Analysis of Multistorey RCC Building with Differents Types of Bracing by using STAAD Pro.

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Abstract:- The primary objective of this research is to evaluate structural stability using appropriate techniques, including standard configurations and the correct cross-sections for columns and beams. This involves developing preferred requirements for various support conditions, load types, and load combinations. It is noted that many buildings in India have been damaged or demolished by earthquakes, resulting in the loss of precious lives. The ability of structures to withstand major earthquakes is significantly improved by understanding how buildings respond to seismic activity and leveraging the expertise of engineers. This study examines the effects of different bracing systems (X-bracing bracing, inverted v bracing, k bracing) on the seismic performance of a building located in seismic Zone IV in India using STAAD Pro software. The analysis reveals that all bracing systems significantly control the lateral displacement of the frame. Designing an earthquake-resistant structure presents numerous challenges, especially in earthquake-prone areas. This research highlights the critical role of bracing systems in improving the seismic resilience of high-rise buildings in India.

Keywords:- *Seismic; Bracing System; Bending Moment; Shear Force; Storey Displacement; Storey Drift; Inverted V Bracing.*

I. INTRODUCTION

The structural integrity of buildings in seismic-prone regions is a critical concern, particularly in countries like India, where seismic activity poses a significant threat to infrastructure. The design and analysis of multi-storey buildings in such areas require meticulous attention to various loads that can impact stability, including dead loads, live loads, seismic loads, wind loads, and temperature variations(Mohammad et al., 2019; Pawar et al., 2015; Vaishnavi & Chandra, 2008). This research focuses on the design of a G+14 building in Seismic Zone 4 of India using STAAD Pro V8i, incorporating M30 grade concrete and Fe500 grade steel. The study aims to evaluate the building's performance under these loads, with particular emphasis on parameters such as storey drift, bending moment, storey displacement, and shear force. The integration of a steel bracing system is a key aspect of this design, enhancing the building's resistance to lateral forces and ensuring compliance with Indian standards IS 1893:2002 for seismic loads and IS 875:2015 for wind loads. By analyzing these factors, the study underscores the necessity of adhering to stringent seismic codes to safeguard multi-storey buildings in high-risk zones, highlighting the critical role of advanced design techniques and materials in enhancing structural resilience. The RC bracing system enhances a structure's resistance to horizontal forces by increasing its stiffness and stability. Bracing systems stabilize structures by transferring horizontal loads, such as those from earthquakes or wind, down to the ground, thereby countering lateral forces and preventing excessive sway. In RC multi-storey buildings, bracing members are cost-effective and easy to install(Ahmed Shariff & Student, 2019; Baikerikar & Kanagali, n.d.; Kumar et al., 2023; Singh et al., 2022). Various types of bracing systems include X bracing, V bracing, inverted V bracing, K bracing, and diagonal bracing, among others.

II. PROBLEM STATEMENT

A G+14 storey RC frame building is modelled in Staad Pro software. Model is created with four different types of bracing (Unbraced, X, V, diagonal and Inverted-V bracing). The basic data details of the selected building frame for analysis are listed in Table 1 &2 .To study the analysis of frames , the basic values are selected form IS1893:2016(part1) to meet the basic requirement of the structure. Moreover, various IS code has been used to calculate the DL, LL, etc. and all are explained in detail(Bhavan et al., 2000; of Indian Standards, n.d.).

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Table 1: Structural Modeling for the Project Models

The geometry of the structure	**Detail of values**
Grids in the direction-X	6
Grids in the direction-Z	5
Grid line space of line in X-direction	4meter
Spacing of Grid line in Z-direction	4meter
Number of Storey	G+14
Height of each storey	4m
Total height of the storey	60m
Beam dimension	450mm x 600mm
Column size	600mm x 600mm
Steel bracing	ISA110x110x12
Thickness of slab	150mm
Density of concrete	25 KN/m^2
Live Load on floors	3 KN/m^2
Live Load on roof	1.5 KN/m^2
External plaster	15mm
Internal plaster	12mm
Density of plaster	18 KN/m^2
Thickness of external wall	230mm
Thickness of internal wall	115mm
Grade of Concrete	M30
Grade of Steel	Fe500
Support	Fixed

Table 2. Seismic Parameters

Parameters	**Details**
Seismic zone	V
Zone factor	0.24
Importance Factor(I)	1
Respose Reduction Factor With SMRF	5
Type Of Soil	Medium Soil
Damping Percent	5%

A. Model & Plan of Building –

In these building four models are considered as follows:

- ***Model 1:*** *Unbraced Structure*
- ***Model 2:*** *X-Braced Structure*
- ***Model 3:*** *V-Braced Structure*
- ***Model 4:*** *Inverted V-Braced Structure*

