Effect of Bracing Systems on Seismic Behavior of Typical RC Tall Building

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***Abstract* – The strengthening and stiffening of the system are most common dynamic performance improvement methods used for buildings to resist lateral forces. Bracing system is one of the effective structural system which plays a vital role in the structural behavior during earthquake. Present study is based on seismic analysis of G+19 stories building using CYPE-CAD to check the lateral force resisting behavior of the structural system. This analytical investigation is on RC bracing systems for lateral load resisting is compared with ordinary RC structures. By providing bracing systems the lateral forces are resisted by the structural system which have increased stiffness, deformability and decreases drift. This investigation has been carried using the parameters - storey displacement, storey drift, base shear and column forces**

***Key Words:* Bracing System, displacement, drifts, shear force, Bending moments, etc.**

I. INTRODUCTION

High rise buildings which have fascinated mankind primarily for defense and subsequently for religious purposes in the earlier eras have found new relevance and wide appeal in recent years due to rapid industrialization, growing urbanization and population explosion. Tall structures are generally slender and are therefore vulnerable to all types of lateral loads ranging from wind, earth quake and blast to wave impact. Amongst the various types of lateral loads, seismic forces are drawing increasing attention in recent years with growth in seismic activity witnesses all over the world and have proved its impact on to be more catastrophic as vast area surrounding the epicenter and the population and infrastructure in the region are devastated by a severe earthquake. Generally, simple framed structures are design to carry gravity and lateral loading. Tall structures on the other hand are often resisting high wind loads and may encounter huge seismic demand. In such cases, it becomes necessary to employ special seismic resisting elements and unique structural configurations.

II. LITERATURE REVIEW

Karthick S (2016) [1]: Explains the analysis of RC building for seismic analysis using different type of structural systems. Shear walls and bracing systems are the most appropriate structural forms in the recent decades. A shear wall is a wall that is designed to resist shear i.e. the lateral force that causes bulk damage to the structures during earthquakes. Bracing is also a highly efficient and economical method of resisting horizontal forces in a frame structures.

P. V. Srivardhan et al (2016) [2]: A typical 20 and 30 storeyed buildings are considered with four distinct plan shapes such as square, rectangle, plus and a T shape within an area of 40m x 40m having a span of 4m. Each building is analysed for Wind and Earthquake loads using the load combinations provided in IS code book. Three bracing types, a concrete shear wall system, steel X-bracing system and a combination of both shear wall and X-bracing for lower and upper half of the structure are used A deflection for rectangular building is lesser than square building along shorter base dimension and is higher along longer base side

Raghavendra et al (2016) [3]: The present study made an attempt to understand the effect of earthquake on building frames resting on sloping ground with shear walls and bracings under severe zone. The computation models of ordinary moment resisting frame was developed in SAP2000 as 3D space frame to carry the seismic analysis as per IS 1893 Part (I) -2002. This study may help to understand the effect of buildings on sloping ground under seismic forces to suggest the efficient lateral force resisting configuration based on parametric study.

III. OBJECTIVES

1. The objective is to evaluate the response of braced and unbraced structure subjected to seismic loads and to identify the suitable bracing system for resisting the seismic load efficiently.
2. To design a typical RC framed structure of a typical tall building located in a high risk seismic zone and investigates the changes in the structural behavior due to the provision of seismic resistant structural systems such as different bracing systems.
3. Critical analyze the important structural response parameters such as base shear, bending moment, shear force, lateral displacement, inter-storey drift, for the configuration investigated such as bare frame and different bracing systems.

