Seismic analysis using X-bracing on G+15 RC Building.

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Abstract : We have prepared a model of G+15 structure taking into account that India has many seismic zones ranging from II to V, and some places like Bhuj, Darbhanga, Guwahati, Imphal, etc. come under high seismic zone V. To ensure our structure can resist the lateral forces caused by earthquakes and wind, providing bracing is the best solution. Therefore, we used X-bracing and took into account Seismic Zone-V and Soil type-I. Using ETABS, we obtained results for storey drift, storey displacement, storey shear, and overturning moment.

Index Terms : Seismic, lateral forces, for storey drift, storey displacement, storey shear, overturning moment, ETABS.

I. INTRODUCTION

India has a diverse population with people of different religions living together, leading to a high population density. In contrast, the land available in India is limited, which has led to a need for high-rise buildings that require larger construction areas. However, constructing high-rise buildings in a small area results in an increase in lateral and vertical loads. To resist lateral loads on these structures, bracing is one of many options.The horizontal and vertical subsystems of the structural system interact and work together to resist gravity and lateral loads. Due to the effects of lateral loads, such as those caused by wind and earthquakes, the choice of structural systems for high-rise buildings is critical. The Lateral Force System includes three primary types of structural systems: bending frame, shear wall, and steel frame. Shear walls are the stiffest and deflect the least under a given load. In comparison, prestressed frames are typically less stiff than shear walls, and moment-resisting frames are the least stiff.

Reinforced concrete buildings' lateral load-resisting systems usually include frames made of posts and beams, and their ability to resist lateral loads is due solely to stiffness and the moment resistance of the beam-to-column connection of individual members.Normally, the structure of a framed building comprises of columns and beams that transfer the gravity load. Bracing, which is an effective and economical method of resisting horizontal forces, is often utilized in both reinforced concrete and steel buildings. Braced frame systems form a vertical cantilever truss-like structure to resist horizontal forces when bracings are fixed to columns and beams.

Bracing members can be connected with fixed-ended or pin-ended connections, with the latter being subjected to axial forces that cause global buckling under compressive load. However, maximum tensile strength does not change much in subsequent cycles. Although often incorrectly referred to as "rigid frames," the ends of the various elements in a braced frame are rigidly connected at the joints.The primary advantage of using braces is that they dissipate energy without damaging the building, and damaged braces can be replaced easily. Bracing is the most efficient and economical method for improving frame stiffness for seismic forces in horizontal load resisting systems..

Bracing are of two types eccentric and concentric.

Eccentric- Where one or both ends of diagonal bracing in plane of frame does not join the end points of our framing member. For e.g., K-Bracing.

Concentric- Where both ends of diagonal bracing in plane of frame join the end points of our framing member. Due to this joining of our diagonal members with end points of framing member the structure formed is truss which is stiff in nature. For e.g., X-Bracing and V-Bracing.

II. LITERATURE REVIEW

2.1 Introduction

There are many researchers whose efforts has been devoted for the present study on finding out the effect of x bracing on the structure. Many journals are available on the seismic analysis methods. In this chapter few of the literatures are available and discussed below.

1) Ketan Chaudhary (2019)

Using ETABS software, the effect of bracing and unbracing on steel structures was studied. The steel frame was modeled according to the specified analysis, and the results were compared for different bracing systems, including X-bracing and diagonal bracing. Conclusions were drawn based on the tables and graphs obtained, and it was found that the X-bracing configuration is the most suitable as it exhibits maximum stiffness and lower drift compared to frames with diagonal or V-bracing.

2) Harshitha & Vasudev (2018)

Analysis of RC framed structure with structural steel braces using ETABS

Using ETABS, research has been conducted to analyze the behavior of various bracing systems for different arrangements. A G+10 building located in Zone IV was selected for the study, and different bracing options were analyzed. The effectiveness of the braces was examined using 16 different models, one of which was a bare frame model. The results of the study showed that the inverted V and X braced frames exhibited the maximum reduction in lateral displacement and better resistance to storey displacement.

3) Ajay Matari, Y.M. Ghugal (2017)

Research has been conducted on 25 stories steel building model is analyzed by using response spectrum method with different pattern of bracings such as X,V, inverted V and K bracing. A commercial package Etabs2013 is used for analysis purpose .It is observed that due to bracing in both direction base shear increases up to 30.63%,modal time reduced up to 14.52%,displacement decreases up to 20.2%.They suggest X bracing is highly effective.

