Non-Linear Static Analysis of Building with and without Bracing

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Abstract— Structures are subjected to lateral loads such as wind loads and seismic loads. A lateral load generates high stresses as compared with gravity loading. Use of steel bracing method is one of highly efficient and economical. This method improves the seismic performance of the frame by increasing its lateral stiffness and its capacity. In this present work three building models were considered such as RCC framed building without bracing, RCC framed building with V- bracing and X- bracing by using ETAABS software. Total height of the building is 34m and number stories are 11 [G+10]. With the help of linear static and non-linear static analysis has been carried out. The main objective of this study is to determine the time period, base shear, displacement and storey drift by using equivalent static analysis, also to study the performance point, location of hinges and ductility ratio by using pushover analysis.

Keywords: Static Analysis, Building, Bracing

I. Introduction

Due to seismic maximum of the structure is destruct and earthquake arises because of sudden transient motion of the ground. After earthquake, earth will be caused by sudden slip on fault. So, study of earthquake is necessary. Structures are subjected to lateral loads such as wind loads and seismic loads. A lateral load generates high stresses as compared with gravity loading. Use of steel bracing method is one of the extremely resourceful and inexpensive. This method improves the structural behaviour in case of lateral stiffness. Generally steel-bracing can be arranged in diagonally to the frame. There are several types of bracing such as X-bracing, V-bracing etc. The main benefit of providing steel bracing is it will prove stiffer to the structure; it will reduce the storey drift value, more vulnerable to earthquake resistance. Bracing members are imperilled to tension and compression, consequently they are delivered to take these forces. Bracings improves the stiffness of structure also reduces the displacements, drifts etc. These braced frame structures increase tensile and compressive of the building.

II. Methodology

A. Parameter considered for Seismic Analysis

As per the clause 6.4.2, Table-2 from IS 1893:2002, Zone factor values were considered as 0.16 for zone-III. Importance Factor will be considered as 1 [All other Buildings Reduction Factor will be considered as 3 [OMRF].

B. Equivalent Static Analysis

In this method we are calculating the maximum base shear of the building also lateral forces are to be calculated at each story level. This method is depending on total weight of the structure and horizontal seismic coefficient.

C. Dynamic Analysis

In the first step design spectrum is to be selected. In analysis period of vibration and mode shape can be calculated. The period of each mode to be considered by reading response from the spectrum. Corresponding to the single degree of freedom calculate the participation of each mode. Add the effect of mode to obtain combined maximum response. For design of the structure moments and shears are converted by maximum response.

D. Pushover-Analysis

Pushover analysis can also be recognized as non-linear static analysis. From the rest state to ultimate failure of structure pushover provides force-displacement curve. The force is representative of equivalent static force of a mode of the structure and may be suitably in use as the total base shear of the structure. Likewise, the displacement may represent the displacement of any storey and may be easily selected as a top storey displacement.

E. Performance of Building

In order to avoid the foremost failure for existing buildings can be retrofitted to make stronger them after assessing their performance and strength. There for it is compulsory to use pushover analysis to evaluate the performance of the buildings. The most important challenge is to design performance-based earthquake design for structure.

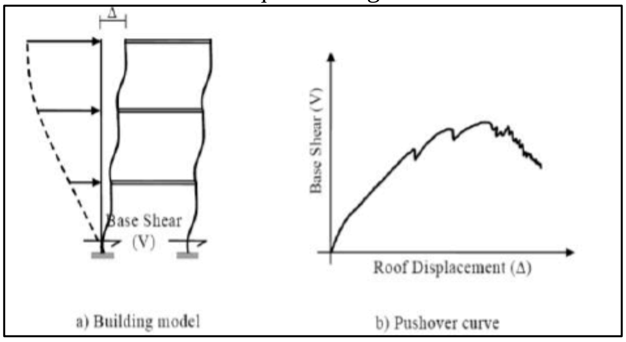

Fig. 1: Pushover Analysis

F. Force-Displacement Curve Description

Point A indicated the origin. Point B- indicates the yielding point bur no deformation. Point C indicates the ultimate state. Point D indicates the structure collapse at initial state. Point E shows the total structure failure.