IV. STRUCTURAL MODELLING

Generally RC tall buildings subjected to lateral forces are appropriately modeled as space frame structures as the geometry and loading are often unsymmetrical and 3-D action is invariably present. In the present study 3D modeling analysis is carried out of all structural configurations. CYPE-CAD software is used for modelling and analysis of the models. Cype software is a user friendly for modelling and analysis of structure like static equivalent and dynamic analysis

A. Model Data

TABLE 1: DETAILS OF BUILDING MODEL

Building Description	Details
Plan dimension	42mx20m
Story height	3m
Size of beams	250x600mm
Size of corner columns	600x600mm
Size of column	350x1200mm
Thickness of slab	150mm
Density of reinforced concrete	$25kN/m^3$
Density of brick	$20kN/m^3$
Dead load	$1.5kN/m^2$
Live load	$4kN/m^2$
Seismic zone factor	V
Importance factor (I)	1
Response reduction factor (R)	5
Type of soil	Type – 2
Grade of Concrete for slabs and beams	M25
Grade of Concrete for columns and shear wall	M40
Grade of Steel	415

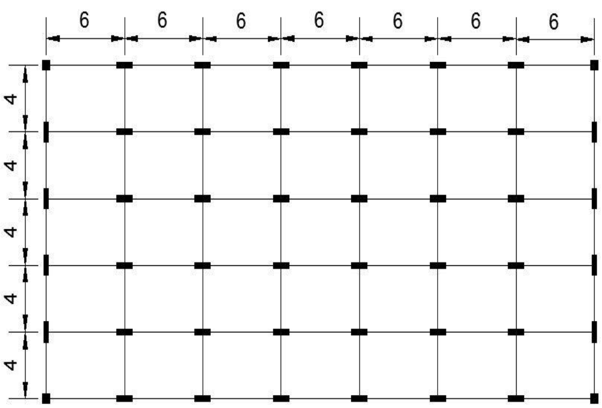

Fig 1: Typical layout plan of building

B. Structural Configurations of the Tall Building

1. Bare frame
2. Diagonal bracing system(DBS)
3. X-braced system (XBS)
4. Eccentric bracing system (EBS)
5. Inverted V bracing system (IVBS)
6. K bracing system (KBS)
7. V bracing system (VBS)
8. Combination of diagonal and x-bracing system (DBS & XBS)

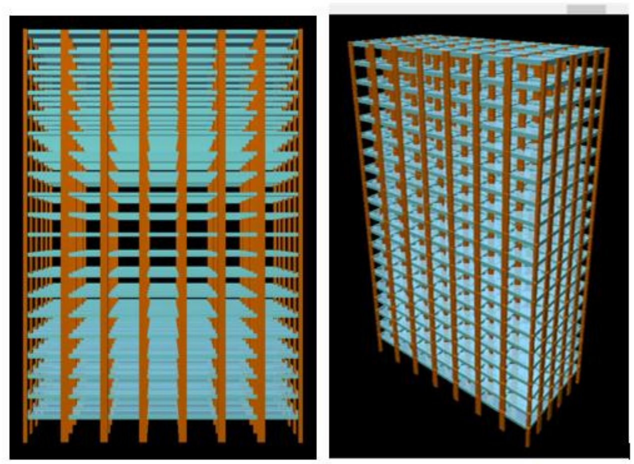

Fig 2: Bare frame

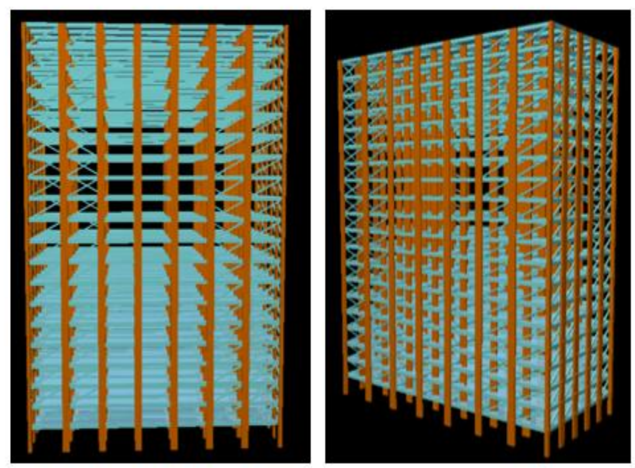

Fig 3: Diagonal bracing system (DBS)

