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Effects of Various Bracing in Building with Rectangular Columns

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ABSTRACT*:* In general the most suitable choices in improvement of reinforcement concrete frame against lateral loading is R.C. bracing system. In this paper, the seismic analysis of reinforced concrete (RC) buildings with different types of bracing (V-type, inverted V-type, X-type) are provided. Eight storey (G+8) building is considered which is situated in seismic zone III. The building models are analyzed by using equivalent static analysis as per recommendation given by IS 1893:2002 using Staad Pro V8i software. In this analysis of multistoreyed building with considering the rectangular columns with different types of bracing are compared.

KEYWORDS*:* Multistorey building, Rectangular column, Bracing system, Seismic zone.

I. INTRODUCTION

Civil engineering is the oldest engineering discipline after military engineering, and it was defined to distinguish non-military engineering from military engineering. It is traditionally broken into several sub-disciplines including environmental engineering, geotechnical engineering, geophysics, geodesy control engineering, structural engineering, etc. Structural engineering is concerned with the structural design and structural analysis of building, bridges, towers, flyovers, tunnels, off shore structures like oil and gas fields in the sea, aero structure and other structure. The construction of RC building is a very common practice in urban India for last 25 years. In the last decade significant developments in architectural expression and increasing demand for taller buildings resulted in a systematic evolution of structural systems. In India RCC structures were predominant in these developments and profiting from the inherent properties of this material, new RCC framing system emerged.

Most of the RC buildings were designed for gravity loads only. These buildings performed very poorly during Bhuj earthquake of January 2001 and Killari earthquake of September 1993. Since then the earthquake design is made mandatory for design of high rise buildings. For resisting the earthquake forces large sections for members need to be provided, these leads to the increase in material cost. Another alternative to resist EQ forces is providing bracings in the structure which reduces the section size and also increase lateral stiffness, lateral strength as well as lateral stability of frames.[6] Concrete bracings of double diagonal form are also used with each diagonal designed as a compression member to cart the full external shear. The conventional use of bracings has been in bay width modules and storey height that are fully concealed in the finished building. More recently external large scale bracings, extending over many stories and bays have been used to produce not only aesthetical attractive buildings but also highly efficient structures. The bracings are highly efficient in being able to produce very stiff structures laterally for a minimum of additional material. Thus makes it an economical structural form for any height of building.[1] The most effective and practical method of enhancing the seismic resistance is to increase the energy absorption capacity of structures by combining bracing elements in the frame. The braced frame can absorb a greater degree of energy exerted by earthquakes. In braced frame reduces the column and girder bending moments. The shear is primarily absorbed by diagonals and not by girders. The diagonals carry the lateral forces directly in predominantly axial action, providing for nearly pure cantilever behavior.[7]

II. RELATED WORK

2.1 Building Description

In this study, A G+8 storey reinforced concrete building of 3 bays have been considered for investigating the effect of Unbraced, X type, V type and inverted V type bracings and there arrangements in the middle bay of the building. The building having 3 bays in X direction and 3 bays in Z direction with the plan dimension is (15 m × 15 m) and in Y direction dimension is 3 m.

- Seismic Analysis of RC multistoreyed building of rectangular columns with unbraced, X

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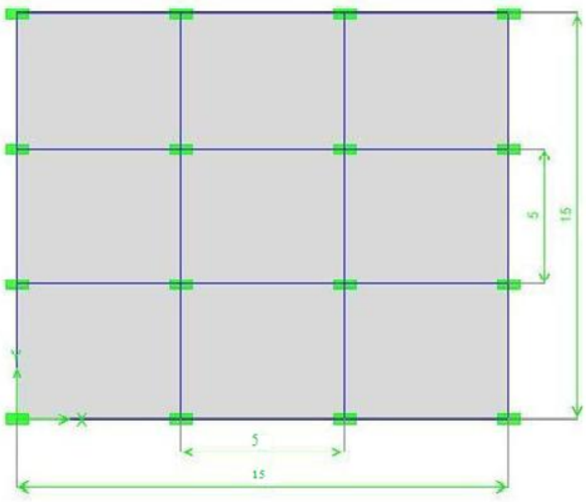
type, V type & inverted V type bracing which is situated in zone III by using STAAD.Pro V8i.

- Bending moments, shear forces, storey displacements, story drifts and axial forces are compared for all type of structural systems.

