combination of X and Y bracing system.

These above mentioned models were analysed and compared with unbraced reference model by equivalent static and wind load analysis method.

V. DATA CONSIDERED FOR MODELLING

Constant parameters	
1) Type of Structure	Steel moment resisting frame
Number of floors	G+19
Height of floor	3.00 m
Type of building	Commercial
Seismic zone	II and V
Basic wind speeds	33 m/s and 50 m/s
Material Properties	
Concrete	
Mass per unit volume	2.5 KN/m³
Weight per unit volume	25 KN/m³
Modulus of elasticity	25×10^{6}
Poisson's ratio	0.17
Co-efficient of thermal expansion	9.900×10^{-6}
Shear Modulus	10416666.7
Concrete Cube compressive Strength	2) 25 N/mm²
Bending Reinforced Yield Stress, Fy	3) 500 N/mm²
Shear reinforced yield stress, Fys	4) 415 N/mm²
steel	
Mass per unit volume	800.2019 Kg/m³
Weight per unit volume	7850 Kg/m³
Modulus of elasticity	2×10^{8}
Poisson's ratio	0.30
Co-efficient of thermal expansion	1.2×10^{-5}
Shear Modulus	76923077
Minimum Yield Stress, Fy	250 N/mm²
Minimum tensile strength, Fu	410 N/mm²
Other element properties	
Density of brick wall	20 KN/m³
Dead load on slab	4 KN/m²
Live load on slab	4 KN/m²
Thickness of wall	0.2 m
Wall load on beams	10 KN/m
Earthquake load parameters	
Zone factor, Z	0.1 for zone II 0.36 for zone V
Importance Factor, I	1
Type of soil	II
Response reduction factor, R for unbraced reference model	5
Response reduction factor, R for braced model	5
Time period, T_a	1.84 seconds
Percentage of imposed load considered during seismic load calculations	50%
Function Damping ratio	0.03
Wind load parameters	
Basic wind speeds	33 m/s and 50 m/s
Terrain Category	1
Class of structure	C
Risk coefficient	1
Topography	1
Windward coefficient	0.8
Leeward coefficient	0.25

Table 1: Data of the modelled structure considered for the study

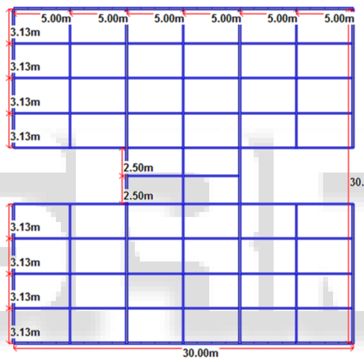

Fig 1: Plan - unbraced reference model

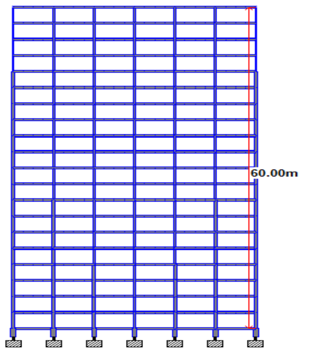

Fig 2: Knee bracing pattern arrangement

VI. RESULTS AND DISCUSSION

A. Drift Index

Model Number	Wind speed - 33 m/sec		
	Displacement (mm)	**Drift Index**	**Percentage Reduction**
Unbraced model	40.603 (DL+LL+EQX)	0.000677	
1	25.570 (DL+LL+EQX)	0.000427	37.025
2	22.230	0.000371	45.251

	(DL+LL+EQX)		
3	21.794 (DL+LL+EQX)	0.000363	**46.325**
4	36.043 (DL+LL-EQX)	0.000601	11.231
5	33.111 (DL+LL+EQX)	0.000552	18.452

Table 2(a): Drift Index

Model Number	Wind speed - 50 m/sec		
	Displacement (mm)	**Drift Index**	**Percentage Reduction**
Unbraced model	62.508 (DL+LL+WLX)	0.001042	
1	35.548 (DL+LL+WLX)	0.000592	43.131
2	30.341 (DL+LL+WLX)	0.000506	51.461
3	29.830 (DL+LL+WLX)	0.000497	**52.279**
4	49.119 (DL+LL+WLX)	0.000819	21.420
5	44.284 (DL+LL+WLX)	0.000738	29.155

