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Seismic Analysis of C Shape Building using Response Spectrum Analysis

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Abstract: Nowadays, the construction of the high-rise multi-storey buildings has been increased due to the increasing population. Earthquake is one of the main phenomena causing damage to the structure. As the height of the structure increases, it undergoes larger seismic forces. So, it is important to improve the resistance of multi-storey building to lateral loads. There are many structural systems which resist lateral loads by the addition of different structural systems. The application of the shear wall system and bracing system in reinforced concrete buildings has become widely used to minimize seismic consequences. Both of the systems have significance of the structural performance. Although both systems are used for same the reasons, their effect shows unequal variations and behavior against seismic load. This is for the reason that the values of response factors are miscellaneous for varying structural systems. In this project work, the seismic analysis of Frame Structure, RC Bracing system and Shear Wall system are considered and compared to their results against lateral forces using Etabs Software. Three structural systems are considered, in which one is framed structure, second is braced frame structure and third is shear wall structure with different height of building. G+13 storey and G+15 storey structures are compared for maximum displacement, storey drift and base shear using Response Spectrum Analysis in zone V.

Keywords: Bracings, Shear Wall, Response Spectrum Analysis, Multi-Story Building.

1. INTRODUCTION

An earthquake is a natural phenomenon that occurs when the ground shakes or vibrates due to movements or cracks in the earth's crust. Earthquakes can be caused by many factors, including crustal activity, volcanic activity and human activity. The most common cause of earthquakes is crustal activity. This occurs when the Earth's crustal plates move and rub against each other. This creates pressure and stress within the crust that can eventually cause earthquakes.
Earthquake can cause a wide range of damages depending on their magnitude, depth and location. For the better structural results, shear walls, bracings, base isolation, stepped footing etc. are designed to resist lateral forces such as wind and seismic loads. Shear Wall and Bracings are the common structural elements.

Shear Wall - Shear walls are structural elements designed to resist lateral forces such as wind loads and seismic loads. Usually, this is a vertical wall made of reinforced concrete or steel. The walls are designed to withstand horizontal forces that can cause buildings to sway and collapse during earthquakes and high winds. Alternatively, a shear wall can be defined as a vertical structural element capable of resisting the combination of shear, moment and axial forces caused by the transmission of shear and gravitational loads from other structural elements of the building to the wall. This wall usually begins at the foundation of the structure.

Bracings - A braced frame is a very strong structural system that is commonly used in structures subject to lateral loads such as wind and seismic pressure. Bracings are connected to the corners of the bay frame for each storey of the building structure. The members in a braced frame are made of reinforced concrete or structural steel, which can work effectively both in tension and compression. The beams and columns that form the frame carry vertical loads and the bracing system carries the lateral loads. Bracing systems will help to decrease the deflection and storey drift values under the action of the lateral loading condition namely seismic load and wind load.

X type Bracings - The X type bracing system is the most commonly used type for the deflection and drift controlling. In this type the bracings are connected to each corner point of the bare frame in the X type shape. The complete bracing system model is shown in the below figure which is consisting of four corners namely 1, 2, 3 and 4. The bracings are connected in two diagonal directions through the points of 1 and 4, 2 and 3. With the help of the four joint connections at the each corner the building will be in stable condition structure will not move in X direction system and it will note move in Y direction system under the application of the lateral loading conditions like seismic loading condition and wind load

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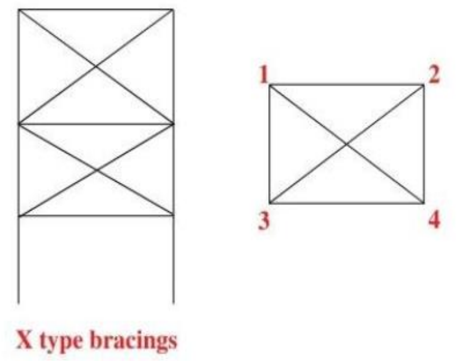
condition and simultaneously it will not move in the deflection direction (height direction)



X type bracing systems

2. OBJECTIVE

The present work is an attempt to analyze the C-shape RC structure with bracings and shear wall under dynamic loading. The objectives of this research are enumerated as follows:

I. To study the seismic behavior of different structure (Frame structure, Structure with Bracings and Structure with Shear Wall) having different height of models (G+13) and (G+15)

II. To carry out dynamic analysis by using Response Spectrum Analysis on an asymmetric building.

III. To analyze the results of Maximum Story Displacement, Story Drift and Base Shear by using Response Spectrum Analysis.

3. STRUCTURAL PARAMETER

C-shape plan layout of (G+13) and (G+15) RC frame structure is considered for the analysis. Shear walls and Bracing system are added at corner surface of the building. The building is founded on medium strength soil. Total ^ models are compared for study.