4) Akhila lekshmi , Aswathy S Kumar(2016)

In this study the analysis of reinforced concrete irregular building(H-Shaped) with different types of bracing is carried out using ETABS software .The main parameters considered in this paper are lateral displacement, storey drift, axial force, base shear, joint displacement.BY using X bracing value for storey displacement in x-direction is 0.63mm and in y-direction is 0.65mm,joint displacement is 7.4413mm,storey shear in x-direction is 875.46kn and in y-direction is 772.03kn.X type bracing is found to be most effective.

5) Jagadish & Tejas Doshi (2013)

This paper is presented to show the effect of different types of bracing systems in multi stories steel buildings. For this purpose they have been used G+15 stories steel building model is used with same configuration and different bracing systems such as single diagonal , X , double X , K, V bracing is used and a commercial software package STAAD-Pro V8i is used for the analysis of steel buildings and different parameters are compared.

III. SUMMARY OF LITERATURE REVIEW :-

1. Most structures use X-bracing.
2. The use of bracing members reduces the lateral force on each node of the structure since the bracing acts as a lateral resisting member.
3. Different seismic parameters such as storey displacement, storey drift, and modal mass participation ratio have been analyzed.

IV. OBJECTIVE

1. To investigate the seismic performance of a multi-storey building.
2. To understand behaviour of building with bracing and without bracing.
3. To check storey drift, storey displacement ,torsional irregularity and Modal mass participation ratio.

V. SCOPE

- Buildings with same types of the zonal condition and for same soft soil type can be adopted.
- Without bracing and X bracing is adopted.
- Analysis of response such as storey drift, storey displacement, torsional irregularity and Modal mass participation ratio is carried out using the ETABS.

VI. METHODOLOGY

1. A thorough literature review to understand the seismic evaluation of building structures and application of Equivalent Static analysis and Response Spectrum analysis
2. Seismic behaviour with concentric ,geometrical and structural details
3. Modelling with concentric bracing by using computer software ETABS.
4. Carry out Equivalent Static Analysis and Response Spectrum Analysis on the models and arrive at a conclusion.
5. Effects of design earthquake loads applied on structures can be considered in two ways, namely:

a) Equivalent static method, and

b) Dynamic analysis method :-

Structural analysis is mainly concerned with finding out the behavior of a physical structure when subjected to force.

Linear dynamic analysis shall be performed to obtain the design lateral force (design seismic base shear, and its distribution to different levels along the height of the building, and to various lateral load resisting elements) for all buildings, other than regular buildings lower than 15 m in Seismic Zone II.

Design base shear(V_B) :- It is the horizontal lateral force in the considered direction of earthquake shaking that the structure shall be designed for.

In turn, dynamic analysis can be performed in three ways, namely:

1) Response Spectrum Method,

2) Modal Time Hi Storey Method, and

3) Time Hi Storey Method.

VII. RESPONSE SPECTRUM METHOD:-

Response spectrum method may be performed for

The design horizontal seismic coefficient A_h for a structure shall be determined by:

$$A_h = \frac{\frac{Z}{2} \times \frac{Sa}{g}}{\frac{R}{I}}$$

VIII. MODELLING & ANALYSIS

In this proposed experimental and parametric study, G+15 storey RC building frame is analysed for X-bracing systems under higher seismic conditions and for soft soil.

Table 1: Design Details

Sr.No.	Description of structure	Values
1	Grade of concrete	M30

2	Grade of steel	Fe500
3	Number of storey	15
4	storey height	3.8m each
5	Total height	57m
6	Column size	C1) 880mm x 350mm C2) 1098mm x 400mm C3) 1074mm x 450mm
7	Beam size	600 mm x 400 mm
8	Thickness of Slab	150mm
9	Bracing (Steel angle)	ISA 110x110x10
10	Individual floor area	3847.38 m^2
11	Total floor area	57710.7 m^2

Table 2 : Seismic Parameters

Sr.no	Parameters		IS Code
1	City	Bhuj	
2	Zone	V	Table 3
3	Zone Factor	0.36	Table 3, Clause 6.4.2
4	Importance factor	1	Table 8, Clause 7.2.3
5	Response reduction factor	4.5	Table 9, Clause 7.2.6
6	Type of soil	Soft (Type III)	Clause 6.4.2.1
7	Damping percent	5 % (0.05)	