- ***Model 1:*** *Unbraced Structure*

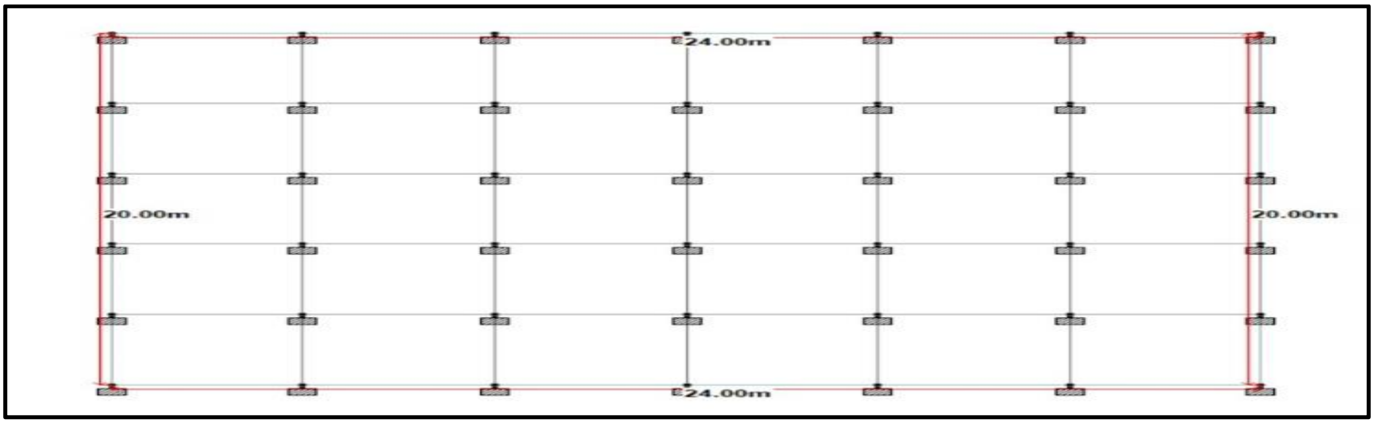

Fig 1: Plan View of RCC Frame Model

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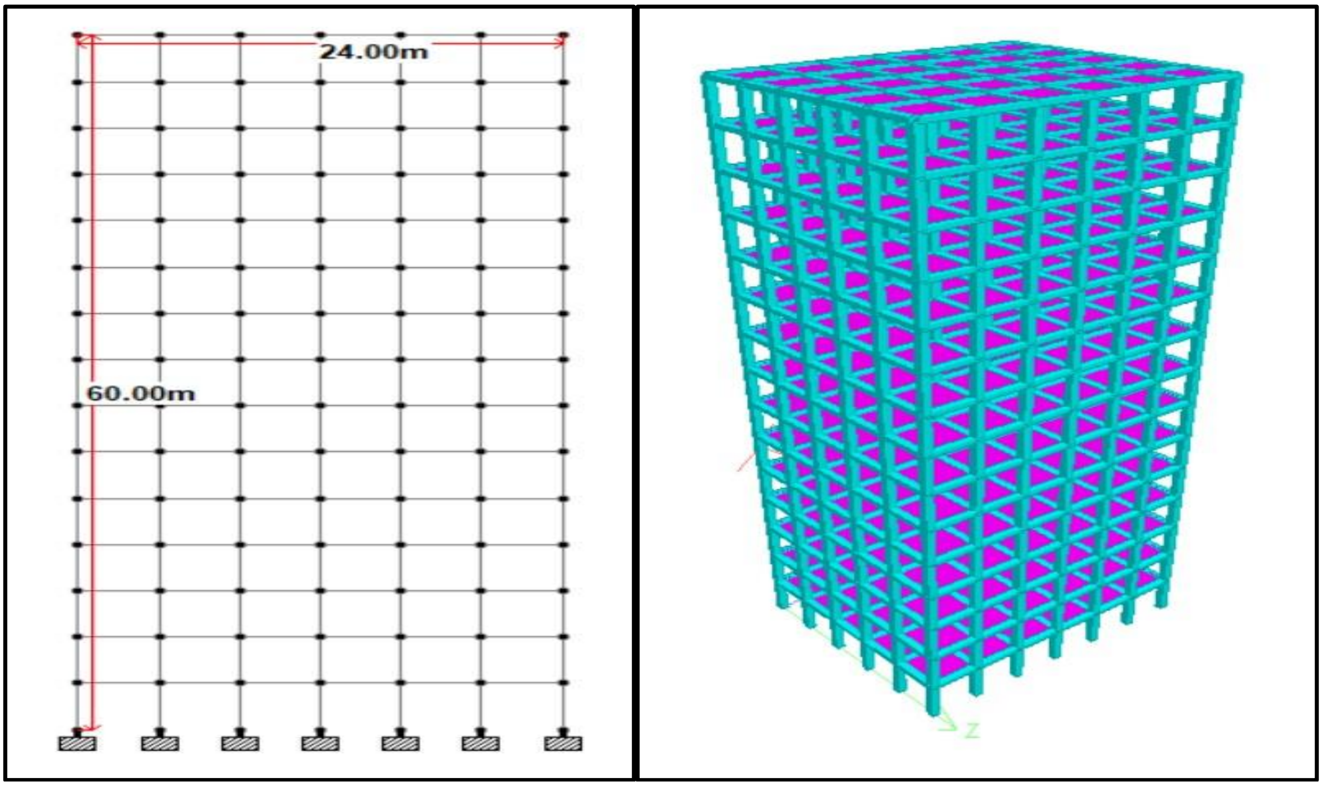

Fig 2: Elevation X & Z View of Building Frame &3-D Rendered View Of unbraced frame