Model Statement

Type of Building	RCC Framed Structure with soft story
Number of stories	17(G+15), 15(G+13)
Plan Size	28m x 31.5m
Floor to floor height	3m

Properties of Members

Grade of concrete	M25
Density of concrete	25 Kn\m³
Grade of steel	Fe500
Density of steel	77.1 Kn\m³

Size of Members

Column size	450mm x 450mm, 500mm x 500mm
Beam size	300mm x 380mm,
Slab thickness	150mm
Shear wall	200mm
Bracings	300mm x 380mm

Seismic Parameter (From IS Code 1893 (Part 1) - 2016)

Zone value	0.36 (V) (Table 3, Clause 6.4.2)
Response reduction factor	5 (S.M.R.F) (Table 9, Clause 7.2.6)
Importance factor	1.2 (Table 8, Clause 7.2.3)
Damping ratio	0.05

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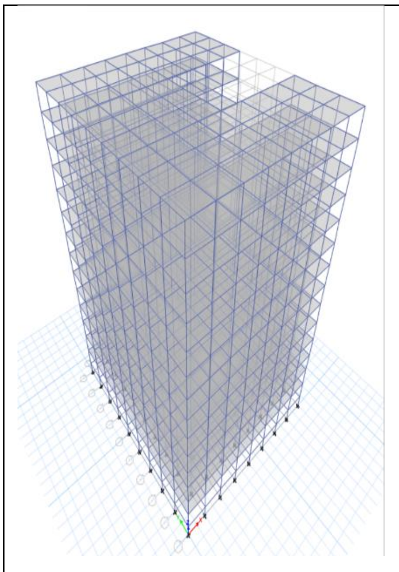
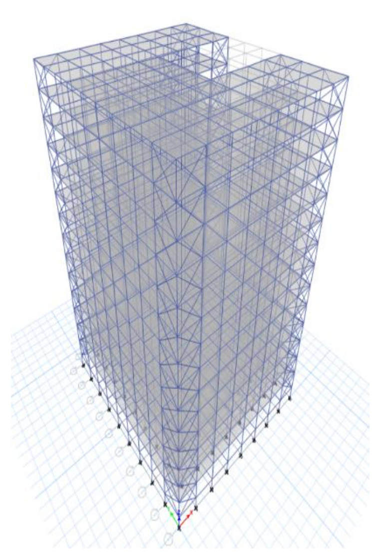
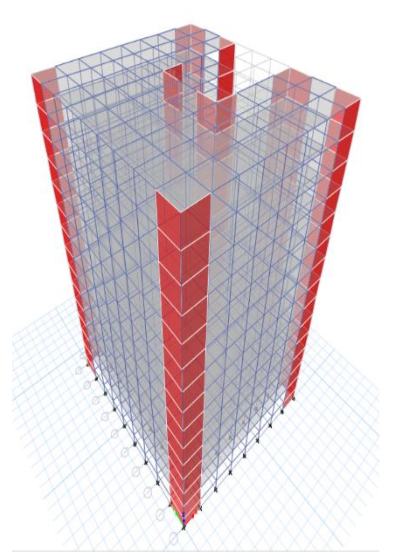
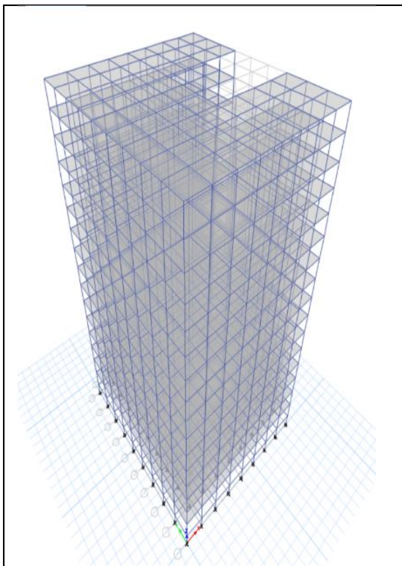
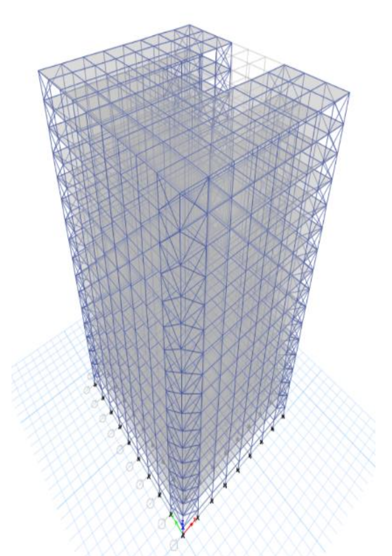
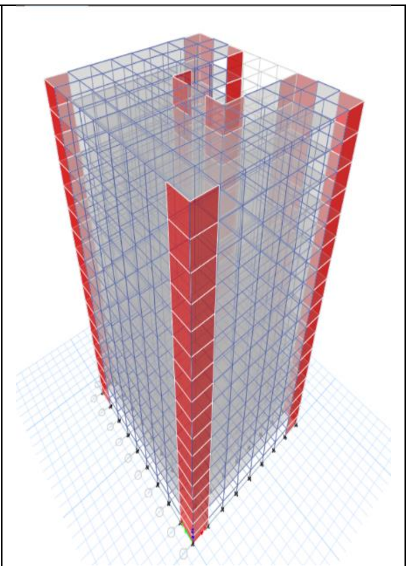
Soil Type	Medium

Load Intensity

Live load	3 KN/m² (From IS Code 875- Part2)
Super imposed dead load	2 KN/m² (From IS Code 875- Part2)
External wall load	12.86 KN/m²
Internal wall load	6.48 KN/m²

