Seismic Performance of Steel Bracings with and without Shear wall in High-rise Buildings

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Abstract: Steel bracing is highly efficient and economical method for resisting lateral forces in frame structures. Bracing has been used for stabilizing the tallest building structures laterally. Shear wall is another efficient structural system in tall building which carries the lateral loads by combined bending-axial-shear action. In this paper three buildings G+19, G+24 and G+29 are analyzed using software ETABS, a comparison is being carried out between three structural systems i.e. SMRF+bracings, SMRF+shear walls and combined system (bracings+shear walls). Bracing system and Combined system models are equipped and analyzed with four types of bracing X bracing, V bracing, inverted V bracing and K bracing. These bracings are equipped with box section (200x200x12). The models are assumed to be located in seismic zone V and the response spectrum method is used in the analysis. The results of different type of building models are obtained and comparison of each one is made in terms of various parameters such as displacement, storey drift, base shear and overturning moment capacity.

Keys Words –Bracings, Shear Wall, Combined System, ETABS etc.

I. INTRODUCTION

The basic cause of increasing demand of the high rise buildings is the scarcity of land in urban areas, evolution of efficient structural system to bear gravity and lateral loads, advances in construction process, availability of higher strength materials and the increasing population. The main aim of structural systems is to transfer safely the gravity loads acting on it and thus assuring the safety of the building. Along with this gravity loads the buildings are also subjected to lateral loads which develops high amount of stresses in the structure and also is responsible for the lateral sway of the structure. Building are subjected to various types of loads, gravity loads due to dead load and live load of the structure and lateral load due the wind and earthquake forces acting on it. When tall structure is subjected to lateral loads due to wind or earthquake, it shows large amount of lateral displacement which in turn causes failure of structural and non-structural elements and second order P-Δ effect. To reduce excessive displacement and storey drift, various types of lateral load resisting structural systems are available. Among these systems the most commonly used systems are shear walls and braces. Without employing structural system buildings cannot bear large displacement in areas with higher seismic intensity. In addition to control the excessive lateral displacement of building subjected to lateral loads by a specific structural system, it is necessary to know the suitability and height limit of each structural system. In the present work various heights of buildings i.e. G+19, G+24, G+29 with only bracings, only shear walls and combination of both are analyzed using four types of bracing X bracing, V bracing, inverted V bracing and K bracing. The bracings are provided at the periphery (alternate bays) of the buildings in dual system (SMRF+bracings) along both directions. Shear walls are provided at the core and at the periphery of the buildings in dual system (SMRF+shear walls). In combined system the bracings are provided at periphery of the building and the shear wall at core. The present works focuses on finding the suitable type of lateral load resisting systems from the various parameters such as displacement, storey drift, base shear and overturning moment capacity of various buildings and different types of bracings.

II. MODELLING AND ANALYSIS OF BUILDINGS

The analysis of G+19, G+24, G+29 storey building was carried out by using the software ETABS, for buildings with bracings, shear walls and combination of both situated in seismic zone V. Various parameters such as displacement, storey drift, base shear and overturning moment capacity were obtained. The below mentioned table 1 shows the various details of the building models.

Table 1 – Data for problem formulation

Various details	No of stories		
	G+19	**G+24**	**G+29**
Plan	Regular rectangular		
Typical floor height	3.5m for G.L. and 3m for all above floors		
Plan dimensions	28m x 44m		
Column size	600mmx800mm for G.L. to 5 storey 500mm x700mm for 6 to 10 storey 400mm x 600mm for 11 to 15 storey 300mm x 500mm for 16 to 20 storey	700mmx900mm for G.L. to 5 storey 600mm x800mm for 6 to 10 storey 500mm x 700mm for 11 to 15 storey 400mm x 600mm for 16 to 20 storey 300mm x 500mm for 21 to 25 storey	800mmx1000mm for G.L. to 5 storey 700mm x900mm for 6 to 10 storey 600mm x 800mm for 11 to 15 storey 500mm x 700mm for 16 to 20 storey 400mm x 600mm for 20 to 25 storey 300mm x 500mm for 26 to 30 storey
Beam size	300mm x 500mm		
Slab thickness	150mm		
Shear wall thickness	300mm		
Type of bracing	X Bracing, V Bracing, Inverted V Bracing and K Bracing		

Type of section	Box section (200x200x12)
Seismic zone	V
Soil type	Medium(II)
Response reduction factor (R)	4 for dual systems (SMRF + shear walls) 4.5 for dual system (SMRF + bracing) 4.5 for combined system (bracings + shear walls)
Imp. factor (I)	1.5
Damping	5% for RCC, 2% for steel
Grade of concrete	M 30
Grade of steel	Fe 415
Live load	3 kN/ sq.m.
Floor finish	1.2 kN/ sq.m.

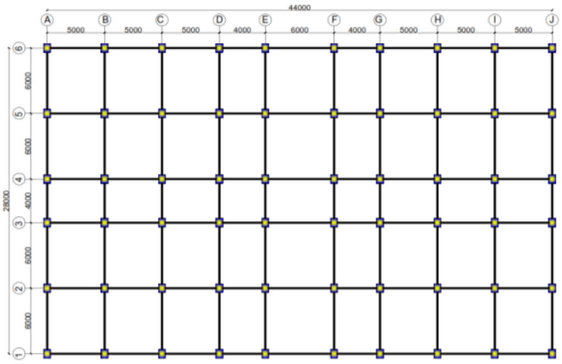

Fig 1. Plan of building

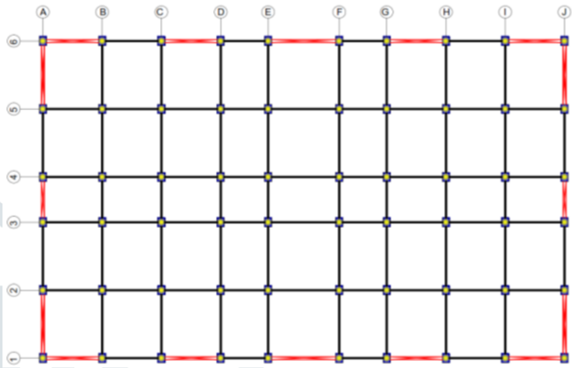

Fig 2. Dual system (SMRF+Bracing)

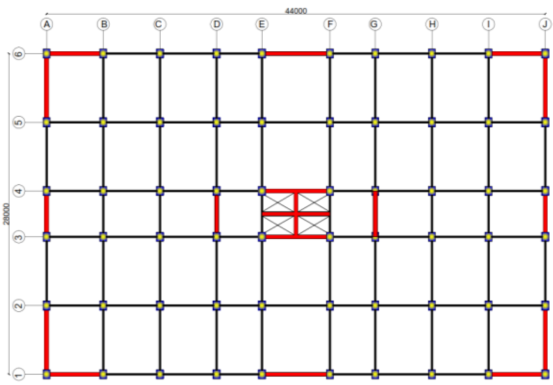

Fig 3. Dual System (SMRF+Shear wall)

