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Seismic Response of Steel Bracing RC Structure with Different Steel Section

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Abstract: **–Increasing the rate of immigration to urban areas, getting up price of land, recent developments in construction sequences, availability of high strength materials, efficient structural systems, etc. are the factors which greatly extended the height limit of the building. As height of the building increases, the lateral loads govern the analysis and design. To control excessive deflection and storey drift in tall structures, its necessary to provide a suitable lateral load resisting system. Combine system (Shear Wall+Bracing) is one of the lateral load resisting system which enhances the seismic response of building. In current research paper, attempt has been made to find out seismic response of tall building provided with combine structural system for varying steel sections in bracing elements and response of structure is compared with shear wall system and bracing system in terms of base shear, overturning moment, top storey displacement and storey drift. Dynamic Response Spectrum analysis is carried out in ETABS.**

Key Words: Lateral Loads, combined structural system, Response Spectrum Analysis, ETABS, Building Response

1.INTRODUCTION

Increasing the rate of immigration to urban areas, getting up price of land, recent developments in construction sequences, availability of high strength materials, efficient structural systems, etc. are the factors which greatly extended the height limit of the building. As height of the building increases, the lateral loads govern the analysis and design of the structure. To control the excessive lateral deflection and storey drift, its necessary to provide an efficient lateral load resisting system in building structure. In recent years, there have been many studies on seismic performance of Shear Wall system and Bracing system. In this research work, attempt has been made to find out seismic response of building provided with combine system (Shear Wall+Bracing). In this system, in addition to providing the bracing at the building perimeter, the shear wall is also provided around service core/elevator to form a concrete core. The Dynamic Response Spectrum analysis of *a G+19 storey* RC building is conducted by Etabs 2015 software and response of Combine system is compared with shear wall System and bracing system in terms of base Shear, overturning moment, top storey displacement and storey drift. Four types of bracing systems (X, V, Inverted V & K) along with three types of steel sections (Pipe, Tube & Double angle) are employed in both Combine and bracing systems to assess the effect of steel section on bracing stiffness and seismic response of building.

1.1 OBJECTIVE

I. In this work attempt has been made to find the effect of different bracing system along with different steel sections on seismic response of combine system (Shear Wall+Bracing) as well as Bracing system as per IS-1893(part I):2016 seismic code.
II. Comparative study between combine system, Shear wall system and Bracing system with the help of Etabs 2015 software.
III. To find out the most effective bracing configuration as well as steel section in both combine system and bracing system.

1.2 METHODOLOGY

IV. In the current study, a typical G+19 storey rectangular building is considered with the 28m*44m plan dimension.
V. To find out the effect of bracing configuration on seismic performance of building, four building models are provided with four bracing systems.
VI. To find out the effect of shear core wall on seismic performance of bracing system in combine building, four building models are provided.
VII. To compare seismic response of bracing system as well as combine system with those of shear wall, a building model provided with the shear wall is modeled.

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VIII. To find out the effect of steel section on seismic response of both bracing & combine system, three different steel sections are provided in each bracing systems.

2. PROBLEM FORMULATION

2.1 Model Category

Nine different building models are considered in this research work.
Model 1- Shear wall system
Model 2 - X bracing system
Model 3 - V bracing system
Model 4 - Inverted V bracing system
Model 5 - K bracing system
Model 6 - Combine X system (Shear core wall+X bracing)
Model 7- Combine V system (Shear core wall+V bracing)
Model 8- Combine inverted V system (Shear core wall+inverted V bracing)
Model 9 – Combine K system (Shear core wall+K bracing)
Except shear wall system, three different steel sections are employed in all eight systems, so totally 25 building models are analysed in current research work.

2.2 MATERIAL PROPERTIES

- M30 grade of concrete
- Fe415 grade of steel

2.3 LOADING DATA

- 3kN/m2 for Dead Load
- 1.2kN/m2 for Floor Finish

2.4 SEISMIC PARAMETERS

- Building is located in seismic zone V (Z= 0.36)
- Importance factor (I) is taken 1.5
- Medium soil type is considered (Type II)
- Damping ratio is considered 5% for RCC and 2% for Steel
- Response Reduction Factor is considered:
  Shear Wall System: 4
  Bracing System: 4.5
  Combine System: 4.5

2.5 GEOMETRIC DATA

- Plan Dimension: 28m*44m
- No. of stories: 20 stories(G+19)
- No. bays along X Direction: 9
- No. bays along Y Direction: 5
- Typical Floor Height: 3.5m for GL and 3m for above floors
- Column Size:

(600mm*800mm) from GL to 5 storey
(500mm*700mm) from 6 to 10 storey
(400mm*600mm) from 11 to 15 storey
(300mm*500mm) from 16 to 20 storey

- Typical Beam Size: (300mm*500mm)
- Typical Slab Thickness: 150mm
- Thickness of shear wall: 300mm
- Types of Bracing: X, V, Inverted V & K
- Steel Section for Bracing:

Pipe (ø200mm outer Diameter, t= 16mm)
Box (200mm*200mm square c/s, t= 12mm)
Double angle(200mm*150mm*15mm)

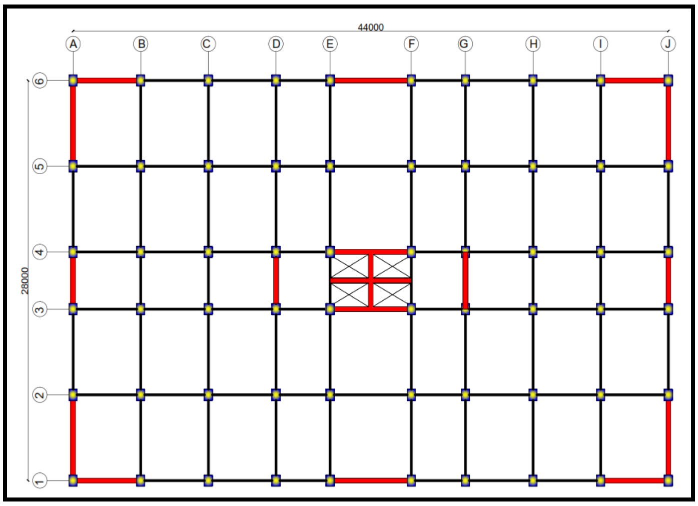

Fig – 1: Building Plan (Shear Wall)

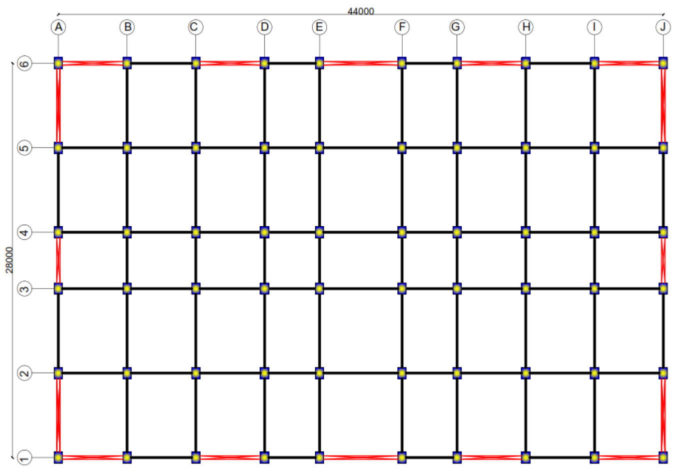

Fig – 2: Building Plan (Bracing system)

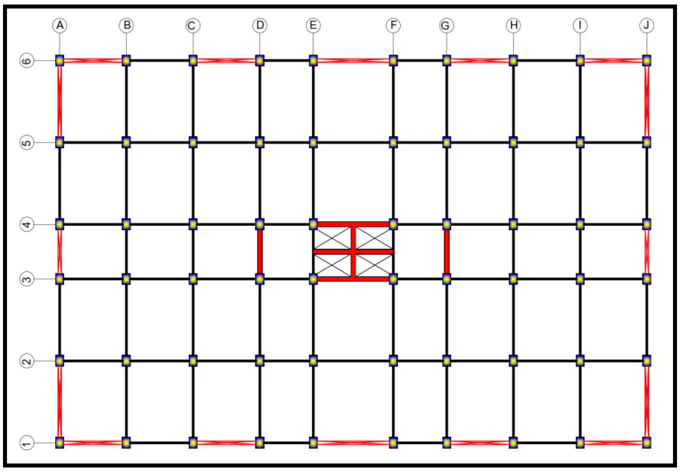

Fig – 3: Building Plan (Combine System)