Model Work

		
G+13 MRF	G+13 Bracings	G+13 Shear Wall

		
G+15 MRF	G+15 Bracings	G+15 Shear Wall

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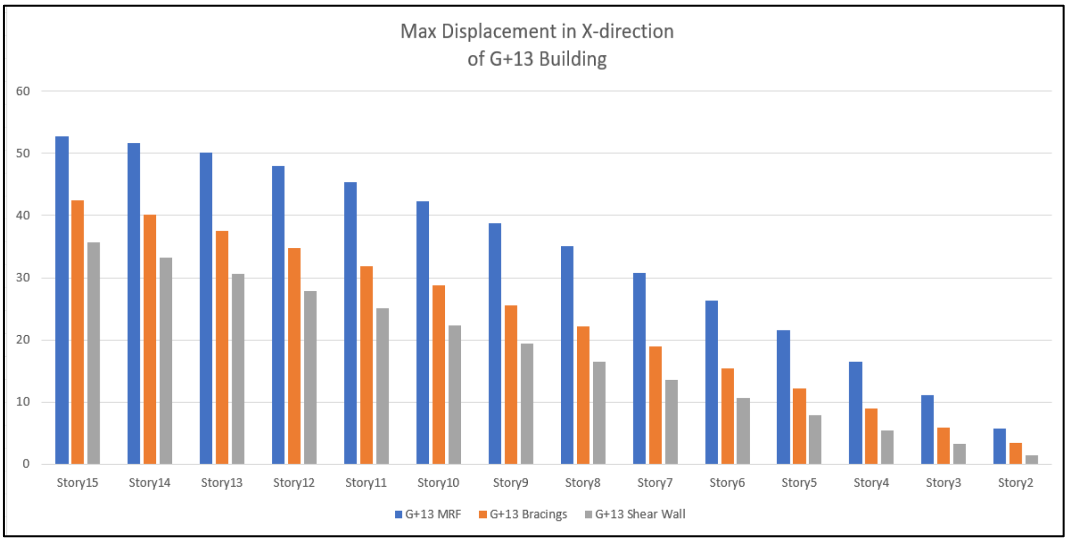
4. PERFORMANCE ANALYSIS

A. Maximum Displacement in X direction (G+13)

Story	Load Case mm	G+13 MRF	G+13 Bracings	G+13 Shear Wall
Story15	RSX Max	52.684	42.448	35.685
Story14	RSX Max	51.655	40.079	33.195
Story13	RSX Max	50.064	37.494	30.603
Story12	RSX Max	47.93	34.74	27.919
Story11	RSX Max	45.312	31.818	25.143
Story10	RSX Max	42.26	28.745	22.287
Story9	RSX Max	38.813	25.543	19.374
Story8	RSX Max	35.001	22.239	16.436
Story7	RSX Max	30.846	18.866	13.512
Story6	RSX Max	26.364	15.47	10.653
Story5	RSX Max	21.573	12.116	7.927
Story4	RSX Max	16.484	8.898	5.415
Story3	RSX Max	11.141	5.945	3.221
Story2	RSX Max	5.733	3.407	1.471



In X-direction of Maximum Story Displacement, it observes
At Top story (Story 15),
Maximum value is 52.684 mm in model G+13 MRF.
Minimum value is 35.685mm in model G+13 shear wall.
Therefore, from the overall observation, it can be concluded that for the Story Displacement of Response Spectrum value in X-direction, the Prominent structure model G+13 shear wall.

B. Maximum Displacement in X direction (G+15)

Story	Load Case mm	G+15 MRF	G+15 Bracings	G+15 Shear Wall
Story17	RSX Max	60.657	50.185	42.312
Story16	RSX Max	59.641	47.827	39.811
Story15	RSX Max	58.118	45.267	37.217
Story14	RSX Max	56.103	42.542	34.534

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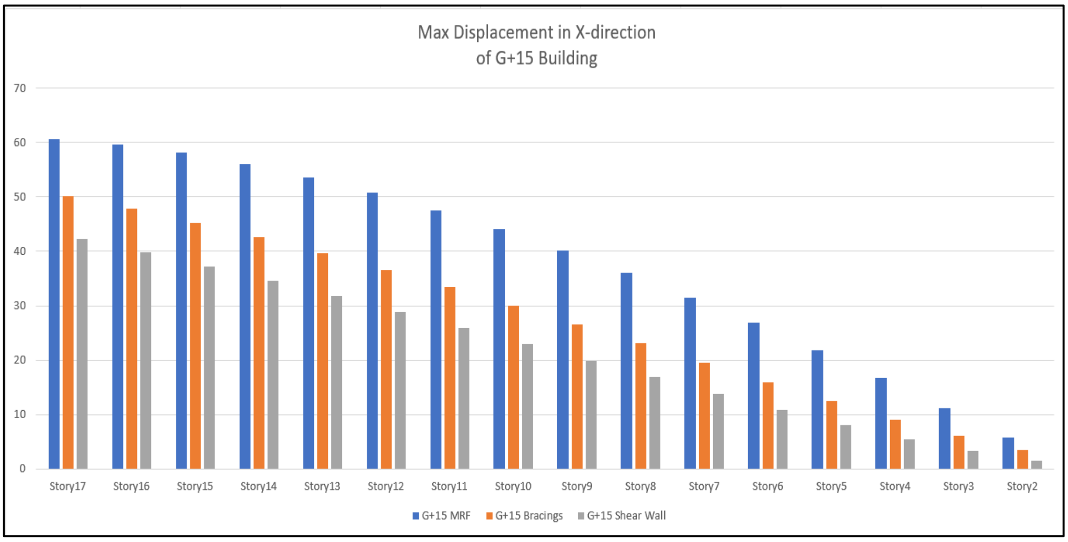
Story13	RSX Max	53.648	39.648	31.758
Story12	RSX Max	50.796	36.592	28.893
Story11	RSX Max	47.581	33.39	25.95
Story10	RSX Max	44.028	30.057	22.948
Story9	RSX Max	40.159	26.613	19.906
Story8	RSX Max	35.993	23.084	16.856
Story7	RSX Max	31.549	19.505	13.834
Story6	RSX Max	26.84	15.925	10.891
Story5	RSX Max	21.876	12.416	8.092
Story4	RSX Max	16.66	9.072	5.52
Story3	RSX Max	11.226	6.026	3.278
Story2	RSX Max	5.763	3.429	1.494