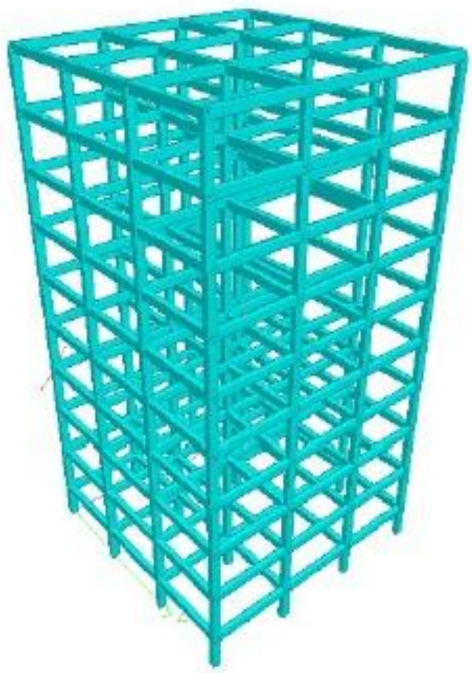
Table 2.1 RC Multistoried Building of Rectangular Columns

Type of Building	Residential
No. of Storeys	G+8
Grade of Concrete	M25
Grade of Reinforced Steel	Fe500
Density of RCC	25 kN/m^3
Beam Size	0.3m X 0.45m
Column Size	0.3m X 0.44m
Size of Bracings	0.2m X 0.2m
Thickness of Slab	130mm
Floor Finishing Load	1 kN/m^2
Live Load Intensity	3.0 kN/m^2
Seismic Loads	As per IS 1893
Seismic Zone	III
Zone factor, (Z)	0.16
Importance Factor, (I)	1
Response Reduction Factor, (R)	5
Soil Conditions	Medium Stiff Gravel Soil
Damping Ratio	5 %
Structure	SMRF
Foundation System	Isolated Foundation

Fig. (a): Plan of Building
Fig. (b): Unbraced **(**Bare frame) RC building
Fig. (c): Building has RC X type braced in outrigger patterns in the middle bay of every storey in all the four sides.
Fig. (d): Building has RC V type braced in outrigger patterns in the middle bay of every storey in all the four sides.
Fig. (e): Building has RC inverted V (chevron) type braced in outrigger patterns in the middle bay of every storey in all the four sides.



(a)



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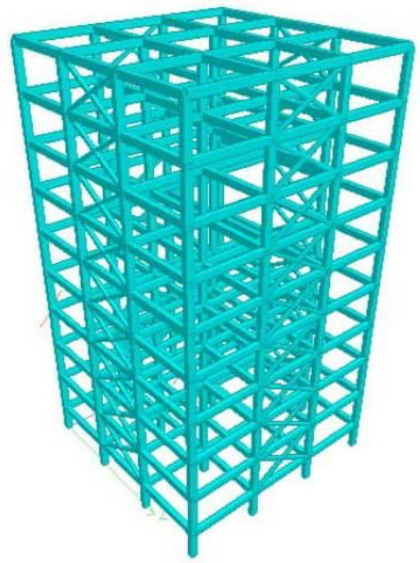

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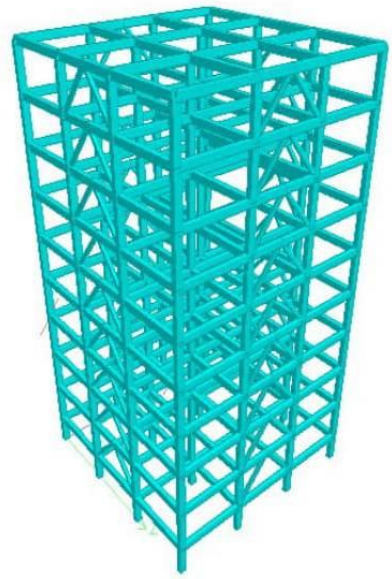

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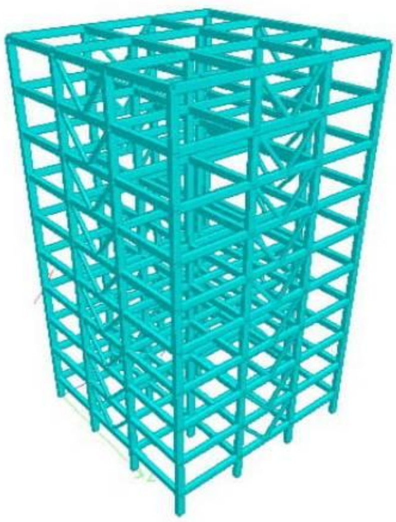

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III. METHODOLOGY

3.1 GENERAL

Behaviour of the structures with rectangular columns subjected to earthquake loading is a complicated phenomenon. There are several numbers of factors affecting the behavior of building out of which the axial loading, moment, shear force, etc. are considered. The 3D analysis is carried out in all the building models. The equivalent static analysis method is carried out on all the 3D models using the software STAAD.Pro V8i. The results obtained from the analysis are discussed in this paper.