- ***Model 2**: X- Braced Structure*

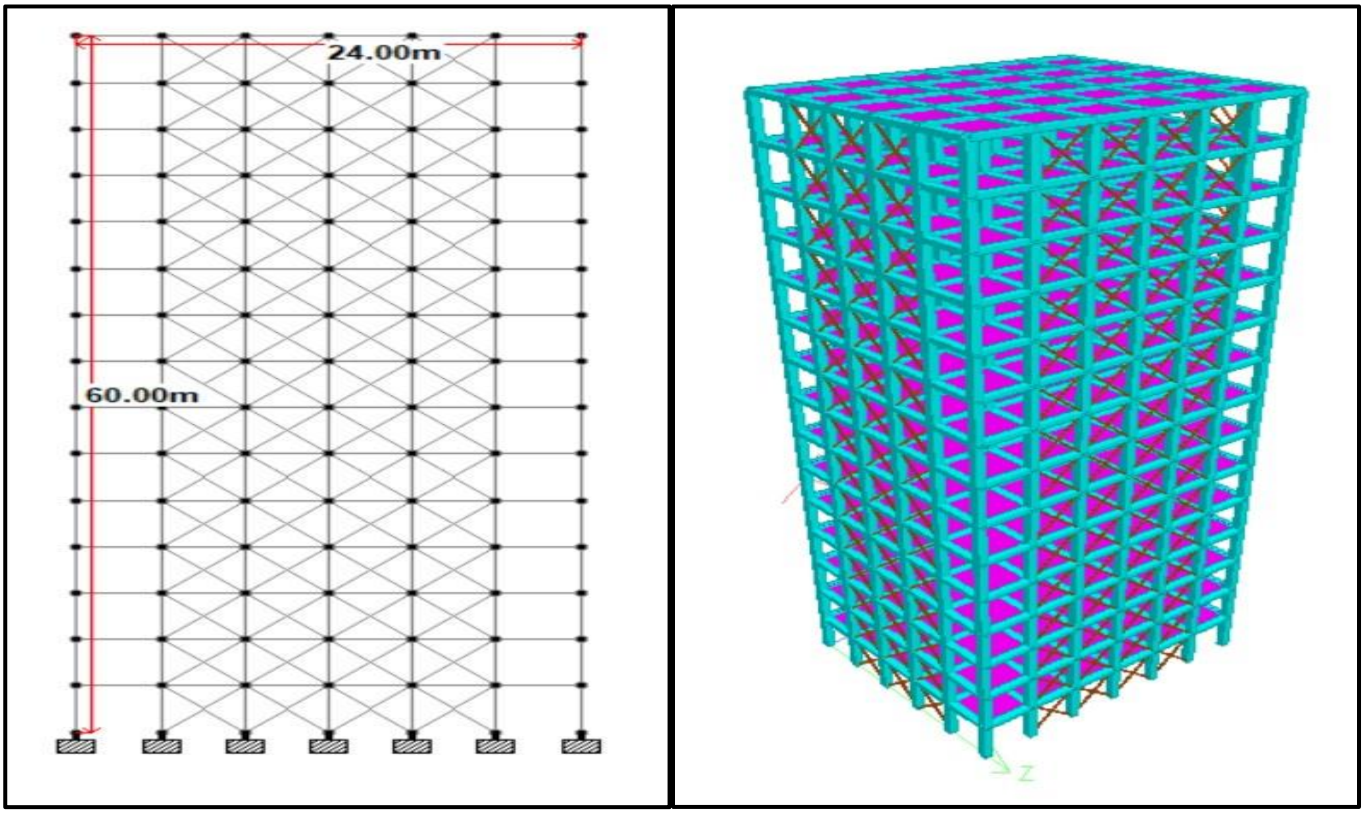

Fig 3" Elevation & 3D Rendering view of Model 2

➢ ***Model 3**: V- Braced Structure*

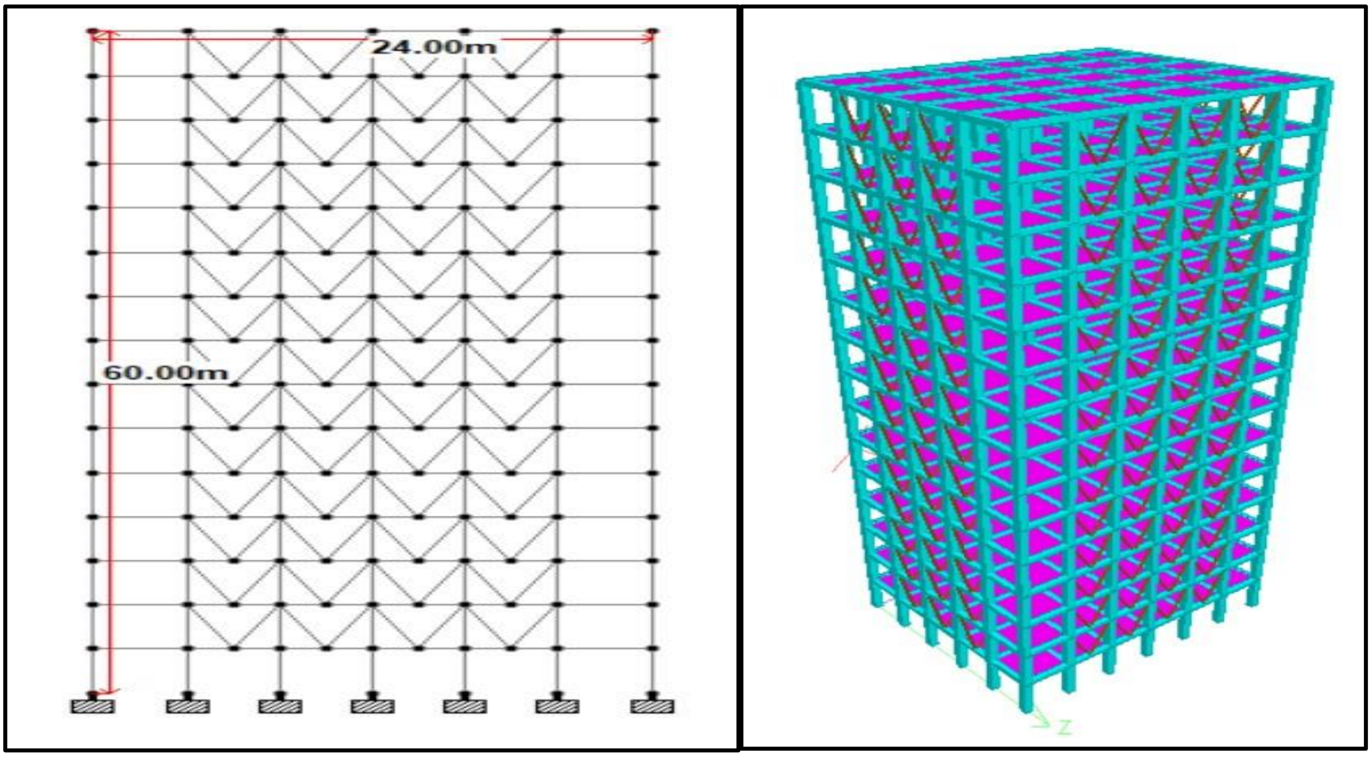

Fig 4: Elevation & 3D Rendering View of Model 3

➢ ***Model 4**: Inverted V Braced Structure*

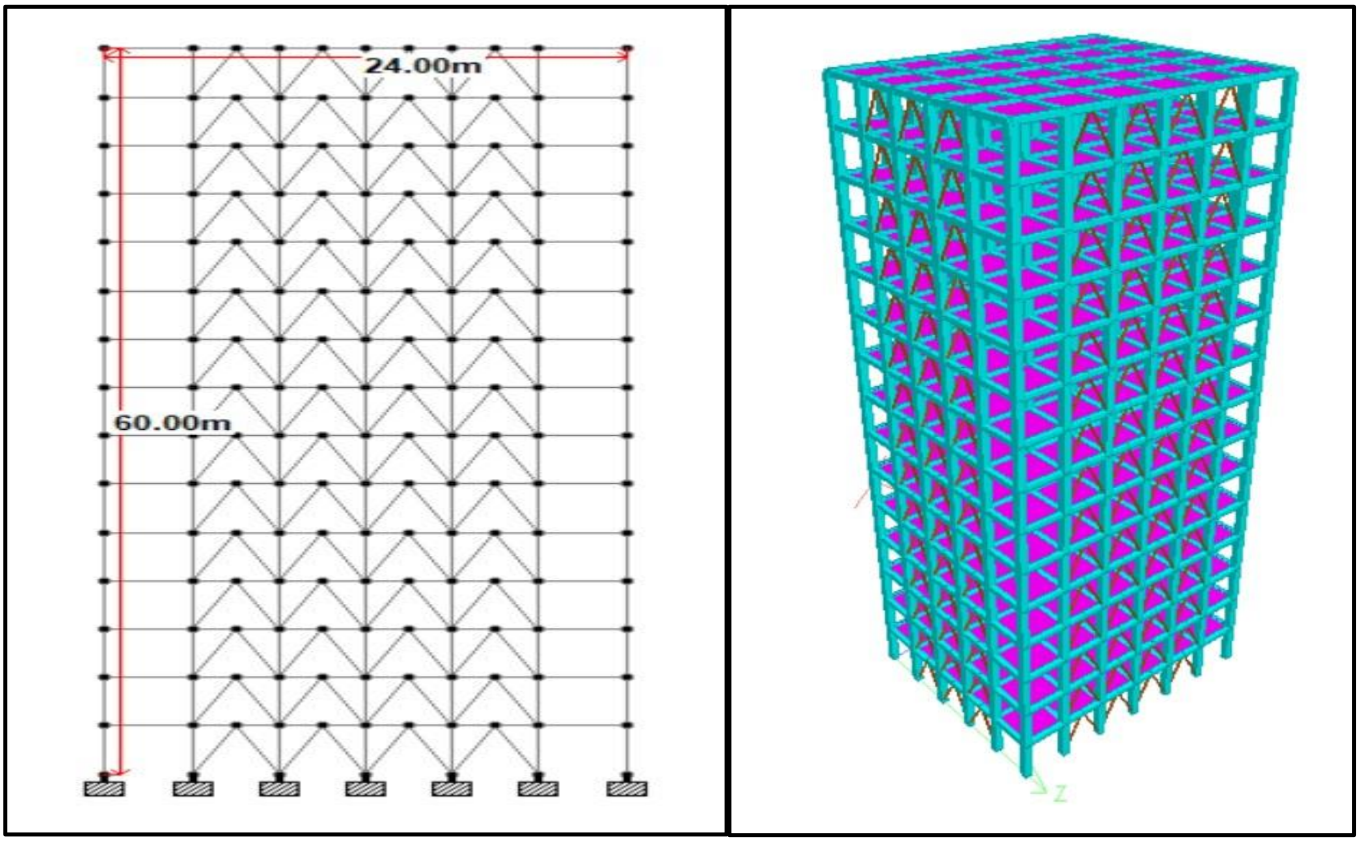

Fig 5: Elevation & 3D Rendering View of Model 4

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III. METHODOLOGY

A. General

The response of structures with rectangular columns to earthquake loading is a complex phenomenon influenced by various factors, such as axial loads, moments, and shear forces. An in-depth 3D analysis was conducted on all the building models. A comprehensive 3D analysis was performed on all the building models. The equivalent static analysis method was used on these 3D models with STAAD. Pro V8i software.