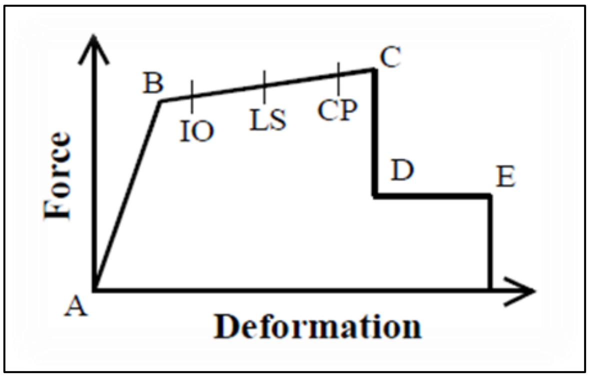

Fig. 2: Force-Displacement Curve

III. Description of the Building

ETABS software has been used for modelling. ETABS is nothing but Extended Three-Dimensional Building System. ETABS software gives better results for non-linear analysis as compared with other software.

Rcc framed building with total width of the building in x-direction is 20m and total depth of the building in y-direction is 20m. total height of the building is 34m and typical storey height is 3m.(G+10) 11number of storey. 5 number of bays in x-direction and 5 number of bays in y-direction. Each 5m spacing of bays in x-direction and also y-direction.

Width of the beam is 230mm and depth of the beam is 450mm.Size of the column is 230x600mm

Slab thickness is provided at 150mm.a steel bracing ISMB 150 is placing in the frame. which is resist buckling of the column.

- Model 1 – RCC framed structure with bare frame.
- Model 2 – RCC frame structure with v bracing
- Model 3 –RCC frame structure with x bracing.

Material Properties	Values
Characteristic strength of concrete, fck	25 MPa
Characteristic strength of steel, fy	500 MPa
Young's modulus of steel, Es	200000 MPa
Young's modulus of concrete, Ec	25000 MPa

Table 1: Material Properties

A. Loads considered for Modelling

1) Dead Load –ETABS will be considered as a self-weight of the structure.
2) Live Load –4 kN/m2 as per IS 875 (Part2).
3) Live Load Roof –2 kN/m2 as per IS 875 (Part2).
4) Floor Finish –1.5 kN/m2 as per IS 875 (Part1).
5) Wall Load –11.73 kN/m
6) EQx –Seismic Analysis along X –axis
7) EQy –Seismic Analysis along Y –axis
8) Pushx –Pushover Analysis along X –axis
9) Pushy –Pushover Analysis along Y –axis

B. Load Combination as per IS 456: 2000

1.5DL + 1.5EQX
1.5DL - 1.5EQX
1.5DL + 1.5EQY
1.5DL - 1.5EQY
1.2DL + 1.2LL + 1.2EQX
1.2DL + 1.2LL - 1.2EQX
1.2DL + 1.2LL + 1.2EQY
1.2DL + 1.2LL - 1.2EQY
0.9DL + 1.5EQX
0.9DL - 1.5EQX
0.9DL + 1.5EQY
0.9DL - 1.5EQY