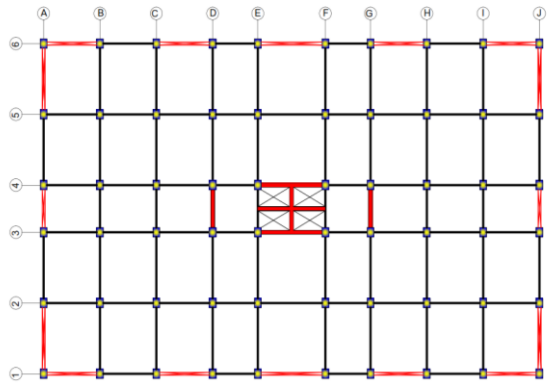

Fig 4. Combined System (Bracing+Shear Wall)

- **Elevation Plan of Bracings and shear walls for G+19 building Models.**

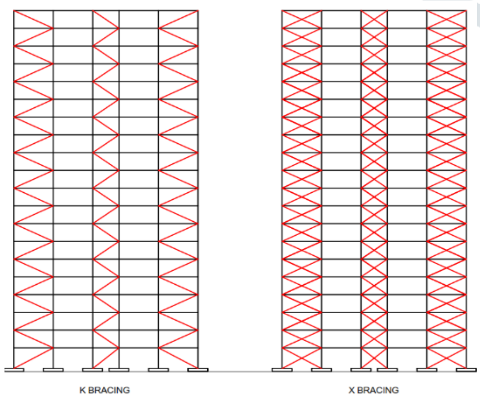

Fig 5. Elevation of K and X bracing

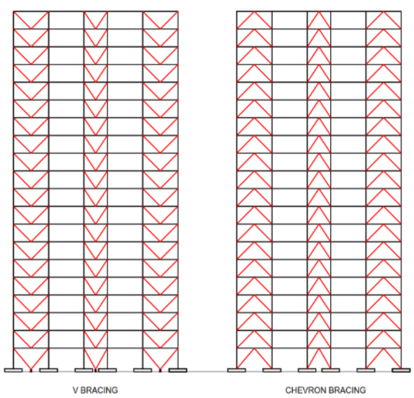

Fig 6. Elevation of V and chevron bracing

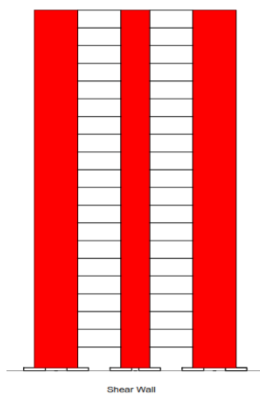

Fig 7. Shear walls

The elevation plan of various bracing systems and shear wall system are the same for G+24 and G+29 model buildings as G+19.

III. RESULTS

Below charts (no. 1 to 18) shows the various parameters obtained after the analysis of G+19, G+24 and G+29 storey buildings.