➢ *Seismic Analysis Method*

Seismic analysis is a critical aspect of structural engineering, especially for buildings and infrastructure located in earthquake-prone regions. STAAD. Pro V8i provides various methods for performing seismic analysis, ensuring that structures are designed to withstand seismic forces effectively. There are some methods used in seismic analysis are:

- **Equivalent Static Analysis:** Equivalent Static Analysis is a simplified method where the seismic forces are represented as static loads. It is simple to apply than the multi-model response method, to calculate of base shear, it is summation of lateral forces.
- **Dynamic Analysis:** Dynamic analysis shall be performed to obtain the design seismic force, it is distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following building:
- **Regular Building**

✓ H> 40m in zones IV and zone
✓ H> 90m in zone II and zone III

- **Irregular Building**

✓ H> 12m in zone IV and zone V
✓ H>40m in zone II and zone III

To calculated loads and the resulting data were compared based on parameters such as bending moment, shear force, story drift, story displacement.

B. Lateral Displacements

Table 3 presents the lateral displacements of an unbraced building under dead and live loads for seismic analysis in all three directions. These results are compared with buildings employing various types of bracing(Komal et al., 1448; Siddiqi et al., 2014). The data indicate that the maximum lateral displacements are significantly reduced in the presence of bracings, with X-type bracing systems showing the greatest reduction in lateral displacements.

Table 3: Storey Displacement (mm)

Storey Height(m)	Model 1	Model 2	Model 3	Model 4
4	2.675	1.47	2.6	1.909
8	7.069	3.44	6.675	4.636
12	11.796	5.532	11.019	7.492
16	16.608	7.727	15.458	10.443
20	21.432	9.988	19.914	13.443
24	26.216	12.28	24.335	16.452
28	30.91	14.573	28.667	19.429
32	35.454	16.832	32.857	22.332
36	39.783	19.023	36.844	25.117
40	43.826	21.112	40.562	27.738
44	47.504	23.061	43.939	30.145
48	50.732	24.833	46.896	32.288
52	53.42	26.393	49.350	34.118
56	55.479	27.714	51.220	35.590
60	56.893	28.751	52.490	36.661

Comparison of top storey displacement for ground motion in X direction & Z direction.

There is reduction in top storey in seismic zone V in the frame due to bracing. Reduction is more in model 2. For model 1 is ineffective without bracing is present in X direction & Z direction. Table 4 & 5 shows the top storey deflection for each model, figure shows the variation in storey deflection in X direction & Z direction & figure shows the Staad pro model for storey deflection.

Table 4: Compression of Top Storey Deflection

Case	Top Storey Deflection (mm)
Model 1	56.893
Model 2	28.751
Model 3	52.49
Model 4	36.661

Table 5: Storey Deflection Percentage Variation Corresponding to Model 1

Case	Deflection Percentage Variation
Model 2	49.46 %
Model 3	7.76%
Model 4	35.56%

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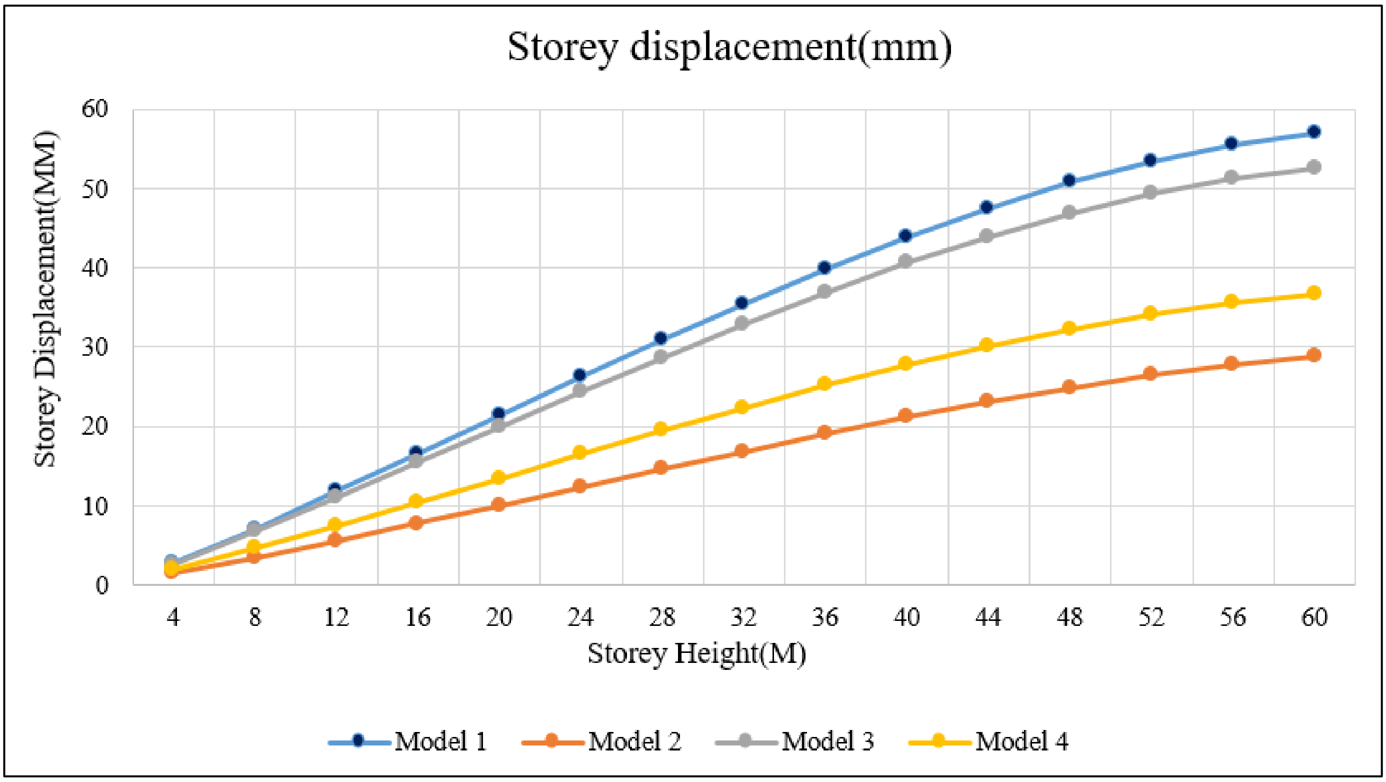