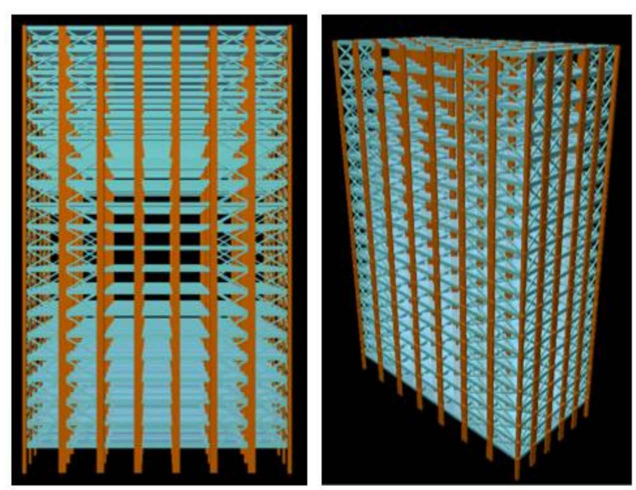

Fig 4: X-braced system (XBS)

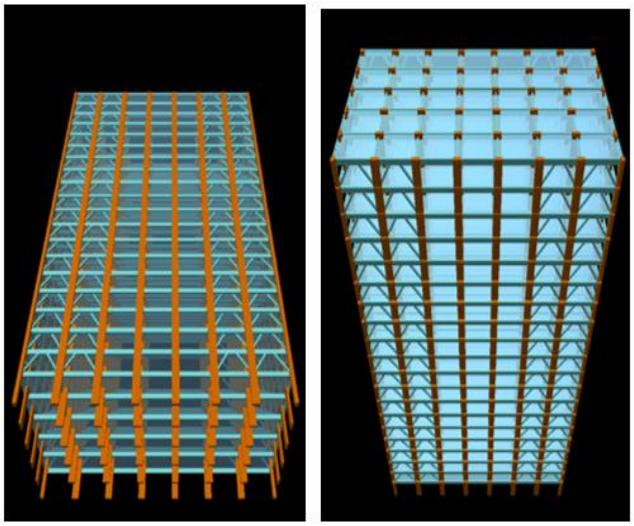

Fig 5: Eccentric bracing system (EBS)

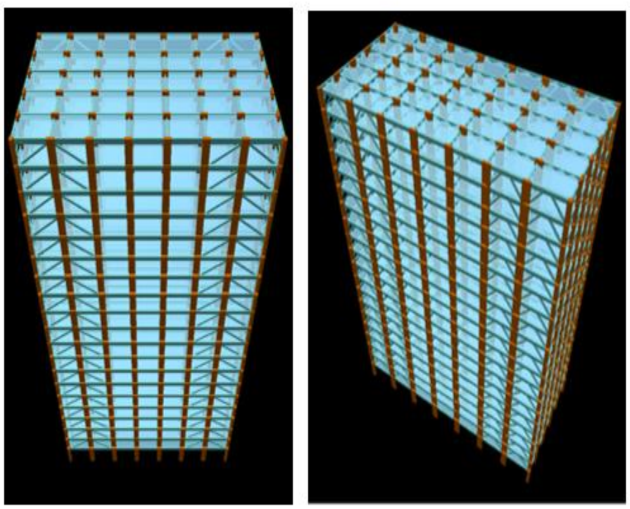

Fig 6: Inverted V bracing system (IVBS)

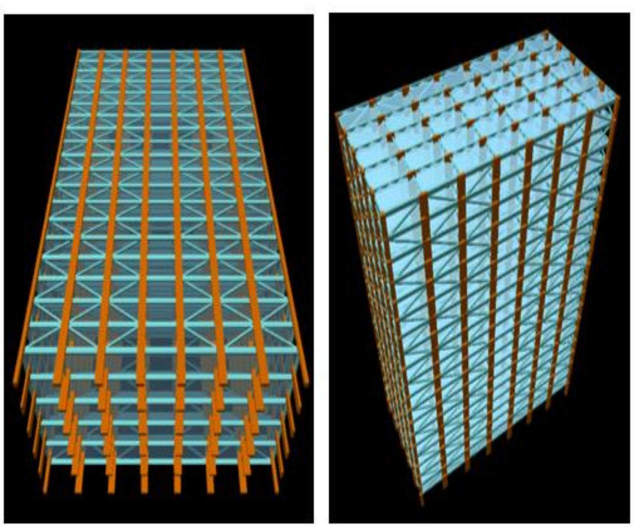

Fig 7: K bracing system (KBS)

