Seismic Performance Assessment of Steel Framed Building with Different Types of Bracing

G.Elavarasi*, prof.S.M.Kavitha**
*Assistant Professor, Department of Civil Engineering, K.Ramakrishnan College of Technology, trichy, Tamil Nadu, India
**Associate Professor, Department of Civil Engineering, Alagappa Chettiyar College of Engineering and Technology, Karaikudi, Tamil Nadu, India.

Abstract

In this study, the seismic performance of the concentric braced steel frames was studied in the proposed structure. In multi storied buildings, the lateral load resisting system must be of closed loops, so that it is able to transfer all the forces either vertically or horizontally. The braced frame is one which resisting lateral load system and provides high plane rigidity to the building, thereby increasing the overall stiffness of the system. The performance of the steel frame building has been investigated for five different types of bracing system such as concentric X bracing, V- bracing, inverted V- bracing, forward and backward bracings. These bracings are placed outer and inner core of the building and to compare the result of seismic analysis of high rise steel frame building with different pattern of bracing system and without bracing system. The results of the above bracing systems will be compared at different locations in the building. The performance of the building has been evaluated in terms of lateral storey displacement of X and Y direction and storey drift for unbraced and different types of braced structure by using finite element software ETABS and the results are compared to both outer and inner core. The diagonal bracing is more efficient when compared to the other bracing systems. The cost analysis for the total building was also calculated.

Keywords*:* *high rise steel frame building, bracing pattern, Etabs.*

I. INTRODUCTION

The primary purpose of all kinds of structural systems used in the building is to support gravity loads. The most common loads resulting from the effect of gravity are dead load, live load and snow load besides these vertical loads, buildings are subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement and cause vibration. Therefore it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. The steel braces are usually placed in vertically aligned spans. This system allows obtaining a great increase of stiffness with a minimal added weight, and so it is very effective for existing structure for which the poor lateral stiffness is the main problems.

II. STRUCTURAL MODELLING

For the analysis work, six models of high rise steel frame building (G+40) floors are made to know the behavior of building during lateral forces. The length of the building is 30m and width is 30m.Height of typical story is 3m. Column sizes changes first at 11storey and then at each 10 story. Building is symmetrical about X and Y-axis. Material concrete grade M30 is used, while steel Fe 415(Mild steel) is used. Analytical modeling that includes all components which Influence the mass, strength and stiffness. The non-structural element and components that do not significantly influence the building behavior was not modeled. Beams and columns are modeled as frame element and joined node to nodes. The columns are assumed to be fixed at the ground level.

A. Structural Configuration

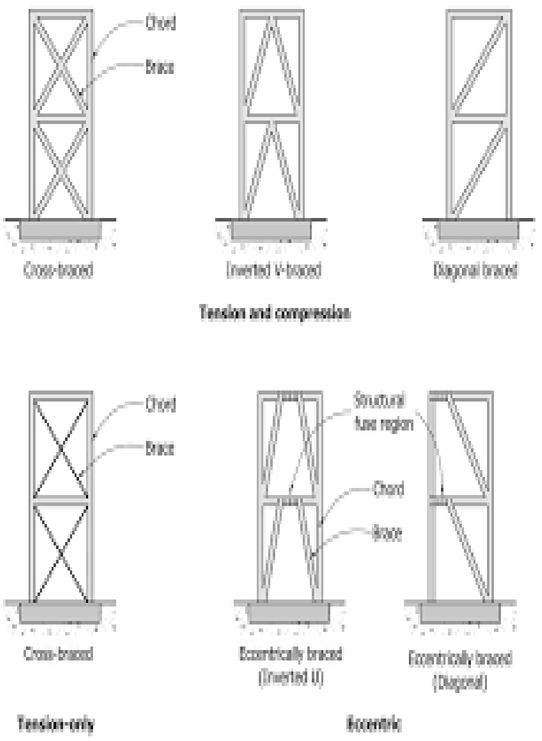
The following three structural configurations were studied.