Table 2: Reduction in drift index percentage for various models in comparison with unbraced model along X direction in zone II

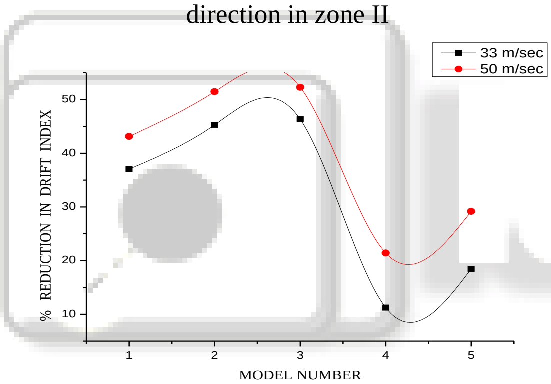

Fig 3: Reduction in drift index percentage verses various models along X direction considered in zone II

Model Number	Wind speed - 33 m/sec		
	Displacement (mm)	**Drift Index**	**Percentage Reduction**
Unbraced model	72.603 (DL+LL+EQY)	0.001210	
1	44.649 (DL+LL+EQY)	0.000744	38.503
2	40.842 (DL+LL+EQY)	0.000681	43.747
3	39.710 (DL+LL+EQY)	0.000662	**45.306**
4	62.687 (DL+LL-EQY)	0.001045	13.658
5	47.398 (DL+LL+EQY)	0.000790	34.717

Table 3(a): Reduction in drift index

Model Number	Wind speed - 50 m/sec		
	Displacement (mm)	**Drift Index**	**Percentage Reduction**
Unbraced model	152.439 (DL+LL-WLY)	0.002541	
1	71.472 (DL+LL+WLY)	0.001191	53.115
2	65.606 (DL+LL+WLY)	0.001093	56.963
3	62.438 (DL+LL+WLY)	0.001041	**59.041**
4	106.538 (DL+LL-WLY)	0.001776	30.112
5	74.795 (DL+LL+WLY)	0.001247	50.935

Table 3: Reduction in drift index percentage for various models in comparison with unbraced model along Y direction in zone II

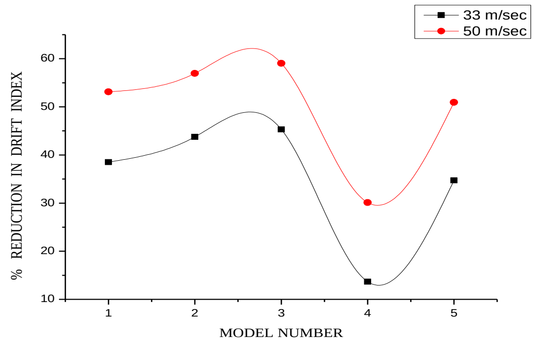

Fig 4: Reduction in drift index percentage verses various models along Y direction considered in zone II

Model Number	Wind speed - 33 m/sec		
	Displacement (mm)	**Drift Index**	**Percentage Reduction**
Unbraced model	144.891 (DL+LL+EQX)	0.002415	
1	90.154 (DL+LL+EQX)	0.001503	37.779
2	78.326 (DL+LL+EQX)	0.001305	45.942
3	77.103 (DL+LL+EQX)	0.001285	**46.786**
4	127.630 (DL+LL-EQX)	0.002127	11.914
5	116.933 (DL+LL+EQX)	0.001949	19.296

Table 4(a): Reduction in drift index

Model Number	Wind speed - 50 m/sec		
	Displacement (mm)	**Drift Index**	**Percentage Reduction**
Unbraced model	144.891 (DL+LL+EQX)	0.002415	
1	86.153 (DL+LL+EQX)	0.001436	40.540
2	75.009 (DL+LL+EQX)	0.001251	48.231
3	73.976 (DL+LL+EQX)	0.001233	**48.944**
4	115.715 (DL+LL-EQX)	0.001929	20.137
5	106.991 (DL+LL-EQX)	0.001784	26.158

Table 4: Reduction in drift index percentage for various models in comparison with unbraced model along X direction in zone V