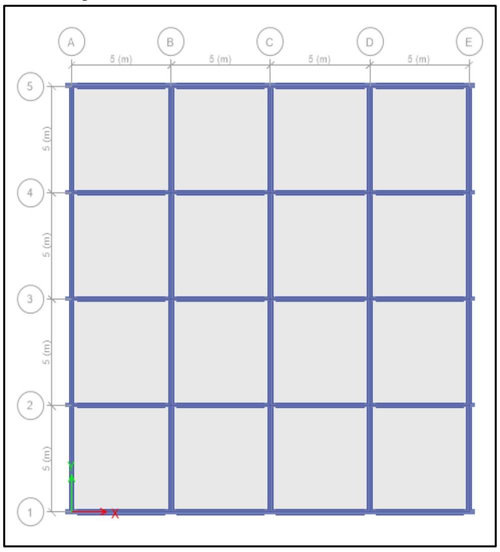

Fig. 3: Plan

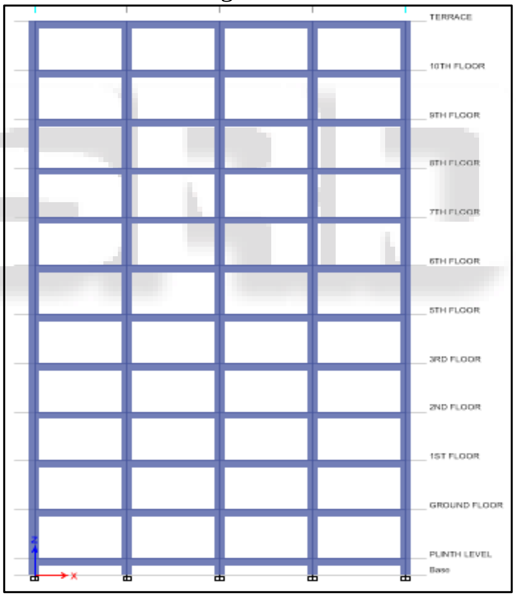

Fig. 4: Elevation for without bracing

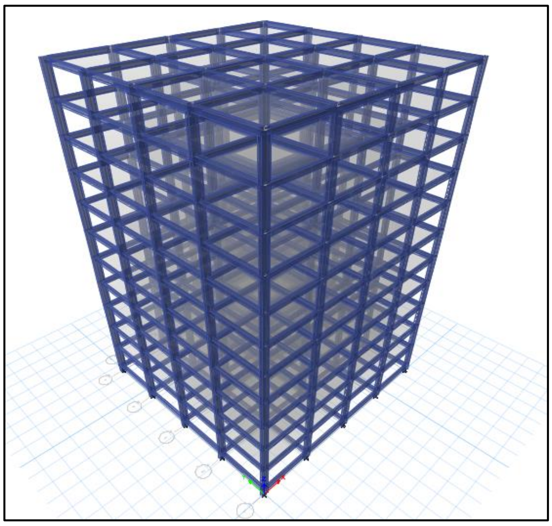

Fig. 5: 3D view of without bracing

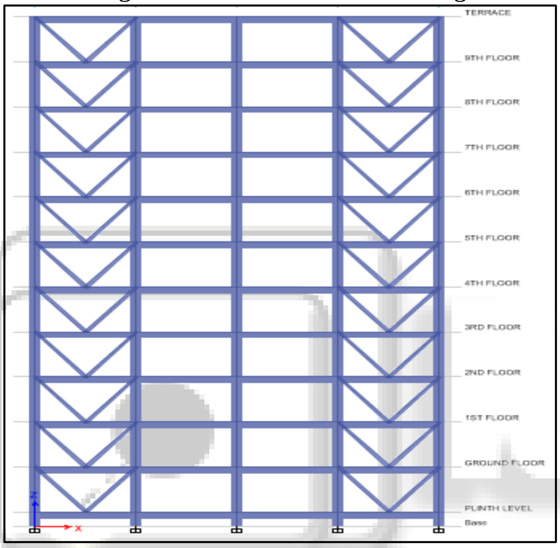

Fig. 6: Elevation for V-Bracing

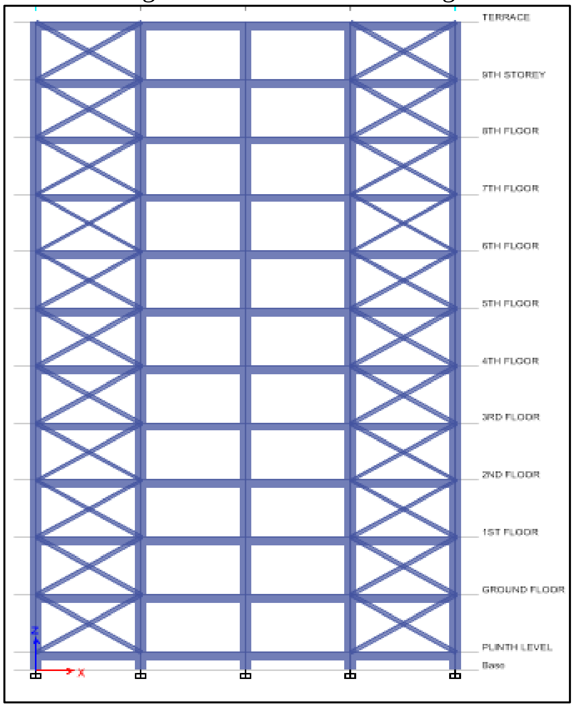

Fig. 7: Elevation for X-Bracing

IV. Results and Descussion

In this present chapter, time period, base shear, displacement, storey drift and performance of hinges were discussed.

