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The Seismic Behaviour of Multi-storeyed Structures with X and V bracings is analyzed using Staad.pro

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Abstract: People typically find shade under buildings. Building big buildings is required since most individuals want to be alone. One problem with tall structures is that they are less likely to survive an earthquake. Therefore, towering structures in seismically active locations may sustain severe damage or even collapse. So, the way a structure is built must be able to handle the sideways and downward stresses that earthquakes cause. There is a certain way that multi-story structures can handle lateral loads. The story's RC-framed structure employed three different ways to brace itself. We have looked at and evaluated the 16 stored RC frame designs for seismic zone IV. We utilize STAAD Pro V8i, a computer-aided software program, to look at the RC-framed models utilizing the Response Spectrum Method. We looked at how the structure behaved with other types of bracing, such as X-bracing and V-bracing. We put these methods in various places on the outside faces and all four sides of the buildings. We look at the time, base shear, storey drift, storey displacement, bending moment, and peak storey shear for both models with and without braces. The base shear value of a braced structure goes up, while the storey displacement, storey drift, bending moment, and duration go down. The braced frames have higher peak shear values than the unbraced frames. When compared to the other bracing method, the model with X-bracing on the mid-bays of the buildings' outside sides makes the structure much stiffer.
Keywords: Bracings, lateral force, storey shear, storey displacement, storey drift, shear at base, peak storey shear.

I. INTRODUCTION

Earthquakes, caused by various factors such as geological faults and human activities, generate seismic waves that exert lateral stresses on structures. These stresses can destabilize buildings, making their tightness more crucial than their ability to withstand lateral loads. In India, many buildings are not properly engineered, despite a significant portion of the land being in high seismic zones (III, IV, V). To mitigate earthquake damage, structures must be strengthened to maintain displacement demands below their capabilities. Generally, buildings with higher rigidity and lower density have lower horizontal displacement requirements. Multi-story reinforced concrete buildings are particularly vulnerable to excessive deformation. A steel bracing system can enhance a building's resistance to horizontal forces and improve rigidity.

To learn and understand STAAD.Pro V8i software.

- Response spectrum analysis of the building model with a Concentric Braced Frame (CBF) steel bracing system.
- Comparative analysis of storey drift, displacement, and time period of seismic zone I V models.
- Study of the parameters i.e., Maximum bending moment, Peak Storey Shear and Base Shear of the

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different models and compare the results.

- To find the appropriate bracing solution for the seismic zone in an RC-framed construction.

II. DESIGN AND METHODS

An embraced frame is a kind of structural design that was mainly created to resist the stresses generated by earthquakes. Bracings support lateral load as inclined components. They axially stress the entire structure, giving it the appearance of a truss, by applying stresses to the related beams and columns. The columns' sections are compressed as a result of this axial tension's reduction of the moment. The bracing pieces can be positioned in a number of ways to support tension only or tension and compression alternately. Crossed diagonals make up the bracing, which only acts as a tension reliever. Depending on the direction of the wind, one diagonal is considered to be passive and the other slanting to be active. Cross bracing is a very common layout. Bracings maintain the stability of the structure by shifting horizontal loads to the ground. They are also employed to offset lateral forces, which keeps the structure from swaying.

A. Detail of the Model

The G+14-story RC frame building was chosen for this seismic investigation, and its performance under seismic stresses is being evaluated. It has been contrasted with other bracing methods that have the similar arrangement. The fourteen-story AG+ building is modeled and examined using computer-aided software. STAAD.ProV8i. Figs. 3.2 and 3.3(a) show the elevation and plan of a building's bare (un braced) RC frame, respectively. The building is square in shape and is 12 m by 12 m. The structural plan of the RC frame model of the construction includes four bays, each spaced 3 m apart, and a total of five gridlines in the X and Z axes. The building is 45 meters tall overall, with each level rising 3 meters higher than the others.

Table 1: RC Frame Data Details Considered for the Analysis

The geometry of the structure	**Detail/value**
Grids in the direction-X	5
Grids in the direction-Z	5
Grid lines pace of line in X-direction	3 meter
Spacing of Grid line in Z-direction	3 meter
Number of Storey	G+15
Height of each storey	3m
Height of the ground-floor	3m
Beam dimension	450mm x450mm
Column size	600mm x600mm
Steel bracing	ISMB200
Soil Type	Medium
Response Reduction Factor	5
Seismic Zone	IV
Dead Load	3kN/m^2
Importance Factor(I)	1
Combination Method	CQC
Support type	Fixed
Live Load	4kN/m^2
Damping Ratio	5%