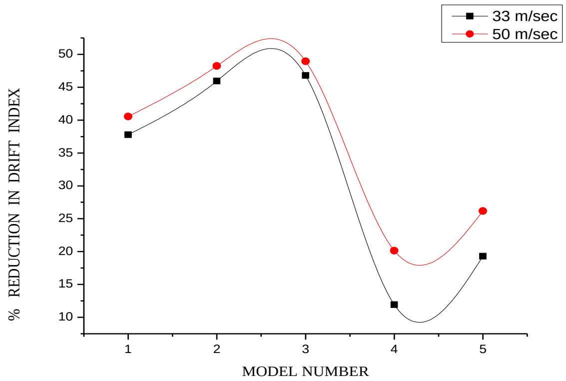

Fig 5: Reduction in drift index percentage verses various models along X direction considered in zone V

Model Number	Wind speed - 33 m/sec		
	Displacement (mm)	Drift Index	Percentage Reduction
Unbraced model	260.354 (DL+LL+EQY)	0.004339	
1	159.864 (DL+LL+EQY)	0.002664	38.598
2	146.103 (DL+LL+EQY)	0.002435	43.883
3	142.110 (DL+LL+EQY)	0.002369	**45.417**
4	224.753 (DL+LL-EQY)	0.003746	13.675
5	169.771 (DL+LL+EQY)	0.002830	34.793

Table 5(a): Reduction in drift index

Model Number	Wind speed - 50 m/sec		
	Displacement (mm)	Drift Index	Percentage Reduction
Unbraced model	260.354 (DL+LL+EQY)	0.004339	
1	150.159 (DL+LL+EQY)	0.002503	42.326
2	140.206 (DL+LL+EQY)	0.002337	46.148
3	134.411 (DL+LL+EQY)	0.002240	**48.374**
4	202.550 (DL+LL-EQY)	0.003376	22.203
5	157.515 (DL+LL-EQY)	0.002625	39.450

Table 5: Reduction in drift index percentage for various models in comparison with unbraced model along Y direction in zone V

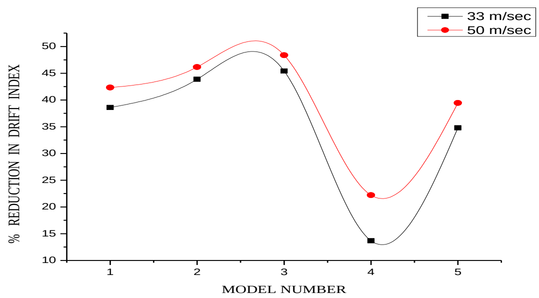

Fig 6: Reduction in drift index percentage verses various models along Y direction considered in zone V

B. Reduction in Drift0index Percentage per Unit0quantity of Steel Consumed

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	133.52	37.025	0.278
2	115.32	45.251	**0.393**
3	178.03	46.325	0.261
4	110.43	11.231	0.102
5	138.86	18.452	0.134

Table 6(a): Reduction in drift index

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone V	
		% Reduction of drift index	% reduction/unit quantity of steel
1	133.52	37.779	0.283
2	115.32	45.942	**0.399**
3	178.03	46.786	0.263
4	110.43	11.914	0.108
5	138.86	19.296	0.140

Table 6: Reduction in drift index percentage per unit quantity of steel consumed for various bracing systems for wind speed 33 m/s along X direction

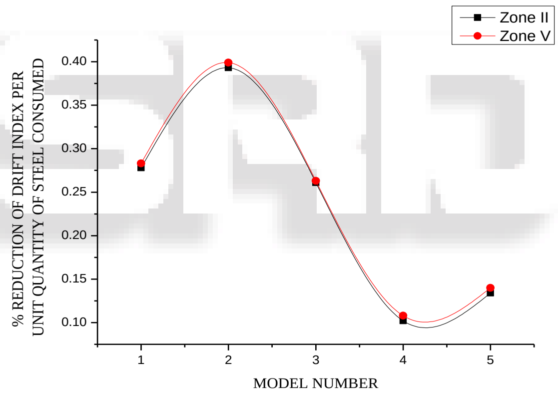

Fig 7: Reduction in drift index percentage per unit quantity of steel consumed verses various models considered along X direction for wind speed 33 m/s

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	133.52	38.503	0.289
2	115.32	43.747	**0.380**
3	178.03	45.306	0.255
4	110.43	13.658	0.124
5	138.86	34.717	0.251

Table 7(a): Reduction in drift index

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone V	
		% Reduction of drift index	% reduction/unit quantity of steel
1	133.52	38.598	0.290
2	115.32	43.883	**0.381**