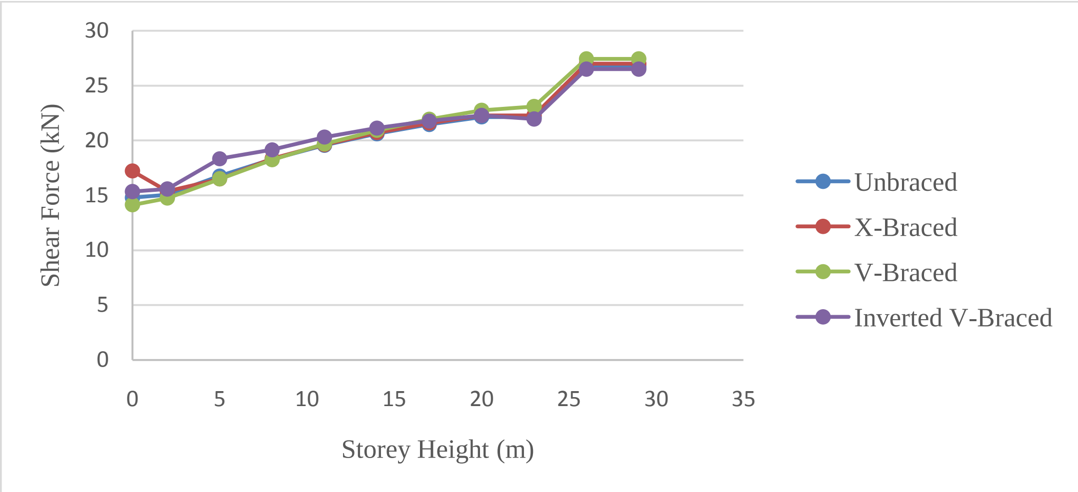
3.2 Method of Analysis

Equivalent static analysis is carried out on all the four models. The results are presented in the form of tables and graphs. The loads are calculated and the results obtained are compared with respect to the following parameters like bending moment, shear force, storey drift, storey displacement and axial force.

Table 3.1 Shear Force (kN) in Rectangular Column

Floors	Height	Nodes	Unbraced	X-Braced	V-Braced	Inv. V-Braced
Base	0	133	14.78	17.21	14.13	15.34
Ground	2	137	15.03	15.38	14.75	15.58
1	5	141	16.75	16.49	16.5	18.33
2	8	145	18.27	18.35	18.23	19.14

3	11	149	19.55	19.62	19.68	20.3
4	14	153	20.61	20.72	20.91	21.12
5	17	157	21.46	21.59	21.93	21.76
6	20	161	22.14	22.28	22.75	22.26
7	23	165	22.12	22.28	23.08	21.94
8	26	169	26.74	27	27.43	26.49
9	29	173	26.74	27	27.43	26.49