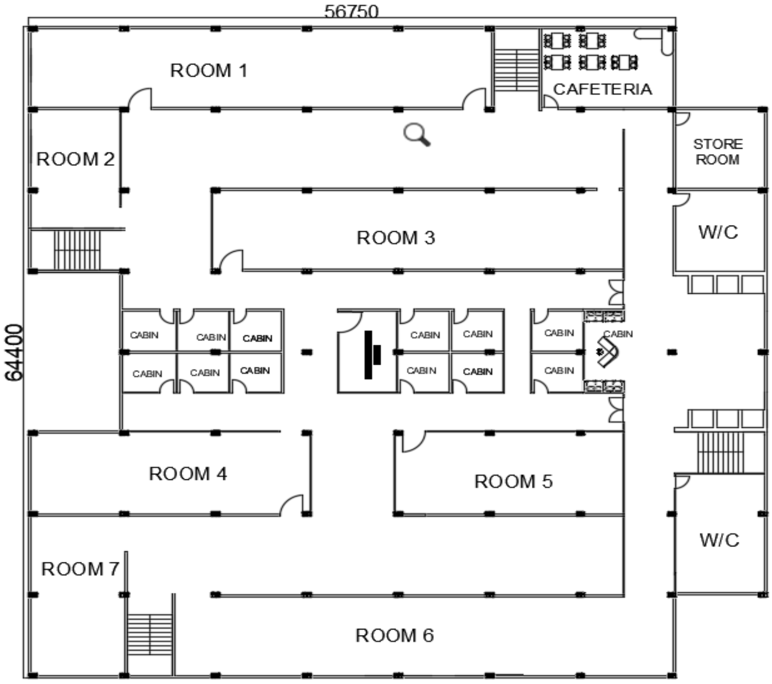


Fig 1: Architectural Plan

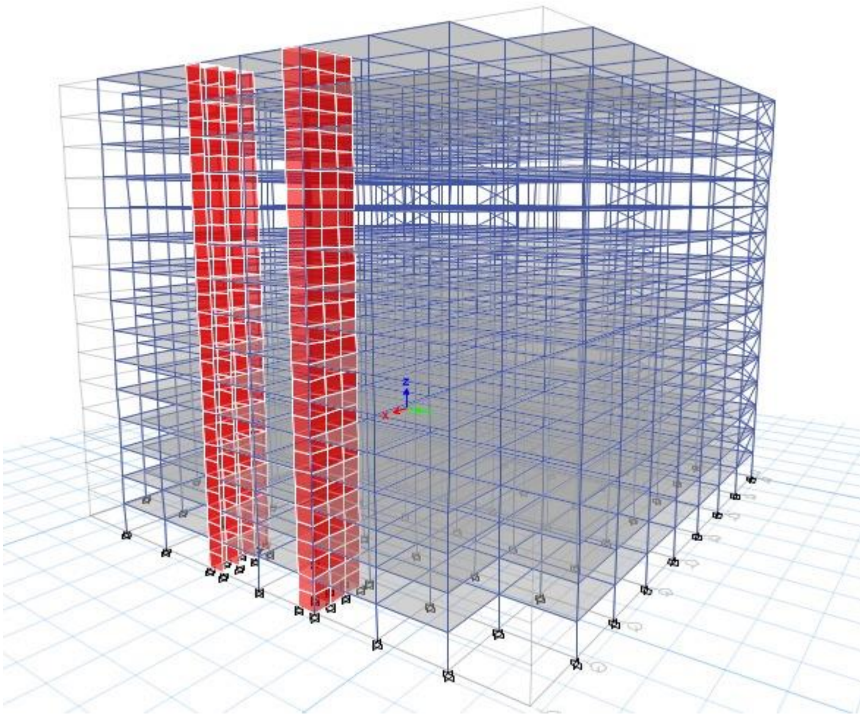
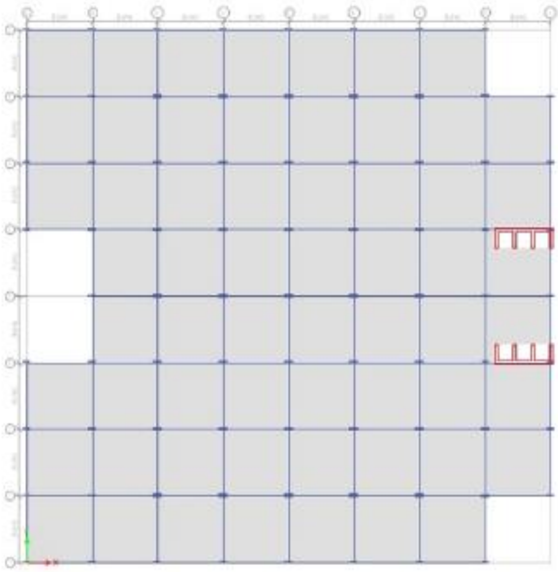
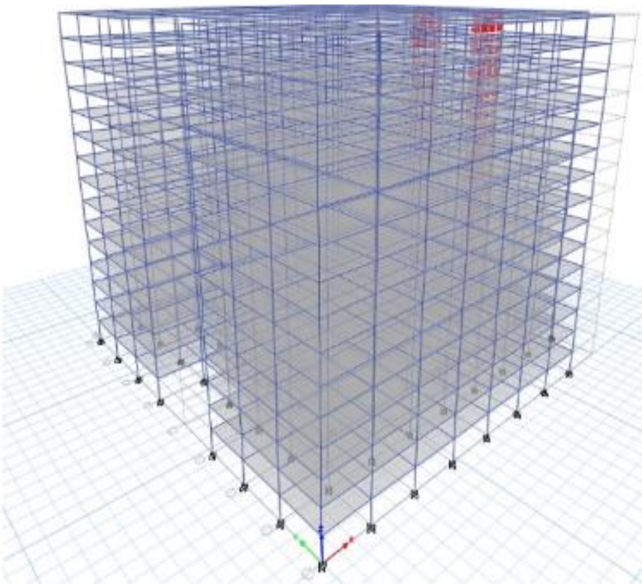