Fig 6: Storey Height Vs Storey Displacement

C. *Maximum Shear Forces and Bending Moments*

Tables 6 to 7 present the maximum shear forces, bending moments in the beam of a building frame without bracing, for both dead and live load analysis and seismic analysis. These results are compared with those of building frames equipped with various types of bracing, with data obtained in all three directions. Additionally, while bracings reduce the bending moments and shear forces in beams and notably, the bending moment values are lower for buildings with inverted v-type bracing systems.

Table 6: Max. Shear Force (KN)

Storey Height(m)	Model 1	Model 2	Model 3	Model 3
4	102.823	103.308	97.918	93.402
8	115.120	117.279	109.048	106.795
12	126.270	129.283	119.389	118.076
16	135.713	139.591	128.237	127.95
20	143.806	148.461	135.925	136.572
24	150.706	156.062	142.559	144.064
28	156.569	162.547	148.255	150.548
32	161.524	168.044	153.111	156.121
36	165.677	172.658	157.207	160.864
40	169.117	176.478	160.613	164.848
44	171.909	179.564	163.376	168.119
48	174.164	182.032	165.600	170.778
52	175.546	183.496	166.934	172.458
56	178.941	186.821	170.024	175.830
60	163.924	171.742	157.664	162.888

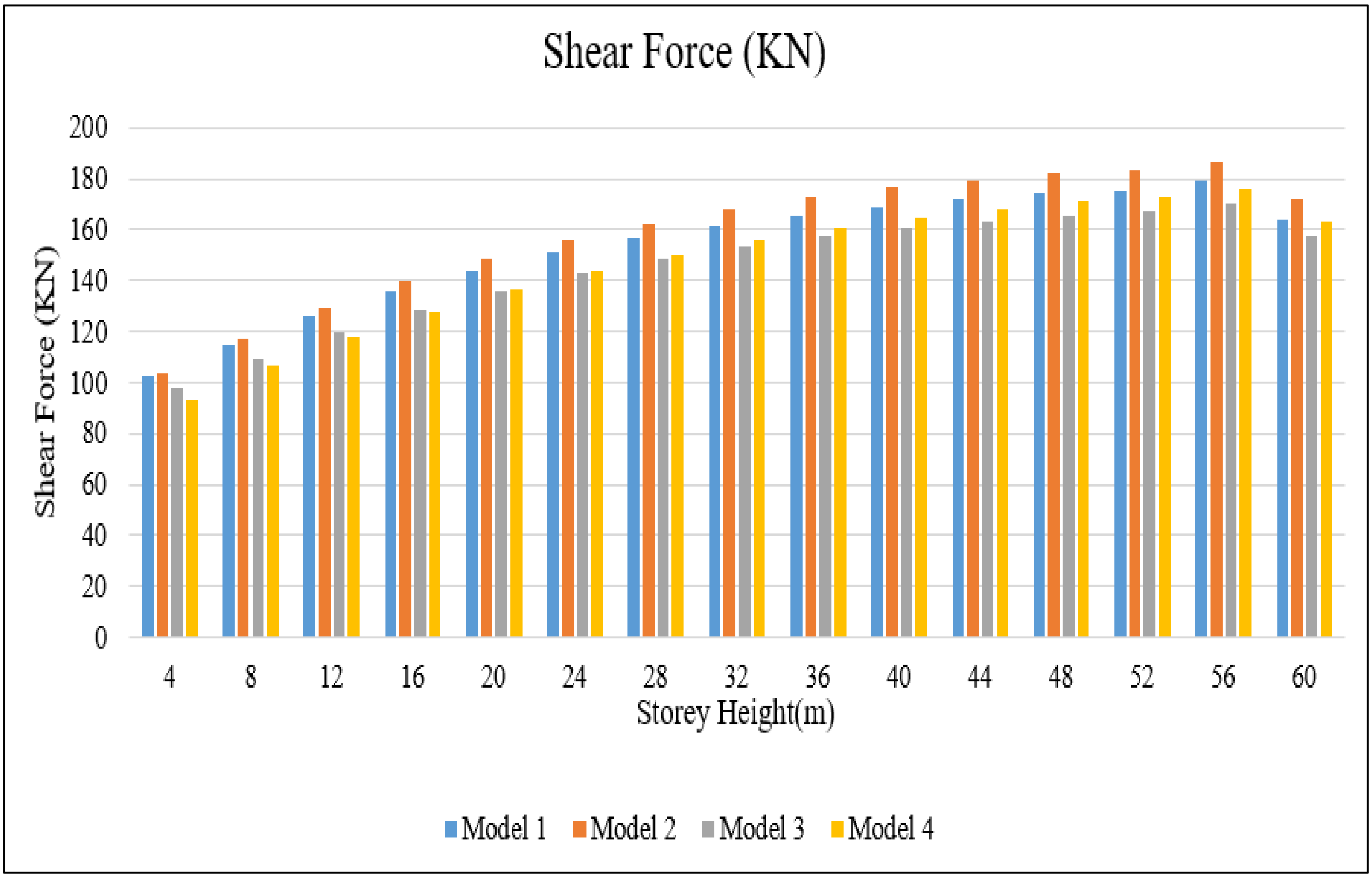

Fig 7: Storey Height Vs Shear Force

Table 7: Max. Bending Moment

Storey height(m)	Model 1	Model 2	Model 3	Model 4
4	91.373	92.245	86.973	173.669
8	116.366	121.059	109.429	101.847
12	138.44	144.94	129.961	124.357
16	157.229	165.602	147.574	144.313
20	173.294	183.351	162.854	161.718
24	186.984	198.564	176.028	176.876
28	198.609	211.541	187.332	190.015
32	208.425	222.539	196.959	201.333
