SEISMIC ANALYSIS AND RETROFITTING USING STEEL BRACING IN A MULTI-STOREYED BUILDING

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Abstract - *In today's scenario of rapid population increase and the unvarying land mass available, multi-storeyed buildings have become inevitable. The structures are more vulnerable to earthquake loads and wind loads as the height of the building increases which will produce lateral displacements and thus accumulates deformations in various members of the building i.e., beams, columns, etc resulting in storey drift. These parameter values may exceed the permissible limits or can even lead to failure of the building. Seismic Retrofitting is the modification of an existing structure to make it more resistant to damages caused to the building due to various earthquake loads. India is divided into four seismic zones i.e., zones II, III, IV and V based on historical seismic activity by the Bureau of Indian Standards among which zone III and IV are considered. Steel Bracings are one of the efficient ways to help the building be seismic resistant. A G+12 storey building is to be analysed using E TABS 2019 software for seismic zones III and IV. The building is analysed against the seismic loads for models that are unbraced, with X bracing, V bracing, Inverted V bracing, K bracing and diagonal bracing at middle and corner configurations. The main parameters to be compared are lateral displacement, storey drift and base shear and the most suitable bracing at both middle and corner configuration among them for both zones III and IV are identified.*

Key Words: **Earthquake, Seismic Analysis, Steel Bracing, Multi-storey Building, ETabs software**

1.INTRODUCTION

Seismic analysis comes under structural analysis, and it includes the calculation of the responses of a structure to earthquakes. In regions where earthquakes are prevalent, seismic analysis is a part of structural design. For the analysis ETABS 2018 software is used which is incorporated with all the major analysis used to analyse and design the buildings. Seismic retrofitting is a solution for seismic inadequacy. It makes a building safer and protects from high winds and earthquakes. It is the moderation of an existing structure to make them more immune to seismic tremor.

A G+12 building is assumed to be in seismic zone III and zone IV, and it is analysed for seismic adequacy using ETABS 2018 software and any seismic inadequacy of the building is satisfied by providing steel bracings as the retrofitting solution.

2. BUILDING SPECIFICATIONS

The building that has been selected for the analysis is a G+12 storey residential building with 2 3 BHK and 2 1 BHK apartments in each floor. The building is assumed to be located at Mumbai at a wind speed of 44 m/s in seismic zone III and located at Mumbai at a wind speed of 47 m/s in seismic zone IV founded on type II medium soil, The building selected is first drafted in AUTOCAD and then modelled on ETABS 2018 unbraced and after providing various bracing systems. The information used for modelling the building is given in Table 1.

Table -1: Building Specifications

Building type	Residential
Foundation	1.5 m below GL
Typical floor height	3m
Wall thickness	230mm
Slab thickness	150mm
Column size	500mm x300mm
Beam size	300mm x 230mm
Staircase details	Rise- 150mm Tread-300mm
Superstructure	Brick Masonry
Grade of concrete	M30

Grade of steel	Fe 415
Density of brick masonry	20 KN/m³
Density of concrete	30 KN/m³
Modulus of elasticity of concrete	25000 N/mm²
From IS 1893(part 1:2016)	
Seismic zone	III
Zone factor	0.16
Seismic zone	IV
Zone factor	0.24
Response Reduction factor	3
Importance factor	1,2
From IS 875(part 3):2015	
Wind speed in Zone III	44 m/s
Wind speed in zone IV	47 m/s
Terrain category	2
Risk coefficient	1
Topography factor	1

P3. EQUIVALENT STATIC ANALYSIS OF THE BUILDING

The analysis of the building was carried out considering all load combinations as specified in IS 456:2000 and IS 1893:2016 using equivalent static analysis for both unbraced as well as braced frames. X, K, V,inverted V and diagonal bracings were provided using the auto select option in ETABS 2018. ISMB 500 Was used for providing steel bracings. Unbraced original building and other five types of bracings in two different trial configurations i.e.., corner configuration and middle configuration were considered and are shown in figures below.