- **For G+19 building Models**

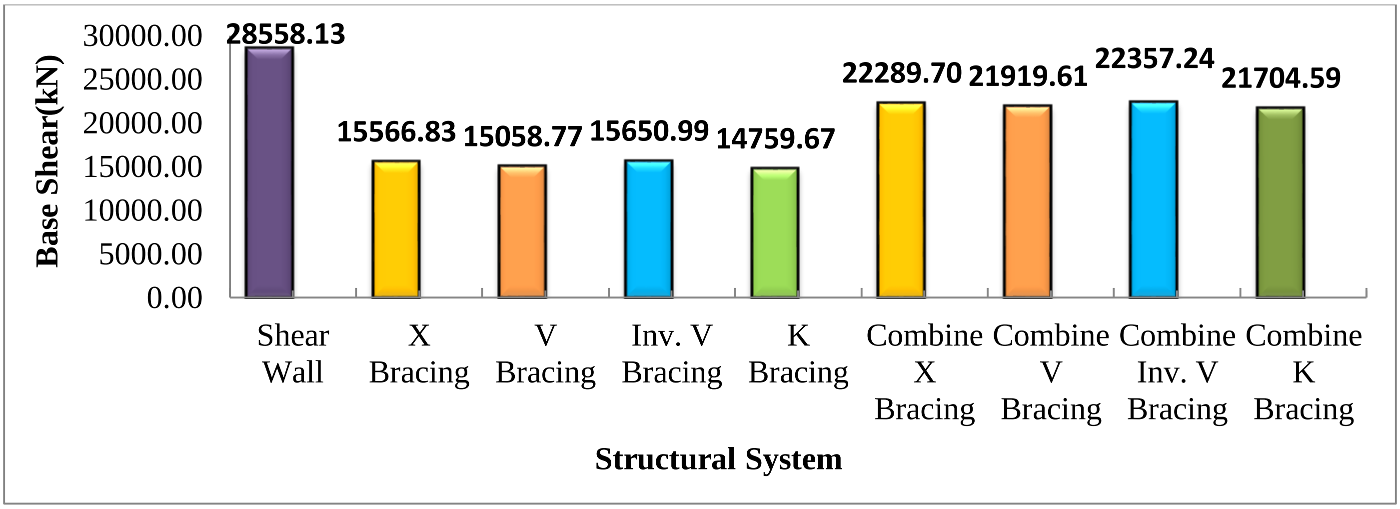

Chart 1. Base shear (kN) in X direction

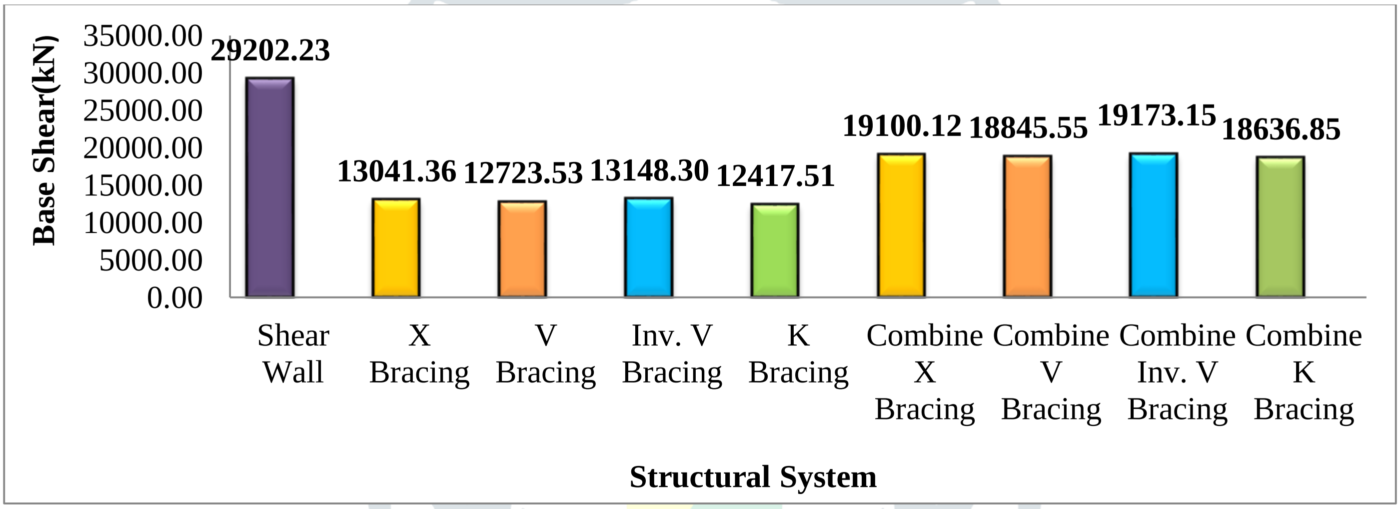

Chart 2. Base shear (kN) in Y direction

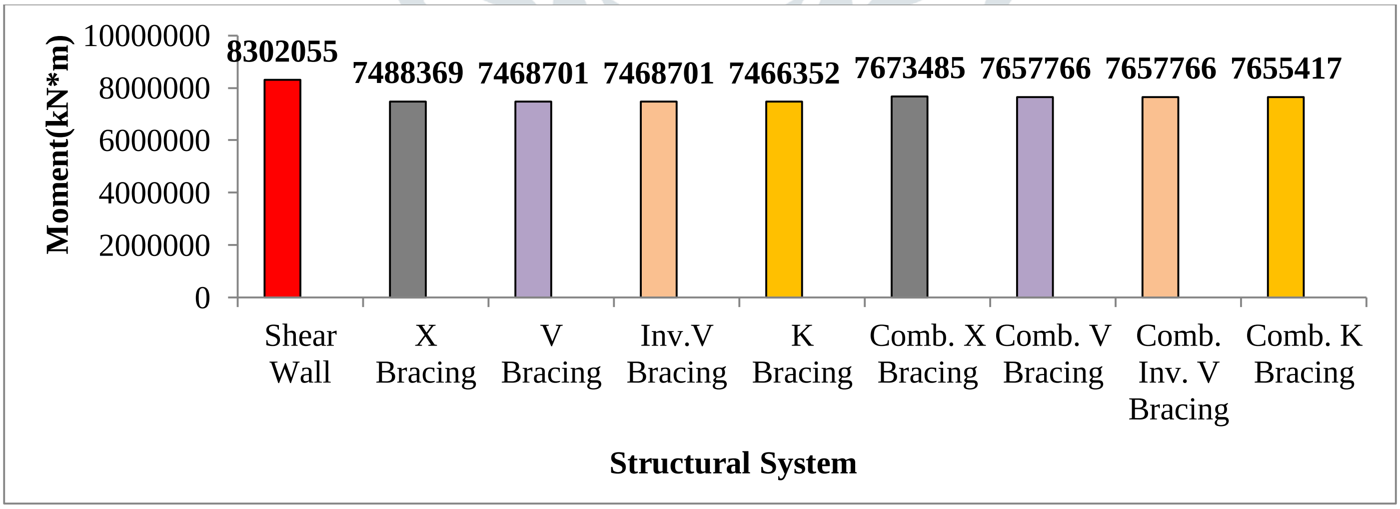