A. *Time period*

Model No.	Time Period
	Sec
1	3.562
2	2.006
3	1.887

Table 2: Time Period

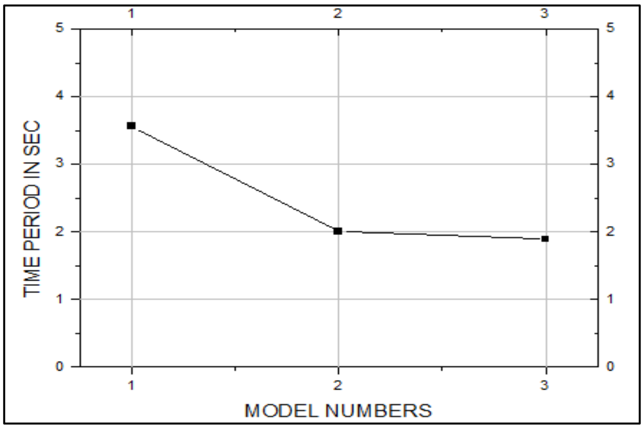

Fig. 8: Time Period

From the above figure 8, it can be clearly observed that time period will be more in without Bracing building model by 1.77 times and 1.890 times as compared to V-Bracing and X-Bracing building model.

B. *Base shear*

Model No.	Base Shear [kN]	
	X- Axis	Y- Axis
1	922.10	639.33
2	1319.92	1138.14
3	1390.99	1211.55

Table 3: Base Shear by using linear Static Analysis

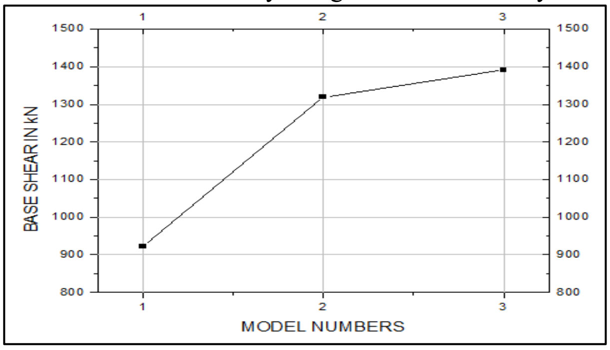

Fig. 9: Base shear along x-direction

From the above figure 9, it can be clearly observed that base shear will be less in without Bracing building model by 30.14% and 33.71% as compared with V- Bracing building model and X- Bracing building model along X-axis

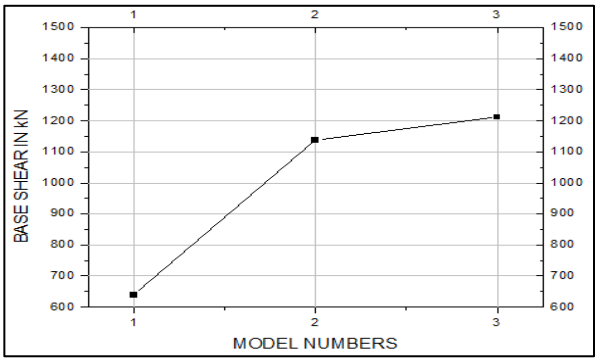

Fig. 10: Base Shear along Y-axis

From the above figure 10, it can be clearly observed that base shear will be less in without Bracing building model by 43.82% and 47.23% as compared with V- Bracing building model and X- Bracing building model along Y-axis.