In X-direction of Maximum Story Displacement, it observes
At Top story (Story 17),
Maximum value is 60.657mm in model G+15 MRF.
Minimum value is 42.312mm in model G+15 shear wall.
Therefore, from the overall observation, it can be concluded that for the Story Displacement of Response Spectrum value in X-direction, the Prominent structure model G+15 Shear Wall.

C. Maximum Displacement in Y direction (G+13)

Story	Load Case mm	G+13 MRF	G+13 Bracings	G+13 Shear Wall
Story15	RSY Max	58.308	45.008	39.971
Story14	RSY Max	56.945	42.633	37.236
Story13	RSY Max	54.997	40.004	34.378
Story12	RSY Max	52.48	37.181	31.41
Story11	RSY Max	49.459	34.167	28.332
Story10	RSY Max	45.987	30.982	25.159
Story9	RSY Max	42.11	27.647	21.915
Story8	RSY Max	37.86	24.186	18.633
Story7	RSY Max	33.262	20.632	15.358
Story6	RSY Max	28.338	17.03	12.147

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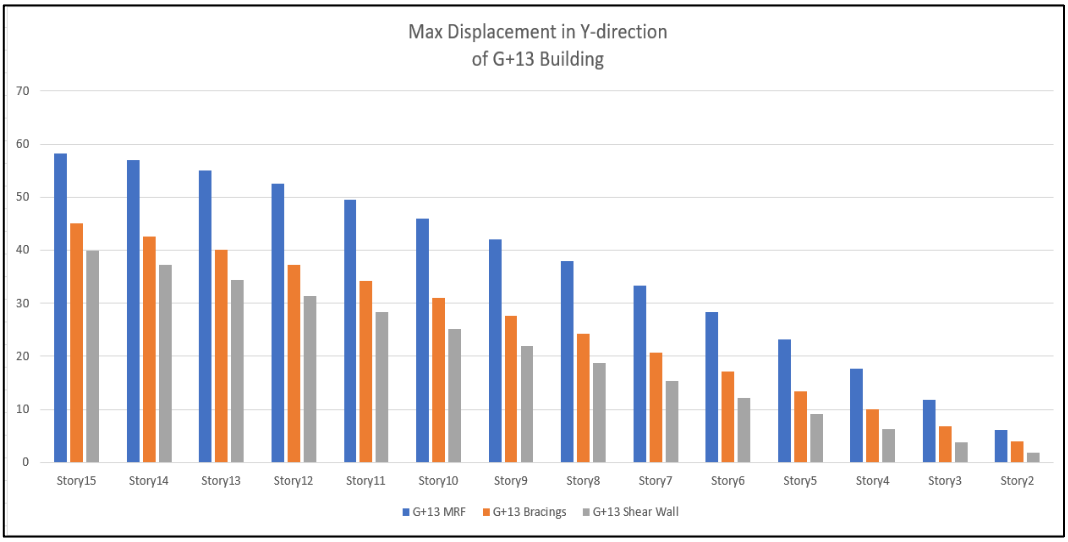
Story5	RSY Max	23.103	13.443	9.074
Story4	RSY Max	17.578	9.967	6.232
Story3	RSY Max	11.812	6.741	3.736
Story2	RSY Max	6.028	3.904	1.731



In Y-direction of Maximum Story Displacement, it observes
At Top story (Story 15),
Maximum value is 58.308mm in model G+13 MRF.
Minimum value is 39.971mm in model G+13 shear wall.
Therefore, from the overall observation, it can be concluded that for the Story Displacement of Response Spectrum value in Y-direction, the Prominent structure model G+13 Shear Wall.