36	216.647	231.77	205.071	210.994
40	223.453	239.408	211.807	219.135
44	228.975	245.579	217.266	225.852
48	233.432	250.501	221.643	231.33
52	236.146	253.449	224.263	234.896
56	**243.155**	**260.052**	**230.544**	**241.83**
60	210.688	228.844	203.951	214.594

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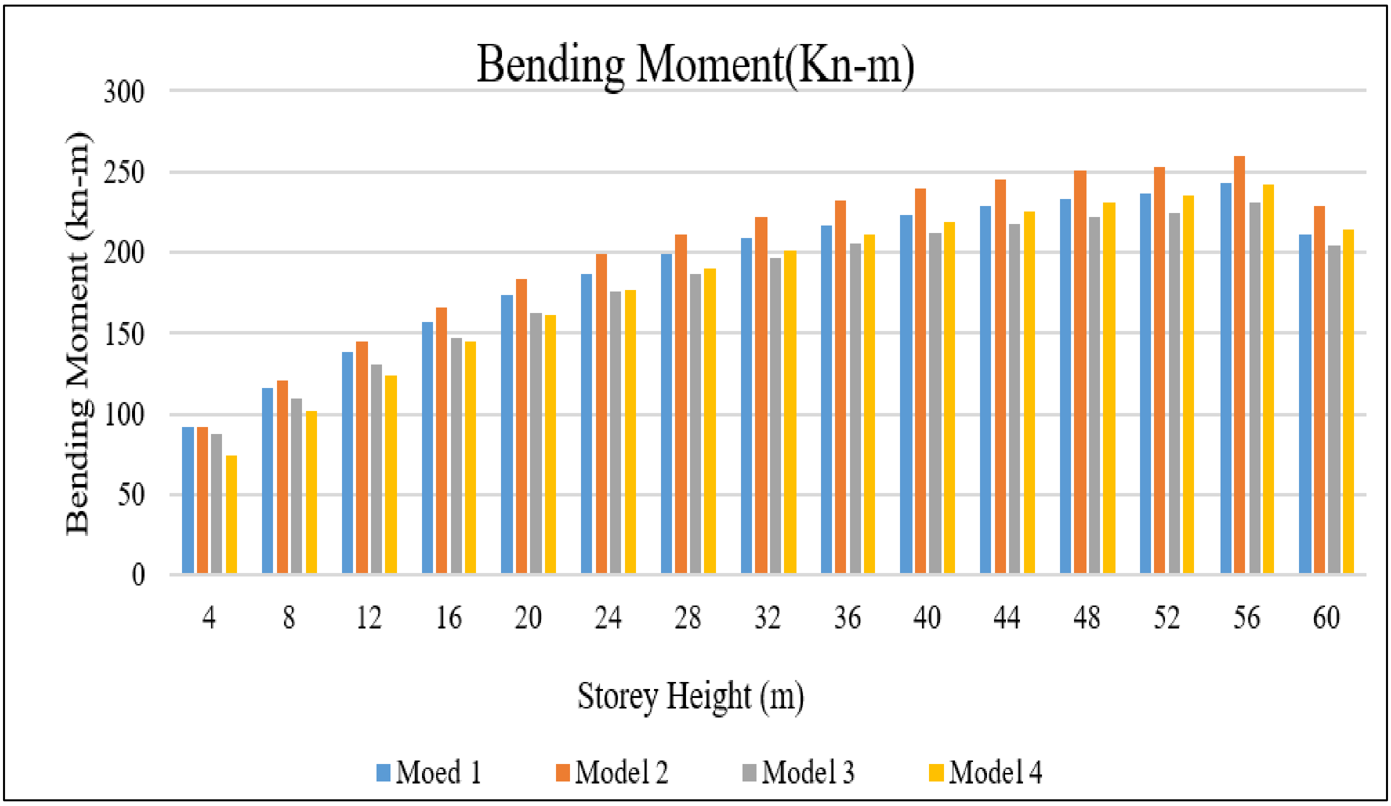

Fig 8: Storey Height Vs Bending Moment

D. Storey Drift

Drift is the lateral movement of a building under the influence of earthquake induced vibrations. It is the displacement of one level relative to the other level above or below. Table 8 shows the storey drift on each floor for all models:

Table 8: Storey Drift (mm)

Storey height(m)	Model 1	Model 2	Model 3	Model 4
4	2.728	1.710	2.674	2.141
8	4.509	2.360	4.258	3.133
12	4.879	2.551	4.576	3.33
16	4.987	2.702	4.694	3.466
20	5.015	2.800	4.728	3.544
24	4.99	2.853	4.704	3.571
28	4.91	2.862	4.624	3.545
32	4.768	2.83	4.485	3.47
36	4.556	2.753	4.281	3.341
40	4.272	2.632	4.007	3.156
44	3.903	2.477	3.655	2.914
48	3.447	2.257	3.221	2.614
52	2.899	2.008	2.698	2.26
56	2.259	1.733	2.089	1.857
60	1.597	1.408	1.459	1.406

Table 9: Comparison of Top Storey Drift

Case	Top storey drift (mm)
Model 1	1.597
Model 2	1.408
Model 3	1.459
Model 4	1.406

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E. Comparison of Storey Drift:

There is reduction in top storey drift due seismic load and wind load in the frame with the bracing system. Reduction is more in model 4. For model 1 is ineffective due to without bracing. Table 9 shows the top storey drift for each model, figure 9 shows the variation in storey drift in X direction and Z direction.