Chart 3. Moment (kN*m) in X direction

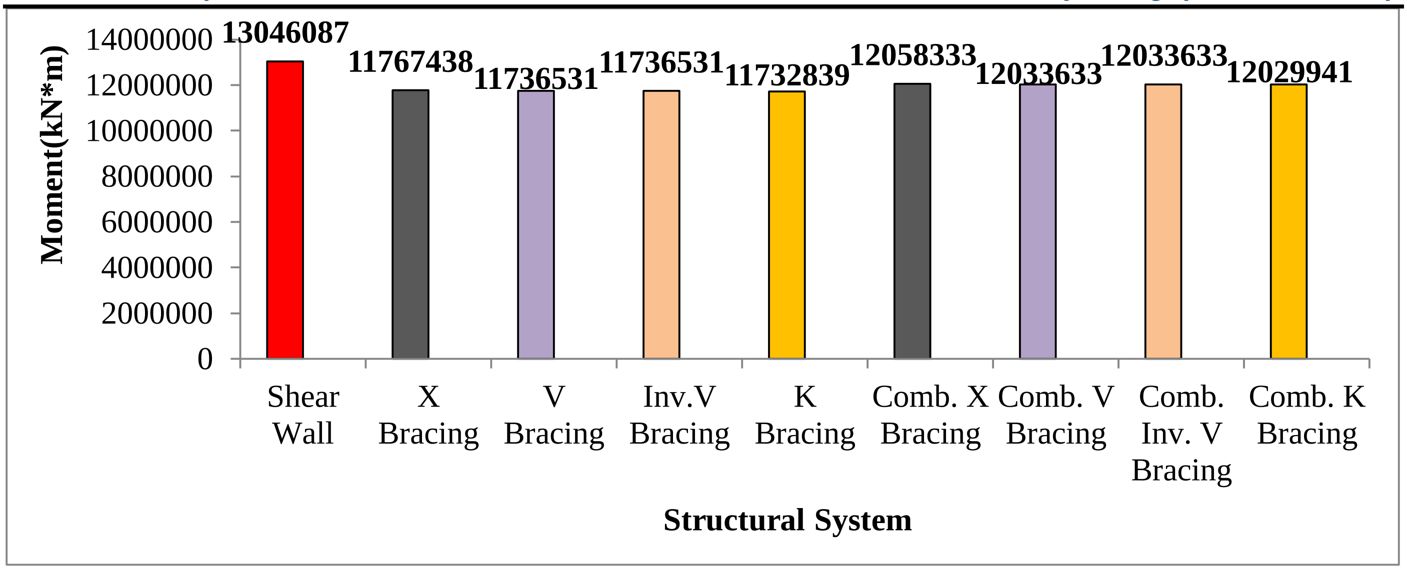

Chart 4. Moment (kN*m) in Y direction

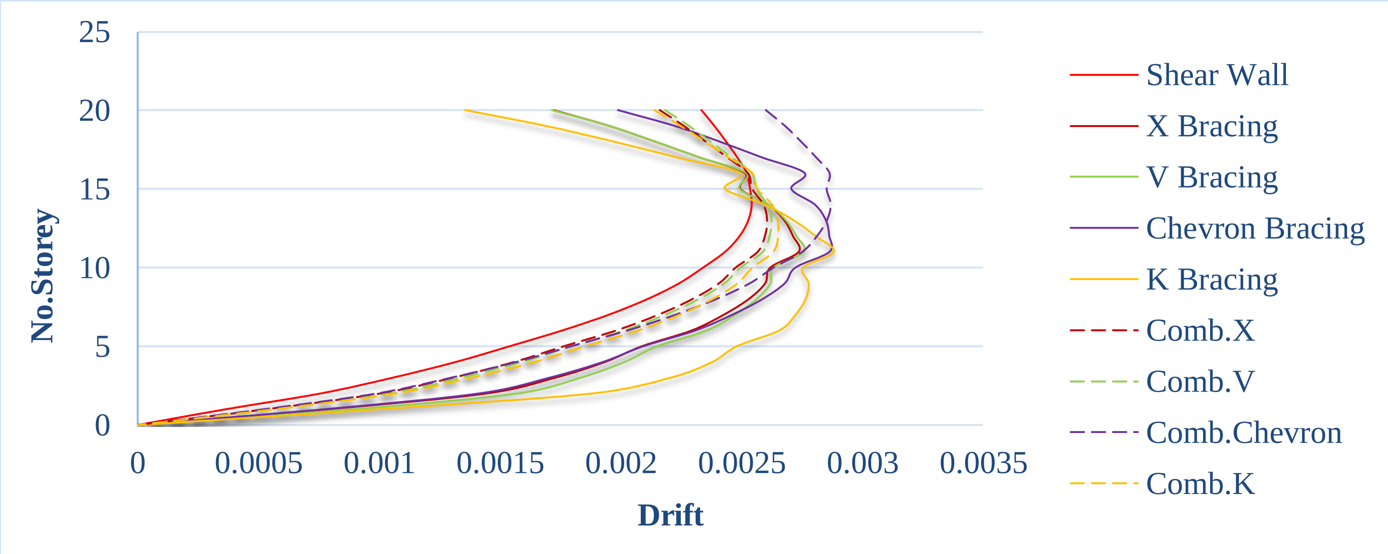

Chart 5. Storey Drift

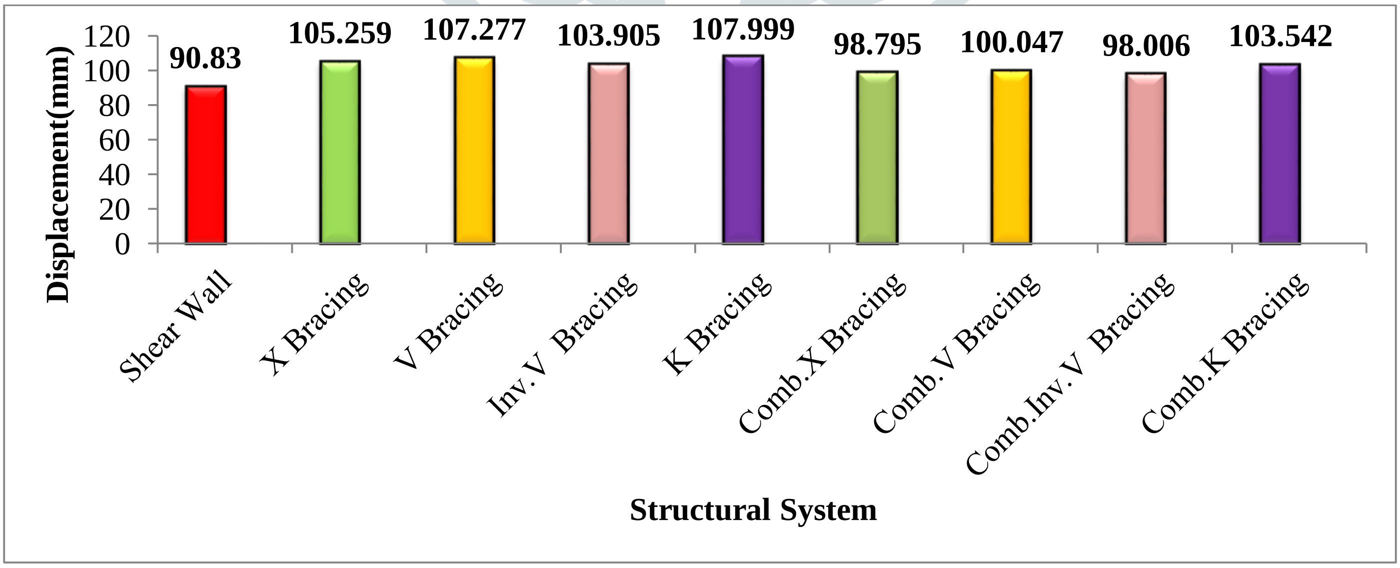

Chart 6. Displacement(mm)