C. Displacement

Storey No.	Model No. [mm]		
	1	2	3
11	39.209	30.461	29.4
10	38.53	28.786	27.7
9	37.006	26.64	25.5
8	34.543	24.082	22.9
7	31.273	21.199	20.1
6	27.368	18.083	17
5	22.99	14.835	13.8
4	18.287	11.556	10.7
3	13.393	8.35	7.6
2	8.459	5.32	4.8
1	3.781	2.555	2.3

Table 4: Lateral Displacement by using linear Static Analysis along X-axis

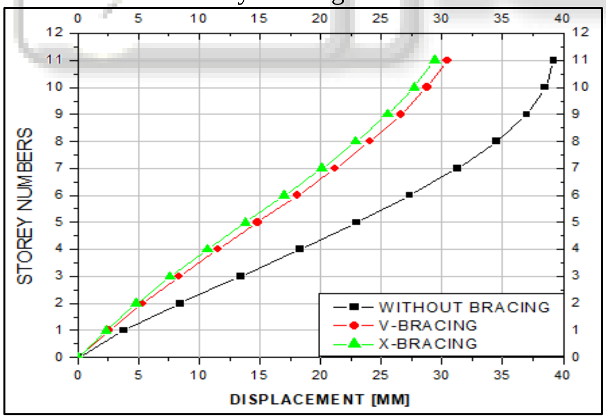

Fig. 11: Displacement along X-axis

From the above fig 11, it can be clearly observed that deflection at roof will be more in without Bracing building model by 28.71% and 33.36% as compared with V and X Bracing building model along X-axis.

Storey No.	Model No. [mm]		
	1	2	3
11	54.996	35.754	34.2
10	54.573	33.538	31.9
9	52.657	30.845	29.2
8	49.333	27.754	26.2
7	44.878	24.352	22.8
6	39.55	20.742	19.3
5	33.576	17.031	15.7
4	27.152	13.331	12.2
3	20.44	9.757	8.8
2	13.574	6.426	5.7
1	6.682	3.443	3

Table 5: Lateral Displacement along Y-axis

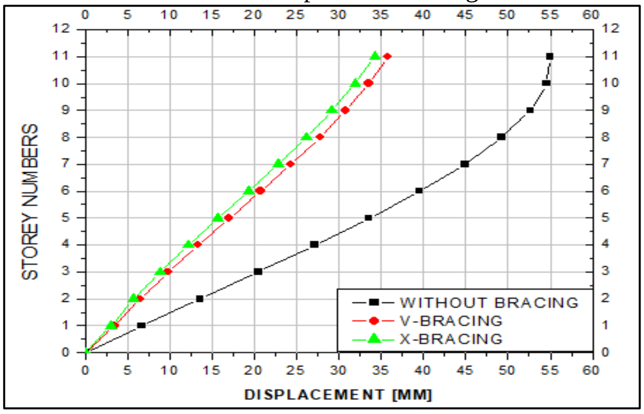

Fig. 12: Displacement along Y-axis

From the above fig 12, it can be clearly observed that deflection at roof will be more in without bracing building model by 53.81% and 60.80% as compared with V and X Bracing building model along Y-axis

D. Storey drift

Storey No.	Model No. [mm]		
	1	2	3
11	0.679	1.675	1.7
10	1.524	2.146	2.2
9	2.463	2.558	2.6
8	3.27	2.883	2.8
7	3.905	3.116	3.1
6	4.378	3.248	3.2
5	4.703	3.279	3.1
4	4.894	3.206	3.1
3	4.934	3.03	2.8
2	4.678	2.765	2.5
1	3.781	2.555	2.3

Table 6: Storey Drift along X-axis

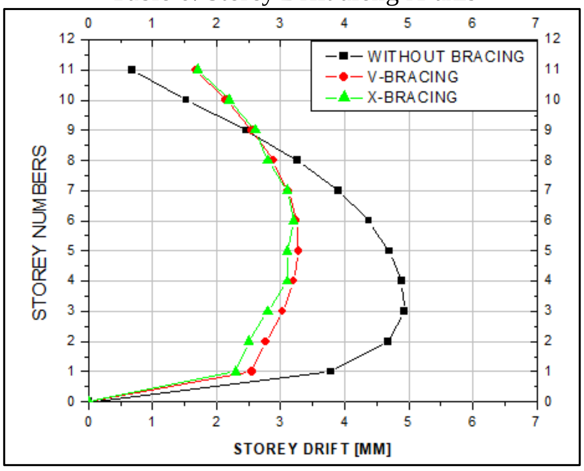

Fig. 13: Storey Drift along X-axis

From the above fig: 13, can be clearly observed that, in all story srorey drift values are within the limits. Limiting value is 12.0mm. From the above fig 5.6, it clearly shows that storey drift value will more in without bracing building model as compared with V- Bracing building model and X- Bracing building model along X-axis.