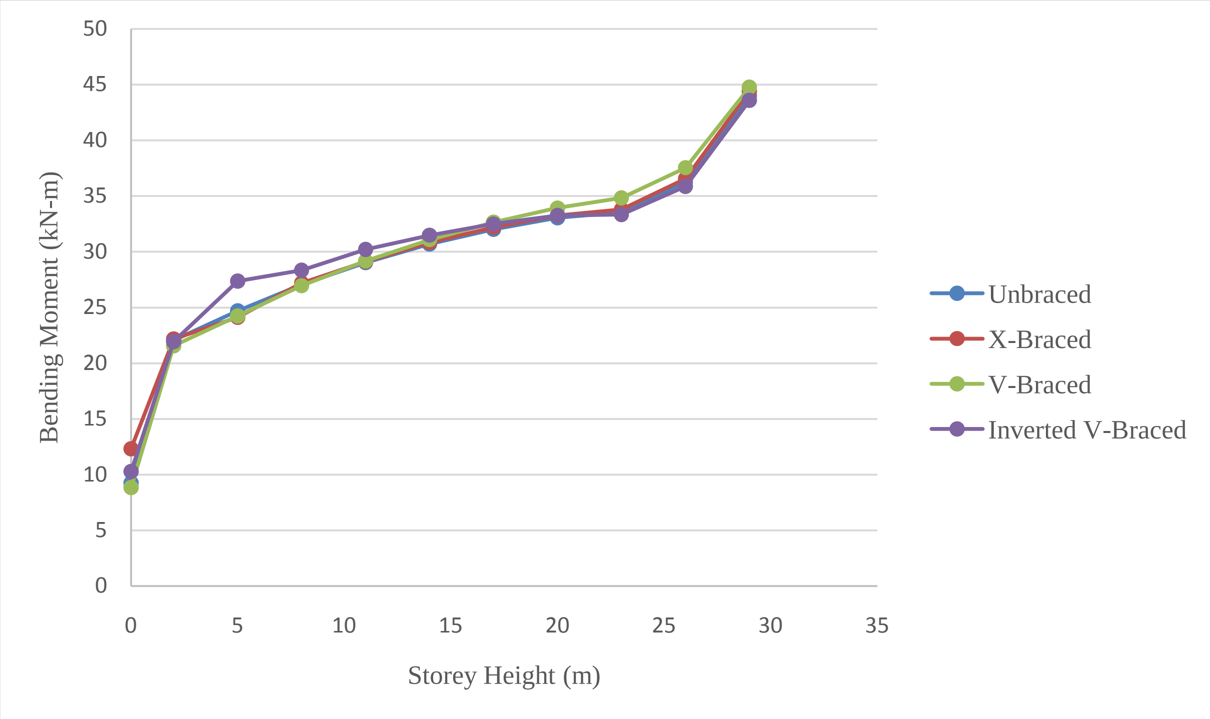


Graph 3.1 Storey Height Vs Shear Force

Table 3.2 Bending Moment (kN-m) in Rectangular Column

Floors	Height	Nodes	Unbraced	X-Braced	V-Braced	Inv. V-Braced
Base	0	133	9.23	12.31	8.83	10.28
Ground	2	137	22.03	22.17	21.54	21.95
1	5	141	24.68	24.12	24.22	27.38
2	8	145	27.04	27.19	26.94	28.34
3	11	149	29.02	29.11	29.17	30.21
4	14	153	30.67	30.82	31.07	31.49
5	17	157	32	32.19	32.65	32.5
6	20	161	33.03	33.24	33.92	33.25
7	23	165	33.53	33.78	34.82	33.34

8	26	169	36.25	36.55	37.53	35.87
9	29	173	43.98	44.41	44.76	43.6



Graph 3.2 Storey Height Vs Bending Moment

Table 3.3 Axial Force (kN) in Rectangular Column

Floors	Height	Nodes	Unbraced	X-Braced	V-Braced	Inv. V-Braced
Base	0	133	1115.75	1153.11	1121.16	1115.8
Ground	2	137	1017.48	1055.5	1025.59	1016.49
1	5	141	910.6	940.63	920.5	909.8
2	8	145	800	823.68	811	799.68
3	11	149	686.4	704.42	697.56	686.25
4	14	153	570.1	583.29	580.69	570.1
5	17	157	451.63	460.77	460.88	451.73
6	20	161	331.48	337.33	338.62	331.62
7	23	165	210.16	213.51	214.41	210.31
8	26	169	87.37	89.11	87.75	87.52
9	29	173	73.38	75.11	73.75	73.53