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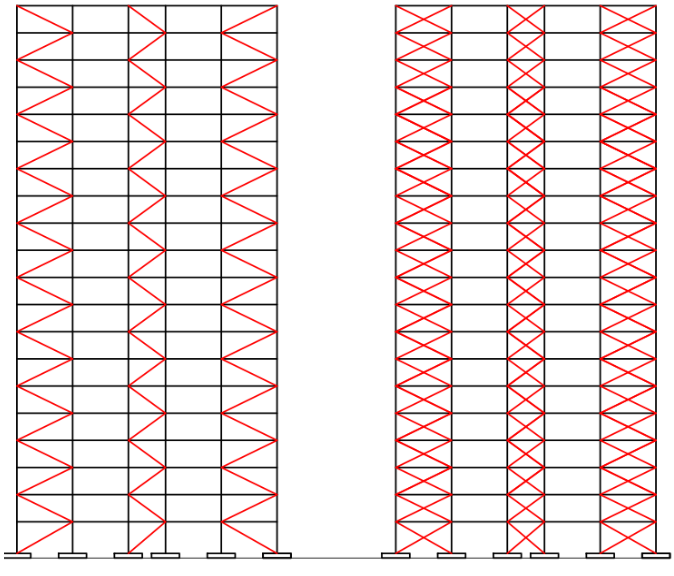

Fig – 4: Model Elevation (X & K bracing)

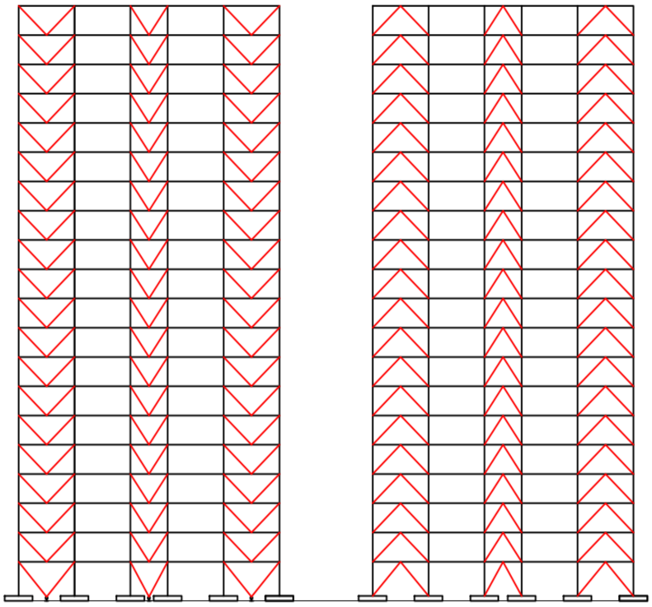

Fig – 5: Model Elevation (V & Chevron bracing)

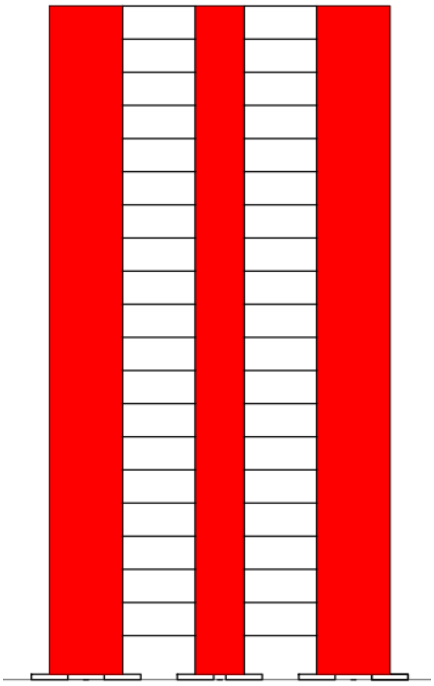

Fig – 6: Model Elevation (Shear Wall)

3. RESULT

3.1 Result for Base Shear

Table -1: Base Shear Value(kN)

System	Base Shear(kN)		
	Pipe Section	Box Section	Double Angle
Shear Wall	28558.13		
X Bracing	15566.83	15524.80	15693.11
comb.X Bracing	22289.70	22252.56	22378.22
V Bracing	15058.77	15015.76	15176.07
comb.V Bracing	21919.61	21769.81	22004.44
Inv. V Bracing	15650.99	15597.38	15797.67
comb.INV.V Bracing	22357.24	22318.18	22464.84
K Bracing	14759.67	14701.31	14908.04
comb.K Bracing	21704.59	21555.40	21811.44