Storey No.	Model No. [mm]		
	1	2	3
11	0.423	2.216	2.3
10	1.916	2.693	2.7
9	3.324	3.091	3
8	4.455	3.402	3.4
7	5.328	3.61	3.5
6	5.974	3.711	3.6
5	6.424	3.7	3.5
4	6.712	3.574	3.4
3	6.866	3.331	3.1
2	6.892	2.983	2.7
1	6.682	3.443	3

Table 7: Storey Drift by using linear Static Analysis along Y-axis

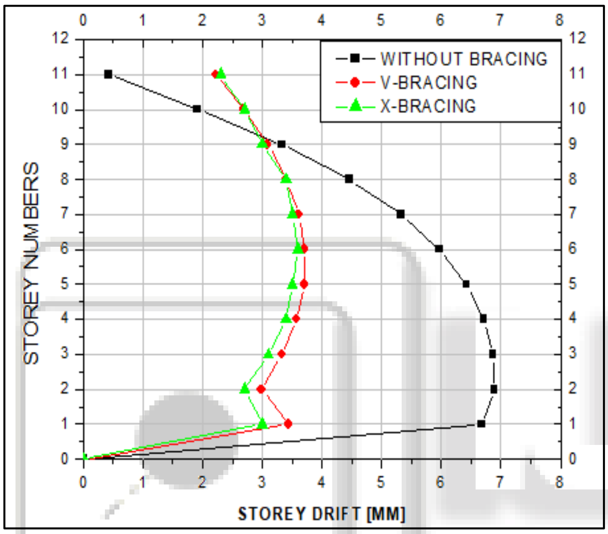

Fig. 14: Storey Drift along Y-axis

From the above fig: 14, it can be clearly observed that, in all storey, srorey drift values are within the limits. Limiting value is 12.0mm. From the above fig 5.6, it clearly shows that storey drift value will more in without bracing building model as compared with V- Bracing building model and X- Bracing building model along Y-axis.

E. Building Performance by using pushover analysis

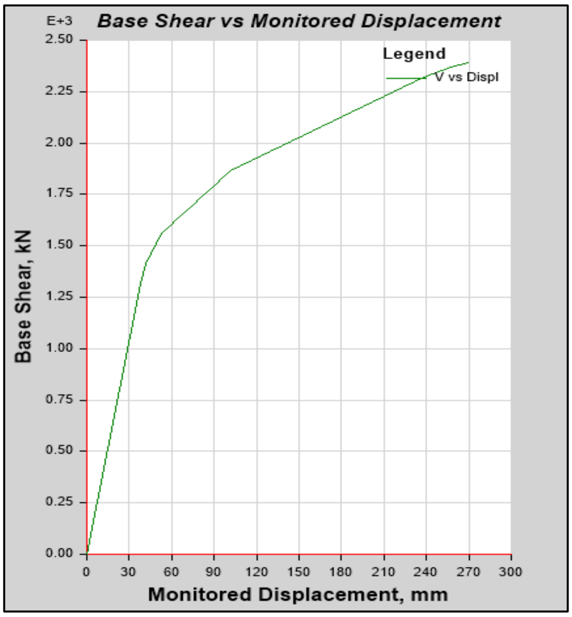

Fig. 15: Pushover-Curve from ETABS for without bracing building along X- direction.

From the above the fig 15, it can clearly observe that all hinges are formed in within the life safety range with 100%.