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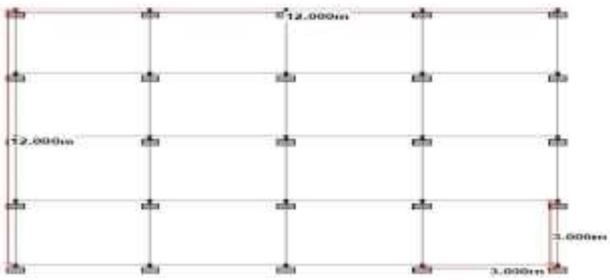

Fig 1: Structural Layout of RC Frame Prototype

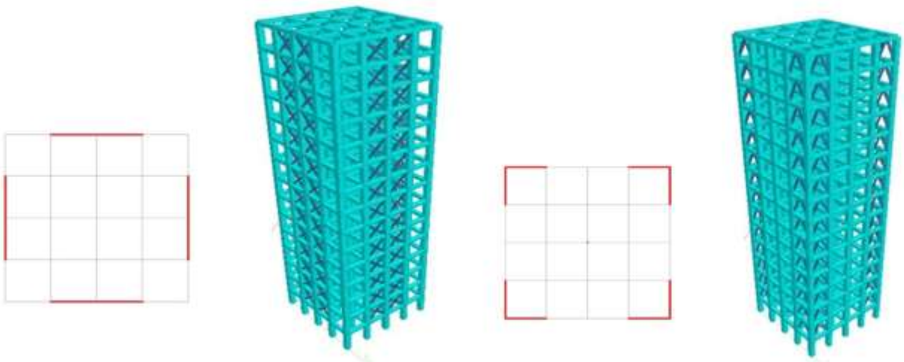

Fig 2: 3D structural model of the building with x and v bracings.

III. ANALYSIS RESULTS AND DISCUSSIONS

These seismic studies of the multi-story structure use several models and features that are taken into account for the analysis in The current study is based on Chapter 3. The previously stated iambic methodology, also referred to as the response spectrum method, is used to assess the performance of the un braced and braced framework in the RC construction. The results of a study of multiple models, both with and without bracing, are described in this chapter. For this, three different types of bracing systems X, inverted-V, and V-bracing as well as different bracing positions have been taken into consideration. STAAD. After taking the seismic zone IV, the analysis is continued using ProV8i. The outcomes are compared to those of an un braced frame.The analysis results obtained are explained one by one in the subsequent sections of this chapter.

B. Seismic Analysis by Software

The linear static analysis and linear dynamic analysis were performed in finite element based software Staad.Pro V8i

Comparison of Time Period

Table 2: Comparison of Time period

Model	Time Period (sec)
Model-1	1.393
Model-2	1.125
Model-3	1.213
Model-4	1.187
Model-5	1.251
Model-6	1.200
Model-7	1.266

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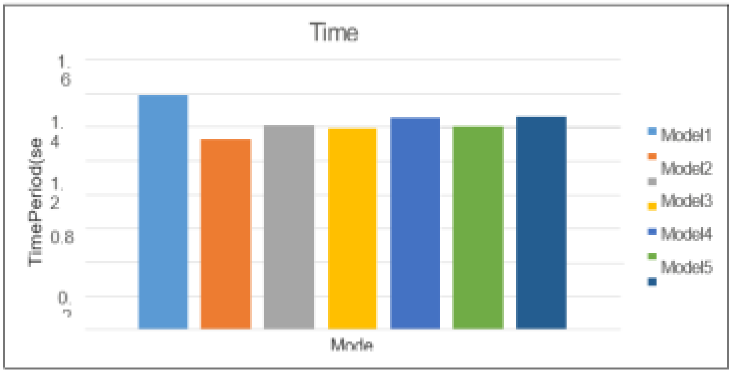

Fig 3: Comparison of Time period

The braced structure's time period values in seconds are shown by the numbers in table 2 and FIG 3. The graph indicates that the time period decreases for different bracing methods as compared to the bare frame. The bar chart shows that the value of the time period is lower for X bracing and inverted-V than for other bracing and bare frame. The time period of Model 2 has been shortened by 19.24% in comparison to Model 1 (bare frame).The most effective bracing, according to the statistics, is Model 2, which has X-bracing in the building's middle bays.

C. Comparison of Base shear

Base shear is the strongest lateral force generated at a structure's base. For analysis, the building has been fixed at the foundation or base level. An RCC-framed structure with and without a bracing system was examined in seismic zone IV in order to assess the base shear. The basis results for the various models that were taken into consideration for the research are listed in Table 4. The base shear graph for different bracing systems is shown in Fig.4.