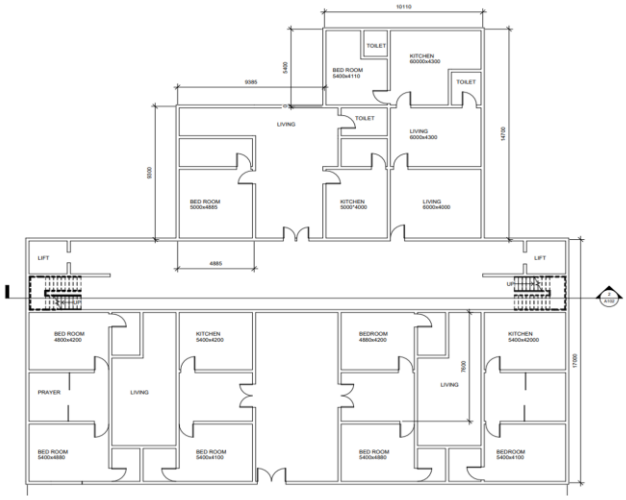

Fig -1: Plan of the building

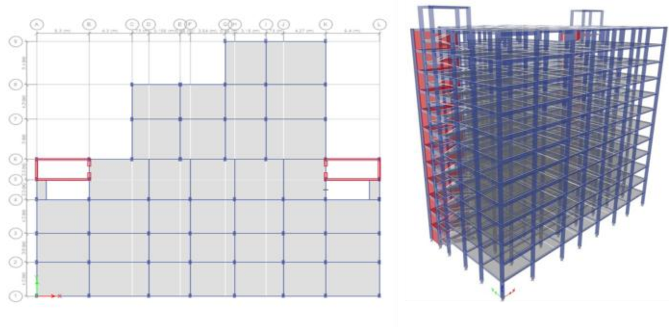

Fig -2: Plan view and 3-D view of the building model in ETabs 2018

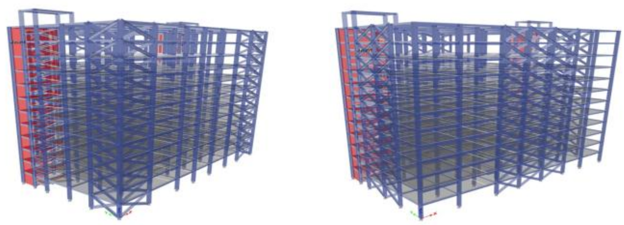

Fig -3: X Bracings provided at corners and middle respectively

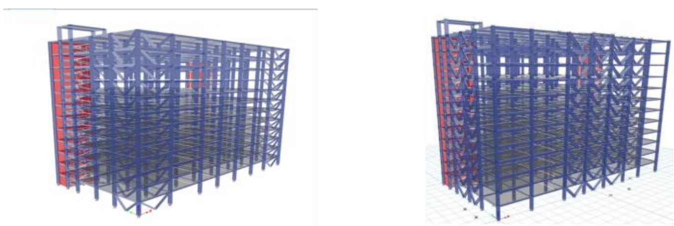

Fig -4: V Bracings provided at corners and middle respectively

Fig -5: Inverted V Bracings provided at corners and middle respectively

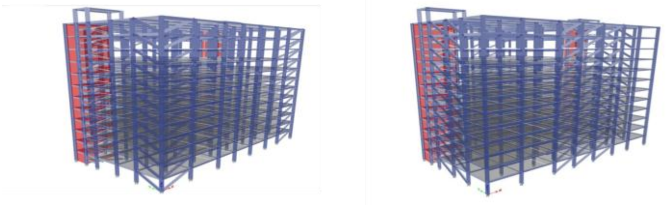

Fig -6: Diagonal Bracings provided at corners and middle respectively

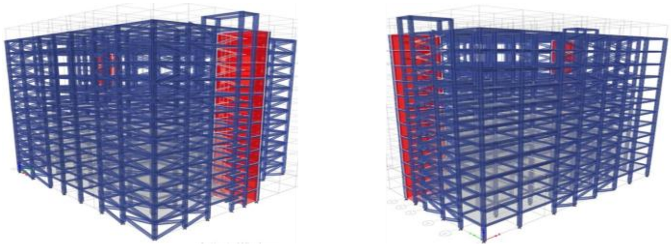

Fig -7: K Bracings provided at corners and middle respectively

4. OBSERVATIONS AND RESULTS

After analysing the unbraced and various braced structures in two different configurations i.e., middle and corner, lateral displacement and storey drift at both zone III and zone IV are compared to each other and the percentage reduction for each bracing compared to that of unbraced structure is found, from which the most suitable bracing system for the given structure is identified.