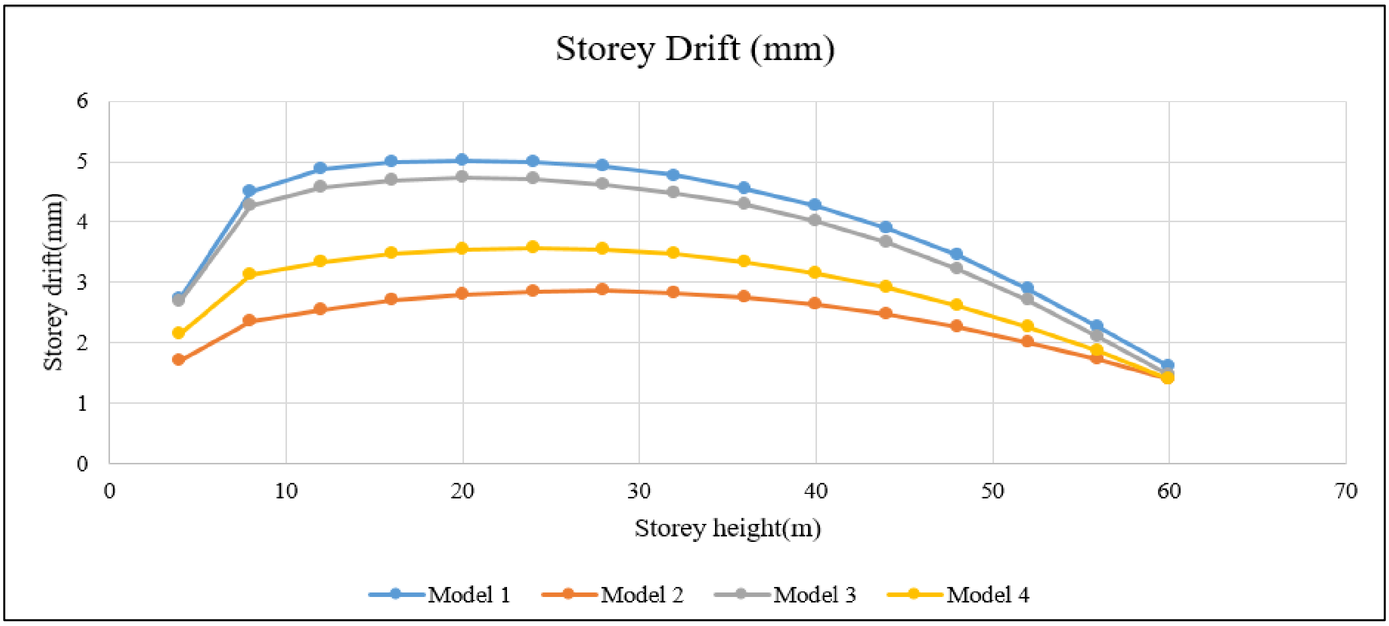

Fig 9: Storey Height Vs Storey Drift

IV. RESULTS ANALYSIS

Table 3 illustrates the maximum storey displacement under seismic load. The top-level displacements are 56.893 mm for the unbraced system, 28.751 mm for the X-braced system, 52.49 mm for the V-braced system, and 36.661 mm for the inverted V-braced system.

Table 6 compares the shear forces at the top and ground stories for various structural systems—model 1, model 2, model 3, and model 4 with rectangular column models. The shear forces at the top levels are 102.83 kN for the unbraced system, 103.308 kN for the X-braced system, 97.918 kN for the V-braced system, and 93.402 kN for the inverted V-braced system. At the base levels, the shear forces are 163.924 kN for the unbraced system, 171.742 kN for the X-braced system, 157.664 kN for the V-braced system, and 162.888 kN for the inverted V-braced system.

Table 7 details the bending moments at the top and base level for the same structural systems. The bending moments at the top levels are 91.373 kN-m for the unbraced system, 92.245 kN-m for the X-braced system, 86.973 kN-m for the V-braced system, and 73.669 kN-m for the inverted V-braced system. At the base levels, the bending moments are 210.688 kN-m for the unbraced system, 228.844 kN-m for the X-braced system, 203.951 kN-m for the V-braced system, and 214.594 kN-m for the inverted V-braced system.

Table 8 highlights the storey drifts under seismic load. The drifts at the top levels are 4.509 mm for the unbraced system, 2.360 mm for the X-braced system, 4.258 mm for the V-braced system, and 3.133 mm for the inverted V-braced system.

V. CONCLUSION

The bracing system reduces both the bending moment but also the shear force in the beams, effectively transferring lateral loads through an axial load mechanism to the foundation. Adding bracing enhances the load-carrying capacity of the building, resulting in a significant improvement in seismic performance. Among the various types of bracing systems specified, the building model with an X-bracing system exhibits a higher axial load compared to others. The performance of the building improves significantly with the application of the X-type bracing system. Therefore, this study concludes that the X-type bracing system is superior to the other specified bracing systems.

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