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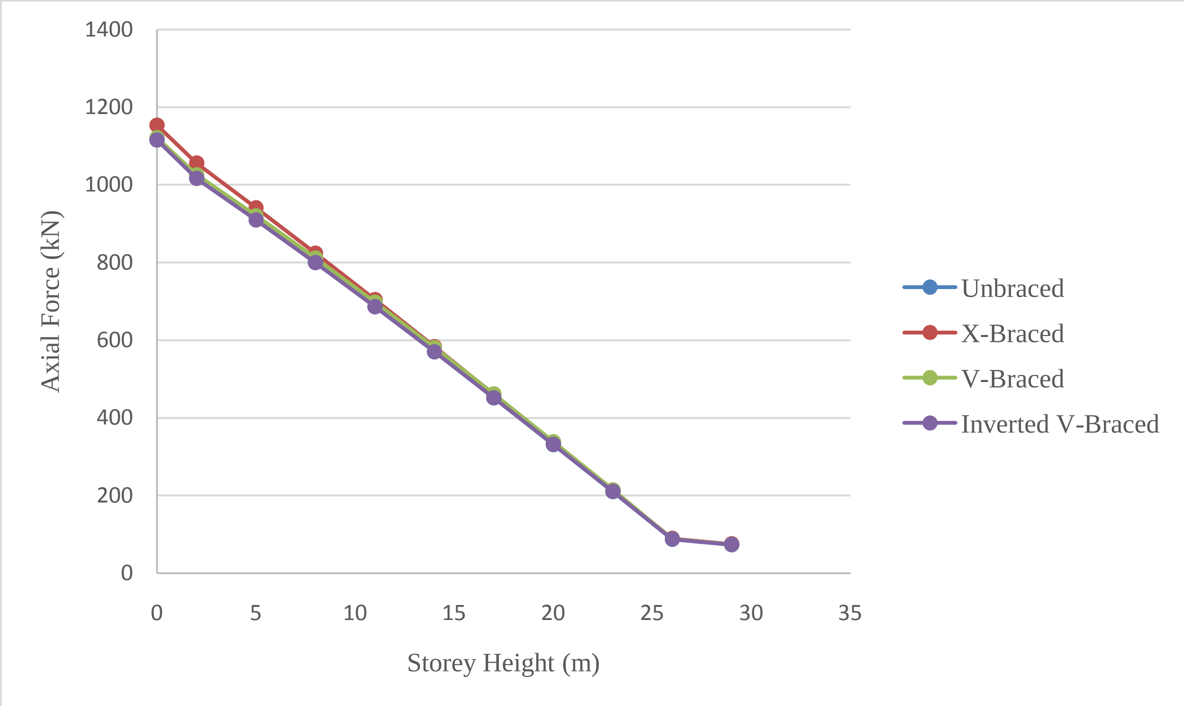
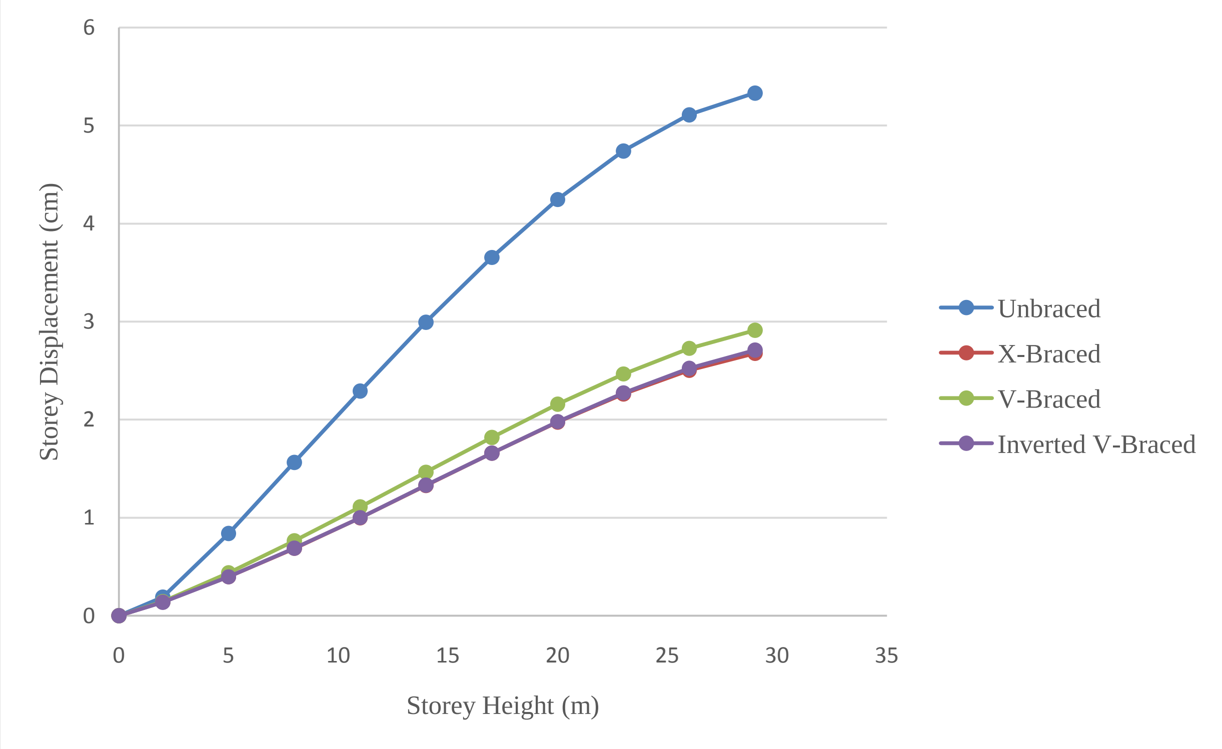