D. Maximum Displacement in Y direction (G+15)

Story	Load Case mm	G+15 MRF	G+15 Bracings	G+15 Shear Wall
Story17	RSY Max	68.53	52.338	47.159
Story16	RSY Max	67.104	50.029	44.429
Story15	RSY Max	65.147	47.484	41.587
Story14	RSY Max	62.668	44.755	38.641
Story13	RSY Max	59.724	41.835	35.585
Story12	RSY Max	56.366	38.735	32.425
Story11	RSY Max	52.63	35.468	29.173
Story10	RSY Max	48.546	32.051	25.846
Story9	RSY Max	44.14	28.501	22.468
Story8	RSY Max	39.435	24.841	19.07
Story7	RSY Max	34.452	21.106	15.695
Story6	RSY Max	29.207	17.344	12.397
Story5	RSY Max	23.711	13.625	9.249
Story4	RSY Max	17.973	10.049	6.343
Story3	RSY Max	12.038	6.756	3.798
Story2	RSY Max	6.126	3.884	1.756

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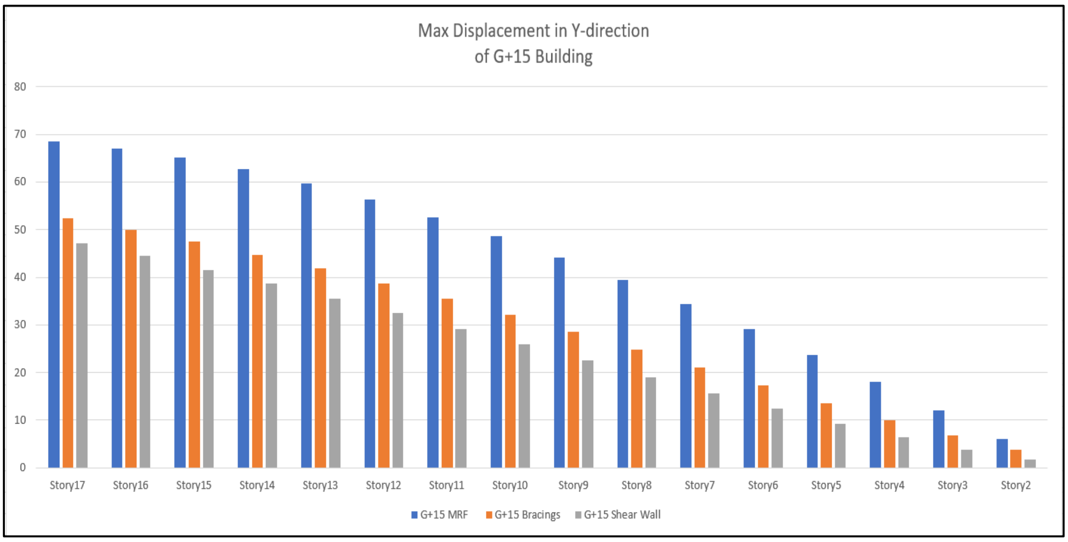

In Y-direction of Maximum Story Displacement, it observes
At Top story (Story 17),
Maximum value is 68.53 mm in model G+15 MRF.
Minimum value is 47.159 mm in model G+15 shear wall.
Therefore, from the overall observation, it can be concluded that for the Story Displacement of Response Spectrum value in Y-direction, the Prominent structure model G+15 Shear Wall.

E. Story Drift in X direction (G+13)

Story	Load Case mm	G+13 MRF	G+13 Bracings	G+13 Shear Wall
Story15	RSX Max	0.000892	0.000782	0.000432
Story14	RSX Max	0.000955	0.000882	0.000679
Story13	RSX Max	0.001023	0.000936	0.000868
Story12	RSX Max	0.001083	0.001053	0.000967
Story11	RSX Max	0.001186	0.001128	0.00099
Story10	RSX Max	0.001300	0.001159	0.001004
Story9	RSX Max	0.001400	0.001177	0.001006
Story8	RSX Max	0.001490	0.001183	0.000994
Story7	RSX Max	0.001574	0.001175	0.000966
Story6	RSX Max	0.001653	0.001147	0.000917
Story5	RSX Max	0.001727	0.001092	0.000842
Story4	RSX Max	0.001792	0.000996	0.000734
Story3	RSX Max	0.001805	0.000853	0.000584
Story2	RSX Max	0.001537	0.000875	0.00039
Story1	RSX Max	0.000822	0.000562	0.000175

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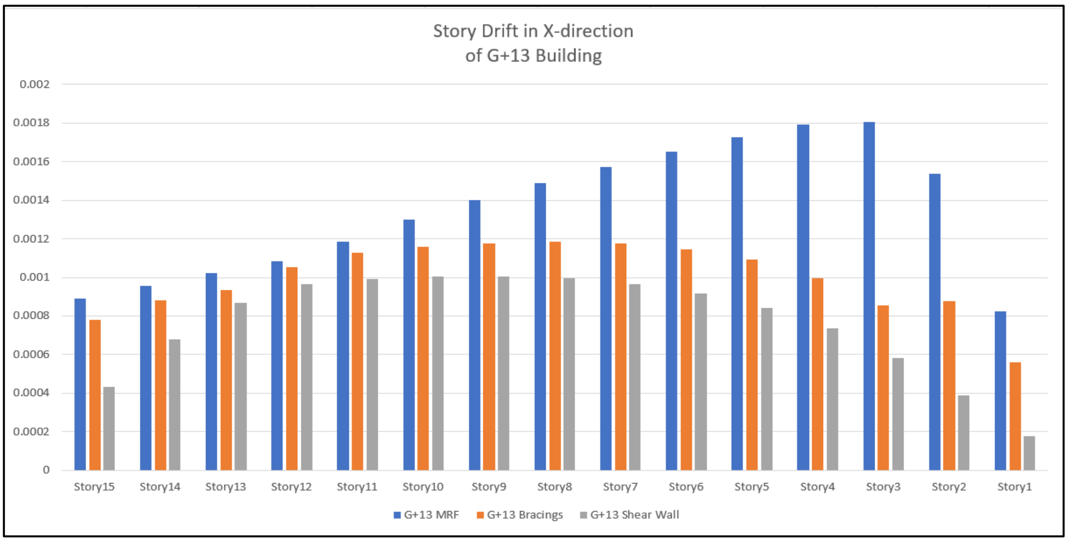