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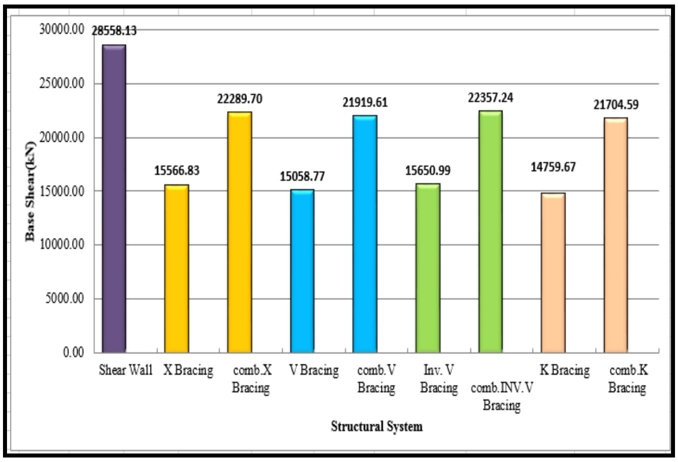

Chart -1: Base Shear Value(kN) for Pipe Section

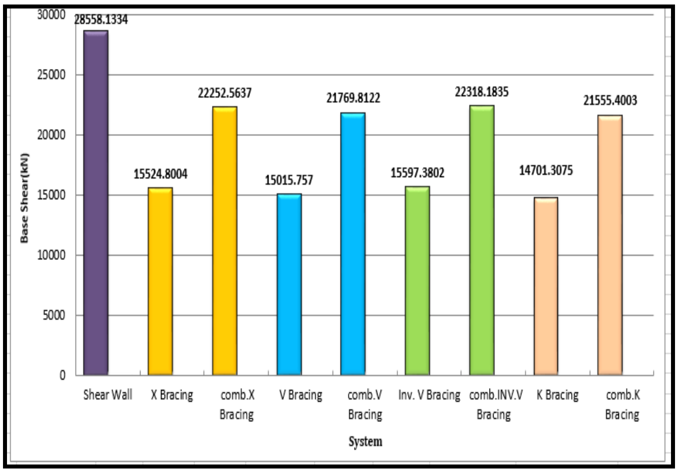

Chart -2: Base Shear Value(kN) for Box Section

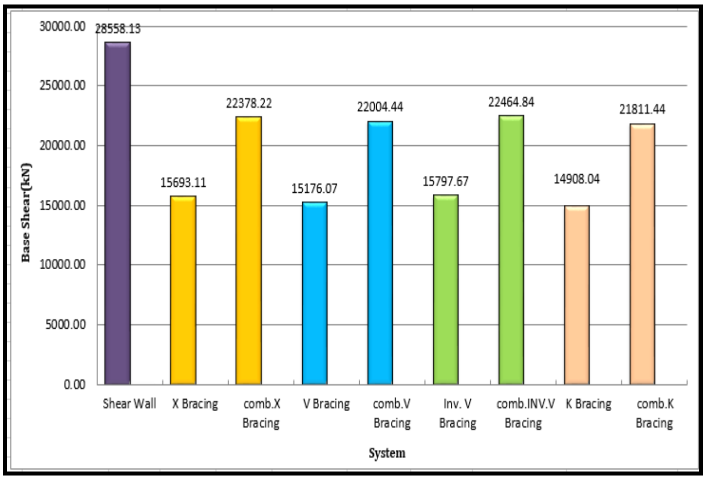

Chart -3: Base Shear Value(kN) for Double Angle

3.2 Result for Moment Capacity

Table -2: Moment (kN*m)

System	Moment(kN*m)		
	Pipe	Box	Double Angle
Shear Wall	8302055		
X Bracing	7488369	7486756	7493601
Comb.X bracing	7673485	7675903	7682666
V Bracing	7468701	7467530	7472161
Comb.V bracing	7657766	7650440	7661308
Inv.V Bracing	7468701	7467530	7472161
Comb.Inv.V	7657766	7656677	7661226
K Bracing	7466352	7465127	7469600
Comb.K bracing	7655417	7676948	7655663