- **For G+24 building Models**

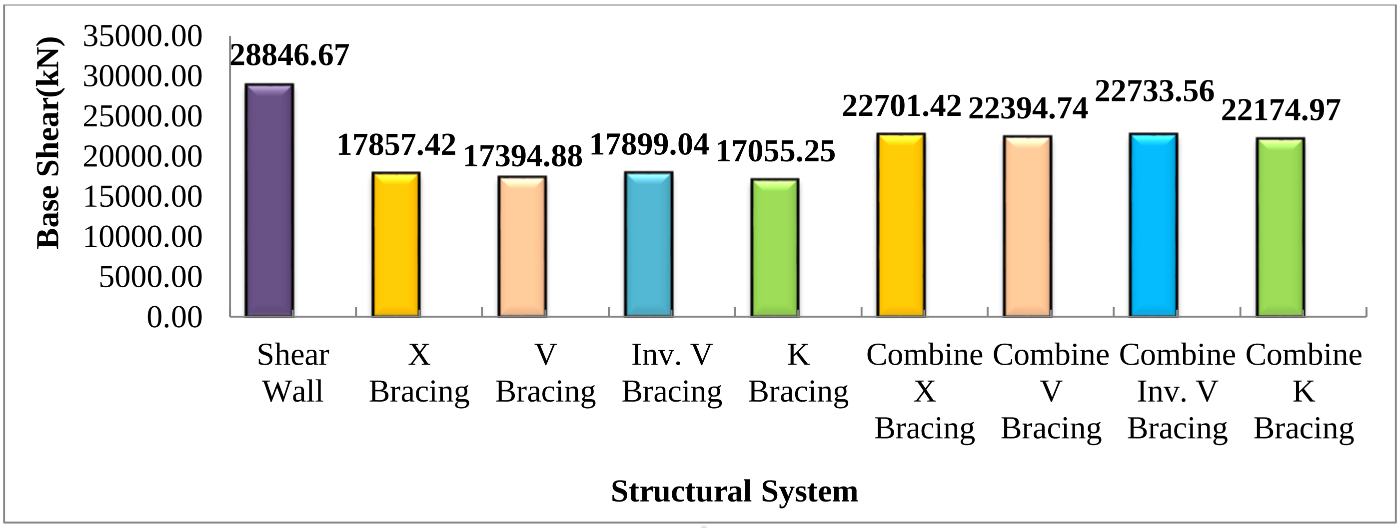

Chart 7. Base shear (kN) in X direction

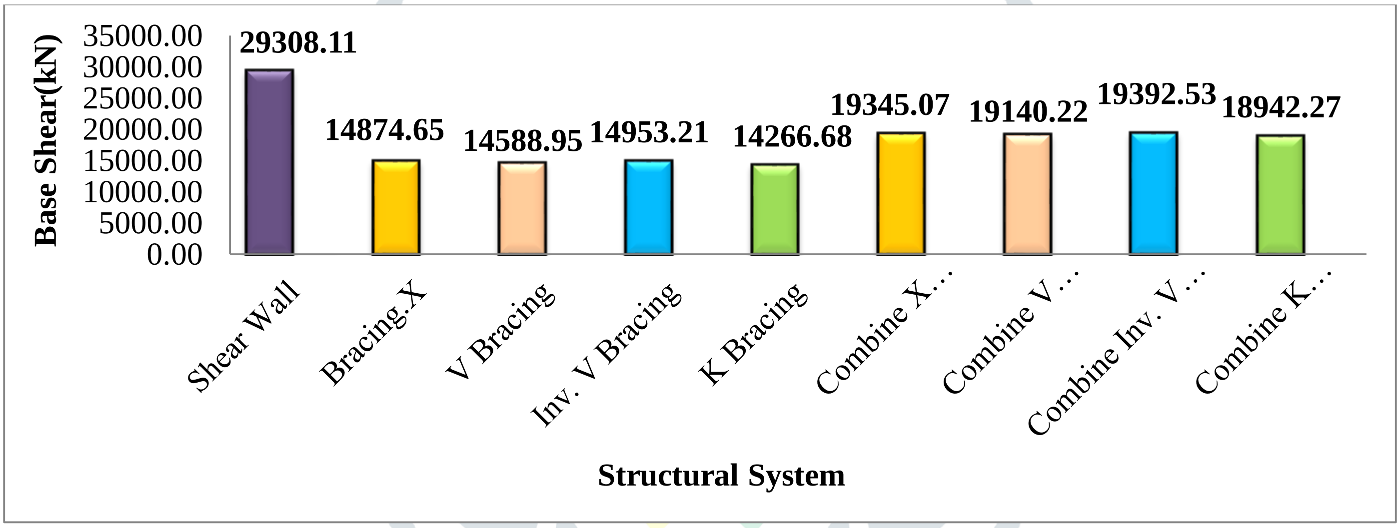

Chart 8. Base shear (kN) in Y direction

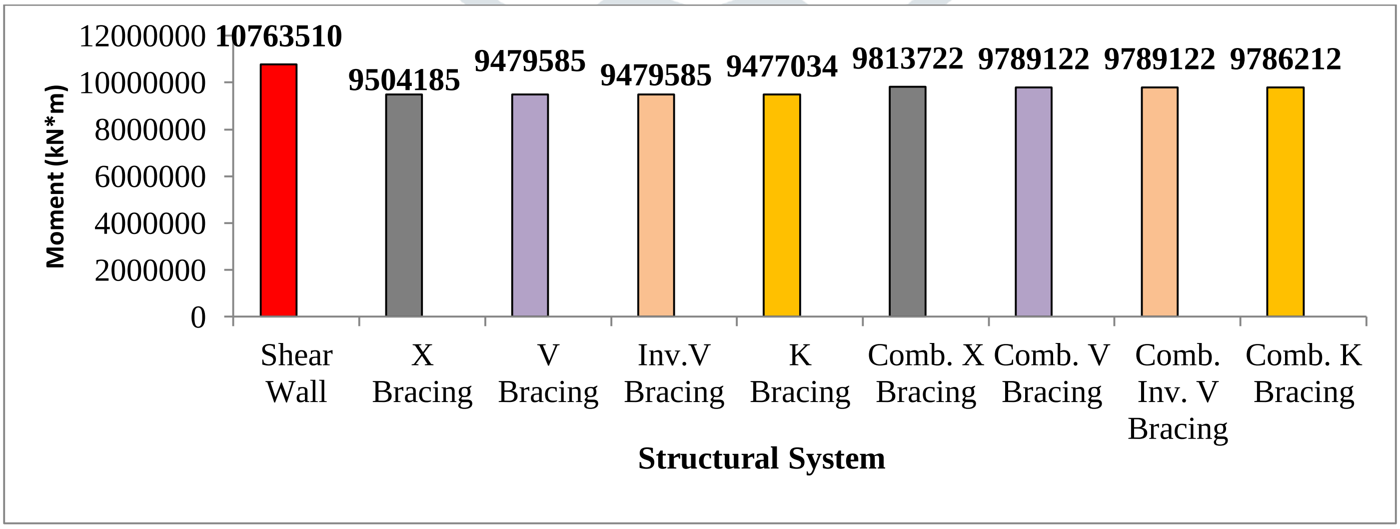

