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Effect of Bracing on Regular and Irregular RCC (G+10) Frame Structure with Different Types of Bracings under Dynamic Loading

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Abstract: ***For buildings the most efficient structural system under high lateral loads from seismic loading and wind loading the braced frames is known to be most efficient. The resistance provided by the steel braced frame under earthquake loads in a multistoried building found to be one of the most efficient structural system . The retrofitting of many of the existing reinforced concrete buildings has to be done to overcome the deficiencies to resist loads under earthquake. This type of system helps in reducing the bending moment and shear forces in the column. The transfer of lateral load to the foundation is done through axial action. After the application of bracings to a existing structure, there is no significant change in the total weight of the building. Steel bracings has some advantages, it is economical, required less space ,can be erected easily and has the flexibility to design for meeting the required strength and stiffness.***

The lateral stiffness, strength capacity and also the displacement capacity of the structure improves by using the bracing system. A building with ten story is analyzed for seismic zone V with the consideration of IS 1893-2002 using ETABS Software. In this study modelling and analysis of building is carried out and comparison between the regular and vertical irregular building with and without bracing and with different types of bracings is done by Equivalent static method and Response spectrum analysis. The comparison of outcomes are carried out with respect to displacement , story drift and base shear for regular and irregular structure.

Keywords: Bracings, story displacement, Response spectrum method ,Equivalent static method ,ETABS ,Story drift, Base shear.

I. INTRODUCTION

A. General

The shortage of land and the population growth is the reason to construct the buildings higher and higher but the problem in High rise buildings is that at great heights they are unable to resist the lateral loads due to winds and specially due to earthquakes. An earthquake in general term is shaking of the earth due to the movements in the crust below the earth surface and results in loss of life and property damage and many other serious issues .So it becomes necessary to increase the seismic performance of the building by suitable designing and one of the most efficient and economical method is the steel bracing system. The use of steel bracing has a huge advantage that is possesses high strength ,cost effective ,high stiffness and required less space and add less weight to the existing structure.

B. Seismic Zones

These are the regions where the probability of occurrence of the earthquake are more. Based on the risk of having earthquake these regions are differentiated in 4 seismic zone the risk of earthquake increases from zone II to zone V.For the purpose of designing the earthquake resistance structure the IS code 1893 has provided with seismic zone factors for all thezones .

C. Regular and Irregular Structures

The difference between the regular and irregular structure is, in the former there is simple regular geometry in the structure and uniformly distributed mass and stiffness in plan and in elevation ,there is continuity in the geometry from base to the top of the structure. Every floor of the structure resembles the same . In irregular structures the discontinuity occurs in geometry of the structure and are irregular in shape. Setbacks are provided to the structure and also the mass and stiffness differ. The models for both is given below.

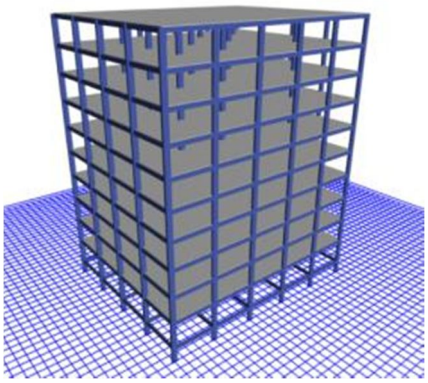

Figure 1 Regular building

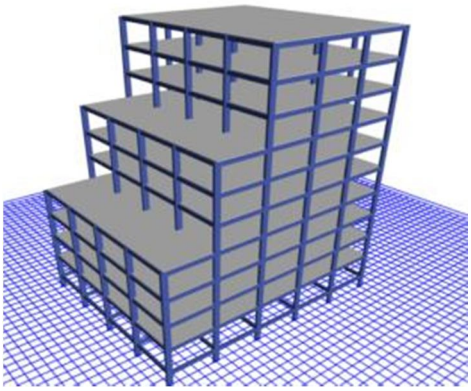

Figure 2 Irregular building

D. Frame Structure

It is an assembly of slabs,beams columns and foundation connected to one another so it act as one unit. In RCC frame structure the load is transferred from a slab to the beams then to the columns and further to the lower columns and finally to the foundation which in turn transfer it to the soil.The walls in such structure are constructed after the frame is ready and they are not meant to carry any load.

E. Braced Structure

The beams and columns in a braced frame are generally arranged in an orthogonal pattern in both,the elevation and on the plan to provide resistance to the horizontal force acting.The structural members are joined using a pinned connection which does not transfer moments. Here beams and columns are analysed under vertical loads only,assuming that the bracing system supportsall lateral load ,the main function of the bracings is that to resist the wind and earthquake loads.

F. Story Displacement

It isthe displacement of the storey with respect to base of the structure. It is one of the important factor considered in the design of earthquake resistant structure .The value of story displacement should be minimum when seen from safety point of view. From the analysis by E-tabs the values of ESM are higher than the values of RSM analysis for the different models.

G. Story Drift

Story drift also known as inter storey drift .It is defined as the lateral displacement of one story with respect consecutive story below or above.It is the absolute value of displacement of the storey under the action of lateral forces.

H. Base Shear

Base shear is the maximum lateral force that will occur due to the seismic ground motion at the base of the structure.The base shear for all the models are tabulated below and the model with cross bracing has the highest base shear among all the models.