3	178.03	45.417	0.256
4	110.43	13.675	0.124
5	138.86	34.793	0.251

Table 7: Reduction in drift index percentage per unit quantity of steel consumed for various bracing systems for wind speed 33 m/s along Y direction

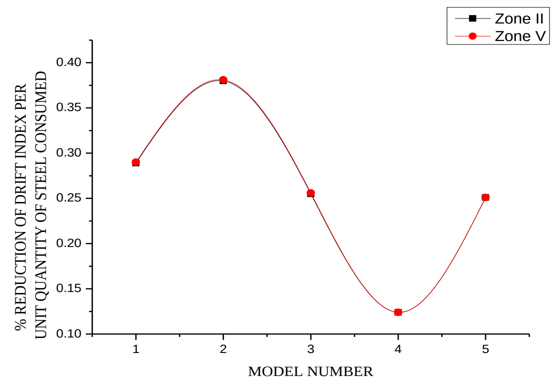

Fig 8: Reduction in drift index percentage per unit quantity of steel consumed verses various models considered along Y direction for wind speed 33 m/s

Model Number	**Quantity of steel consumed for bracing (in tonnes)**	**Zone II**	
		% Reduction of drift index	**% reduction/unit quantity of steel**
1	202.51	43.131	0.213
2	174.42	51.461	**0.296**
3	270.01	52.276	0.194
4	166.81	21.420	0.129
5	210.82	29.155	0.139

Table 8(a): Reduction in drift index

Model Number	**Quantity of steel consumed for bracing (in tonnes)**	**Zone V**	
		% Reduction of drift index	**% reduction/ unit quantity of steel**
1	202.51	40.540	0.201
2	174.42	48.231	**0.277**
3	270.01	48.944	0.182
4	166.81	20.137	0.121
5	210.82	26.158	0.125

Table 8: Reduction in drift index percentage per unit quantity of steel consumed for various bracing systems for wind speed 50 m/s along X direction

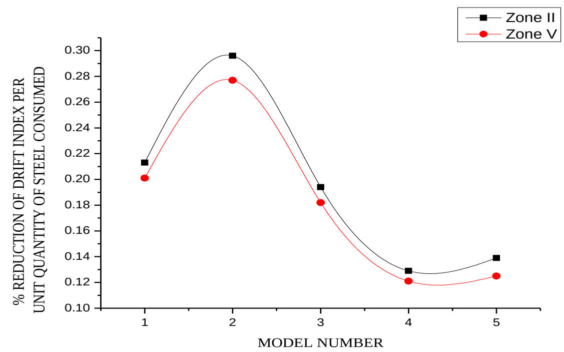

Fig 9: Reduction in drift index percentage per unit quantity of steel consumed verses various models considered along X direction for wind speed 50 m/s

Model Number	**Quantity of steel consumed for bracing (in tonnes)**	**Zone II**	
		% Reduction of drift index	**% reduction/unit quantity of steel**
1	202.51	53.115	0.263
2	174.42	56.963	**0.327**
3	270.01	59.041	0.219
4	166.81	30.112	0.181
5	210.82	50.935	0.242

Table 9(a): Reduction in drift index

Model Number	**Quantity of steel consumed for bracing (in tonnes)**	**Zone V**	
		% Reduction of drift index	**% reduction/unit quantity of steel**
1	202.51	42.326	0.210
2	174.42	46.148	**0.265**
3	270.01	48.374	0.180
4	166.81	22.203	0.134
5	210.82	39.450	0.188

Table 9: Reduction in drift index percentage per unit quantity of steel consumed for various bracing systems for wind speed 50 m/s along Y direction

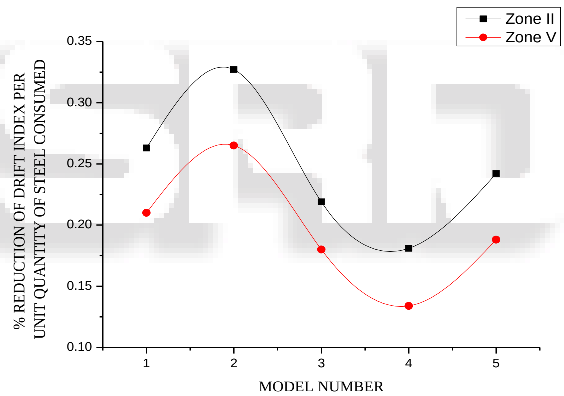

Fig 10: Reduction in drift index percentage per unit quantity of steel consumed verses various models considered along Y direction for wind speed 50 m/s