Table 4: Comparison of Base Shear

Model	Base Shear(kN)
1	724.66
2	730.30
3	730.30
4	729.12
5	729.12
6	729.12
7	729.12

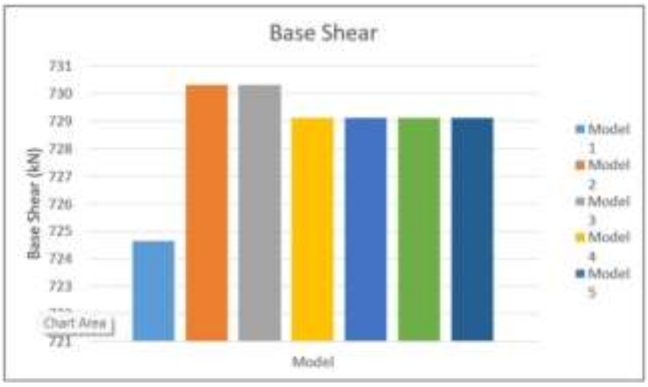

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Fig 4: Comparison of Base Shear

The information in the table and graph shows how much the braced framework increases the base shear of the structure. The base shear magnitude is nearly consistent across different bracing methods, as the graph illustrates. The base shear relation indicates that, in contrast to other bracing and bare frames, the amplitude of the base shear in the case of X bracing is significant.

D. Storey Displacement

Displacement is the movement of the entire structure from its starting position when it is subjected to lateral forces. Throughout the inquiry, the overall displacement value for each storey has been determined. Table 5 below displays the maximum displacement values for the various models that were taken into consideration for the study. The maximum lateral displacement curve for various bracing systems is displayed in Fig.5.
The graph indicates that, in contrast to alternative bracing and bare frame, the lateral displacement significantly lowers in the case of X bracing. The location of the X bracing in the middle bays is more efficient than the others. Table 5 shows the % decrease in lateral displacement at floor heights of 24 and 42 meters for the various braced models in zone IV as opposed to the un braced model; the soil medium remains constant throughout the investigation.

Table 5: Maximum storey displacement for different models for different storey

Storey Height (m)	Maximum Lateral Displacement(mm)						
	Model Without Bracing	Model With Bracing					
	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0
3	0.807	0.543	0.587	0.610	0.640	0.622	0.658
6	2.248	1.488	1.626	1.677	1.774	1.711	1.823
9	3.863	2.508	2.777	2.838	3.030	2.900	3.116
12	5.547	3.550	3.982	4.026	4.338	4.117	4.460
15	7.261	4.617	5.234	5.235	5.686	5.354	5.841
18	8.984	5.797	6.525	6.459	7.063	6.606	7.248
21	10.695	6.812	7.840	7.688	8.454	7.861	8.666
24	12.372	7.920	9.159	8.908	9.839	9.107	10.076
27	13.990	9.015	10.462	10.101	11.197	10.324	11.457
30	15.523	10.078	11.726	11.248	12.505	11.496	12.787
33	16.942	11.092	12.931	12.328	13.739	12.600	14.042
36	18.218	12.034	14.052	13.317	14.873	13.613	15.198
39	19.321	12.879	15.060	14.190	15.880	14.510	16.228
42	20.221	13.595	15.920	14.919	16.725	15.260	17.092
45	20.920	14.164	16.610	15.492	17.396	15.851	17.781

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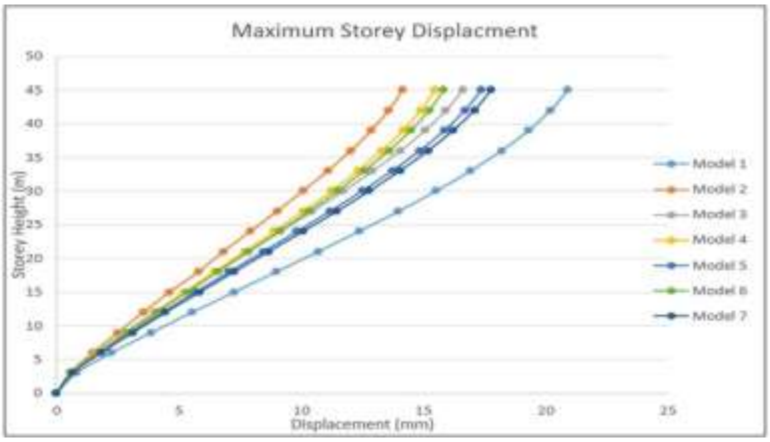

Fig 5: Maximum storey displacement for different models for different storey

E. Storey Drift

The relative movement between the floors that are either above or below the storey. Maximum storey drift values have been determined using STAAD.Pro. The maximum values of storey drift as established by the analysis at each storey level for the various models are listed in the table below. The storey drift values, which are listed in Table 6, are also plotted against the storey height in order to assess the efficacy of different bracing systems at various locations. Fig. 6 shows this plot.

The graph illustrates the analogous pattern for the decline in storey drift value per storey height. The storey drift reduction rate was initially discovered to be quite low in all braced structures up to the 2–3 storey level. After that, it has been noted that the storey drift values reduce fast up to the 5-7 storey level, after which they drop once more.