Figure 3: Inverted V bracing

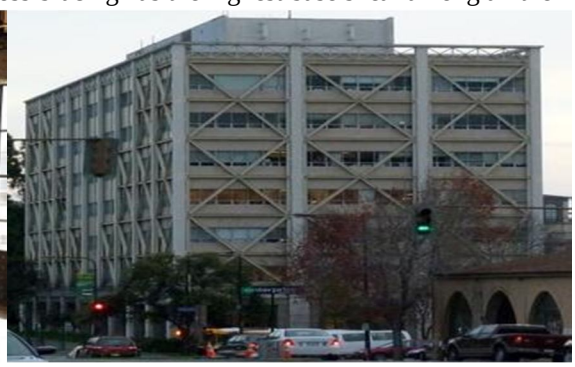

Figure 4: Showing bracing as retrofit solution

II. OBJECTIVE AND SCOPE OF THE PROJECT

A. *Objectives*

1) To carryout analysis of the G+10 storey building with different types of bracings by creating a 3D model using E-tabs software.
2) To carryout seismic analysis for building models as per codes.
3) To get familiar with the various features of the software E-tabs used in seismic analysis and design of the structure.
4) To analyse the building for earthquake resistance by application of various types of bracing systems.
5) To compare the displacement,story drift and base shear for different system of bracings.
6) To know the efficient and a suitable system of bracing to resist seismic loading.

B. *Scope Of The Study*

To create and analyse models of a G+10 regular and irregular RCC frame structure with bracings and without bracings and also with various types of bracing system. The seismic performance is analysed by the ESM and RSM method'

III. METHODOLOGY

3D modelling and Analysis of G+10 RCC multi-story building with different types of bracings is done using ETABS. In this study RCC framed building having an area of 25m X 20m and height 30m with all supports are fixed. In this study, twelve models of RCC frame structure having G+10 floors with different bracing types for both regular and irregular structures, were selected in order to determine the behaviour of building during seismic activity in seismic zone V. The analysis is carried out by applying loads as per required IS code requirement

A. *Methods Of Seismic Analysis*

1) Equivalent static method
2) Response spectrum method

B. *Equivalent Static Method*

It is a simple method in which for the purpose of analysis the dynamic loading impact of the earthquake is replaced by a static force laterally transmitted on the structure.In the ESM method the total applied force is evaluated in two horizontal directions to the main axis of the building.

C. *Response Spectrum Analysis*

In the RSM method, for different frequencies the mode shapes and modal mass of the structure is taken into consideration as it is a dynamic analysis.Every building has its own frequencies of vibrations and at the time of earthquake different natural frequencies are cumulated for response.

IV. ANALYTICAL MODEL

A. *General Description Of Models*

Sl. No.	Regular Building Bracings	Irregular Building Bracings
1	Bare frame	Bare frame
2	X type	X type
3	V type	V type
4	Inverted V type	Inverted type
5	Eccentric forward	Eccentric forward
6	Eccentric backward	Eccentric backward

Plan dimension	25x20m
Type of structure	Braced frame
Number of floor	G+10
Column size	230x600
Beam size	230x450
Slab thickness	150mm
Grade of concrete	M25
Grade of steel	Fe500
Seismic zone	Zone V
Zone factor	0.36
importance factor	1
response reduction factor	5
Structure height	30m
Soil condition	Medium
Damping ratio	5%
floor Finish	1.0 KN/m2
Imposed load	4.0 KN/m2
Density of steel	78.50 KN/m3
Bracing	ISMB250
Floor tallness	3m

B. Images of Different Models

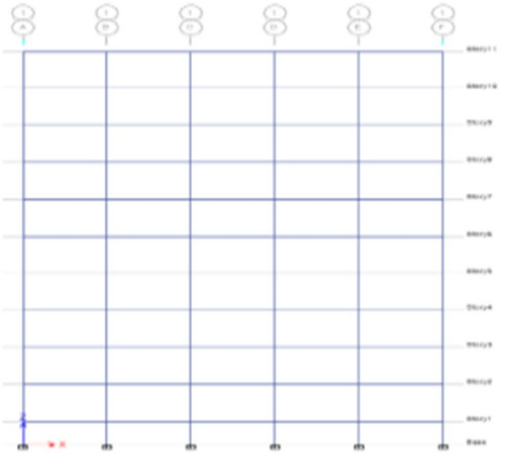

Figure 5:- Elevation Regular building

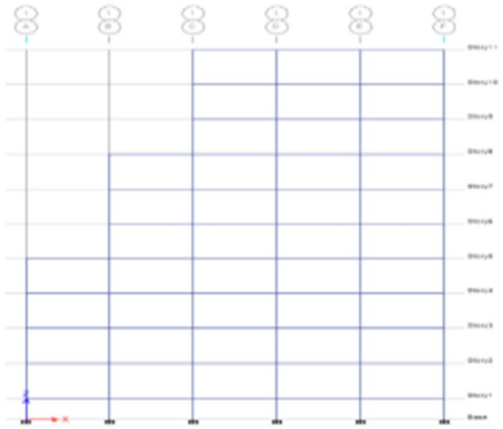

Figure 6:- Elevation Irregular building

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V. REGULAR FRAME STRUCTURE MODELS