C. Inter story drift

Model Number	**Wind speed-33m/s**		**Wind speed-50m/s**	
	Inter story drift	**% reduction**	**Inter story drift**	**% reduction**
Unbraced model	0.000795		0.001545	
1	0.000482	39.372	0.000677	56.182
2	0.000468	41.133	0.000561	63.690
3	0.000458	**42.390**	0.000553	**64.208**
4	0.000692	12.956	0.001260	18.447
5	0.000637	19.875	0.001058	31.522

Table 10: Reduction in inter story drift percentage for various models considered in comparison with unbraced model along X direction in zone II

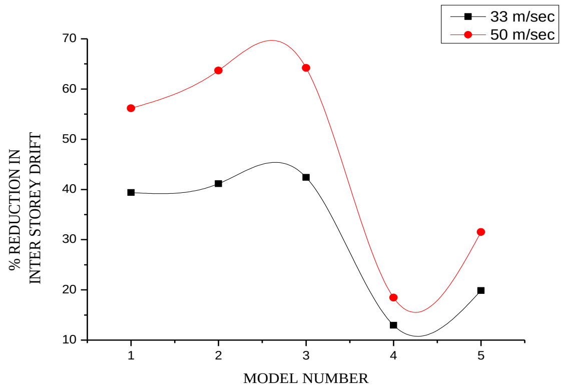

Fig 11: Reduction in inter story drift percentage versus various models considered along X direction in Zone II

Model Number	Wind speed-33m/s		Wind speed-50m/s	
	Inter story drift	% reduction	Inter story drift	% reduction
Unbraced model	0.001475		0.003693	
1	0.000924	37.356	0.001777	51.882
2	0.000851	42.306	0.001726	53.263
3	0.000834	**43.458**	0.001684	**54.401**
4	0.001269	13.967	0.002924	20.824
5	0.000990	32.882	0.001921	47.983

Table 11: Reduction in inter story drift percentage for various models considered in comparison with unbraced model along Y direction in zone II

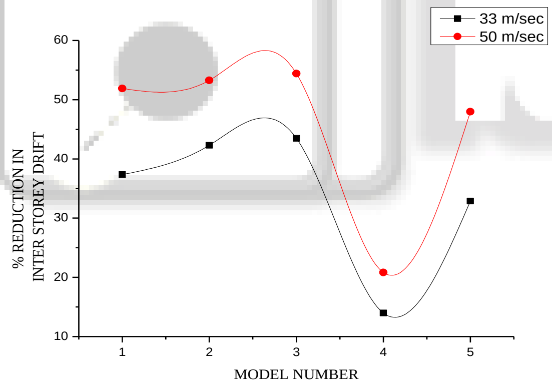

Fig 12: Reduction in inter story drift percentage versus various models considered along Y direction in Zone II

Model Number	Wind speed-33m/s		Wind speed-50m/s	
	Inter story drift	% reduction	Inter story drift	% reduction
Unbraced model	0.002838		0.002838	
1	0.001675	40.980	0.001612	43.120
2	0.001500	47.156	0.001428	49.658
3	0.001486	**47.640**	0.001422	**49.895**
4	0.002473	12.862	0.002228	21.495
5	0.002297	19.063	0.002059	27.449

Table 12: Reduction in inter story drift percentage for various models considered in comparison with unbraced model along X direction in zone V

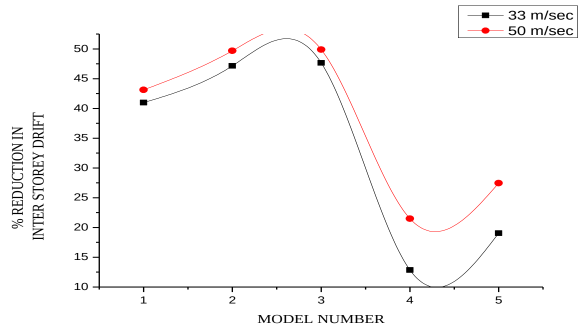

Fig 13: Reduction in inter story drift percentage versus various models considered along X direction in Zone V