Graph 3.3 Storey Height Vs Axial Force

Table 3.4 Storey Displacement (cm) in Rectangular Column

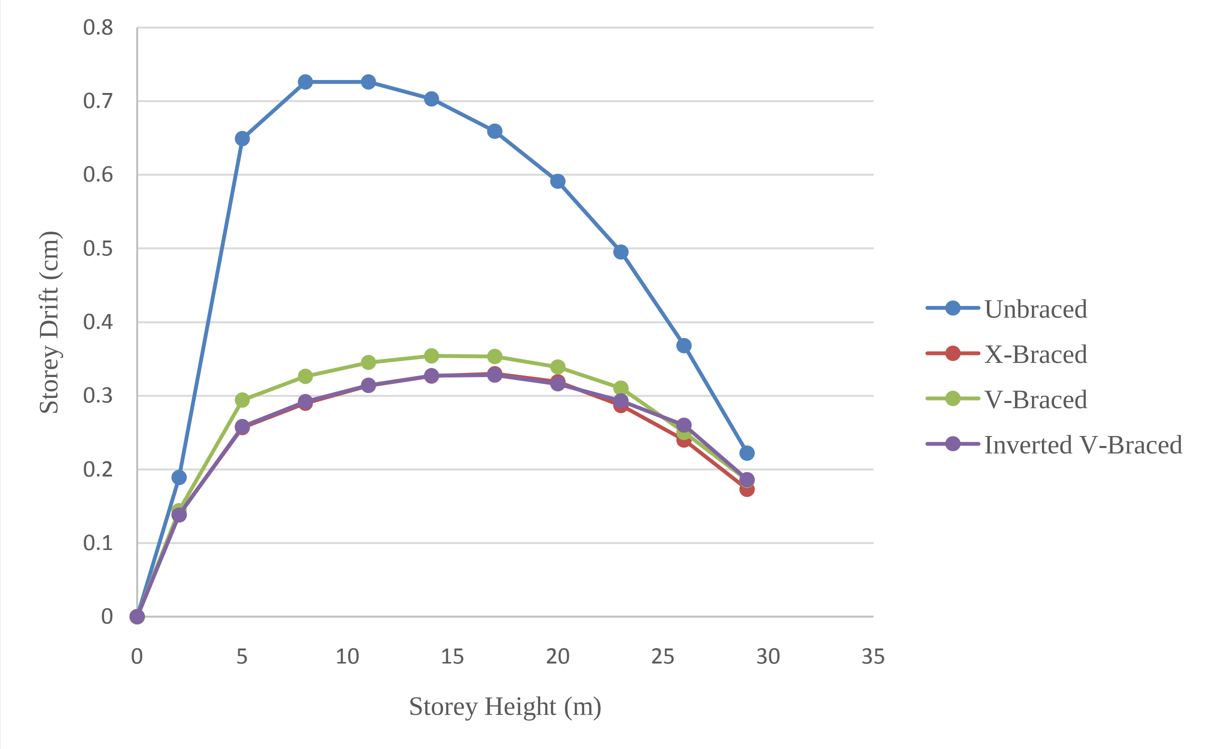
Floors	Height	Nodes	Unbraced	X-Braced	V-Braced	Inv. V-Braced
Base	0	133	0	0	0	0
Ground	2	137	0.189	0.139	0.144	0.138
1	5	141	0.839	0.397	0.438	0.397
2	8	145	1.565	0.687	0.765	0.689
3	11	149	2.292	1	1.11	1
4	14	153	2.995	1.329	1.465	1.331
5	17	157	3.655	1.659	1.819	1.659
6	20	161	4.246	1.975	2.158	1.979
7	23	165	4.741	2.263	2.467	2.273
8	26	169	5.109	2.503	2.728	2.523
9	29	173	5.332	2.677	2.913	2.709