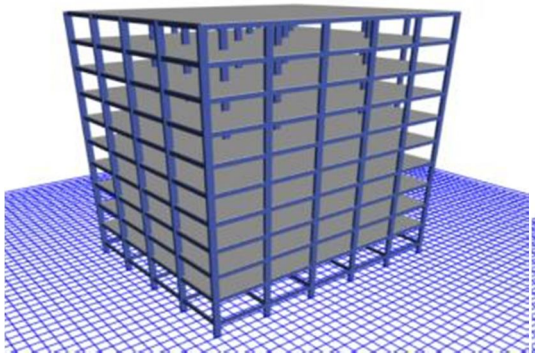

Figure 7 : Bare Frame

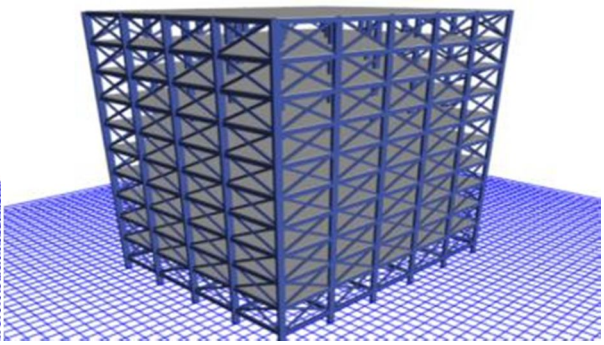

Figure 8 : X Bracing

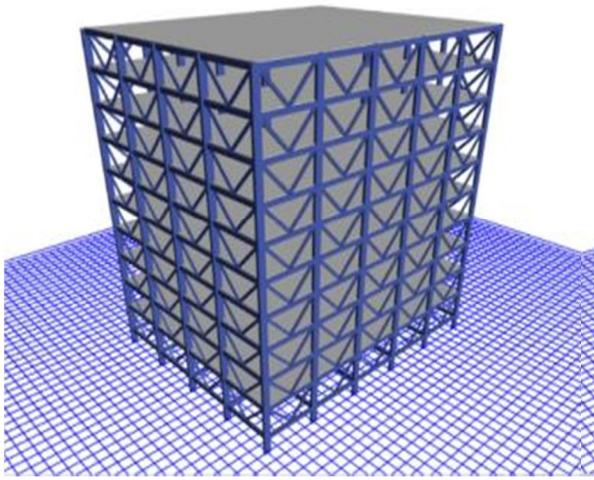

Figure 9 : V Bracing Frame

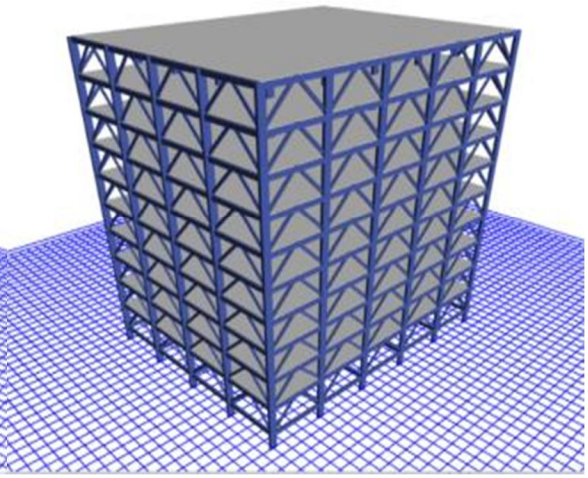

Figure 10 : Inverted V Bracing

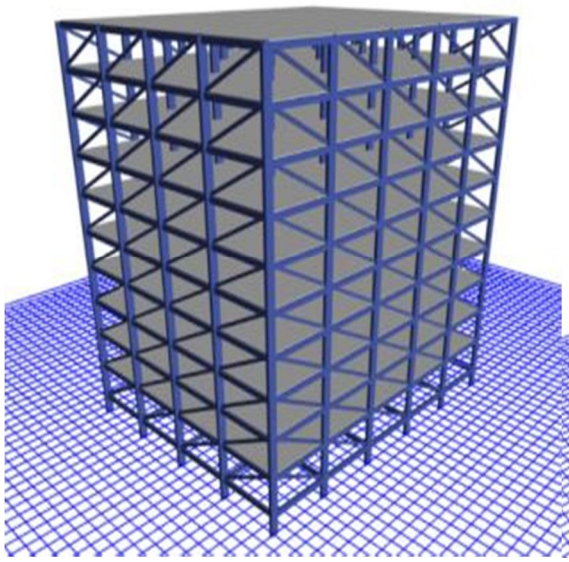

Figure 11 : Eccentric Forward Bracing

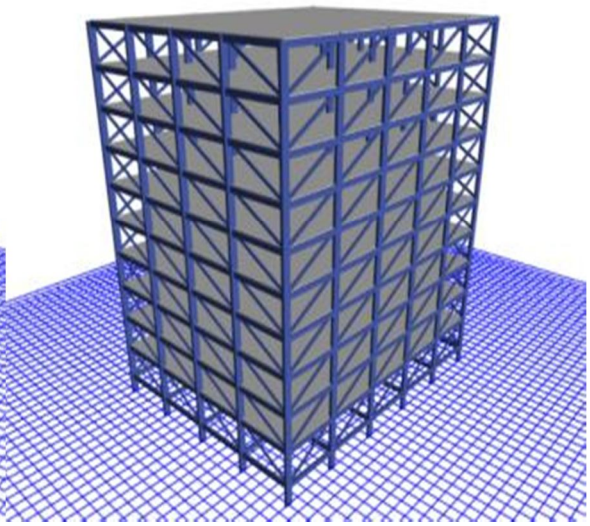

Figure 12 : Eccentric Backward Bracing

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VI. IRREGULAR FRAME STRUCTURE MODELS