Model Number	Wind speed-33m/s		Wind speed-50m/s	
	Inter story drift	% reduction	Inter story drift	% reduction
Unbraced model	0.005346		0.005346	
1	0.003363	37.094	0.003170	40.704
2	0.003108	41.864	0.002992	44.033
3	0.003034	**43.248**	0.002873	**46.259**
4	0.004615	13.674	0.004162	22.148
5	0.003588	32.885	0.003329	37.730

Table 13: Reduction in inter story drift percentage for various models considered in comparison with unbraced model along Y direction in zone V

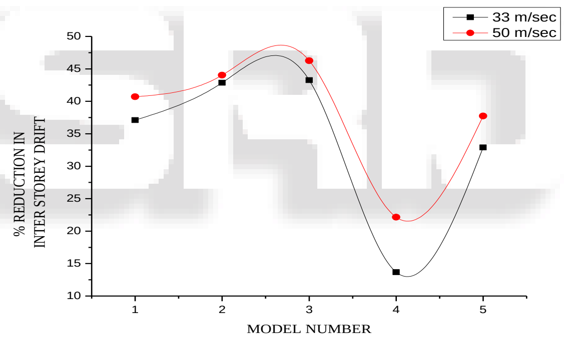

Fig 14: Reduction in inter story drift percentage versus various models considered along Y direction in Zone V

D. Reduction In Inter Story Drift0index Percentage per Unit0quantity of Steel Consumed

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	133.52	39.372	0.295
2	115.32	41.133	**0.357**
3	178.03	42.390	0.239
4	110.43	12.956	0.118
5	138.66	19.875	0.144

Table 14(a): Reduction in inter story drift

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone V	
		% Reduction of drift index	% reduction/unit quantity of steel
1	133.52	40.980	0.307

2	115.32	47.156	**0.409**
3	178.03	47.640	0.268
4	110.43	12.862	0.117
5	138.66	19.063	0.138

Table 14: Reduction in inter story drift percentage per unit quantity of steel consumed for various bracing systems for wind speed 33 m/s along X direction

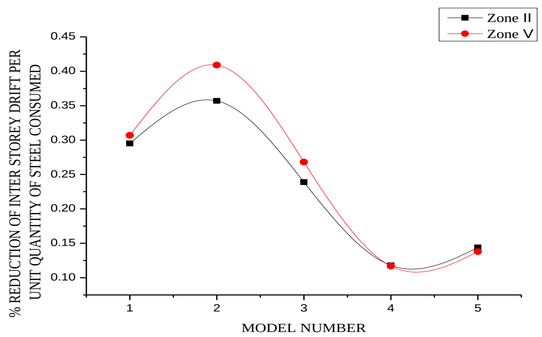

Fig 15: Reduction in drift index percentage per unit quantity of steel consumed verses various models considered along X direction for wind speed 33 m/s

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	133.52	37.356	0.280
2	115.32	42.306	**0.367**
3	178.03	43.458	0.245
4	110.43	13.967	0.127
5	138.66	32.882	0.238

Table 15(a): Reduction in inter story drift

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	133.52	37.094	0.278
2	115.32	42.864	**0.372**
3	178.03	43.248	0.243
4	110.43	13.674	0.124
5	138.66	32.885	0.238

Table 15: Reduction in inter story drift percentage per unit quantity of steel consumed for various bracing systems for wind speed 33 m/s along Y direction

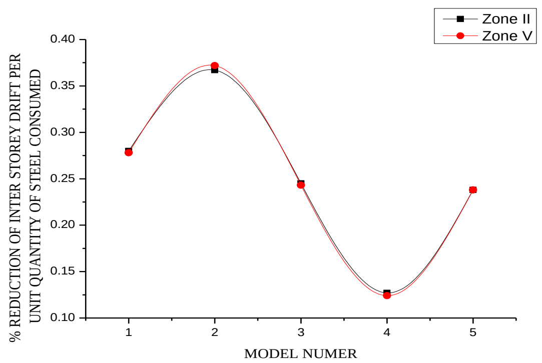

Fig 16: Reduction in drift index percentage per unit quantity of steel consumed verses various models considered along Y direction for wind speed 33 m/s

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	202.51	56.182	0.278
2	174.42	63.690	**0.366**
3	270.01	64.204	0.238
4	166.81	18.447	0.111
5	210.82	31.522	0.150