In X-direction of Story Drift, it observes
At Top story (Story 15),
Maximum value is 0.000892 mm in model G+13 MRF.
Minimum value is 0.000432 mm in model G+13 shear wall.
Therefore, from the overall observation, it can be concluded that for the Story Drift of Response Spectrum value in X-direction, the Prominent structure model G+13 Shear Wall.

F. Story Drift in X direction (G+15)

Story	Load Case mm	G+15 MRF	G+15 Bracings	G+15 Shear Wall
Story17	RSX Max	0.000883	0.000673	0.000483
Story16	RSX Max	0.000963	0.000904	0.000678
Story15	RSX Max	0.001032	0.000959	0.00085
Story14	RSX Max	0.001095	0.001019	0.000998
Story13	RSX Max	0.001146	0.001108	0.001019
Story12	RSX Max	0.001244	0.001186	0.001039
Story11	RSX Max	0.001339	0.001215	0.001051
Story10	RSX Max	0.001426	0.001235	0.001054
Story9	RSX Max	0.001505	0.001246	0.001047
Story8	RSX Max	0.001579	0.001245	0.001029
Story7	RSX Max	0.001646	0.001231	0.000995
Story6	RSX Max	0.001707	0.001196	0.000942
Story5	RSX Max	0.001766	0.001132	0.000862
Story4	RSX Max	0.001821	0.001025	0.00075
Story3	RSX Max	0.001823	0.000872	0.000596
Story2	RSX Max	0.001546	0.000881	0.000397
Story1	RSX Max	0.000819	0.000565	0.000177

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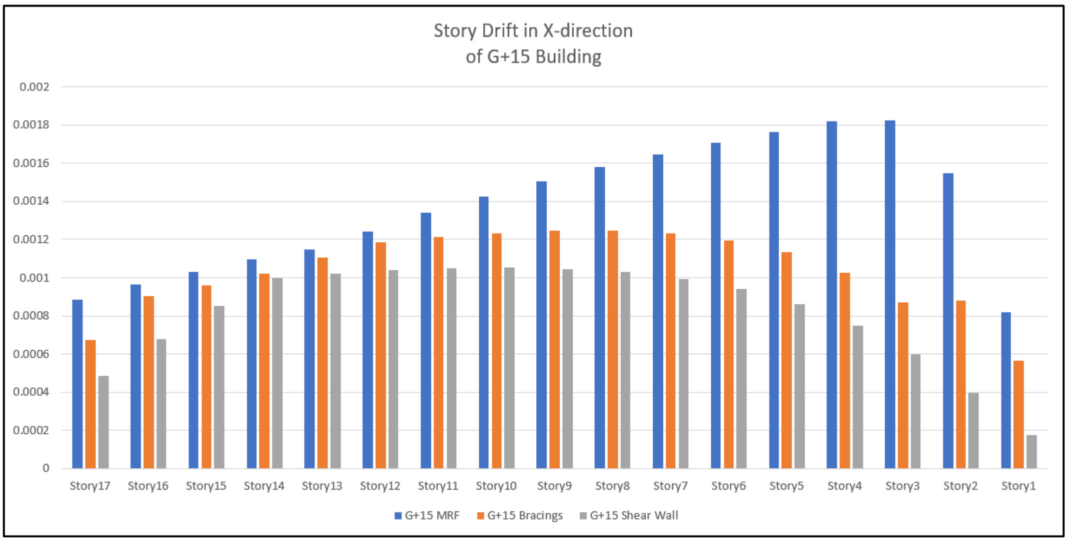

In X-direction of Story Drift, it observes
At Top story (Story 17),
Maximum value is 0.000883 mm in model G+15 MRF.
Minimum value 0.000483 mm in model G+15 shear wall.
Therefore, from the overall observation, it can be concluded that for the Story Drift of Response Spectrum value in X-direction, the Prominent structure model G+15 Shear Wall.