Graph 3.4 Storey Height Vs Story Displacement

Table 3.5 Storey Drift (cm) in Rectangular Column

Floors	Height	Nodes	Unbraced	X-Braced	V-Braced	Inv. V-Braced
Base	0	133	0	0	0	0
Ground	2	137	0.189	0.139	0.144	0.138
1	5	141	0.649	0.257	0.294	0.258
2	8	145	0.726	0.29	0.326	0.292
3	11	149	0.726	0.314	0.345	0.314
4	14	153	0.703	0.327	0.354	0.327
5	17	157	0.659	0.33	0.353	0.328
6	20	161	0.591	0.319	0.339	0.316
7	23	165	0.495	0.287	0.31	0.293
8	26	169	0.368	0.24	0.25	0.26
9	29	173	0.222	0.173	0.185	0.186



Graph 3.5 Storey Height Vs Story Drift

IV. RESULTS ANALYSIS

➢ Table 3.1 shows the shear forces at top and ground storeys for all the structural systems i.e. unbraced, X-braced, V-braced and inverted V-braced structural systems for rectangular columns models respectively. The shear forces of the structure for various types of bracing systems are compared. It can be seen that the shear forces at top levels in rectangular column models are 14.78 kN, 17.21 kN, 14.13 kN, 15.34 kN for unbraced, X-braced, V-braced and inverted V-braced structural systems respectively. It can also be seen that the shear forces at base levels in rectangular column models are 26.74 kN, 27 kN, 27.43 kN, 26.49 kN for unbraced, X-braced, V-braced and inverted V-braced structural systems respectively.

➢ Table 3.2 shows the bending moment at top and ground stories for all the structural systems i.e. unbraced, X-braced, V-braced and inverted V-braced structural systems for rectangular columns models respectively. The bending moments of the structure for various types of bracing systems are compared. It can be seen that the bending moment at top levels in rectangular column models are 9.23 kN-m, 12.31 kN-m, 8.83 kN-m, 10.28 kN-m for unbraced, X-braced, V-braced and inverted V-braced structural systems respectively. It can also be seen that the bending moment at base levels in rectangular column models are 43.98 kN-m, 44.41 kN-m, 44.76 kN-m, 43.6 kN-m for unbraced, X-braced, V-braced and inverted V-braced structural systems respectively.

➢ Table 3.3 shows the axial force at top and ground stories for all the structural systems i.e. unbraced, X-braced, V-braced and inverted V-braced structural systems for rectangular columns models respectively. The axial forces of the structure for various types of bracing systems are compared. It can be seen that the axial forces at top levels in rectangular column models are 1115.75 kN, 1153.11 kN, 1121.16 kN, 1115.8 kN for unbraced, X-braced, V-braced and inverted V-braced structural systems respectively. It can also be seen that the axial forces at base levels in rectangular column models are 73.38 kN, 75.11 kN, 73.75 kN, 73.53 kN for unbraced, X-braced, V-braced and inverted V-braced structural systems respectively.

➢ Table 3.4 shows the maximum storey displacement for seismic load for all the structural systems i.e. unbraced, X-braced, V-braced and inverted V-braced structural systems for rectangular columns models respectively. The storey displacements of the structure for various types of bracing systems are compared. It can be seen that the storey displacement at top levels in rectangular column models are 5.332cm, 2.677cm, 2.913cm, 2.709cm for unbraced, X-braced, V-braced and inverted V-braced structural systems respectively.

➢ Table 3.5 shows the storey drifts for seismic load for all the structural systems i.e. unbraced, X-braced, V-braced and inverted V-braced structural systems for rectangular columns models respectively. The storey drifts of the structure for various types of bracing systems are compared. It can be seen that the storey drift at top levels in rectangular column models are 0.222cm, 0.173cm, 0.185cm, 0.186cm for unbraced, X-braced, V-braced and inverted V-braced structural systems respectively.

V. CONCLUSION

Bracing system reduces not only bending moment but also shear force in the columns and also transfer the lateral loads through; axial load mechanism to the foundation. Bracing system increases the axial loading in the column. Building model with X-bracing system having more axial load compare with different types of specified bracing system. Performance of the building increases after the application of X-type bracing system.

In this paper, it can conclude that X-type bracing system is better than other specified bracing system.

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