4.1 Lateral Displacement

Lateral displacement is the deflection of a single storey relative to the base or ground level of the structure. The variation of Lateral displacement in X and Y direction for Zone III and IV for middle and corner configurations for unbraced structure with that with bracings provided are as given below.

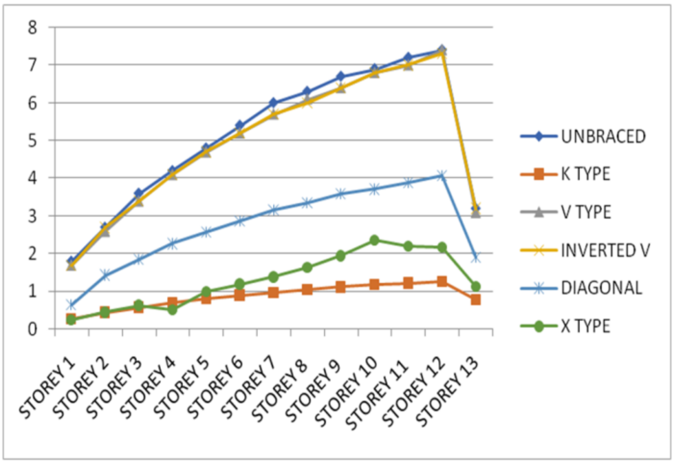

Chart -1: Lateral displacement in X direction for corner bracing in zone III

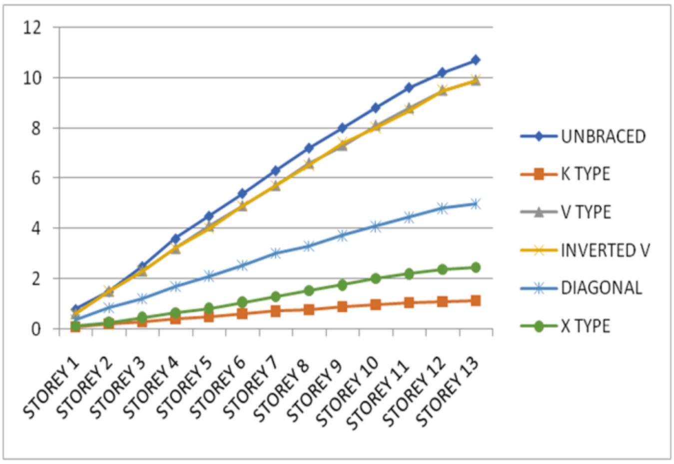

Chart -2: Lateral displacement in Y direction for corner bracing in zone III

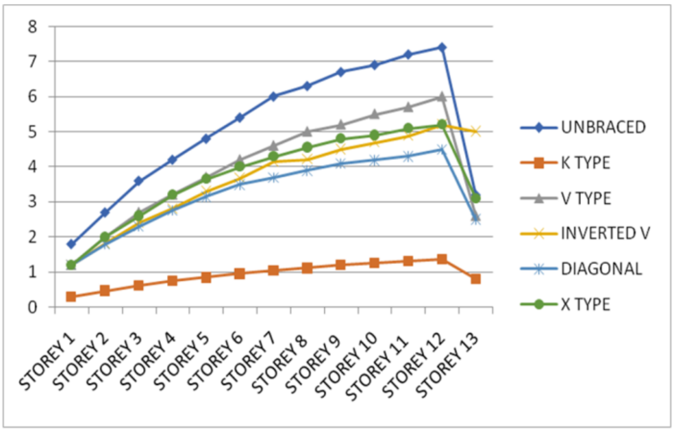

Chart -3: Lateral displacement in X direction for middle bracing in zone III

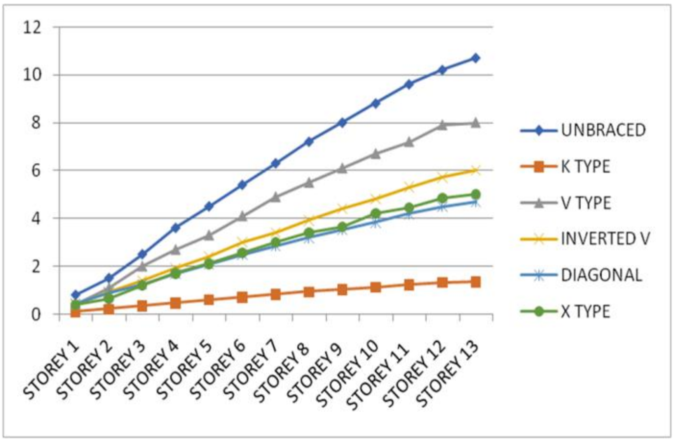

Chart -4: Lateral displacement in X direction for middle bracing in zone III

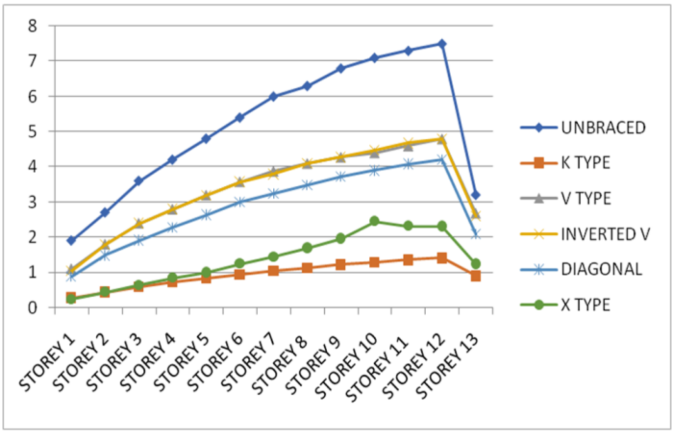

Chart -5: Lateral displacement in X direction for corner bracing in zone IV

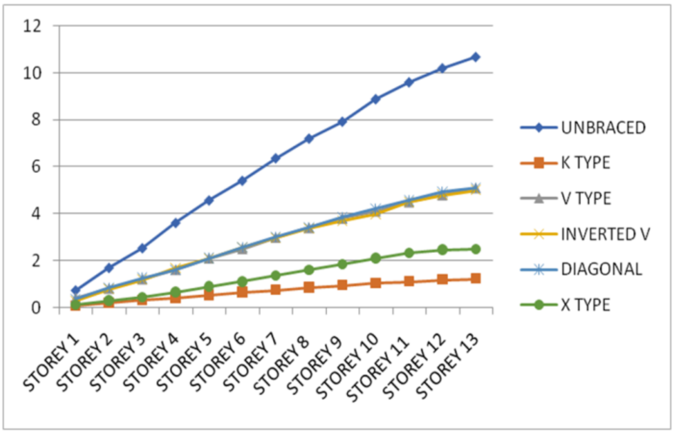

Chart -6: Lateral displacement in Y direction for corner bracing in zone IV