Chart 9. Moment (kN*m) in X direction

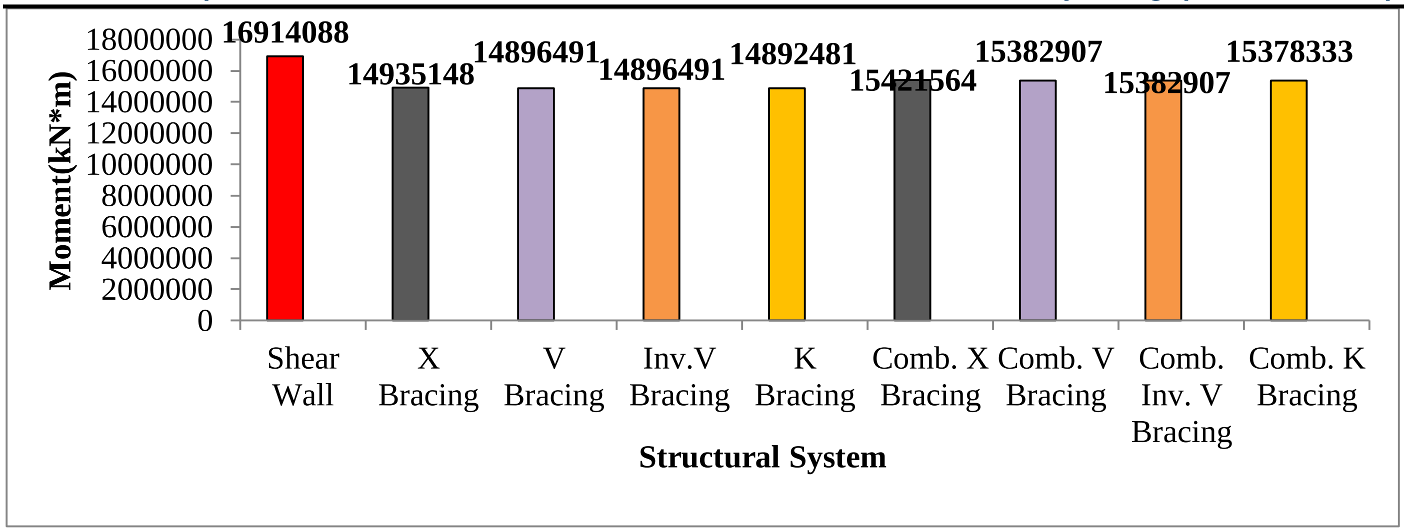

Chart 10. Moment (kN*m) in Y direction

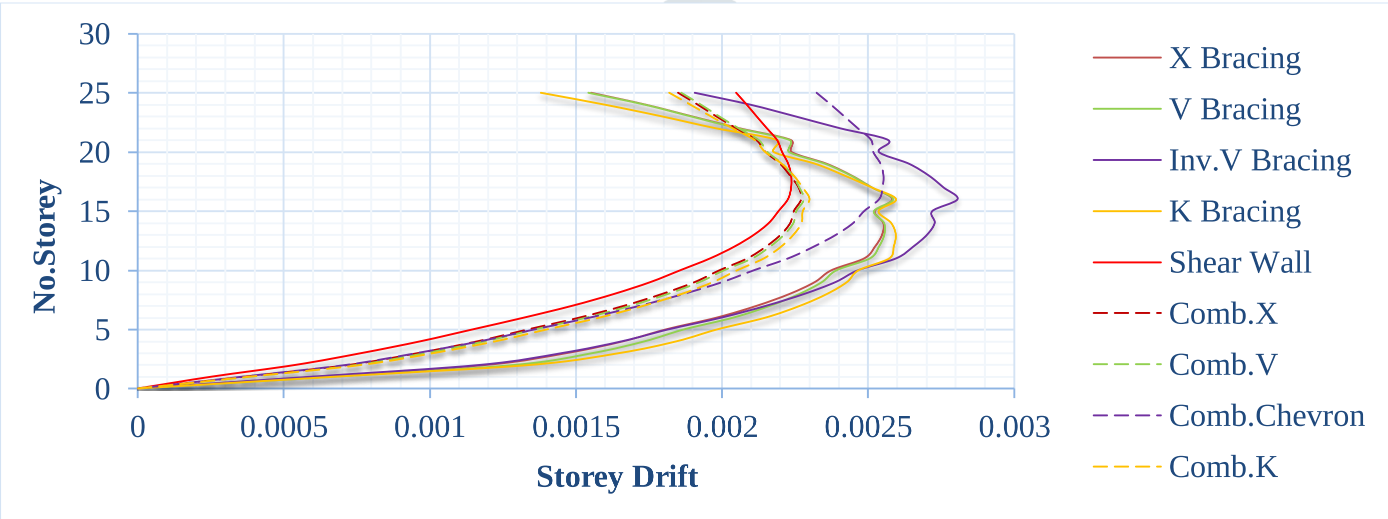

Chart 11. Storey Drift

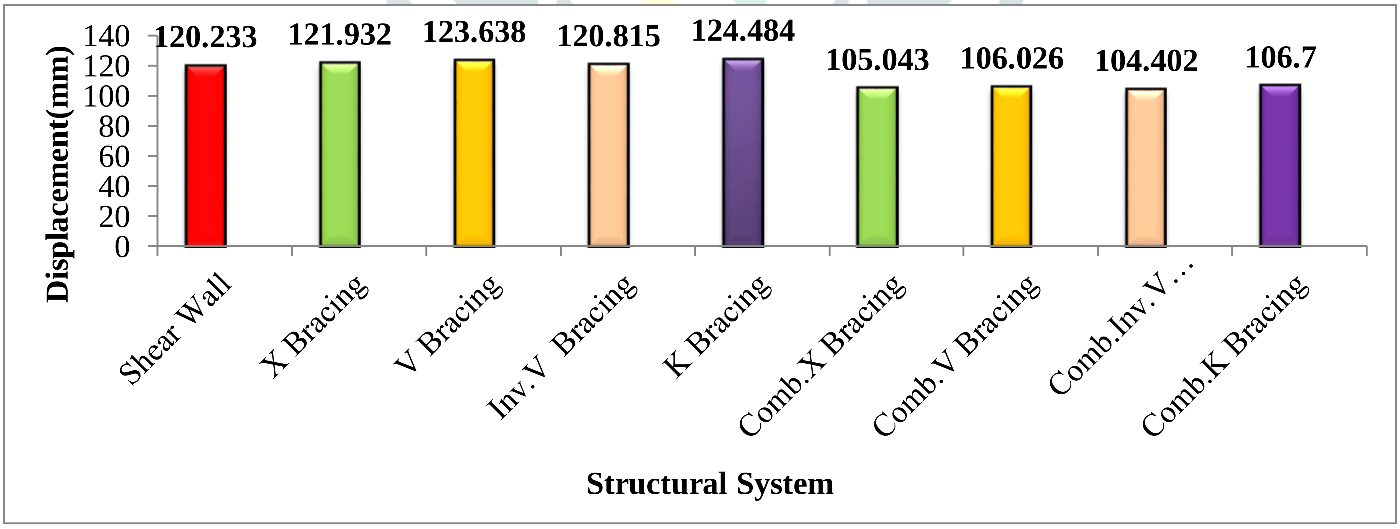

Chart 12. Displacement(mm)