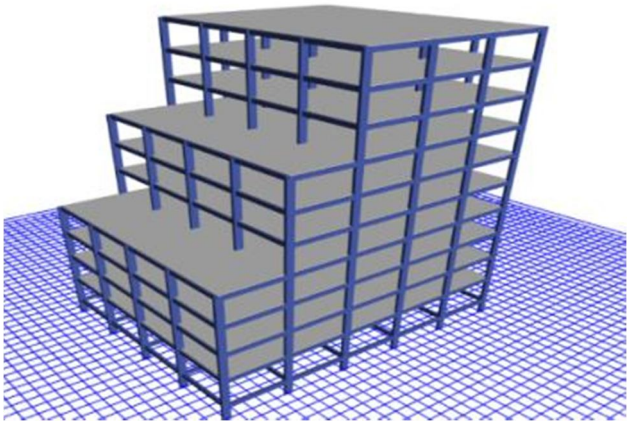


Figure 13 : Bare Frame

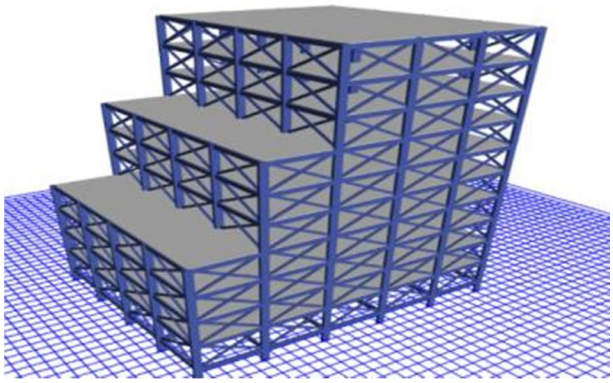


Figure 14 : X Bracing

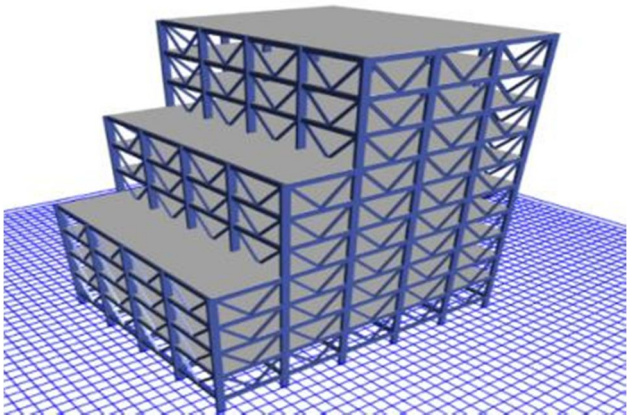


Figure 15 : V Bracing Frame

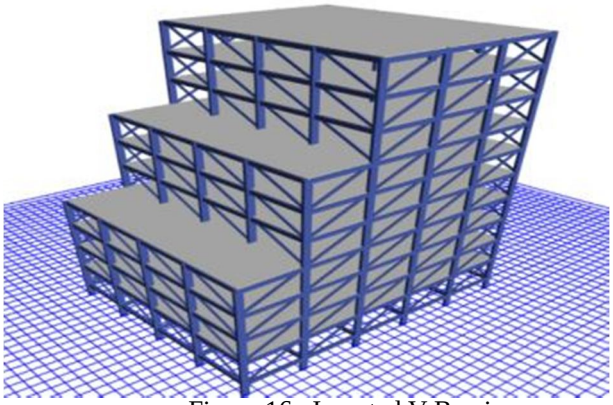


Figure 16 : Inverted V Bracing

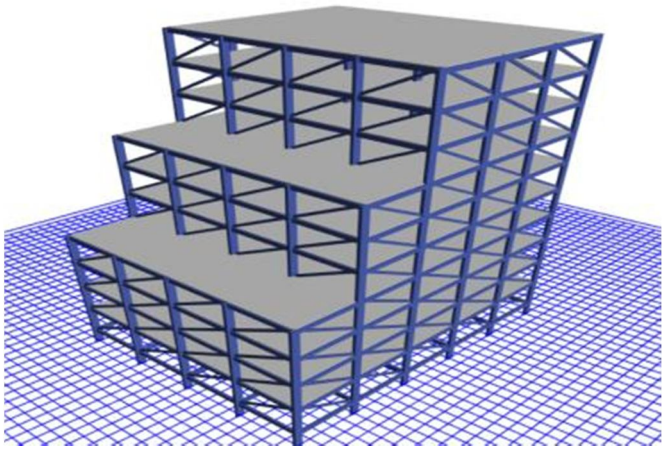


Figure 17 : Eccentric Forward Bracing

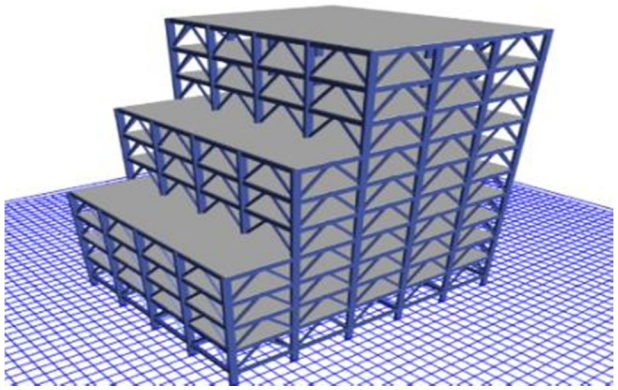


Figure 18 : Eccentric Backward Bracing

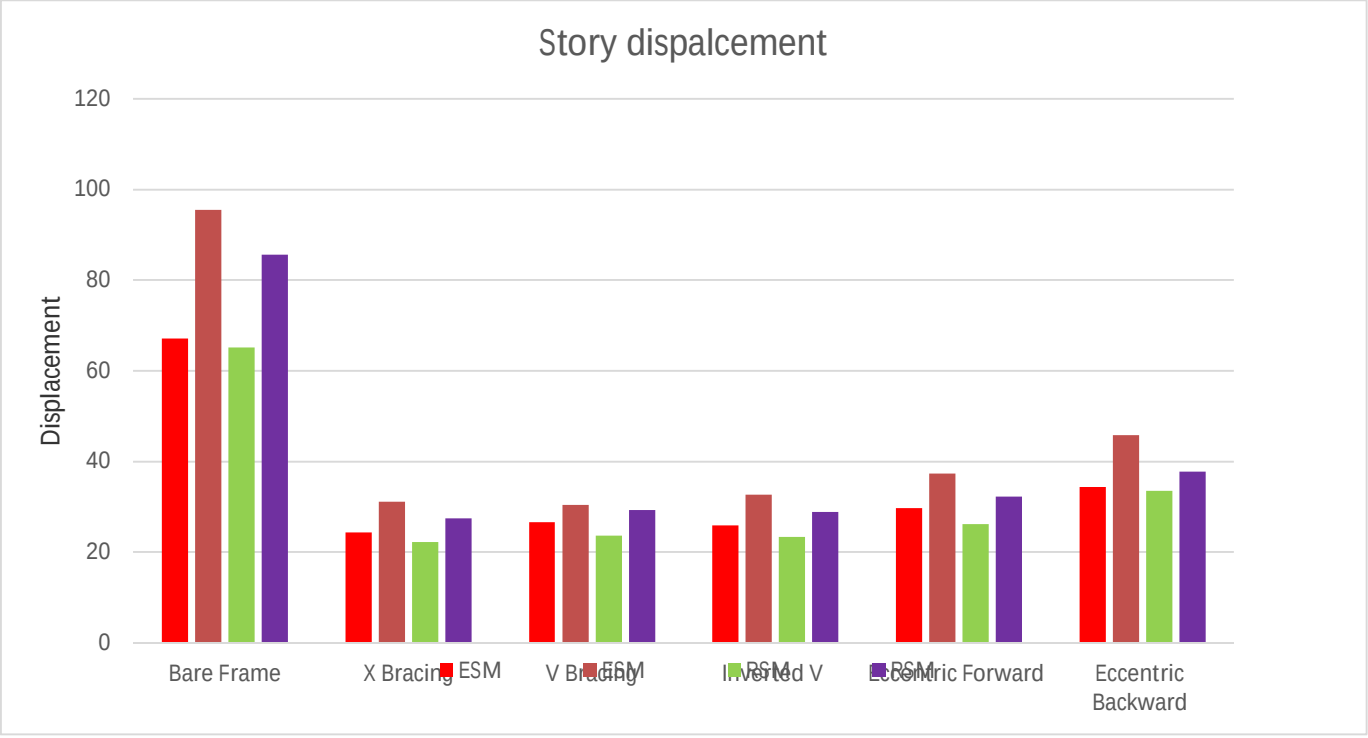
VII. RESULTS AND DICUSSION

The seismic analysis is done for all the models of the regular and the irregular buildings with different bracing systems and