Fig 2: 3D-View



Top View



3D Elevation

Fig 3: Without Bracing model

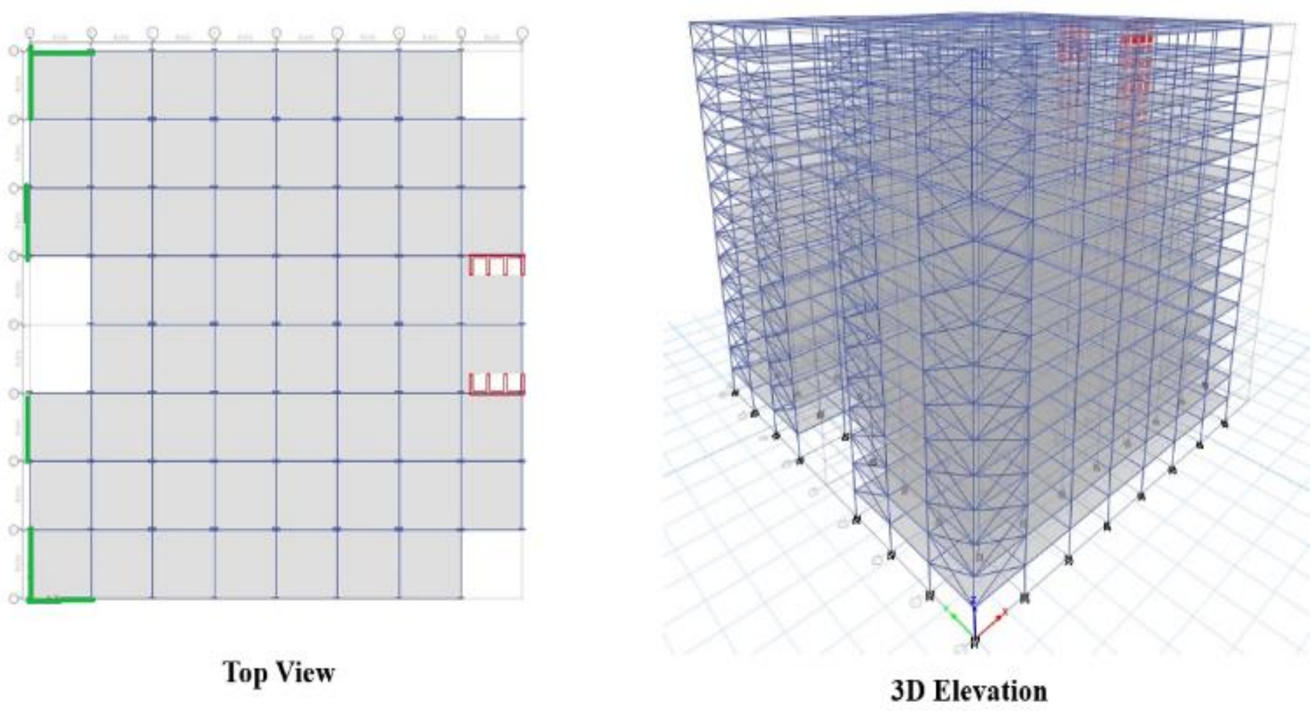
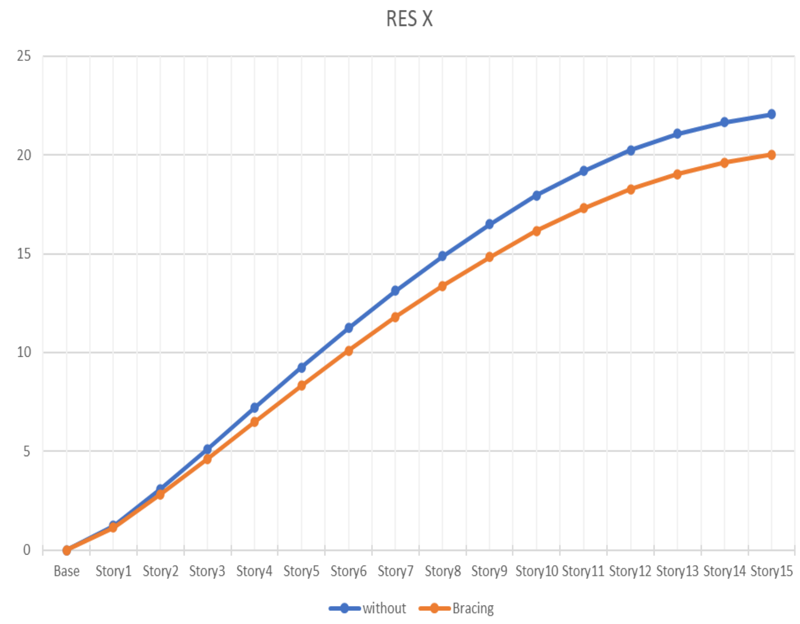