- **For G+29 building Models**

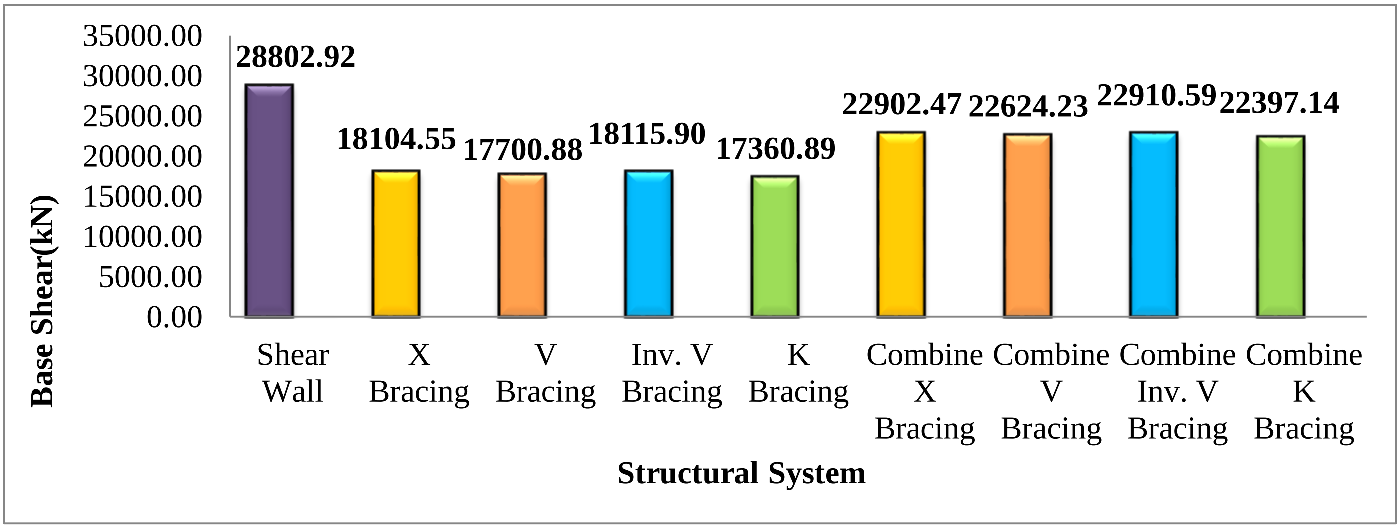

Chart 13. Base shear (kN) in X direction

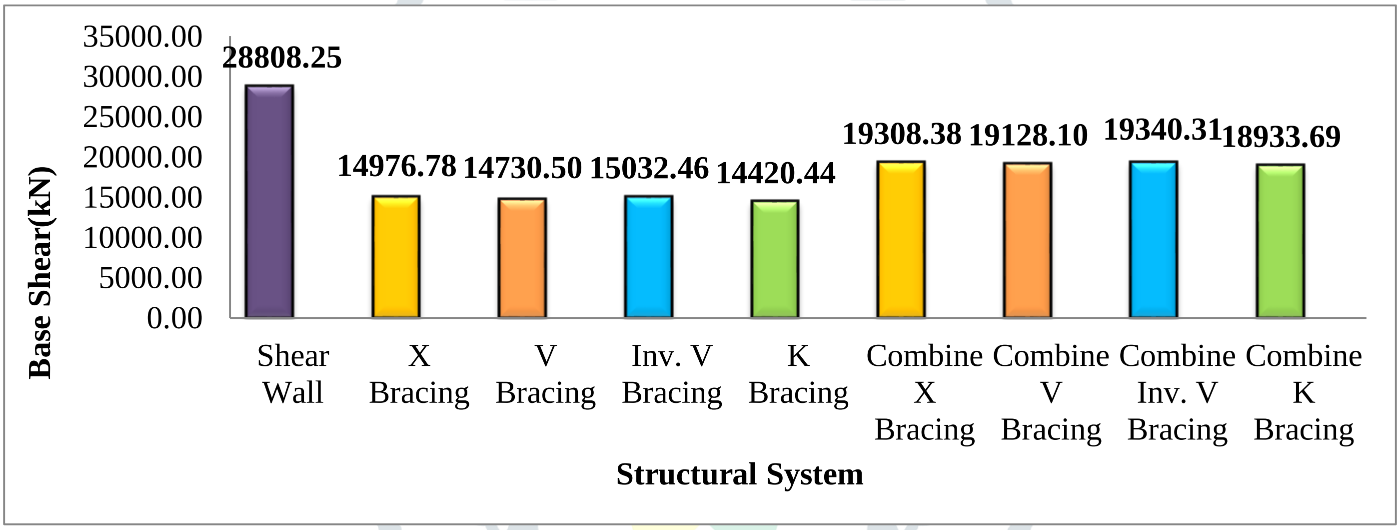

Chart 14. Base shear (kN) in Y direction

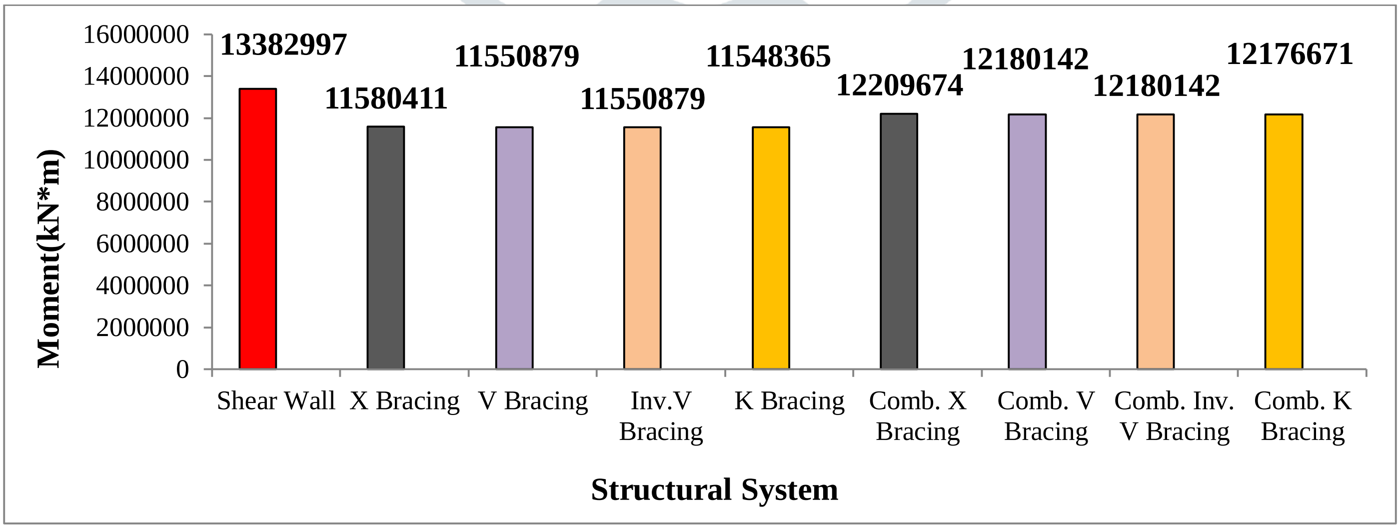

Chart 15. Moment (kN*m) in X direction

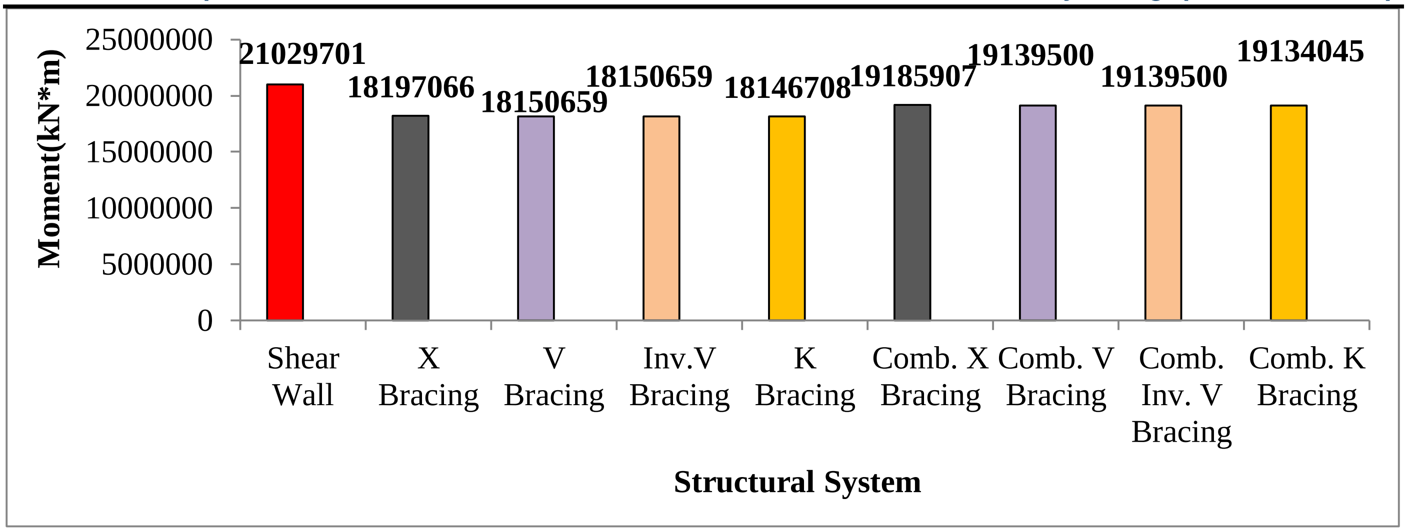

Chart 16. Moment (kN*m) in Y direction

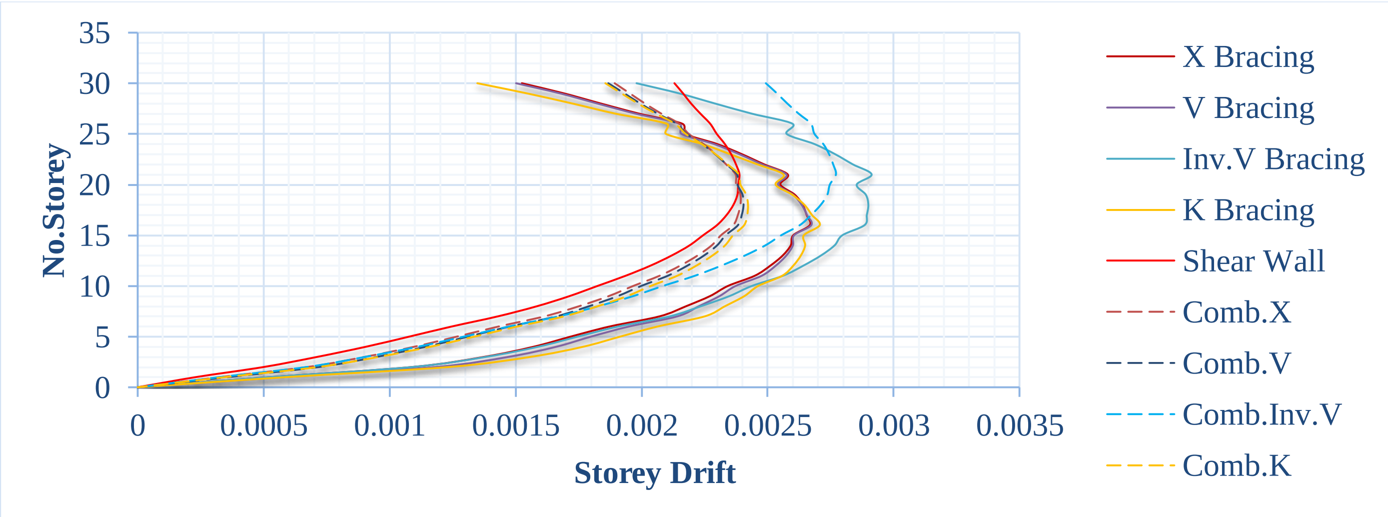

Chart 17. Storey Drift

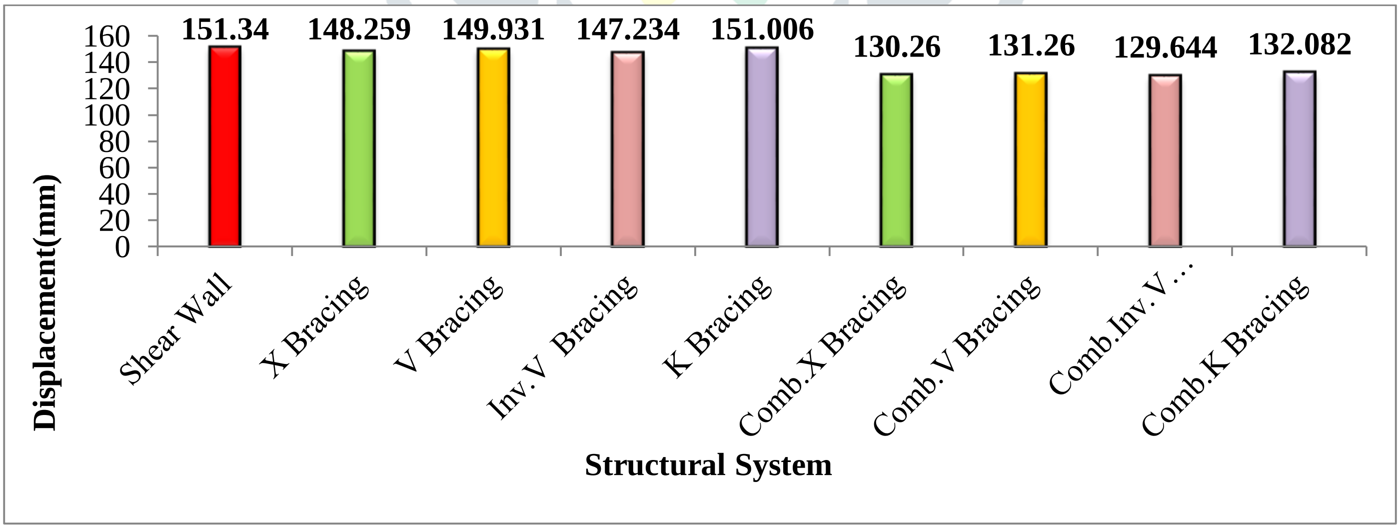

Chart 18. Displacement(mm)

IV. Result Discussion

Shear Wall system has higher base shear capacity than bracing and combined systems due to its higher in-plan stiffness. For shear wall system, the variation of percentage increase in base shear is (37.1%- 45.2%) compared to bracing system and (20.45% - 21.7%) compared to combined system.

Bracing system is not capable of enhancing overturning capacity of building due to its axial action of lateral load carrying system. Like base shear, overturning moment capacity of shear wall system is higher than bracing and combined system. By employing shear core wall in buildings equipped with bracing, the overturning resistance of building can be improved.

Lateral deflection of building model provided with shear wall system is lower in G+19 building model. As height of building increases, the bracing and combined systems are becoming more effective than shear wall system in terms of lateral displacement. The lateral displacement of G+24 building model is less in combined system than other two systems. In G+29 building models the lateral displacement of shear wall system is higher than combined system and bracing system.

Storey drift of shear wall system is less in G+19 building model compared to other systems. The storey drift of G+29 building model is almost the in shear wall system and combined system.

V. CONCLUSSION

[1] Shear wall system is a good option as lateral load resisting system for low to midrise buildings up to 20 stories. The increase in Base shear & overturning Moment capacity are higher in shear wall compared to Bracing and Combined systems. Lateral displacement of building provided with shear wall is also reduced compared to Bracing and Combined systems.

[2] Bracing system can't enhance overturning moment capacity of building due to axial action lateral load carrying mechanism of bracing, provision of core shear wall in bracing system increases the moment capacity of the building.

[3] X and inverted V bracings are effective systems than V and K bracings. Both X and V bracings are having almost the same response.

[4] Combined system is an effective system than shear wall and bracing systems in terms of lateral displacement for tall buildings having more than 20 stories.

Above results may vary by changing size and location of shear wall.

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