G. Story Drift in Y direction (G+13)

Story	Load Case mm	G+13 MRF	G+13 Bracings	G+13 Shear Wall
Story15	RSX Max	0.00096	0.000881	0.000548
Story14	RSX Max	0.00111	0.000993	0.000807
Story13	RSX Max	0.001073	0.001009	0.000941
Story12	RSX Max	0.001205	0.001141	0.001077
Story11	RSX Max	0.001345	0.001192	0.001105
Story10	RSX Max	0.001461	0.001228	0.001122
Story9	RSX Max	0.001561	0.00125	0.001127
Story8	RSX Max	0.00165	0.00126	0.001116
Story7	RSX Max	0.001732	0.001256	0.001087
Story6	RSX Max	0.001807	0.001233	0.001035
Story5	RSX Max	0.001876	0.001183	0.000954
Story4	RSX Max	0.001934	0.00109	0.000835
Story3	RSX Max	0.001931	0.000953	0.00067
Story2	RSX Max	0.001619	0.000975	0.000457
Story1	RSX Max	0.000954	0.000584	0.000215

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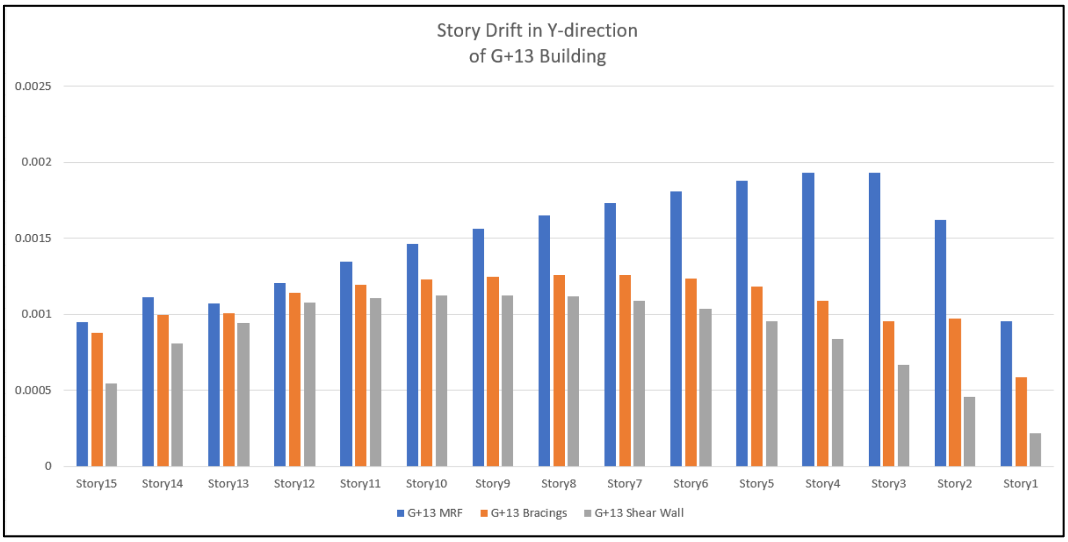

In Y-direction of Story Drift, it observes,

At Top story (Story 15),

Maximum value is 0.00096 mm in model G+13 MRF.

Minimum value is 0.000548 mm in model G+13 shear wall.

Therefore, from the overall observation, it can be concluded that for the Story Drift of Response Spectrum value in Y-direction, the Prominent structure model G+13 Shear Wall.

H. Story Drift in Y direction (G+15)

Story	Load Case mm	G+15 MRF	G+15 Bracings	G+15 Shear Wall
Story17	RSX Max	0.00097	0.000874	0.000567
Story16	RSX Max	0.00102	0.000982	0.000812
Story15	RSX Max	0.001062	0.00104	0.001011
Story14	RSX Max	0.001197	0.001133	0.0011
Story13	RSX Max	0.001328	0.00119	0.001132
Story12	RSX Max	0.001438	0.001234	0.001156
Story11	RSX Max	0.001536	0.001267	0.00117
Story10	RSX Max	0.001623	0.001291	0.001175
Story9	RSX Max	0.001700	0.001305	0.00117
Story8	RSX Max	0.001771	0.001310	0.001152
Story7	RSX Max	0.001834	0.001301	0.001117
Story6	RSX Max	0.001889	0.001272	0.00106
Story5	RSX Max	0.001943	0.001213	0.000975
Story4	RSX Max	0.001989	0.001110	0.000852
Story3	RSX Max	0.001972	0.000964	0.000682
Story2	RSX Max	0.001646	0.000974	0.000464
Story1	RSX Max	0.000939	0.000595	0.000217