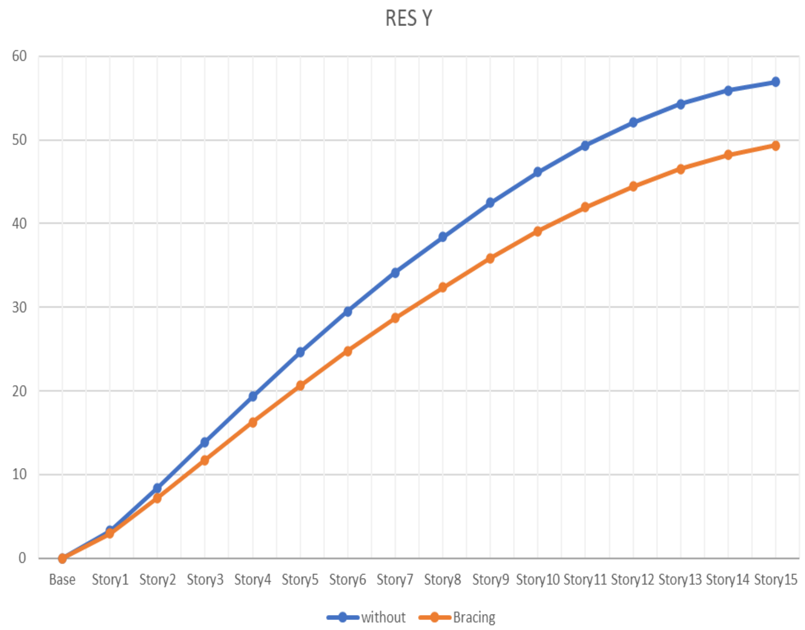
Fig 4 : Bracing

IX. COMPARISON OF RESULT

1. Storey Displacement in X-Direction

RES X		
Storey	Without	Bracing
Base	0	0
Storey 1	1.23	1.13
Storey 2	3.09	2.81
Storey 3	5.12	4.62
Storey 4	7.19	6.47
Storey 5	9.25	8.31
Storey 6	11.24	10.09
Storey 7	13.12	11.79
Storey 8	14.87	13.37
Storey 9	16.50	14.84
Storey 10	17.95	16.15
Storey 11	19.20	17.29
Storey 12	20.24	18.26
Storey 13	21.06	19.03
Storey 14	21.66	19.61
Storey 15	22.06	20.01





