A Review on 3D Moment Resisting Steel Frame with and without Bracing Subjected to Lateral Load (Seismic Load)

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Abstract— The idea of utilizing steel supporting is one of the beneficial ideas which can be used to strengthen or retrofit the current structures. In this present study, the seismic performance of steel frame building structure rehabilitated using concentric and eccentric bracing is investigated. The different kinds of bracing like X-bracing, V- bracing, Inverted v-bracing, Diagonal1 bracing, Diagonal 2 bracing, k-bracing and Inverted k- bracing are provided for exterior part of buildings. A G+16 steel frame building is analyzed for seismic zone5 and hard soil as of IS-1893:2002 by equivalent static method and response spectrum method using E-tabs. The effect of distribution of steel bracing along the height of the structure on seismic performance of rehabilitation is studied. The execution of the steel frame building is evaluated in terms of lateral displacements, storey drifts, base shear and time period. It is noticed that X bracing give more stiffness when compared to different types of bracing. The steel frame building with X bracing systems will have minimum possible lateral displacements in comparison to other types of bracing systems. By providing X bracing on exterior part of building the displacement of building is reduced up to 20.59% and 77.52% in longitudinal and transverse direction by equivalent static method. By providing X bracing on exterior part of building the displacement is reduced up to 17.73% and 73.24% in longitudinal and transverse direction by response spectrum method.

Key words: Bracing System, 3D Moment Resisting Steel Frame

I. INTRODUCTION

A. Background of the Study

For high seismic region or areas of medium and tall structure need resistance mechanism to sustain it stability without sudden collapse. Bracing structures are the most widely utilized in steel buildings to increase the resistance of the overall structural systems. It is noted that for different orientation of bracing system the resistance capacity of bracing are different. From the previous study it is observed that X bracing show better performance compared to another type of concentrically bracing. But their criteria of measurement are not stipulated clearly. In order to compute such set back, this study is considered with weight of bracing assumed to be constant parameter for all selected bracing type.

To compare the efficiency of bracing, seven types of steel bracing are selected in this study. These are:

1) X- bracing
2) V- bracing
3) Inverted V-bracing
4) Diagonal 1 bracing
5) Diagonal 2 bracing
6) K bracing
7) Inverted K bracing

Each of this seven bracing are provided on exterior part of steel frame building of G+16.Then these steel frame building is analyzed by using E-tabs.

B. Bracing System

Nowadays tall steel-edge building is well setting up in metro urban zones. For improvement of raised structure supporting are worked for robustness and parallel weight resistance reason. Steel layout generally speaking suggests a building framework with a "skeleton edge" of vertical steel sections and level I-shafts, created in a rectangular structure to strengthen floors, housetop and dividers of a building which are all associated with the packaging. The change of this strategy made the advancement of the elevated structure possible. Bracings are strong in weight. Supporting with their including housings must be considered for extension in parallel weight restricting utmost of structure. Exactly when bracings are set in steel plot it carries on as corner to corner weight strut and transmits weight energy to another joint.

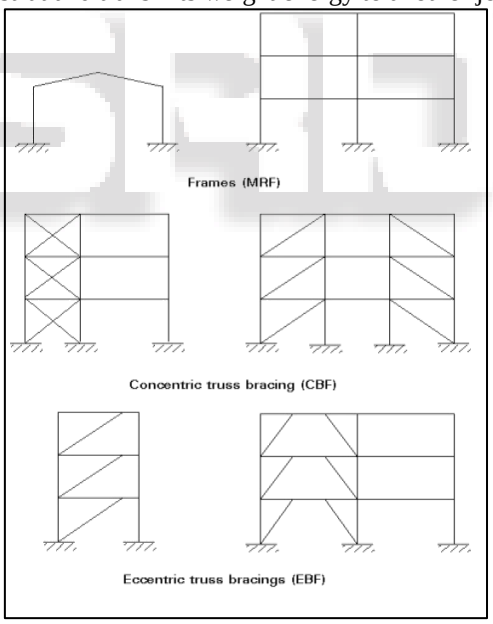

Fig. 1: Different types of bracing systems

II. OBJECTIVES OF THE STUDY

The following are the objectives

1) The Generation of 3D symmetrical moment resisting steel frame structure model with different kinds of bracing and without bracing
2) The lateral load analysis of different 3D symmetrical steel frame building models is analyzed using E-tabs.
3) To study the effect of different types of bracings (X-bracing, V-bracing, Inverted V-bracing, Diagonal1 bracing, Diagonal 2 bracing, K-bracing, Inverted k-bracing) on exterior part of steel frame structure.