- G+30 steel framed building without bracing.
- G+30 steel framed building with bracings are located in outer portion of building.
- G+30 steel framed building with bracings are located

B. Member Size Of The Beams, Columns And Bracings

Storey level	Beam sizes	Column sizes	Bracing sizes
G+10	ISMB 500	ISMB 450	ISA200×150×15
11 to 20	ISMB 400	ISMB 350	ISA200×150×15
21 to 30	ISMB 350	ISMB 300	ISA200×150×15

III. DIFFERENT TYPE OF BRACING PATTERN USED IN THIS STUDY



IV. ANALYSIS

A. Location of Bracing in Outer Portion of Building

To find the lateral storey displacement of X and Y direction and storey drift of building with different types of bracings such as X bracing, V bracing, inverted V bracing, forward diagonal bracing and backward diagonal bracing. These bracings are located on outer portion of the building. These results are compared to without bracing of building.

1) Storey Displacement In X Direction of Bracing Located in Outer Portion of Building

storey	Without bracing (m)	With X bracing (m)	With V bracing (m)	With inverted V bracing (m)	With forward diagonal bracing (m)	With backward diagonal bracing (m)
1	0.425	0.078	0.082	0.072	0.068	0.072
5	0.75	0.129	0.14	0.125	0.119	0.123
10	1.05	0.18	0.203	0.175	0.16	0.176
15	1.27	0.234	0.283	0.257	0.234	0.229
20	1.3	0.305	0.331	0.3	0.28	0.276
25	1.5	0.395	0.409	0.398	0.377	0.32
30	1.655	0.475	0.489	0.476	0.462	0.36

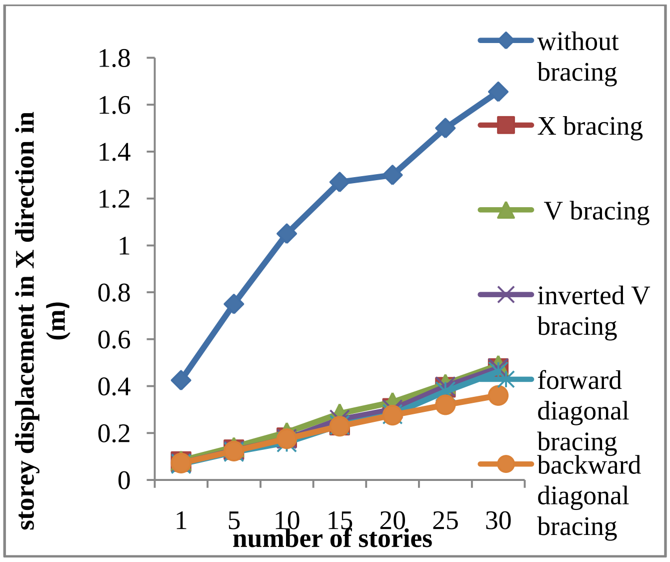


Fig 4.1 storey displacement in X direction of outer portion of building

2) Storey Displacement In Y Direction of Bracing Located in Outer Portion of Building

storey	Without bracing (m)	With X bracing (m)	With V bracing (m)	With inverted V bracing (m)	With forward diagonal bracing (m)	With backward diagonal bracing (m)
1	0.251	0.141	0.138	0.154	0.139	0.141
5	0.38	0.168	0.16	0.183	0.169	0.177
10	0.512	0.182	0.186	0.191	0.187	0.187
15	0.71	0.229	0.224	0.244	0.225	0.217
20	0.872	0.297	0.283	0.284	0.283	0.284
25	0.956	0.383	0.374	0.346	0.373	0.345
30	1.07	0.548	0.519	0.509	0.5	0.437