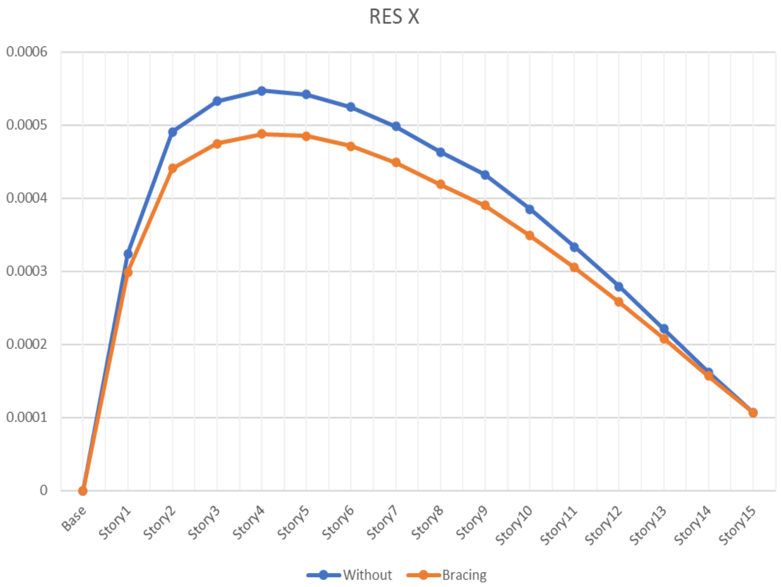
1. Storey Displacement in Y-Direction

RES X		
Storey	Without	Bracing
Base	0	0
Storey 1	3.28	2.91
Storey 2	8.40	7.21
Storey 3	13.89	11.74
Storey 4	19.34	16.24
Storey 5	24.58	20.59
Storey 6	29.53	24.75
Storey 7	34.14	28.68
Storey 8	38.40	32.34
Storey 9	42.48	35.86
Storey 10	46.14	39.07
Storey 11	49.36	41.95
Storey 12	52.10	44.46
Storey 13	54.30	46.55

Storey 14	55.92	48.19
Storey 15	56.95	49.36

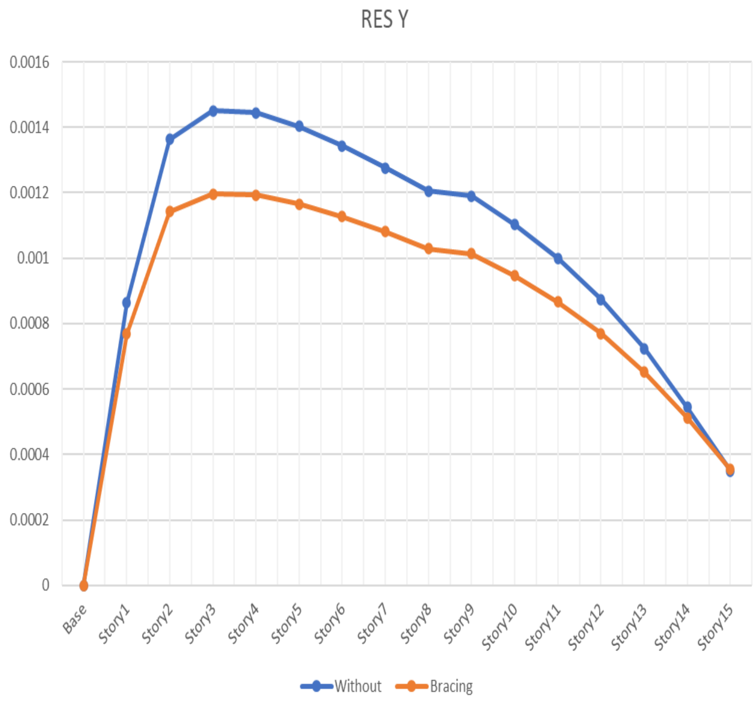
2. Storey Drift in X Direction

RES X		
Storey	Without	Bracing
Base	0	0
Storey 1	0.000324	0.000299
Storey 2	0.000491	0.000441
Storey 3	0.000533	0.000475
Storey 4	0.000547	0.000488
Storey 5	0.000542	0.000485
Storey 6	0.000525	0.000471
Storey 7	0.000498	0.000449
Storey 8	0.000463	0.000419
Storey 9	0.000432	0.00039
Storey 10	0.000385	0.000349
Storey 11	0.000333	0.000305
Storey 12	0.000279	0.000258
Storey 13	0.000221	0.000208
Storey 14	0.000162	0.000157
Storey 15	0.000107	0.000107