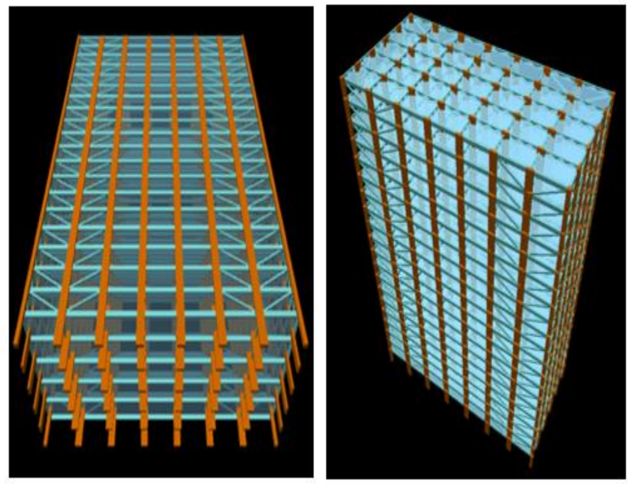

Fig 8: V bracing system (VBS)

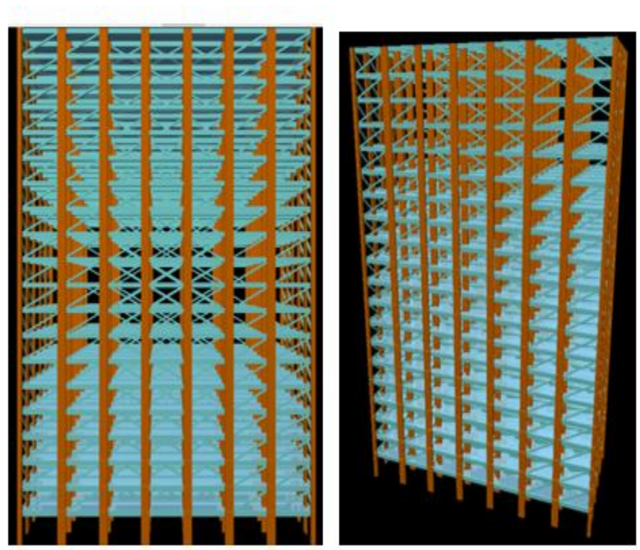

Fig 9: Combination of DBS & XBS

V. RESULTS AND DISCUSSIONS

Storey displacement, storey drifts, base shear, Shear force and bending moments are taken from the software. The comparison between bare frame and other shear wall structural configurations for the parameters mentioned above presented in tables and figures below.

A. Lateral Displacement

1. The story displacement at various story levels for Shear wall and bracing system are shown in Figure 10 to 11
2. From the Fig 10 & Table 2, it can be see that the bare frame undergoes a maximum storey displacement of 98.47mm & 126.54mm along X and Y- direction at the top story level which are well within the

permissible range of story displacement i.e., 0.0015 h to 0.003h.

3. Fig 12 shows that, all the bracing systems investigated in the study are effective in reducing displacement in Y-direction by 20-42% of that of BF, however in X-direction were found well effective in the reducing the displacement by about 33-55% of that of the bare frame.
4. For the bracing configuration system investigated, effectiveness of two orthogonal directions is found to be different. Among them Comb of DBS and XBS showed lower displacement of 44.12mm in X-direction and X bracing system showed lower order displacement of 73.45mm in Y-direction.