also the bareframe by the ESM and RSM method. The various factors such as storey displacement ,storey drift and the base shear are found out and compared. The results shows the cross bracing system is most efficient among all models.

VIII. RESULTS FOR REGULAR STRUCTURE:-

A. *Story Displacement*

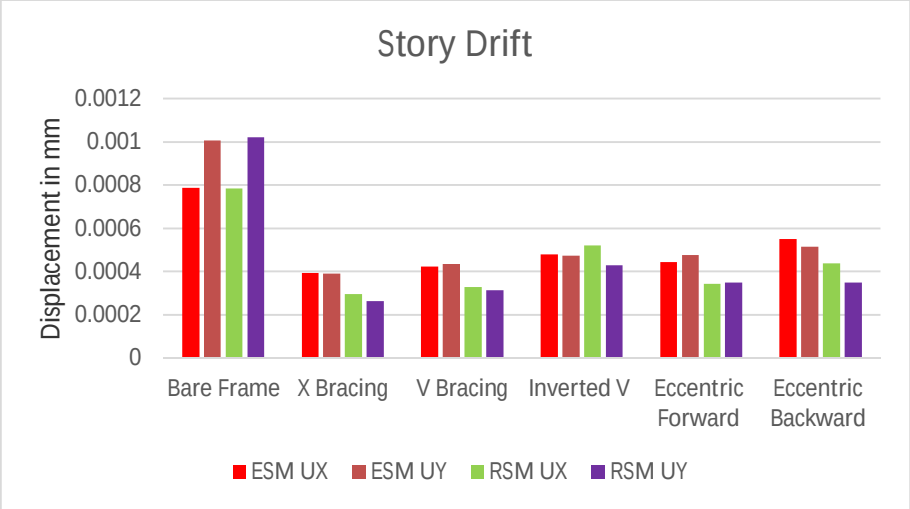
Story displacement	ESM		RSM	
Models	UX	UY	UX	UY
Bare Frame	67.155	95.531	65.217	85.629
X Bracing	24.416	31.147	22.225	27.475
V Bracing	26.613	30.451	23.643	29.366
Inverted V	25.843	32.695	23.395	28.878
Eccentric Forward	29.784	37.287	26.171	32.225
Eccentric Backward	34.405	45.846	33.599	37.77