RES Y		
Storey	Without	Bracing
Base	0	0
Storey 1	0.000863	0.000768
Storey 2	0.001363	0.001143
Storey 3	0.00145	0.00196
Storey 4	0.001445	0.001193
Storey 5	0.001403	0.001166
Storey 6	0.001343	0.001127
Storey 7	0.001275	0.001081
Storey 8	0.001205	0.001029

Storey 9	0.00119	0.001014
Storey 10	0.001102	0.000946
Storey 11	0.000999	0.000867
Storey 12	0.000874	0.00077
Storey 13	0.000723	0.000652
Storey 14	0.000544	0.000512
Storey 15	0.00035	0.000355



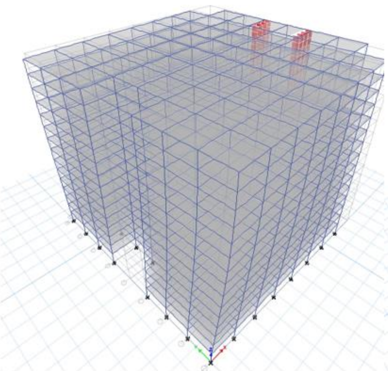
Storey Drift in Y Direction

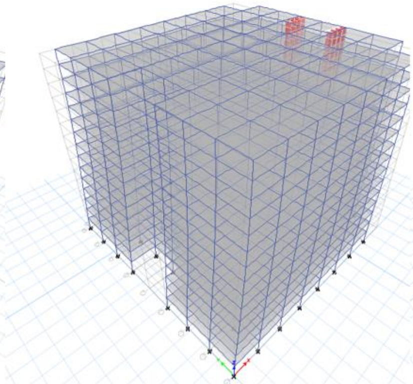
3. MODAL PARTICIPATING MASS RATIOS (UNBRACED STRUCTURE)

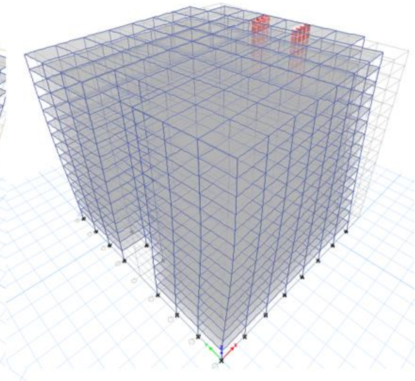
Mode	Period sec	UX	UY	RZ	Sum UX	Sum UY	Sum RZ
1	2.111	0	**0.4368**	0.3601	0	0.4368	0.3601
2	0.7	2.10E-06	0.0586	0.0432	2.10E-06	0.4953	0.4032
3	0.669	**0.7974**	0	0	0.7974	0.4953	0.4032
4	0.445	0	0.3713	**0.4421**	0.7974	0.8666	0.8453
5	0.402	0	0.017	0.022	0.7974	0.8836	0.8673
6	0.278	0	0.0106	0.01	0.7974	0.8942	0.8773
7	0.218	0.1038	0	0	0.9012	0.8942	0.8773
8	0.208	0	0.0072	0.0055	0.9012	0.9013	0.8828
9	0.165	0	0.0047	0.0039	0.9012	0.906	0.8867
10	0.148	0	0.0418	0.051	0.9012	0.9478	0.9376

11	0.135	0	0.0029	0.0034	0.9012	0.9507	0.941
12	0.126	0.0409	0	0	0.9421	0.9507	0.941
Summation of 12 Modes					94.21	95.07	94.1

- Mode No.01 has Maximum Mass Participation in Translational y-direction with 43.68% and Time Period of 0.7 Sec.
- Mode No.03 has Maximum Mass Participation in Translational x-direction with 79.74% and Time Period of 0.669 Sec.
- Mode No.04 has Maximum Mass participation in Rotational z-direction with 44.21 % and Time Period of 0.445 Sec.
- Maximum Mass Participation for Summation of 12 Modes is 95.07% in Translational y-direction.