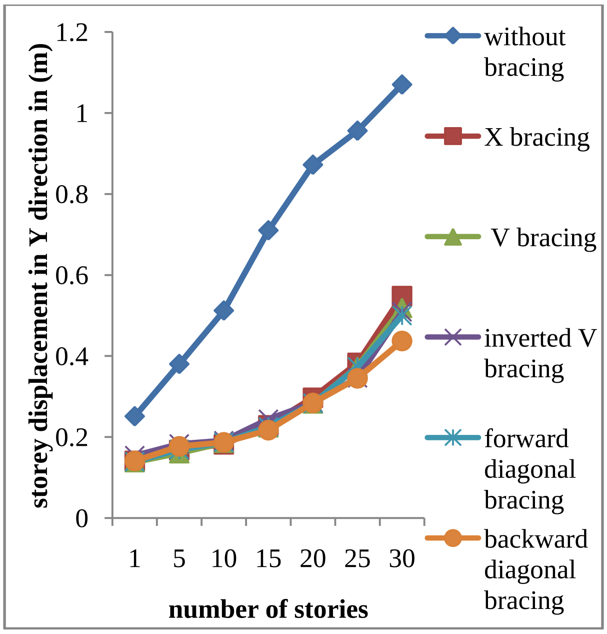


Fig 4.2 storey displacement in Y direction of outer portion of building

3) Storey Drift Of Bracing Located In Outer Portion Of Building

storey	Without bracing (mm)	With X bracing (mm)	With V bracing (mm)	With inverted V bracing (mm)	With forward diagonal bracing (mm)	With backward diagonal bracing (mm)
1	1.425	0.262	0.824	0.193	0.146	0.225
5	2.09	0.562	1.058	0.2	0.311	0.49
10	4.575	0.928	2.258	1.463	0.503	0.745
15	7.005	1.366	5.043	2.106	0.718	1.063
20	10.11	1.636	7.404	2.977	0.78	0.346
25	14.35	1.925	9.13	3.71	1.22	0.435
30	17.90	2.17	12.10	4.172	1.761	0.498

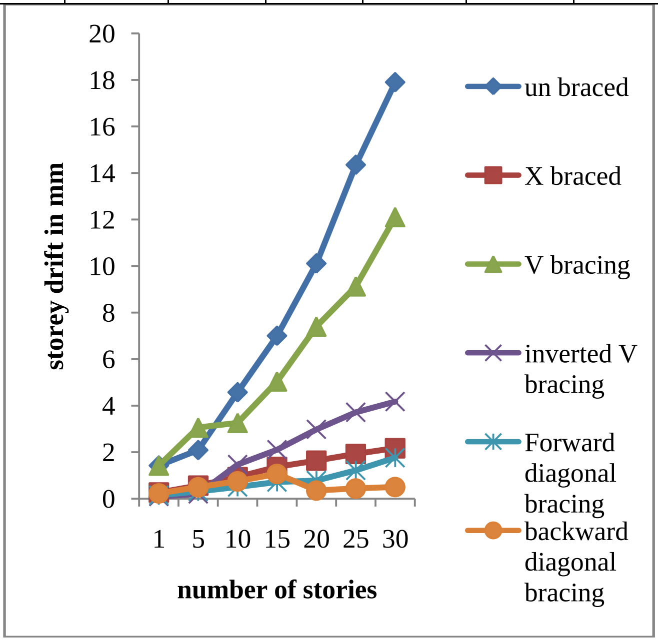


Fig 4.3 storey's drift of outer portion of building

B. Bracing Is Located on Core of The Building

To find the lateral storey displacement of X and Y direction and storey drift of building with different types of bracings such as X bracing, V bracing, inverted V bracing, forward diagonal bracing and backward diagonal bracing. These bracings are located on core of the building. These results are compared to without bracing of building.