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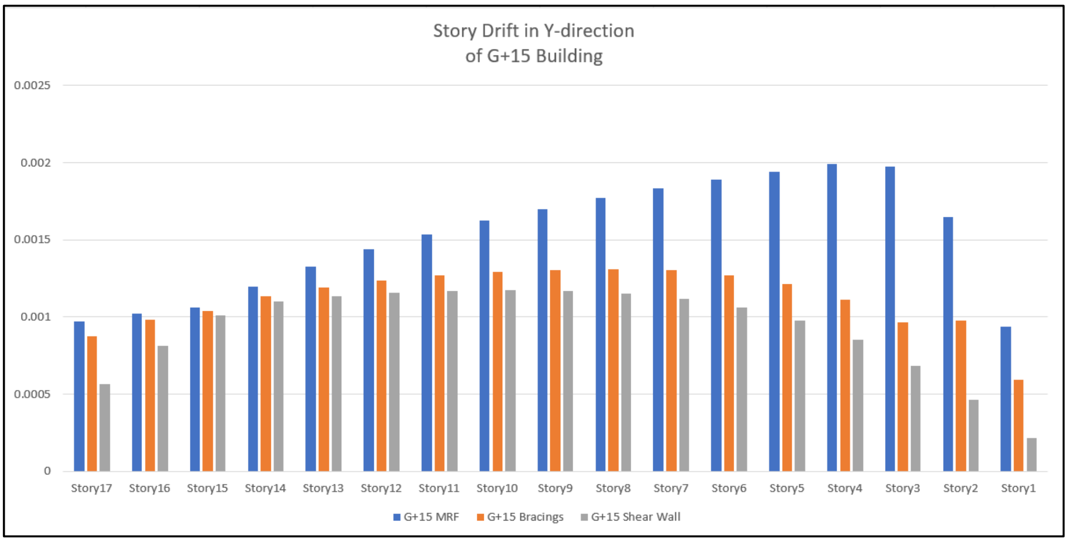
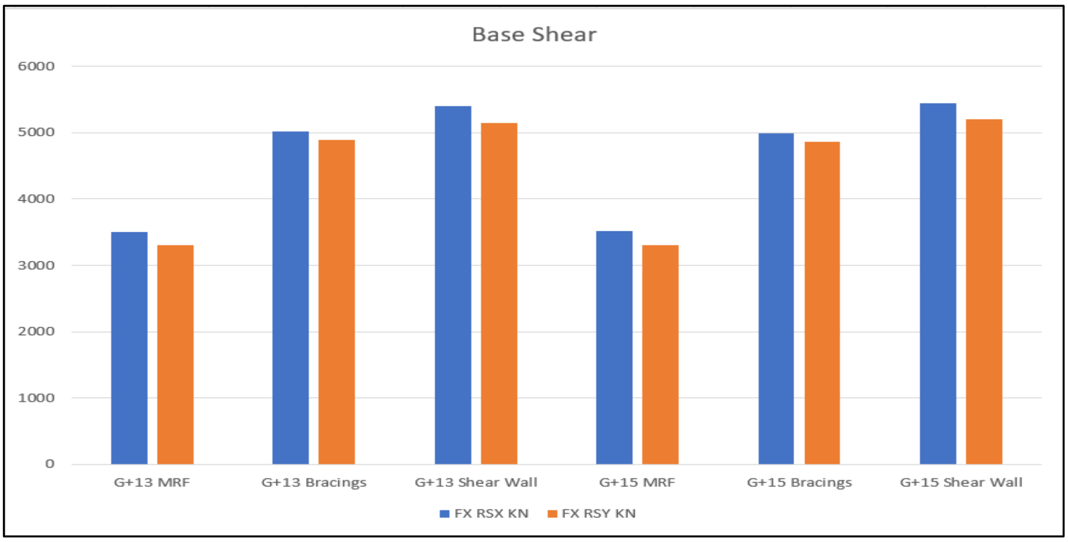


In Y-direction of Story Drift, it observes,
At Top story (Story 17),
Maximum value is 0.00097 mm in model G+15 MRF.
Minimum value is 0.000567 mm in model G+15 shear wall.
Therefore, from the overall observation, it can be concluded that for the Story Drift of Response Spectrum value in Y-direction, the Prominent structure model G+15 Shear Wall.

I. Base Shear

MODEL	Load Case	FX - KN		MODEL	Load Case	FY - KN
G+13 MRF	RSX Max	3506.6369		G+13 MRF	RSY Max	3309.5868
G+13 Bracings	RSX Max	5012.93		G+13 Bracings	RSY Max	4889.2834
G+13 Shear Wall	RSX Max	5400.1772		G+13 Shear Wall	RSY Max	5145.4158
G+15 MRF	RSX Max	3516.0615		G+15 MRF	RSY Max	3305.4034
G+15 Bracings	RSX Max	4989.9335		G+15 Bracings	RSY Max	4867.3284
G+15 Shear Wall	RSX Max	5440.6019		G+15 Shear Wall	RSY Max	5199.2617



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In **X-direction** of Base Shear, it observes,

Maximum value is 5440.6019 KN in model G+15 shear wall.

Minimum value is 3506.6369 KN in model G+13 MRF.

In **Y-direction** of Base Shear, it observes,

Maximum value is 5199.2617 KN in model G+15 shear wall.

Minimum value is 3305.4034 KN in model G+15 MRF.

5. CONCLUSION

1. In high rise buildings, the parameters like strength and stiffness are more important. So, for this purpose bracings and shear walls are adopted to enhance both these parameters.
2. Shear wall and Bracing are good structural solutions for reduction of lateral displacement and story drift. MRF buildings showed higher storey displacement that it is weak as compared other buildings, so prone to excessive damage in earthquake.
3. **Story Displacement** – In both X and Y direction, minimum Displacement gets in model with shear wall.
4. Overall, the Storey Displacement is less in G+13 Structure.
5. **Story Drift** – In both X and Y direction, minimum Drift value gets in model with shear wall.
6. Overall, the Storey Drift is less in G+13 Structure.
7. **Base Shear** is maximum in model G+13 shear wall in both X and Y direction.
8. The base shear of shear wall buildings increased as compared to other building which indicates that the stiffness of building increases.
9. Overall, Etabs software is versatile software has an easy and intuitive interface for modeling, allowing the user to model complicated structural models with ease for any axial or lateral load.

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