MODE 1

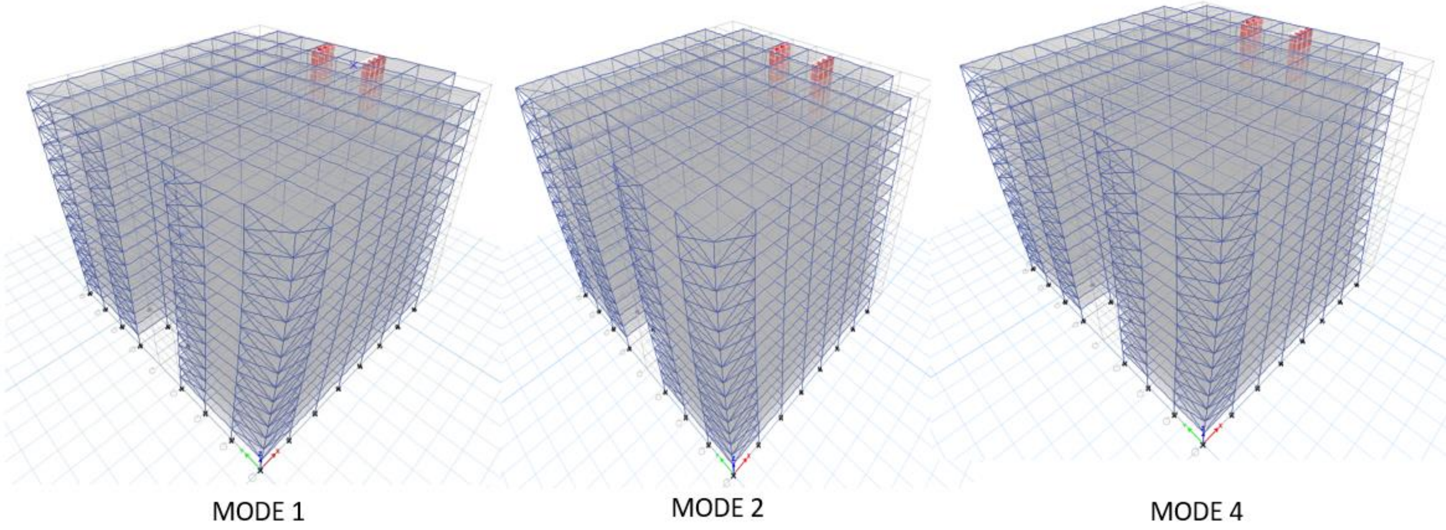

MODE 3


MODE 4

MODAL PARTICIPATING MASS RATIOS (X-BRACED STRUCTURE)

Mode	Period sec	UX	UY	RZ	Sum UX	Sum UY	Sum RZ
1	1.856	0	**0.4416**	0.3579	0	0.4416	0.3579
2	0.667	**0.7975**	0	0	0.7975	0.4416	0.3579
3	0.613	6.47E-07	0.0651	0.0446	0.7975	0.5067	0.4025
4	0.445	0	0.3619	**0.4519**	0.7975	0.8686	0.8544
5	0.349	0	0.0202	0.0175	0.7975	0.8888	0.8719
6	0.243	0	0.0101	0.0089	0.7975	0.8989	0.8808
7	0.217	0.104	0	0	0.9015	0.8989	0.8808
8	0.184	0	0.0066	0.0046	0.9015	0.9055	0.8854
9	0.148	0	0.0368	0.0545	0.9015	0.9422	0.94
10	0.147	0	0.0082	0.0006	0.9015	0.9504	0.9406
11	0.125	0.0408	0	0	0.9423	0.9504	0.9406
12	0.122	0	0.0027	0.0024	0.9423	0.9531	0.9429
Summation of 12 Modes					94.23	95.31	94.29

- Mode No.01 has Maximum Mass Participation in Translational y-direction with 44.16% and Time Period of 0.613 Sec.
- Mode No.02 has Maximum Mass Participation in Translational x-direction with 79.75% and Time Period of 0.667 Sec.
- Mode No.04 has Maximum Mass participation in rotational z-direction with 45.19% and Time Period of 0.445 Sec.



Maximum Mass Participation for Summation of 12 Modes is 95.31% in Translational y-direction.

X. CONCLUSION

- Result of present study shows that bracing element will have very important effect on structural behaviour of structure. The displacement is reduced by the use of bracings in both the directions with minimum value for X brace is 1.13m in X direction and 2.91m in Y direction.
- Drift is reduced by the use of bracings in both the directions with minimum value for X brace is 0.000107 m in X direction and 0.00077m in Y direction
- Maximum Mass Participation for Summation of 12 Modes is 95.07% in Translational y-direction for Unbraced structure.
- Maximum Mass Participation for Summation of 12 Modes is 95.31% in Translational y-direction for Braced structure.
- and it is suggested that X bracing is highly effective bracing system.

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