STOREY DISPLACEMENT IN X DIRECTION OF BRACING LOCATED IN CORE OF BUILDING

storey	Without bracing (m)	With X bracing (m)	With V bracing (m)	With inverted V bracing (m)	With forward diagonal bracing (m)	With backward diagonal bracing (m)
1	0.425	0.068	0.072	0.0635	0.0528	0.063
5	0.75	0.115	0.124	0.11	0.1056	0.108
10	1.05	0.159	0.178	0.155	0.1404	0.155
15	1.27	0.209	0.249	0.228	0.2059	0.207
20	1.3	0.269	0.295	0.268	0.2469	0.245
25	1.5	0.348	0.365	0.352	0.337	0.284
30	1.655	0.419	0.432	0.423	0.405	0.318 6

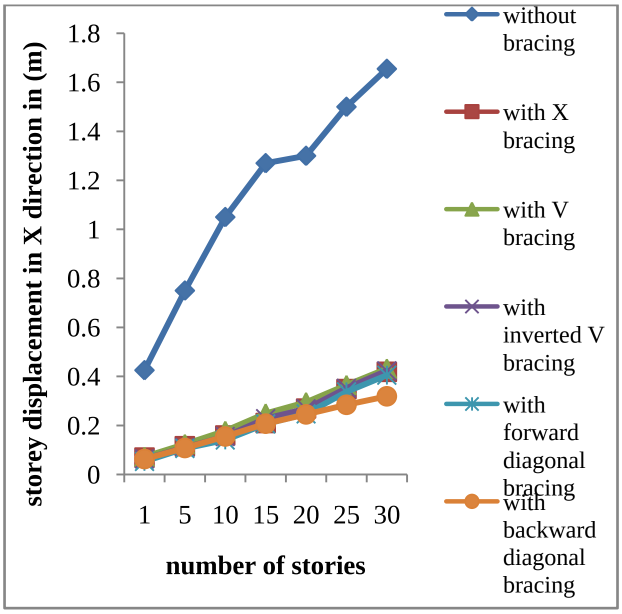


Fig 4.4 storey displacement in X direction of core of building

STOREY DISPLACEMENT IN Y DIRECTION OF BRACING LOCATED IN CORE OF BUILDING

storey	Without bracing (m)	With X bracing (m)	With V bracing (m)	With inverted V bracing (m)	With forward diagonal bracing (m)	With backward diagonal bracing (m)
1	0.251	0.127	0.121	0.1355	0.122	0.124
5	0.38	0.149	0.142	0.162	0.151	0.155
10	0.512	0.161	0.164	0.179	0.166	0.167
15	0.71	0.204	0.198	0.198	0.199	0.162
20	0.872	0.264	0.249	0.249	0.248	0.186
25	0.956	0.337	0.329	0.306	0.33	0.303
30	1.07	0.49	0.459	0.447	0.45	0.383

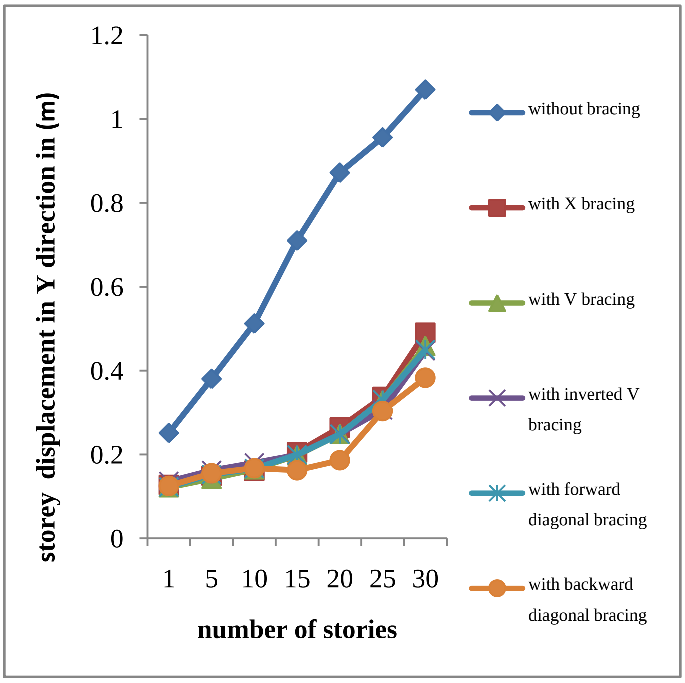


Fig 4.4 storey displacement in Y direction of core of building

Storey Drift Of Without Bracing And Each Type Of Bracing Located In Core Of Building