Table 16(a): Reduction in inter story drift

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	202.51	43.120	0.213
2	174.42	49.683	**0.285**
3	270.01	49.895	0.185
4	166.81	21.495	0.129
5	210.82	27.449	0.131

Table 16: Reduction in inter story drift percentage per unit quantity of steel consumed for various bracing systems for wind speed 50 m/s along X direction

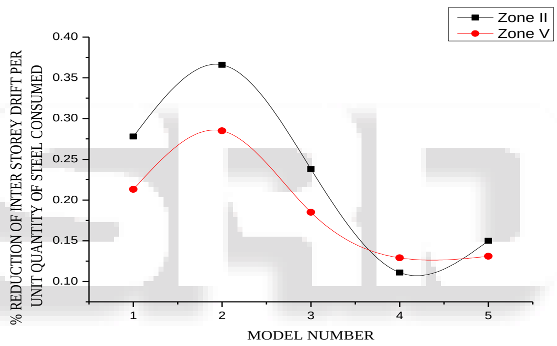

Fig 17: Reduction in drift index percentage per unit quantity of steel consumed verses various models considered along X direction for wind speed 50 m/s

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	202.51	51.882	0.257
2	174.42	53.263	**0.306**
3	270.01	54.401	0.202
4	166.81	20.824	0.125
5	210.82	47.983	0.228

Model Number	Quantity of steel consumed for bracing (in tonnes)	Zone II	
		% Reduction of drift index	% reduction/unit quantity of steel
1	202.51	40.704	0.201
2	174.42	44.033	**0.253**
3	270.01	46.259	0.172
4	166.81	22.148	0.133
5	210.82	37.730	0.179

Table 17: Reduction in inter story drift percentage per unit quantity of steel consumed for various bracing systems for

wind speed 50 m/s along Y direction

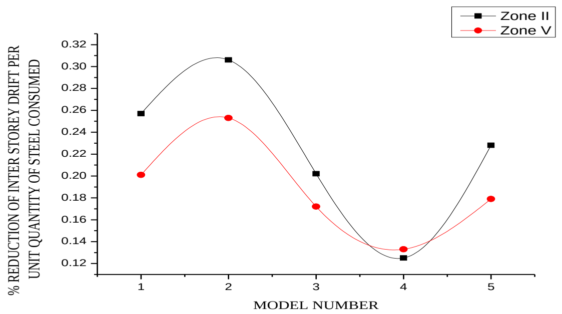

Fig 18: Reduction in drift index percentage per unit quantity of steel consumed verses various models considered along Y direction for wind speed 50 m/s

E. Base Shear

Model Number	Wind speed-33m/s Base shear (KN)	Wind speed-50m/s Base shear (KN)
Unbraced model	1183.48	1183.48
1	1193.35	1198.33
2	1195.66	1199.92
3	**1196.63**	**1203.28**
4	1191.43	1195.53
5	1193.71	1198.73

Table 18: Base shear value of various models considered in zone II

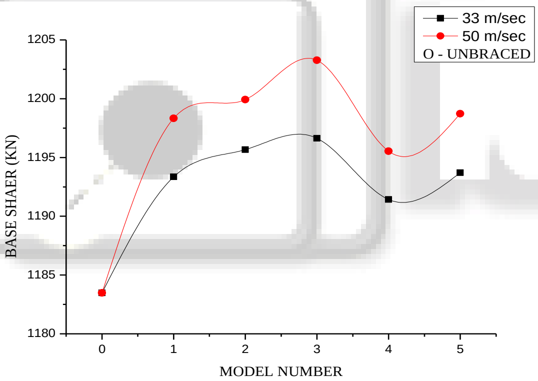

Fig 19: Base shear versus various bracing systems considered in zone II

Model Number	Wind speed-33m/s Base shear (KN)	Wind speed-50m/s Base shear (KN)
Unbraced model	4254.77	4254.77
1	4289.58	4307.50
2	4297.88	4313.22
3	**4301.40**	**4325.29**
4	4282.71	4397.42
5	4290.89	4308.95