From the analysis result it is observed that, displacement is less in braced frame structure compared to unbraced structure from both the methods. In Equivalent Static Method the X Bracing is having least displacement of 24.416mm & 31.147mm in x & y directions. In Response Spectrum Method the X Bracings is having least displacement of 22.225mm and 27.475mm in x & y directions

B. *Story Drift*

Story Drift	ESM		RSM	
Models	UX	UY	UX	UY
Bare Frame	0.000788	0.001007	0.000784	0.001021
X Bracing	0.000395	0.000392	0.000296	0.000264
V Bracing	0.000424	0.000436	0.000328	0.000315
Inverted V	0.000479	0.000474	0.000522	0.000428
Eccentric Forward	0.000444	0.000475	0.000343	0.000349
Eccentric Backward	0.000549	0.000515	0.000437	0.000349

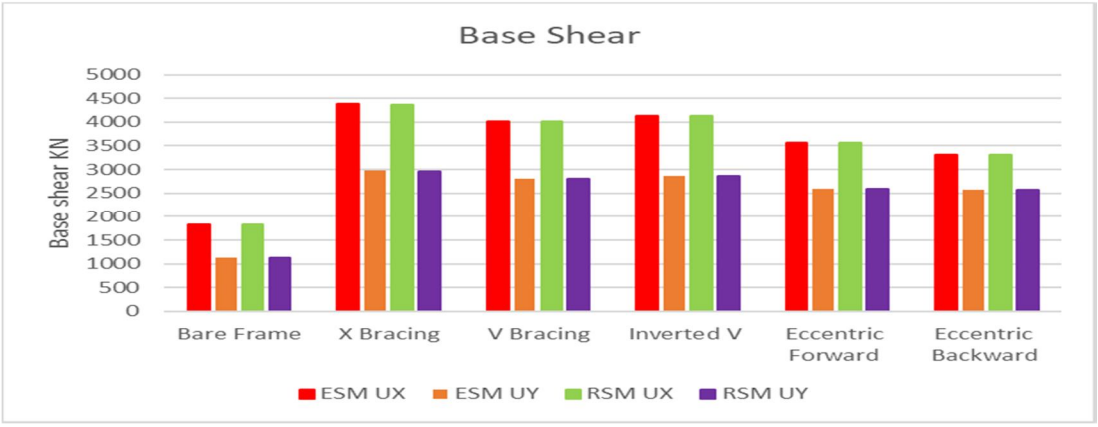


From the analysis result it is observed that, the story drift of braced structure is less than that of unbraced structure. From the analysis result it is found that x bracing have least amount of story drift in both directions. In ESM the story drift value for X bracing in x & y direction is 0.000395 and 0.000392. In RSM the story drift value for X bracing in x & y direction is 0.000296 & 0.00026

C. Base Shear

TABLE 5.3

Base Shear	ESM		RSM	
Models	UX	UY	UX	UY
Bare Frame	1827	1138	1824	1132
X Bracing	4388	2977	4362	2959
V Bracing	4023	2816	4020	2814
Inverted V	4136	2871	4134	2869
Eccentric Forward	3569	2586	3568	2585
Eccentric Backward	3315	2567	3314	2565

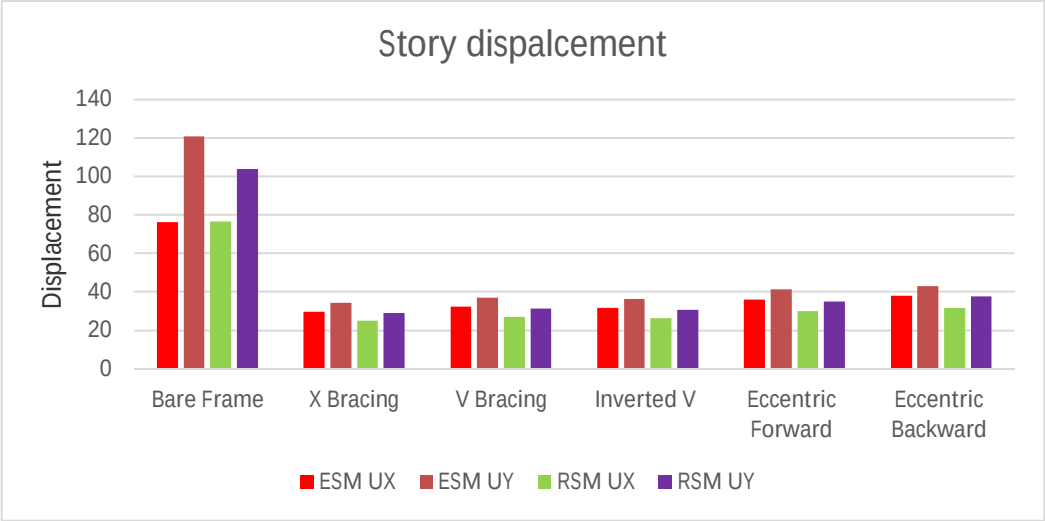


From the analysis result it is observed that, Base shear of structure with bracings is more than base shear of unbraced structure. In this base shear of X bracing is more than that of other bracing system. The value of base shear for X bracing in X and Y direction are 4388and 2977 KN respectively.