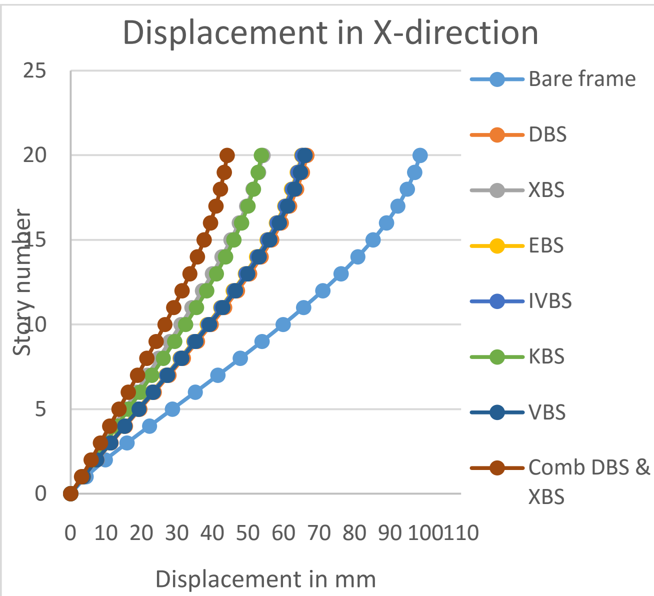

Fig 10: Lateral displacement along X-direction for bracing systems

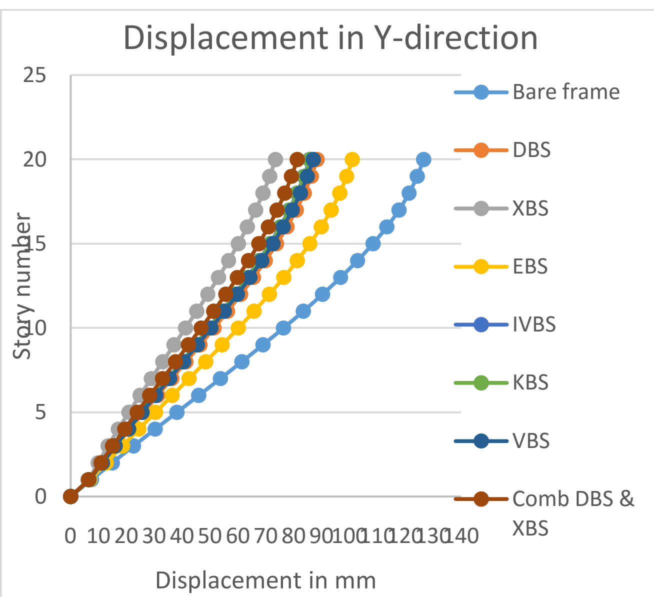

Fig 11: Lateral displacement along Y-direction for bracing systems

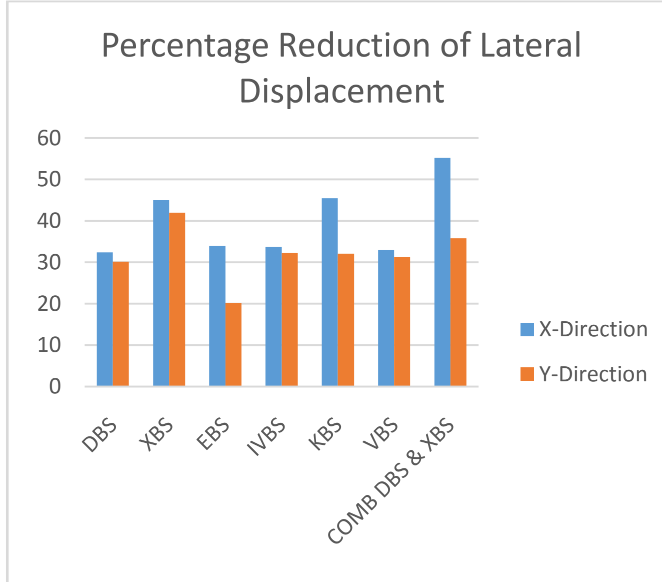

Fig 12: Percentage reduction of lateral displacement for bracing systems

TABLE 2: LATERAL DISPLACEMENT AT TOP STOREY FOR BRACING SYSTEMS

Bracing System		
Configuration system	Lateral displacement (mm)	
	UX	UY
Bare Frame	98.47	126.54
DBS	66.6	88.39
XBS	54.18	73.45
EBS	65.08	101.04
IVBS	65.29	85.77
KBS	53.72	85.97
VBS	66	87.01
COMB DBS & XBS	44.12	81.27