4) To analysis a 3D symmetrical steel frame building models using equivalent static analysis and response spectrum analysis for different load combination of IS1893:2002.
5) To study the maximum lateral displacement, storey drift, base shear and time period of 3D symmetrical steel frame building model with different kinds bracing and without bracing.

III. METHODOLOGY

- Modeling of G+16 storey moment resisting steel frame building without bracing and with various concentric and eccentric bracing using E-tabs software
- Analyzing the steel frame structure by Equivalent static method and Response spectrum method in Longitudinal and transverse direction.
- Analyzing the seismic behavior of steel frames with basic components like lateral displacement, storey drift, base shear and time period

IV. DETAILS OF THE BUILDING

Serial no	Building Description	
1	Structure type	moment resisting steel frames
2	Earthquake zone	Zone 5
3	Zone factor	0.36
4	Soil condition	Hard
5	Response reduction factor	5
6	Importance factor	1
7	Height of each storey	3.2 m
8	Bottom Storey height	2 m
9	Beam type	ISMB 400
10	Column type	ISHB 450
11	Bracing angle	120X120X10
12	Slab type	Deck slab 155mm thick
13	Slab material	Concrete,solid slab
14	Wall load	13.24 KN/m^3
15	Live load	4 KN/m^2
16	Floor finish load	1 KN/m^2
17	Grade of concrete	M20

Table 1: Details of Building

A. *Models Geometry*

No of Storey	G+16
No of bays in X direction	9
Bay width in X direction	4
No of bays in Y direction	8
Bay width in Y direction	5
Bottom Storey Height	2
Storey Height	3.2 m

Table 2: Models Geometry

B. *Description of Steel Frame Models*

In this study the steel frame models has been considered. The steel frame model has considered into 2 categories.

1) Model without bracing
2) Model with different types of bracing

- Model 1: The steel frame building without bracing is considered and earthquake load is applied to seismic zone 5 as considered.
- Model 2: The steel frame building is provided with X bracing on exterior part of building and earth quake load is applied to seismic zone 5 as considered
- Model 3: The steel frame building is provided with V-bracing on exterior part of building and earth quake load is applied to seismic zone 5 as considered.
- Model 4: The steel frame building is provided with inverted V-bracing on exterior part of building and earth quake load is applied to seismic zone 5 as considered.
- Model 5: The steel frame building is provided with Diagonal 1 bracing on exterior part of building and earth quake load is applied to seismic zone 5 as considered.
- Model 6: The steel frame building is provided with Diagonal 2 bracing on exterior part of building and earth quake load is applied to seismic zone 5 as considered
- Model 7: The steel frame building is provided with K-bracing on exterior part of building and earth quake load is applied to seismic zone 5 as considered
- Model 8: The steel frame building is provided with inverted K-bracing on exterior part of building and earth quake load is applied to seismic zone 5 as considered.

C. *Models*

The following 3d models of G+16 storey steel frame structure with and without bracing are considered for study.