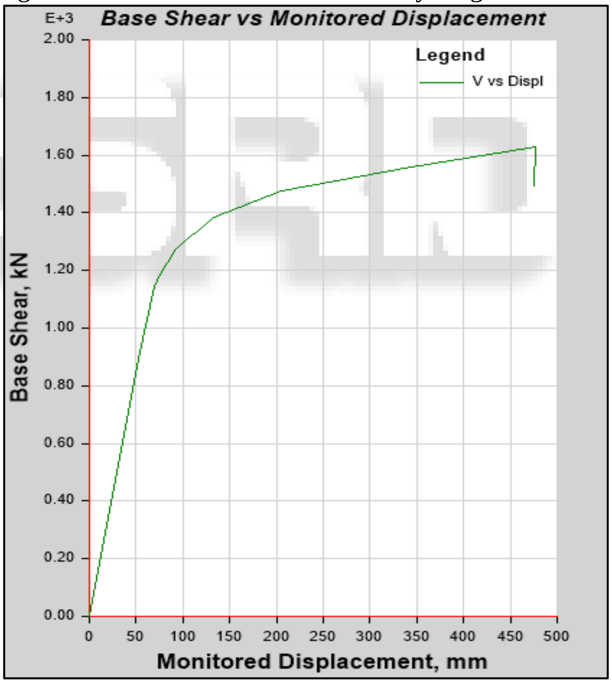

Fig. 16: Pushover-Curve from ETABS for without bracing building along Y- direction.

From the above the fig 16 it can clearly observe that; all hinges are formed in within the life safety range with 100% up to the step 7. only in step 8 hinges are formed in within the life safety range by 98.39%. and 1.61% hinges formed in collapse prevention.

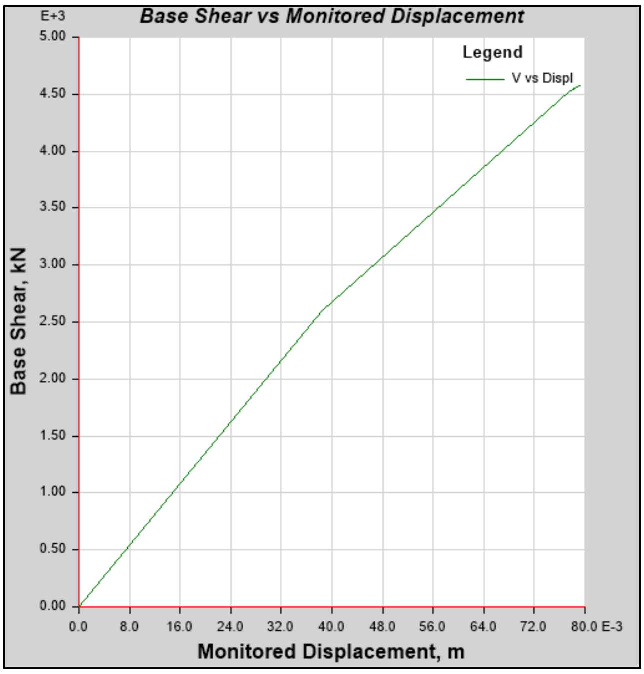

Fig. 17: Pushover Curve from ETABS for V-Bracing building along X-direction

From the above fig-17, all hinges are formed in within Life Safety range. No hinges are formed in collapse prevention.

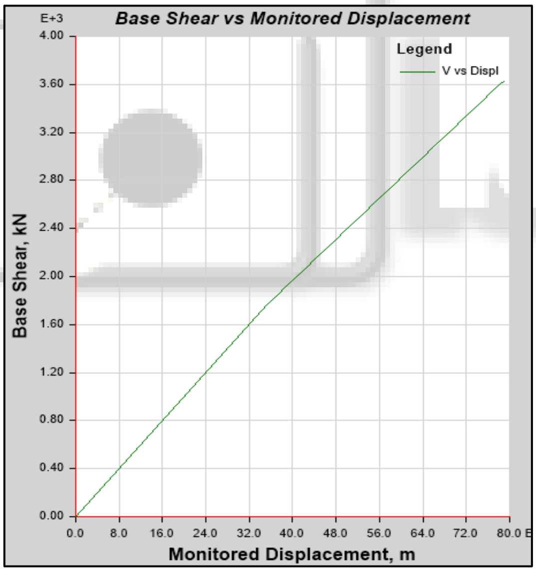

Fig. 18: Pushover Curve from ETABS for V-Bracing building along Y-direction

From the above fig 18 it can clearly observe that; all hinges are formed in within the LS range with 100% up to the step 1. In step 2 and step 3 hinges are formed in within the life safety range by 99.71% and 99.71% respectively. and 0.29% hinges formed in collapse prevention for step 2 and 3.