B. *Maximum Storey Drifts*

1. The inter-storey drift @ various storey levels for different configurations are investigated as shown in Fig 13 & 14
2. In Bracing configuration system considered, the XBS system reduced the ISD level of 1.28mm in comparison of 2.6mm to the BF.
3. For the bracing configuration system, the DBS, XBS, IVBS, KBS, VBS and Comb of DBS and XBS shows almost same magnitude of ISD of range 0.68mm to 2.0mm in Y-direction and 0.32mm to 1.36mm in X-direction.

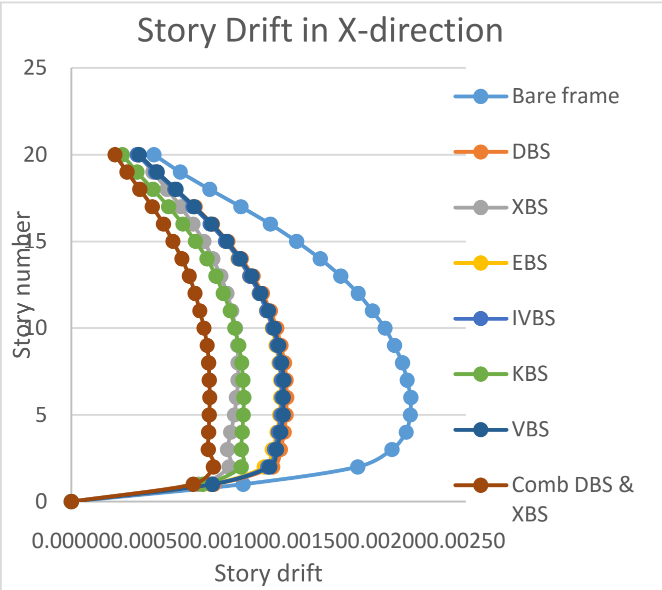

Fig 13: Comparison of inter-story drift along X-direction for bracing system

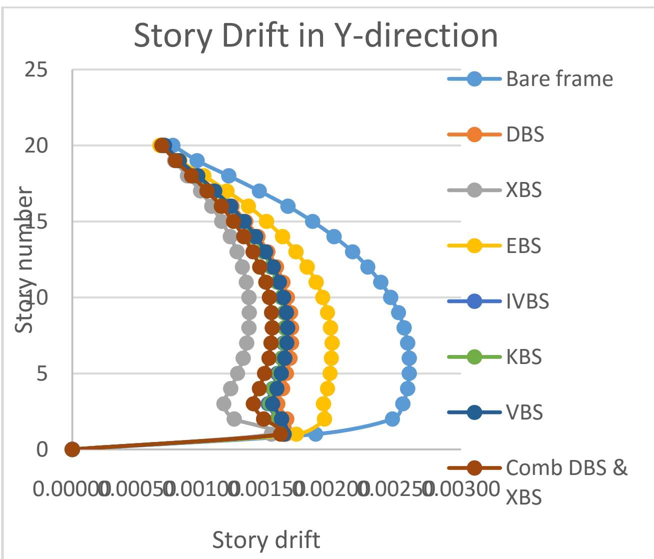

Fig 14: Comparison of inter-story drift along Y-direction for bracing systems

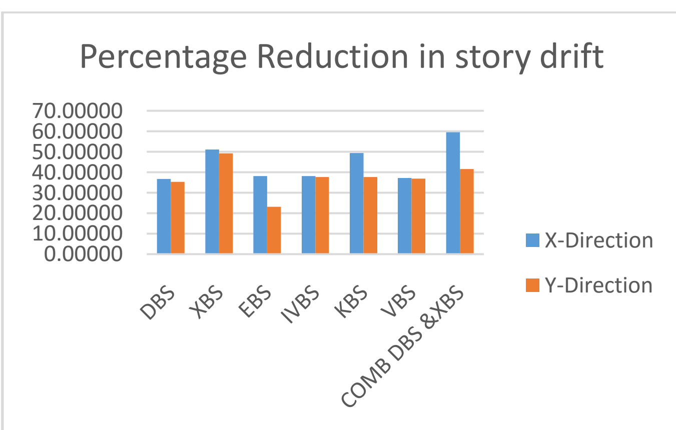

Fig 15: Percentage reduction of inter-story drift for bracing systems

C. Column Forces

1. The structural configurations investigated are found to be effective in reducing the BM in columns. For instance, the highest BM ranging from 988-1952 kN-m was obtained in the Bare Frame as seen from table 3.
2. For the bracing configuration system, the VBS reduced the BM in the exterior column around 80% (C2 & C4) & about 87% in the interior column (C31 & C38) compared with BF system. The EBS, IVBS, KBS, and Comb of DBS and XBS reduced the bending moments in both exterior and interior column about 90%, while DBS and XBS reduced the bending moment both in exterior and interior column around 17%.
3. For the bracing system results in transferring more shear force to the interior and exterior column due to the stiffening action of the bracing system.

TABLE 3: MAXIMUM BENDING MOMENT OF COLUMN OF DIFFERENT STRUCTURAL CONFIGURATION FOR BRACING SYSTEMS

Bending Moment in kN-m (For Bracing System)								
COLUMN	BARE	DBS	XBS	EBS	IVBS	KBS	VBS	COMB DBS &XBS
C1	988	931	910	974	887	918	229	927
C2	1942	1716	1608	419	409	410	409	408
C4	1952	1731	1624	393	163	172	385	382
C31	1855	1632	1535	303	238	299	241	432
C38	1855	1632	1535	300	233	275	236	255