storey	Without bracing (mm)	With X bracing (mm)	With V bracing (mm)	With inverted V bracing (mm0	With forward diagonal bracing (mm)	With backward diagonal bracing (mm)
1	1.42	0.24	0.29	0.32	0.127	0.199
5	2.09	0.48	0.42	0.46	0.273	0.412
10	4.57	0.52	1.92	0.88	0.442	0.655
15	7.00	0.53	4.59	0.90	0.635	0.93
20	10.1	0.57	6.28	1.64	0.678	0.306
25	14.3	0.59	8.0	1.80	1.097	0.387
30	17.9	1.25	10.2	3.67	1.540	0.435

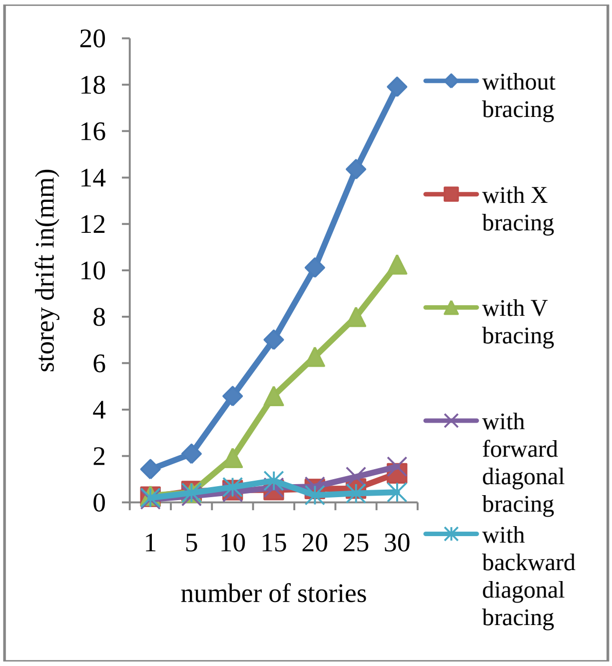


Fig 4.6 storey drifts of core of building

4.8comparison Of Core And Outer Portion Of Bracing

STOREY DISPLACEMENT AND DRIFT OF CORE AND OUTER PORTION OF THE BRACING SYSTEM WAS COMPARED AND RESULTS ARE LISTED IN TABLE.

Storey Displacement In X DIRECTION

storey	With X bracing (%)	With V bracing (%)	With inverted V bracing (%)	With forward diagonal bracing (%)	With backward diagonal bracing (%)
10	82.85	81.66	83.73	84.76	83.53
10	84.82	83.74	85.93	86.62	85.83

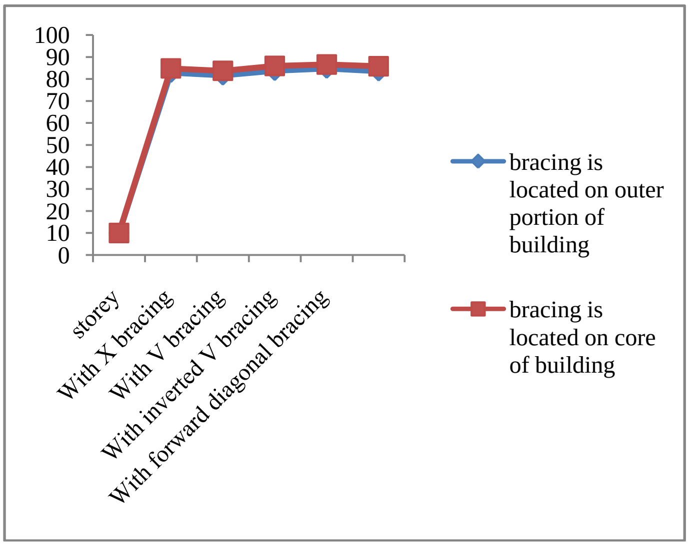


Fig 4.7 comparison of storey displacement in X direction of core and outer portion