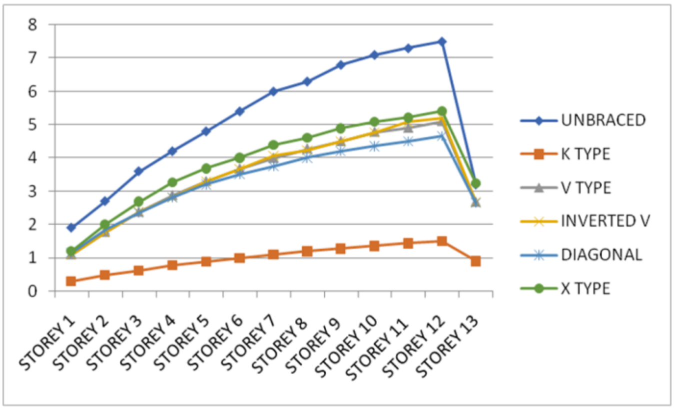

Chart -7: Lateral displacement in X direction for middle bracing in zone IV

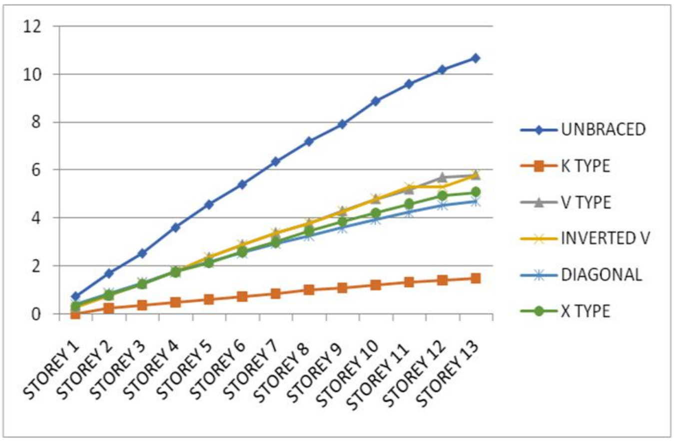

Chart -8: Lateral displacement in Y direction for middle bracing in zone IV

	ZONE III				ZONE IV			
	MIDDLE CONFIGURATION		CORNER CONFIGURATION		MIDDLE CONFIGURATION		CORNER CONFIGURATION	
	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION
K TYPE	82	87	86	89	80	86	81	88
V TYPE	19	25	0	7.5	32	46	36	52
INVERTED V	30	44	1.35	7.5	31	46	36	53
DIAGONAL	39	56	45	53	38	56	44	52
X TYPE	30	53	71	77	28	52	69	77

Fig -8: Maximum percentage reduction in lateral displacement of braced structures compared to unbraced structure

4.2 Storey Drift

Storey Drift is the displacement of a single storey relative to the storey just below it. The variation of storey drift in X and Y direction for Zone III and IV for middle and corner configurations for unbraced structure with that of bracings provided are as given below.