IX. RESULTS OF IRREGULAR STRUCTURE

A. *Story Displacement*

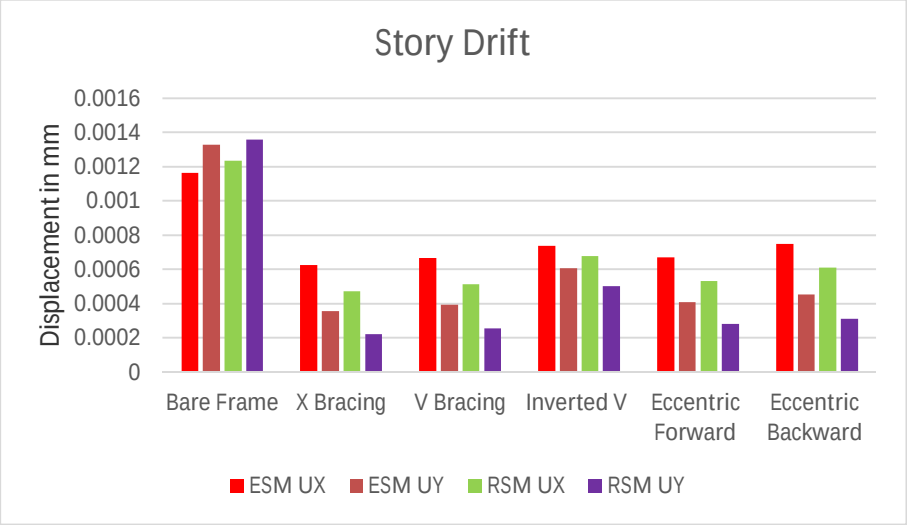
Story displacement	ESM		RSM	
Models	UX	UY	UX	UY
Bare Frame	76.401	120.688	76.68	103.706
X Bracing	29.788	34.264	24.855	29.038
V Bracing	32.448	37.082	26.883	31.284
Inverted V	31.641	36.165	26.321	30.574
Eccentric Forward	35.966	41.402	30.096	34.872
Eccentric Backward	37.905	43.112	31.703	37.77



From the analysis result it is observed that, displacement is less in braced frame structure compared to unbraced structure from both the methods. In Equivalent Static Method the X Bracing is having least displacement of 29.788mm & 34.264mm in x & y directions. In Response Spectrum Method the X Bracings is having least displacement of 24.855mm and 29.038mm in x & y directions.

B. *Story Drift*

Story Drift	ESM		RSM	
Models	UX	UY	UX	UY
Bare Frame	0.001163	0.001329	0.001235	0.001358
X Bracing	0.000625	0.000355	0.000471	0.000223
V Bracing	0.000665	0.000393	0.000512	0.000256
Inverted V	0.000737	0.000606	0.000679	0.000503
Eccentric Forward	0.00067	0.000409	0.000533	0.00028
Eccentric Backward	0.000747	0.000453	0.000609	0.000311

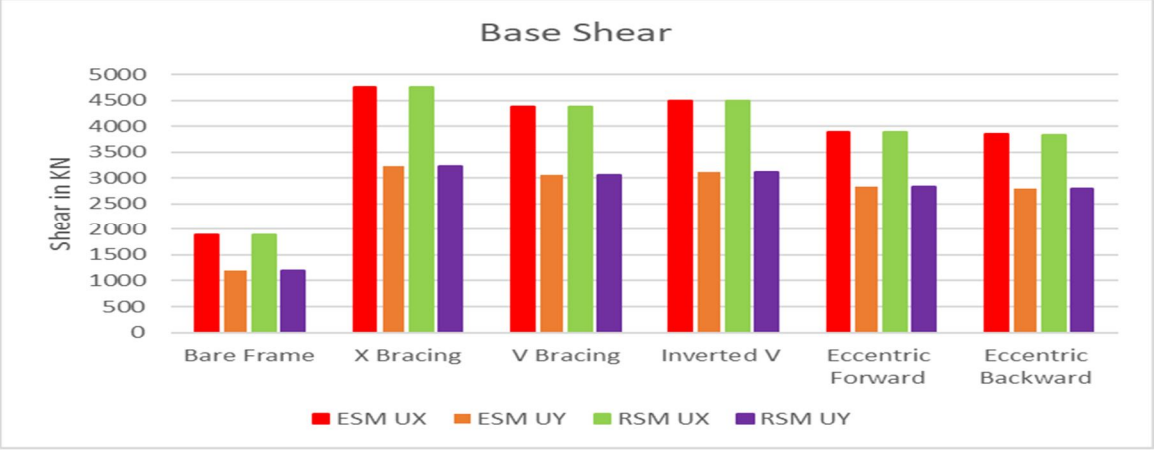


From the analysis result it is observed that, the story drift of braced structure is less than that of unbraced structure. From the analysis result it is found that x bracing have least amount of story drift in both directions. In Equivalent Static Method the story drift value for X bracing in x & y direction is 0.000625 and 0.000355. In Response Spectrum Method the story drift value for X bracing in x & y direction is 0.000471 & 0.000223.