Storey Displacement In Y Direction

storey	With X bracing	With V bracing	With inverted V bracing	With forward diagonal bracing	With backward diagonal bracing
15	67.74	68.45	65.63	63.80	69.43
15	71.15	72.11	72	71.97	77.18

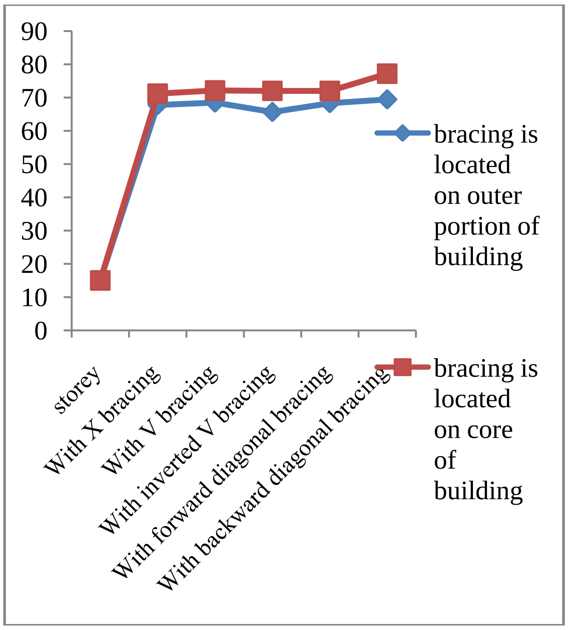


Fig 4.8 comparison of storey displacement in Y direction in core and outer portion

Storey Drift

storey	With X bracing	With V bracing	With inverted V bracing	With forward diagonal bracing	With backward diagonal bracing
30	87.88	32.37	76.69	90.16	97.21
30	93.00	82.69	89.50	91.39	97.86

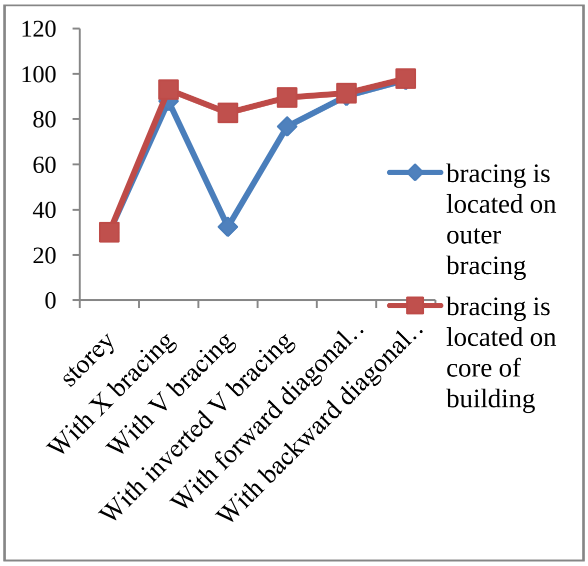


Fig 4.9 comparison of storey drift of core and outer portion of bracing

V. COST ESTIMATION OF BUILDING

ITEM	COST	UNIT
Without Bracing Structure	128528769.6	Rs
With X, V, And Inverted V Bracing In Outer Portion Of Building	132319689.6	Rs
With Forward And Backward Diagonal Bracing In Outer Portion Of Building	130424253.4	Rs
With X, V, And Inverted V Bracing In Core Of Building	129792425	Rs
With Forward And Backward Diagonal Bracing In Core Of Building	129160598	Rs

VI. CONCLUSION

- As compared to core and outer portion of bracing, the storey displacement and drift was low in core of building.
- The diagonal bracing was more efficient as compared to other types of bracing in both outer and inner core of the building.
- As compared to all types of bracing V bracing has more displacement in both bracing configuration.
- Total Cost of building material was estimated. The total cost of the braced building is more as compared to unbraced building.
- Total cost of core of building is less as compared to outer portion of building.

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