TABLE 4: MAXIMUM SHEAR FORCE OF COLUMN OF DIFFERENT STRUCTURAL CONFIGURATION FOR BRACING SYSTEMS

Shear Force in kN (For Bracing System)								
COLUMN	BARE	DBS	XBS	EBS	IVBS	KBS	VBS	COMB DBS &XBS
C1	103	91	82	72	92	91	93	87
C2	509	517	528	527	518	214	522	528
C4	517	532	541	531	533	534	319	535
C31	497	504	510	503	504	506	504	509
C38	498	505	509	502	504	506	504	510

VI. CONCLUSIONS

The present investigation was conducted on the effect of structural configuration on seismic behavior on typical 20 storey RC framed structure by analyzing and evaluating different types of bracing systems to assess the reduction in lateral displacement, bending moment and shear force compare to bare frame structure. Based on the results obtained the following conclusion are drawn.

1. For bracing configuration systems, the XBS, KBS and Comb of DBS and XBS systems are found to be most effective configurations and resulting in substantial reduction of lateral displacement (31-54%), inter-storey drift (38-59%), column bending moments and shear forces (69%) compare to bare frame system.
2. Amongst the seven configurations of bracing systems investigated in this study, the COMB and XBS is found to give the best performance. The performance based ranking in different configurations studied is as follows.

	Performance based Ranking of the structural configuration investigated						
Configurations	COMB	XBS	KBS	VBS	DBS	IVBS	EBS
Ranking	1	2	3	4	5	6	7

The results of the study are based on a single tall structure. Therefore, the conclusion drawn from the study has limited applicability to similar structures only. In order to generalized the conclusions and make it applicable to any high-rise structure, it may be necessary to carry out further investigation. They indicate that there is a need to undertake detailed investigation of considering structures of varying height with and without symmetry and considering nonlinear behavior of the elements in order to draw useful design guidelines.

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