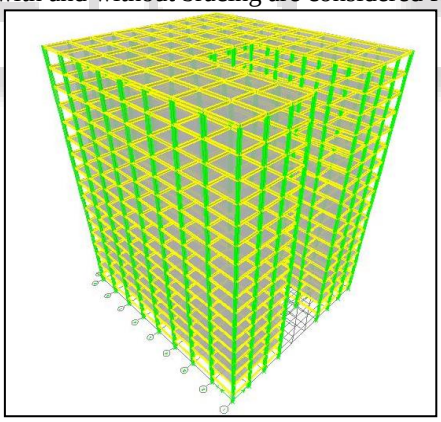

Fig. 2: 3D model of G+16 storey building without bracing

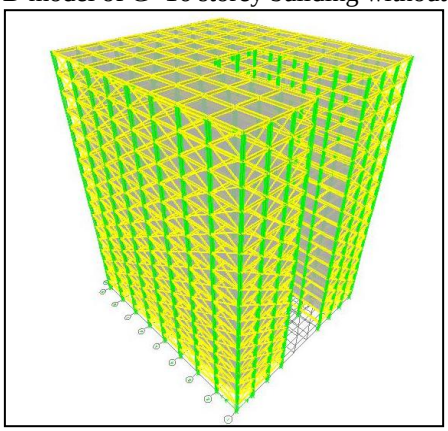

Fig. 3: 3D model of G+16 storey building with X-bracing

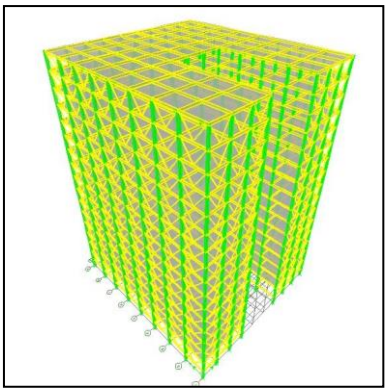

Fig. 4: 3D model of G+16 storey building with V- bracing

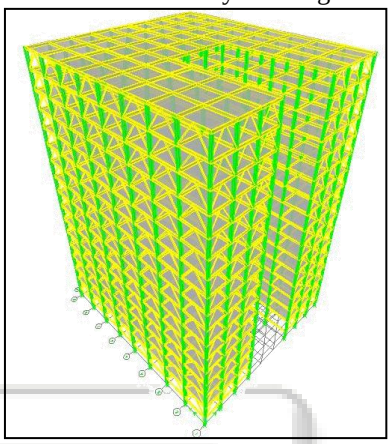

Fig. 5: 3D model of G+ 16 storey building with Inverted V bracing

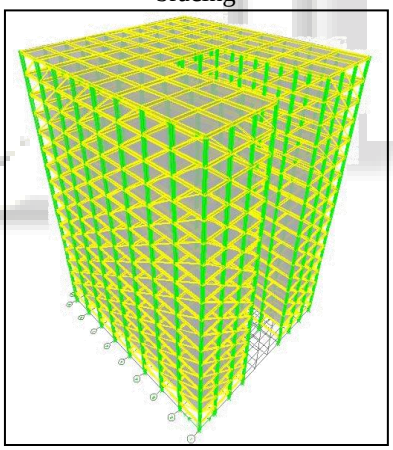

Fig. 6: 3D model of G+16 storey building with Diagonal 1 bracing

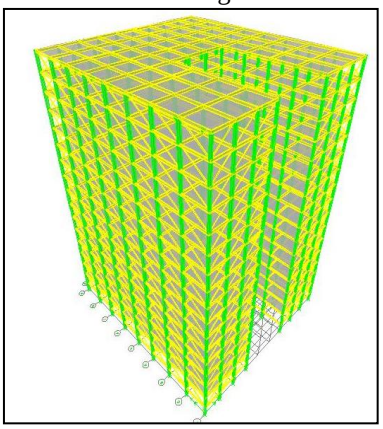

Fig. 7: 3D model of G+16 storey building with Diagonal 2 bracing

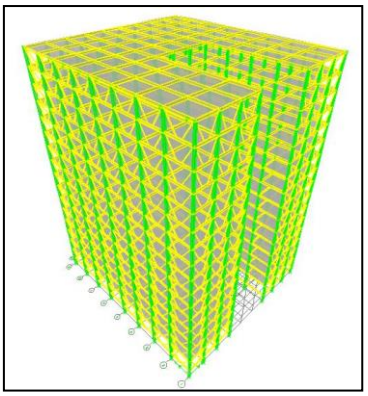

Fig. 8: 3D model of G+16 storey building with K-bracing.

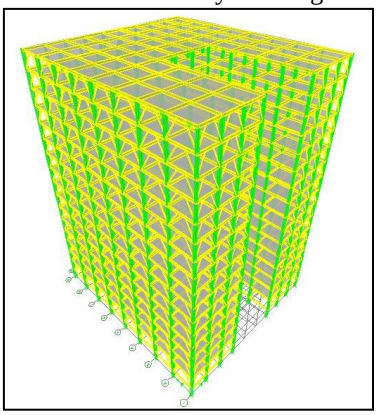

Fig. 9: 3D model of G+16 storey building with Inverted K bracing.

V. RESULTS & DISCUSSION

A. *Lateral Displacement*

LATERAL DISPLACEMENT (mm)					
Model no	Types of Bracings	Equivalent static method (ESA)		Response spectrum method (RSA)	
		EQX	EQY	RSX	RSY
1	Without bracing	56.58	200.45	50.52	136.44
2	X-bracing	44.93	45.05	41.56	36.500
3	V-bracing	48.32	48.35	48.32	38.49
4	Inverted V-bracing	47.25	47.89	42.88	38.19
5	Diagonal 1-bracing	49.47	55.25	45.09	42.59
6	Diagonal 2-bracing	49.87	54.01	47.05	41.52
7	K-bracing	53.32	57.42	48.54	43.65
8	Inverted K-bracing	52.01	56.65	46.75	43.17