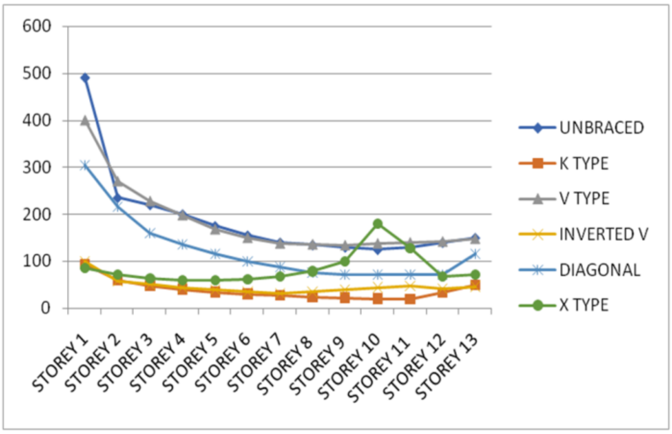

Chart -9: Storey drift in X direction for corner bracing in zone III

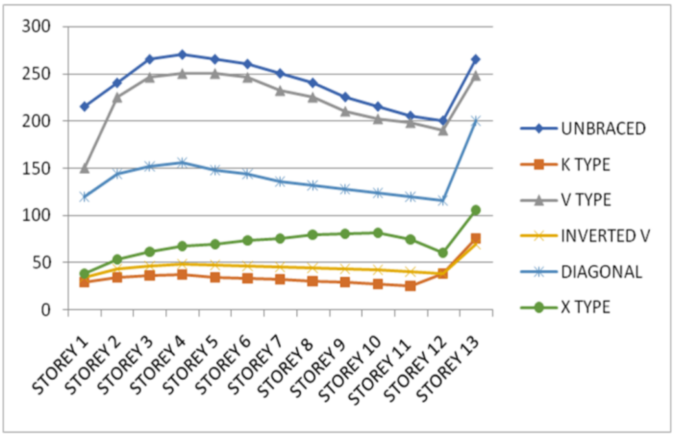

Chart -10: Storey drift in Y direction for corner bracing in zone III

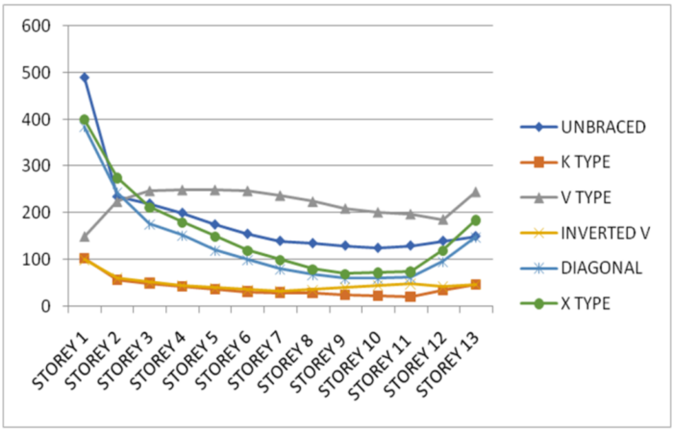

Chart -11: Storey drift in X direction for middle bracing in zone III

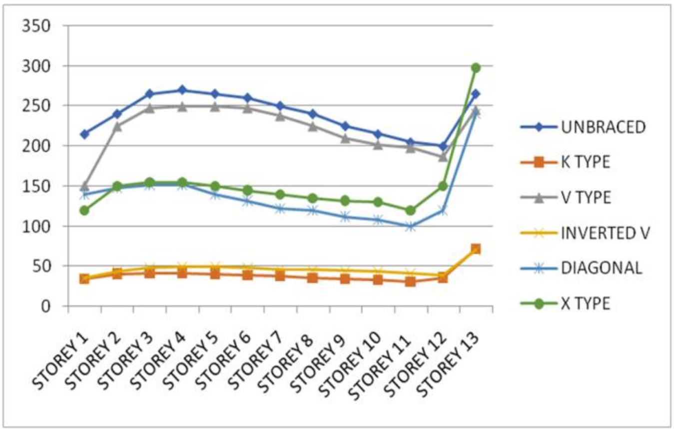

Chart -12: Storey drift in Y direction for middle bracing in zone III

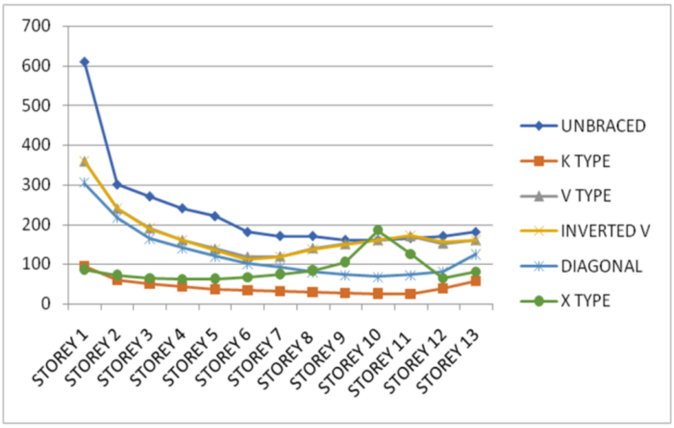

Chart -13: Storey drift in X direction for corner bracing in zone IV

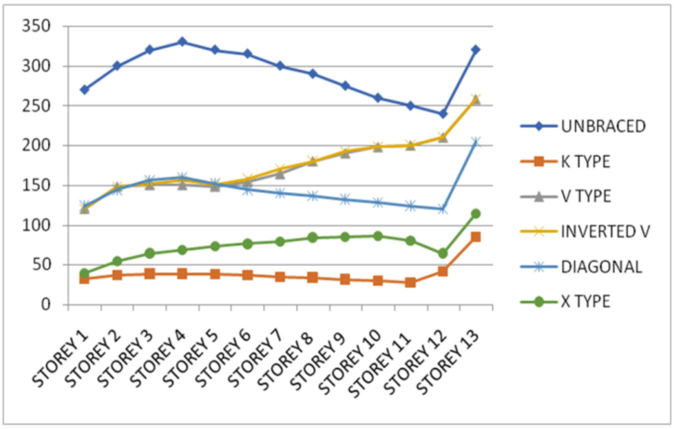

Chart -14: Storey drift in Y direction for corner bracing in zone IV

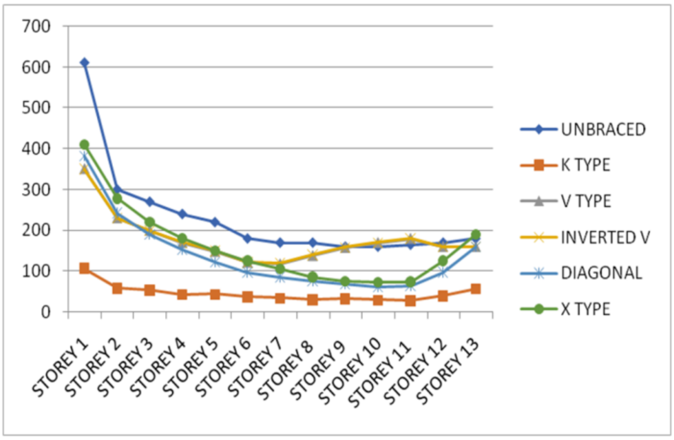

Chart -15: Storey drift in X direction for middle bracing in zone IV

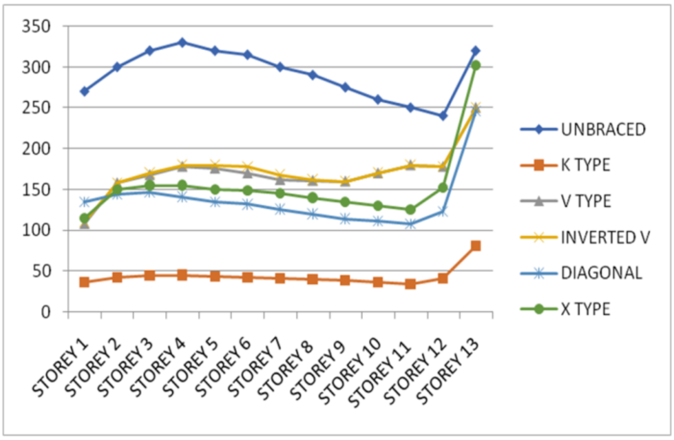

Chart -16: Storey drift in Y direction for middle bracing in zone IV

	ZONE III				ZONE IV			
	MIDDLE CONFIGURATION		CORNER CONFIGURATION		MIDDLE CONFIGURATION		CORNER CONFIGURATION	
	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION
K TYPE	80.81	79.18	80.8	71.85	82.49	75.64	84.43	74.24
V TYPE	18.37	48.9	18.36	7.41	42.62	24.24	40.98	21.81
INVERTED V	79.59	79.59	79.59	74.07	42.62	24.24	40.98	21.81
DIAGONAL	37.96	21.63	37.95	25.93	37.38	25.45	50.16	38.18
X TYPE	63.27	18.37	63.27	60.7	32.79	8.48	69.65	65.45

Fig -9: Maximum Percentage Reduction in Storey Drift Of Braced Structures Compared to Unbraced Structure

		ZONE III		ZONE IV	
		CORNER	MIDDLE	CORNER	MIDDLE
LATERAL DISPLACEMENT(TOP STOREYS)	X DIRECTION	86%	82%	81%	80%
	Y DIRECTION	89%	87%	88%	86%
STOREY DRIFT (BOTTOM STOREYS)	X DIRECTION	81%	81%	84%	83%
	Y DIRECTION	72%	79%	74%	76%

Fig -10: Maximum Percentage Reduction Observed in K Bracing Compared to Unbraced Structure

5. CONCLUSIONS

The structure was analysed and concluded that the application of different types of steel bracings in two configurations decreases the drift and the displacement of the structure. For this building K bracing system showed better performance than the other considered bracing systems. Lateral displacement have a percentage reduction of an average of 85% in X and Y direction in both zones III and IV when seismic load is applied in x direction, using K type bracing. Storey drift have a percentage reduction of an average of 79% in X and Y direction in both zones III and IV using K bracing. Identified K type bracing as the most suitable bracing system for resisting the seismic load efficiently for the given structure.

REFERENCES

[1] Hyderuddin, M., Imran, M., & Mohsin, S. (2016). Retrofitting of Reinforced Concrete Frames using Steel Bracing. IJSRD-International Journal for Scientific Research & Development, 4, 2321-0613

[2] Rakshith G M et.al "Analysis of G+20 RC Tall Building in Different Zones using ETABS", International Journal of Innovative Research in Science, Engineering and Technology vol 8 Issue 5, May 2019

[3] Laguardia, R., & Franchin, P. (2022). Risk-Based Optimization of Bracing Systems for Seismic Retrofitting of RC Buildings. Journal of Structural Engineering, 148(6), 04022049.

[4] Sharma, M. A. K., & Kumar, m. A. Analysis of G + 30 highrise buildings by using ETABS for various frame sections in zone IV and zone V