Table 19: Base shear value of various models considered in zone V

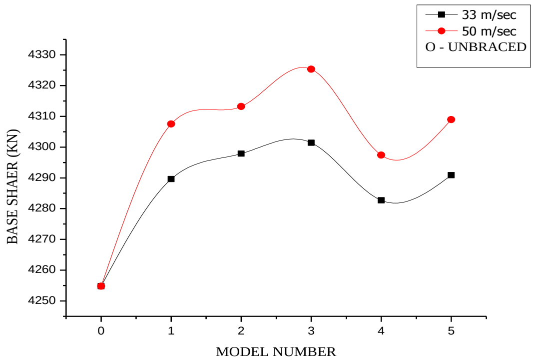

Fig. 20: Base shear versus various bracing systems considered in zone V

VII. CONCLUSION

1) Model 3 has the maximum0reduction of drift index percentage in comparison0with the unbraced reference0model, the maximum0reduction of inter storey0drift percentage and maximum base shear value as compared to other type of bracing arrangements.
2) Model 2 has the maximum0reduction of drift0index percentage per unit0quantity of0steel consumed0and maximum reduction of inter0storey drift per unit0quantity of steel0consumed as compared to other type of bracing arrangements.
3) Apart from0reducing the inter0storey drift0and drift index,0an effective bracing0system should transfer0the lateral forces0to the columns in0the frame such0that there is no0stress concentration in0a particular column.. Based on0this concept, by observing all those parameters, model 2 has the0least lateral internal0forces such as0bending moment, shear0forces and axial0forces in the0columns.

Hence from0the structural design0point of view, model 20which has0maximum reduction0in inter storey drift per0unit quantity0of steel consumed0as well maximum reduction0in drift index0per unit quantity0of steel consumed0and sufficient base0shear value. Also from economical point0of view the0model has sufficient reduction0in inter storey drift0and drift index0for bracing and0least flexure and shear0demand in columns, thereby0improving its0structural efficiency distribution0of internal forces0and the minimum0flexural and shear0demands in columns.

Thus we0can conclude that model 2 consisting0of inverted V bracing is the0 effective0bracing system0 among0the 5 types0of bracing arrangements0considered in this0study.

REFERENCES

[1] Ying Zhou and Xilin Lu "Seismic Performance Evaluation of An Irregular High-Rise Building" Paper No. 099, 4th International Conference on Earthquake Engineering Taipei, Taiwan, October 2006.
[2] Rakesh K. Goel, "Base0shear estimated0from floor acceleration0and column0shears", structural0 engineering and applied0 mechanics. Report no0CP/ SEAM-2010/01. Septmber-20, 2010 - department0of civil and environmental0engineering, California0

polytechnic state university. SAN LUIS0OBISPO, CA 93407.

[3] Kelvin Z. Truman0and Thomas0Jan, "optimal bracing0schemes for structural0systems subjected to0the ATC-3-06, UBC and BOCA0seismic provisions", proceedings0of north world conference0on earthquake0engineering. August 2-9, 1998, Tokyo-Kyoto, JAPAN0(Vol.IV).

[4] R.0Narayanan, "Steel framed0structure" stability0and strength, Elsevier0applied science publishes, London0and New York. 2005.

[5] Ram0Chandra, "Design of steel0structures", standard0book house, Vol II, 7th0edition 2006.

[6] S. K.0Duggal, "Design0of steel0structures", Tata0McGraw Hills publishing0company limited, 3rd edition, 2009.

[7] L. S.0Negi, "Design of0steel structures", Tata McGraw0Hills publishing0company limited, 2nd edition, 1999.

[8] R.0Agor, "Steel0tables" MKS and SI units. Birla0publications Pvt Ltd. Fifteenth edition 2009.

[9] Bryan0Stafford Smith and Alex0Coull, "Tall Building0Structures-Analysis0and Design" Wiley Publication, Illustrated0edition, 1991.

Codes:

[10] IS: 456-2002, "Code0of practice – plain0and reinforced0concrete" Bureau0of Indian Standards, New Delhi, India.

[11] IS: 800-2007, "General0construction in steel0code of practice" Third0version, Bureau0of Indian0Standards, New Delhi, India.

[12] IS: 18930(Part 1)-2002, "Criteria0for earthquake0resistant design of0structures" part 1 – general provisions0and building, Fifth0edition, Bureau of0Indian Standards, New0Delhi, India.

[13] IS: 8750(Part 1,2,3)-1987, "Code0of practice for design loads (other than earthquake) for building and structures, part 3 wind loads" 6th reprint, November 1998 Bureau of Indian0Standards, New Delhi,0India.