Table 3: Comparison of maximum displacement for different models by ESA and RSA

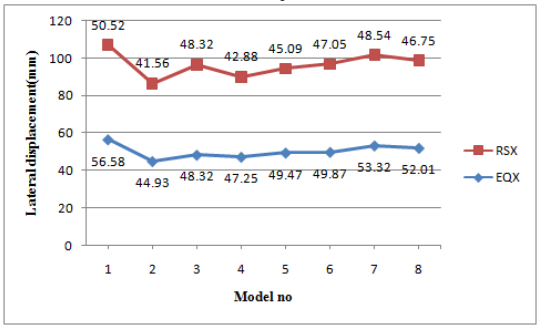

Fig. 10: Comparison of maximum displacement for different models by ESA and RSA in X direction

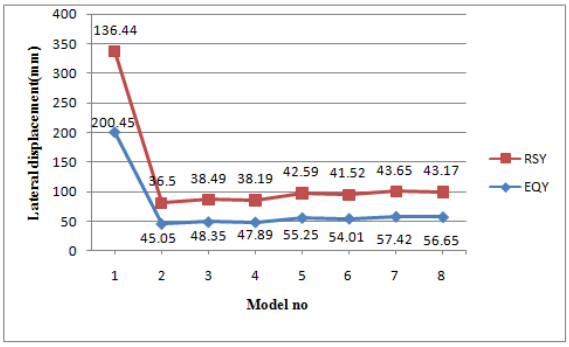

Fig. 11: Comparison of maximum displacement for different models by ESA and RSA in Y direction

B. Storey Drift

STOREY DRIFT (mm)					
Model no	Types of Bracings	Equivalent static method (ESA)		Response spectrum method (RSA)	
		EQX	EQY	RSX	RSY
1	Without-bracing	0.001290	0.006805	0.001119	0.005627
2	X-bracing	0.002021	0.011928	0.003675	0.011246
3	V-bracing	0.001878	0.011482	0.001878	0.010782
4	Inverted V-bracing	0.001983	0.011582	0.003319	0.010879
5	Diagonal 1-bracing	0.001959	0.010648	0.003171	0.009875
6	Diagonal 2-bracing	0.001754	0.010844	0.003124	0.009994
7	K-bracing	0.001712	0.010327	0.002768	0.009476
8	Inverted K-bracing	0.001796	0.010505	0.002730	0.009666

Table 4: Comparison of maximum drift for different models by ESA and RSA

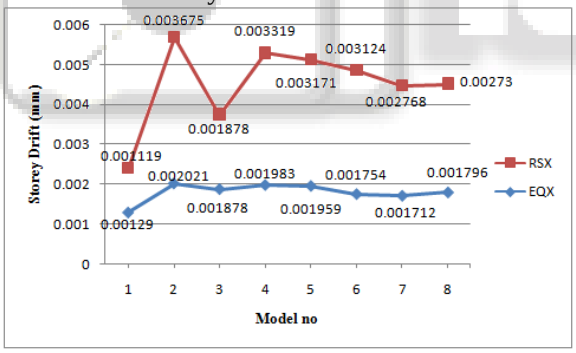

Fig. 12: Comparison of maximum storey drift for different models by ESA and RSA in X direction

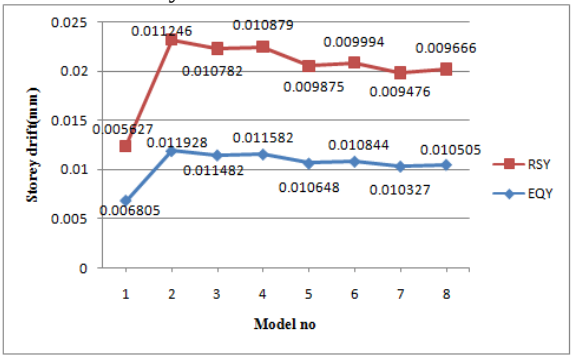

Fig. 13: Comparison of maximum storey drift for different models by ESA and RSA in Ydirection

C. Base Shear

BASE SHEAR (KN)				
MODEL	Equivalent Static Analysis (E TABS)		Response Spectrum Analysis (E TABS)	
	EQX	EQY	RSX	RSY
1	2410.13	2345.51	2143.18	2032.84
2	3595.97	2688.56	3384.96	2621.86
3	3315.13	2605.23	3104.62	2535.2
4	3206.03	2441.88	2966.54	2348.49
5	3168.75	2442.36	2947.06	2349.14
6	3382.29	2615.20	3152.66	2546.12
7	2907.15	2368.6	2681.64	2261.88
8	2976.78	2391.23	2730.96	2286.86