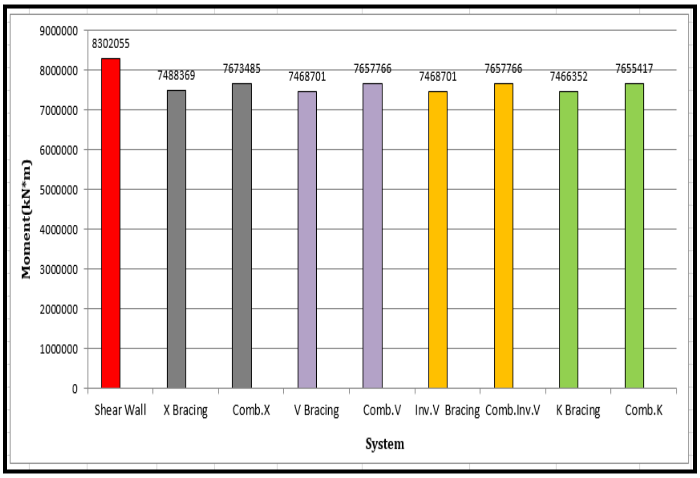

Chart -4: Moment (kN*m) for Pipe Section

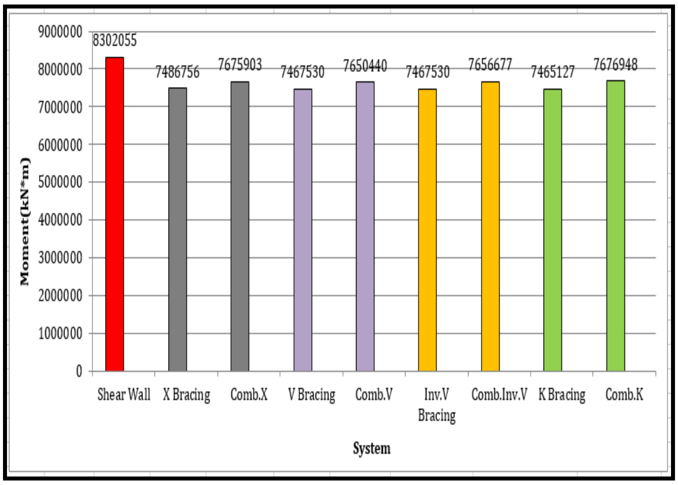

Chart -5: Moment(kN*m) for Box Section

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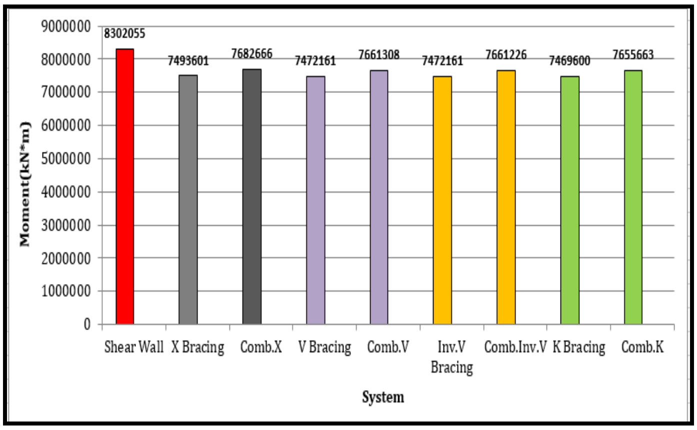

Chart -6: Moment(kN*m) for Double Angle

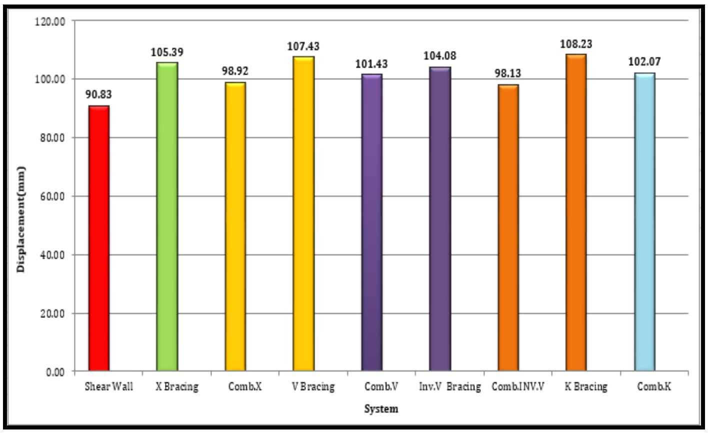

Chart -8: Lateral Displacement(mm) for Box Section

3.3 Result for Lateral Displacement

Table -3: Lateral Displacement(mm)

System	Displacement(mm)		
	Pipe	Box	Double angle
Shear Wall	90.83		
X Bracing	105.26	105.389	104.882
Comb.X bracing	98.80	98.918	98.573
V bracing	107.28	107.425	106.886
Comb.V bracing	100.05	101.433	99.779
Inv.V bracing	103.91	104.08	103.438
Comb.INV.V bracing	98.01	98.127	97.681
K Bracing	108.00	108.228	107.395
Comb.K bracing	103.54	102.069	100.295