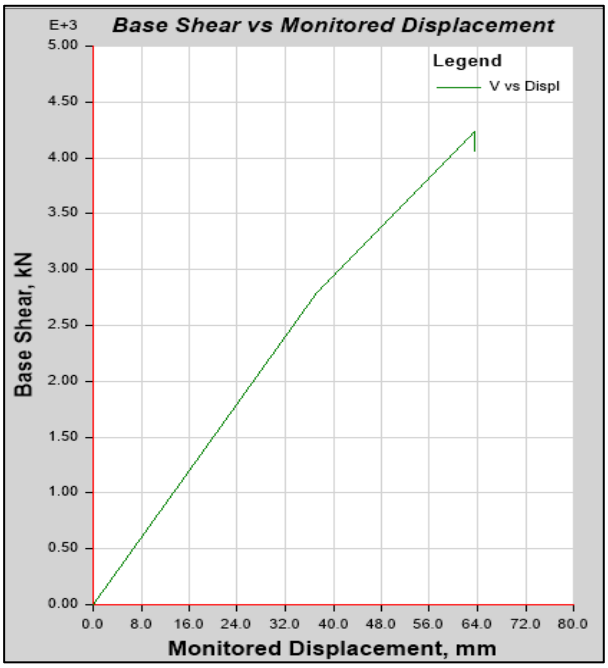

Fig. 19: Pushover Curve from ETABS for X-Bracing building along X-direction

From the above the fig 19 it can clearly observe that; all hinges are formed in within the Life Safety range with 100%.

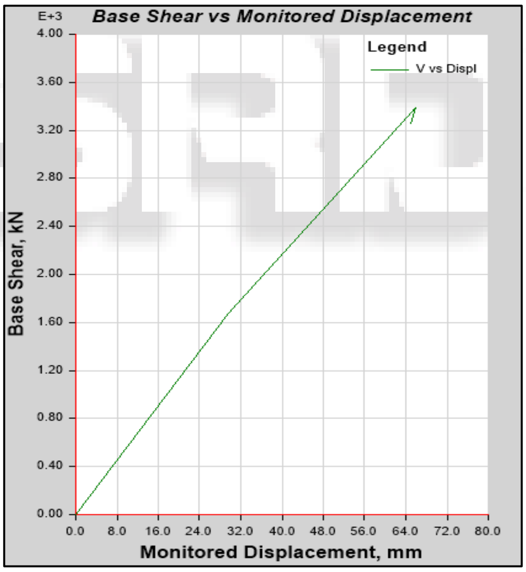

Fig. 20: Pushover Curve from ETABS for X-Bracing building along Y-direction

From the above the fig 20 it can clearly observe that; all hinges are formed in within the LS range with 100% up to the step 1. In step 2 and step 3 hinges are formed in within the life safety range by 99.88% and 99.88% respectively. and 0.12% hinges formed in collapse prevention for step 2 and 3.

F. Ductility ratio

Model No.	X-direction			Y-direction		
	IY	CY	DR	IY	CY	DR
1	37.82	269.78	7.13	53.18	476.08	8.95
2	38.33	79.25	2.07	35.29	78.88	2.24

3	37.22	63.58	1.70	29.68	66.00	2.22

Table 8: Ductility ratio by pushover analysis

From the above table 8 can be clearly observed that, ductility ratio will be 3.44 and 4.19 time found more in without bracing model as compared with V- bracing and X bracing model along X-axis.

Similarly, from the above table it can be clearly observed that, ductility ratio will be 3.99 and 4.03 time found more in without bracing model as compared with V- bracing and X bracing model along Y-axis.

V. CONCLUSIONS

The following conclusions are obtained from analysis,

1) It observes that fundamental natural time period will be more in without bracing model as compared with bracing models. Bracing models are stiffer than without bracing model.
2) Base shear occurs less in without bracing model as compared with bracing model.
3) Lateral displacement at the roof will be more in without bracing model as compared with bracing models.
4) Storey drift is inversely proportional to the stiffness of the building, as the stiffness increases the storey drift decreases. With bracing models are stiffer as compared with without bracing models. Storey drift values found to be safe for all building modals.
5) Flexure hinges are formed within the life safety range.
6) Ductility ratio found more in without bracing models as compared with bracing models.

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