Table 5: Comparison of base shear for different models by ESA and RSA in X and Y direction

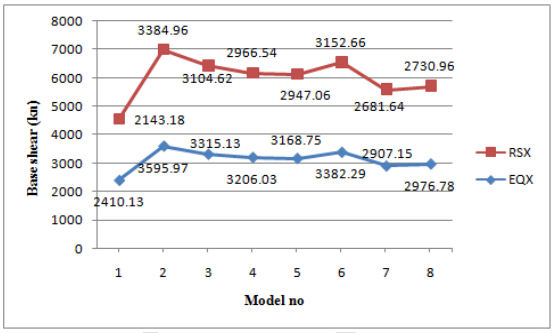

Fig. 14: Comparison of Base shear for different models by ESA and RSA in X direction

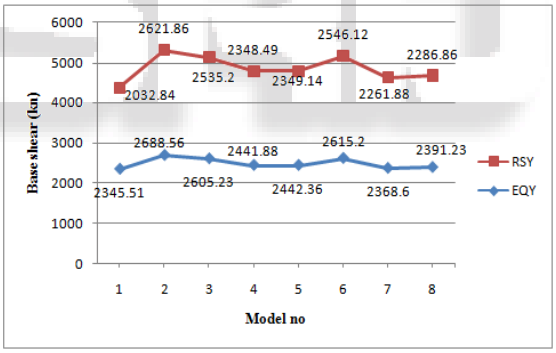

Fig. 15: Comparison of Base shear for different models by ESA and RSA in Y direction

D. Time Period

TIME PERIOD (Sec)		
MODEL NO	E-tabs analysis	IS 1893:2002
1	6.896	1.702
2	3.502	1.702
3	3.618	1.702
4	3.604	1.702
5	3.856	1.702
6	3.856	1.702
7	3.978	1.702
8	3.98	1.702

Table 6: Time period comparison between E-tab analysis and IS 1893:2002

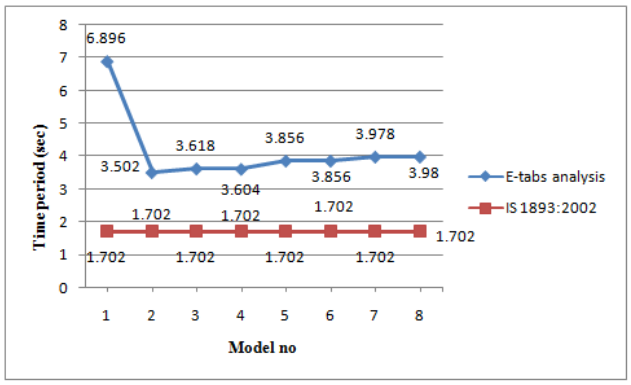

Fig. 16: Time period comparison between E-tab analysis and IS1893:2002

E. Calculation of time period as of IS 1893:2002 by equivalent static method

For G+16storey Steel frame building Time period(Ta)
(Ta) = 0.085* h $^{(0.75)}$
= 0.085*(54.4) $^{0.75}$
= 1.702 sec

VI. Conclusion

1) The idea of utilizing steel bracing is one of beneficial ideas which can be used to strengthen or retrofit the current structures.
2) By providing X-bracing on exterior part of building, the lateral displacement of building is lessened up to 20.59% and 77.52% in longitudinal and transverse direction by equivalent static method.
3) By providing X bracing on exterior part of building, the lateral displacement of building is lessened up to 17.73% and 73.24% in longitudinal and transverse direction by response spectrum method.
4) The X-bracing is very much effective, as it show minimum lateral displacement as compared to other bracing
5) The Inverted V-bracing show minimum lateral displacement next to X-bracing.
6) The x-bracing show more stiffness than the other kind of bracing (V,Inverted V,Diagonal 1, Diagonal 2, K, Inverted K bracings).
7) The x-bracing show maximum storey drifts than the other kind of bracing.
8) The steel frame structure with bracing show maximum storey drift than the steel frame structure without bracing.
9) By providing x-bracing on exterior part of building, the storey drift of building is increased upto 36.17 % in x-direction and 42.94 % in y-direction by equivalent static method
10) By providing x-bracing on exterior part of building, the storey drift of building is increased upto 69.55 % in x-direction and 49.96% in y-direction by response spectrum method
11) The time period of steel frame building goes on decreasing as the stiffness of steel frame building.increases.
12) The steel frame building with X-bracing will show maximum base shear compared to bare frame and other kind of bracing(V,inverted V,diagonal1, diagonal2, k, inverted k bracing)

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