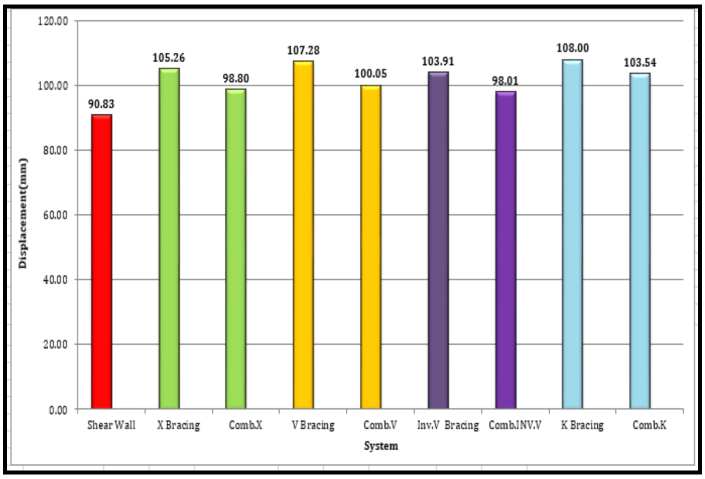

Chart -7: Lateral Displacement(mm) for Pipe Section

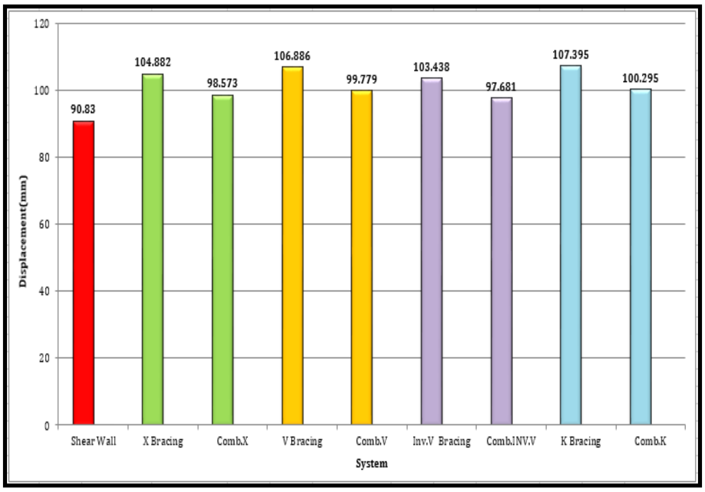

Chart -9: Lateral Displacement(mm) for Double Angle Section

4. RESULT DISCUSSION

Shear wall system has better seismic response among all structural system for G+19 storey building. This system has higher base shear than other structural system because in-plan stiffness of shear wall system is large. Like base shear, the overturning resistance of building provided with shear wall system is also higher than other structural system due to bending action of shear wall system. Top storey displacement of shear wall system is lower compared to remaining systems and are within permissible limit.

Since bracing system carries the lateral loads in truss action, overturning resistance of the buildings provided with bracings are not enhance so it is better to add shear core wall in bracing system to form a new structural system (combined system). In combined system, in addition of increase in overturning capacity and base shear of building, the top storey displacement also decreases.

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Among all bracing configurations, X and Chevron bracings seem to be good system due to having efficient seismic response compared to V and K bracings.

Like bracing configuration, provision of an appropriate Steel section has its own effect on strength and stiffness of bracing and building. Sections which are having the same sectional property (moment of inertia etc.) about major and minor axis are seem to exhibit effectively when subjected to compressing loads. In current study the Double angle has better seismic response than Pipe and Box sections. The cross sectional area of double angle(100.8cm2) is greater than Pipe section(92.5cm2) and Box section(90.2cm2).

5. CONCLUSION

- Based on analytical results, shear wall is a good practice as lateral load resisting system in building with low to mid-rise stories subjected to major earthquake shaking.
- Provision shear wall around stairs, service core and elevators give an additional resistance to buildings specially bracing system. The lack of bending property in bracing system can be solved by employing shear core wall in buildings.
- X and inverted V bracing are good configuration among all types of bracing systems. Inverted v bracing is flexible for provision of openings for doors and windows, hence inverted V bracing is an optimal choice.
- Pipe section has the same sectional property (moment of inertia, depth, etc.) along both axises and is effective in resisting the cyclic loading induced due to lateral forces.
- It is better to analyse and design the building as Combined system instead of bracing system because the provision of shear core wall is mandatory in tall buildings for accommodating stairs, elevators etc. by taking into account the effect of shear core wall in stiffness and strength of buildings provided with bracings, we get small and economical structural elements.

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