C. Base Shear

TABLE 6.3

Base Shear	ESM		RSM	
Models	UX	UY	UX	UY
Bare Frame	1888	1199	1887	1198
X Bracing	4760	3234	4757	3233
V Bracing	4371	3070	4370	3069
Inverted V	4486	3122	4483	3121
Eccentric Forward	3897	2834	3894	2833
Eccentric Backward	3844	2802	3842	2801



From the analysis result it is observed that, Base shear of structure with bracings is more than base shear of unbraced structure. In this base shear of X bracing is more than that of other bracing system. The value of base shear for X bracing in X and Y direction are 4760 and 3234 KN respectively

X. CONCLUSION

The above project is an approach to understand and study the behaviour of the frame structure with the application of various system of bracings.Conclusion are made on the basis of entire analysis and result is listed as follows.

A. Buildings with steel bracings shows efficient performance in high seismic zone.
B. In RCC frame building, the displacement and story drift decreases for different types of bracing system used compared to RCC frame building without bracings and the base shear increases for different types of bracings system used compared to unbraced frame structures.
C. In regular and irregular RCC frame structure, X- bracing gives less displacement and story drift and base shear is increased.
D. The performance of X-bracing or Cross bracing gives better results compared to other bracing system.
E. From the result the regular RCC frame is having more stiffness compared to vertical irregular RCC frame structure.
F. Additional strength is provided for existing structure by the application of steel bracing.

XI. SCOPE OF FURTHER STUDIES

A. Further studies can be carried out by adopting Shear walls and bracings positions at different locations.
B. Dynamic loadings can be varied by using Wind Loads and one can study the behavior of structure.
C. Models can be analysed by designing the building with mass and stiffness irregularities.

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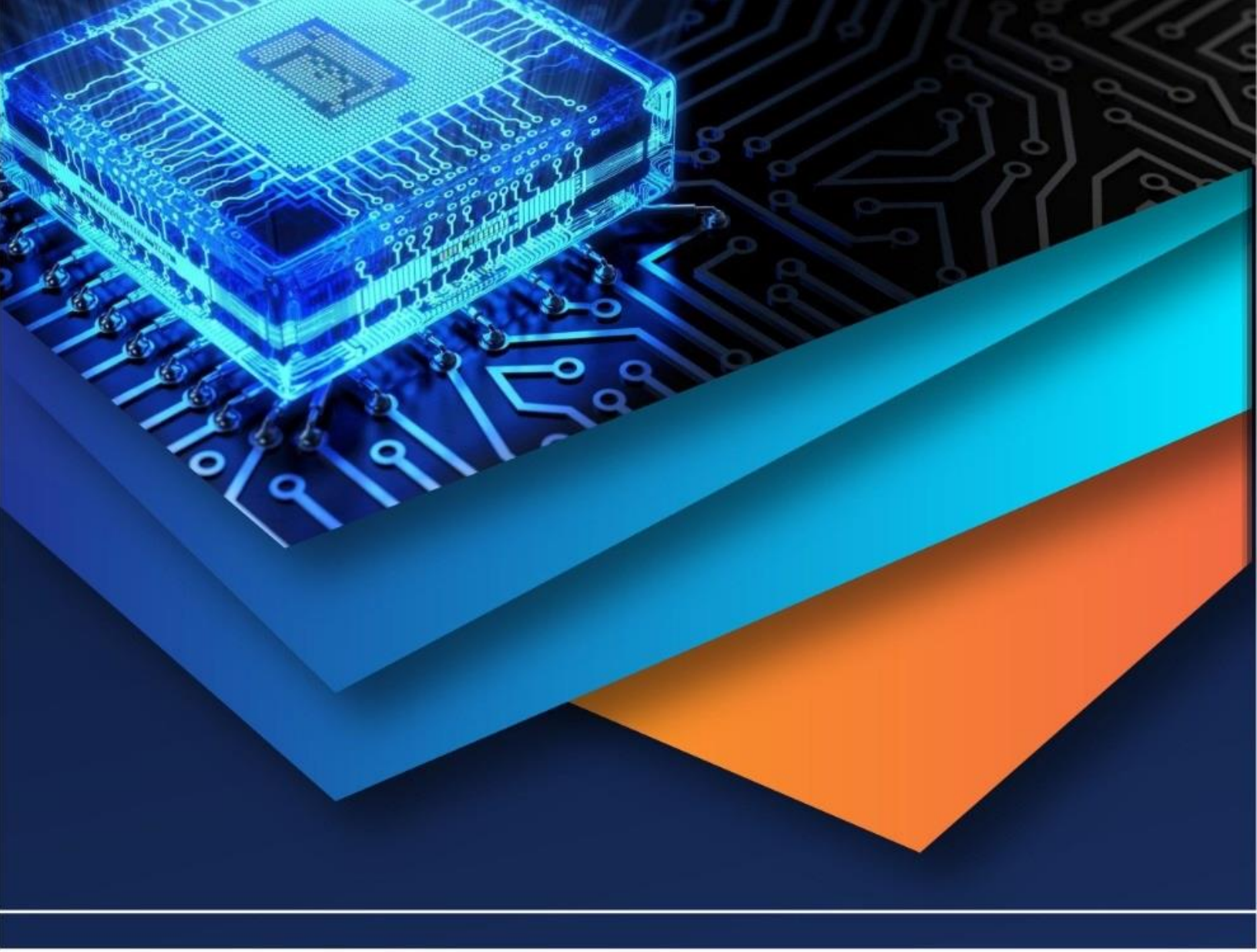

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