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Table 6: Maximum Storey Drift for Different models for different storey level

Storey Height (m)	Maximum Storey Drift(cm)						
	Model Without Bracing	Model With Bracings					
	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0
3	0.1213	0.1007	0.1045	0.1062	0.1088	0.1078	0.1121
6	0.2158	0.1346	0.1477	0.1556	0.1653	0.1592	0.1694
9	0.2422	0.1430	0.1635	0.1664	0.1799	0.1711	0.1865
12	0.2522	0.1509	0.1764	0.1737	0.1920	0.1782	0.1977
15	0.2569	0.1573	0.1862	0.1789	0.2005	0.1832	0.2055
18	0.2581	0.1619	0.1929	0.1822	0.2058	0.1862	0.2102
21	0.2563	0.1645	0.1966	0.1831	0.2080	0.1870	0.2118
24	0.2511	0.1446	0.1969	0.1861	0.2068	0.1853	0.2104
27	0.2422	0.1623	0.1940	0.1774	0.2024	0.1810	0.2056
30	0.2294	0.1573	0.1876	0.1702	0.1945	0.1738	0.1976
33	0.2123	0.1497	0.1787	0.1600	0.1832	0.1638	0.1863
36	0.1908	0.1393	0.1664	0.1466	0.1685	0.1502	0.1717
39	0.1647	0.1260	0.1510	0.1298	0.1504	0.1335	0.1537
42	0.1345	0.1095	0.1324	0.1098	0.1291	0.1135	0.1325
45	0.1040	0.0903	0.1113	0.0881	0.1062	0.0917	0.1104

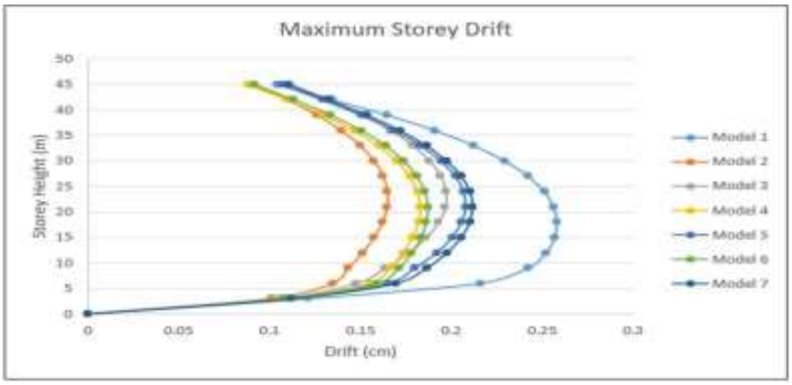

Fig 6: Maximum Storey Drift for Different models for different storey level

F. *Bending Moment*

Table 7: Maximum Bending Moment for Different Models

Model	Bending Moment (kNm)
1	72.567
2	54.560
3	57.159

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4	59.283
5	61.064
6	60.092
7	62.233

It has been discovered that the bracing system reduces the bending moment and benefits the structure. The building construction with the X bracing system in the middle outside bays would have the least amount of bending moment when compared to other types of bracing systems.

IV. CONCLUSIONS

- The time period measures a building's response to an earthquake, with longer time periods indicating higher responses and shorter time periods indicating smaller responses. Model-2 has a shorter time period (1.125 seconds), making it more rigid and the most efficient among the models. In comparison, the unbraced structure has a longer time period (1.393 seconds). Model-2's time period is reduced by 19.24% compared to the bare frame (Model-1).
- As the building height increases, the bracing system's lateral displacement diminishes in comparison to the bare frame. The structural model-2 shows less lateral displacement than the other bracing (inverted-V bracing and V-bracing) and un braced structures in zone IV. In zone IV, the reduction in lateral displacement values for model-2 at storey heights of 24 and 45 meters is 35.98% and 32.29%, respectively.
- Models 2 and 3 have high base shear values compared to other models, according to the overall base shear correlation. The braced models' base shear is higher than that of the un braced RC frame model.
- The model minimizes storey drift by utilizing a variety of bracing techniques. A structural model with X-bracing on the outside of the building and on the middle bays (model-2) exhibits less floor drift than the braced and un braced structures. When compared to bare frame at storey heights of 24 and 45 meters, the model-2's storey drift values are reduced by 42.41% and 13.17%, respectively.
- Bending moment values for the central column in the braced frame are lower than those in the un braced frame. The braced model with the X-bracing in the mid-bays has the lowest potential bending moment when compared to the other versions. Consequently, the X-bracing in the middle two bays of the construction is more effective.
- At different structural levels, peak storey shear values increased in the braced frame model relative to the un braced frame model. The frame model-2 yielded better results because it could sustain more shear than the other models. It is minimum at the top of the building and maximum at the bottom. Thus, in terms of advantages, Model 2 is better than previous models.

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