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SEISMIC ANALYSIS OF TUBE IN TUBE STRUCTURES WITH DIFFERENT TYPES OF BRACINGS

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Abstract: The demand of tall buildings is increasing due to increasing population and less availability of land.Tubular structure is a structural system for tall buildings.The main concept of tubular structures is that building is designed in such a way that it acts like a hollow cantilever which is perpendicular to the ground. Tubular structures are of different types of in which tube in tube structure is more suitable for tall buildings. A tube in tube structure consists of two tubes i.e. outer tube and inner tube which are connected by floor slab.The inner tube is shear wall and the outer tube have columns.Since the inner tube is a shear wall, it has an advantage of column free surface.The outer tube carries the lateral loads.Tubular structure is a better structural system because it have less storey displacement and story drift.In this study we will analyse a 30 storey tube in tube structure with different types of bracings like diagonal,X and V bracing by response spectrum analysis on ETABS 2016 software and we will compare the values of storey displacement,storey drift and storey shear.

Keywords: Tube in Tube structures, Shear Wall, Storey Displacement, Storey drift, Storey Shear.

I. INTRODUCTION

Different types of tubular structures are used for resisting the lateral loads on the buildings. Tubular structures are of four types i.e. frame tube structure, braced tube structure, tube in tube structures and bundled tube structure. A Frame tube consists of columns having a spacing of 2 to 4 metres. It consists of outer tube and inner tube. The outer side of frame tube structures have moment resisting frames. The gravity loads are taken by interior columns. The outer tube and inner tube are connected by floor slab with deep girders. Frame tube structures are suitable for 40 to 100 storied buildings.De-Witt Chestnut Apartment in Chicago is an example of frame tube structures Braced tube structure is a structural system having X bracings provided at the outer side of the building. This bracings reduce the effect of shear lag which occurs because the stress distribution is not uniform and this phenomenon is called as 'shear lag effect'. The interior part of braced tube structures have columns which resists the gravity loads. John Hancock Building in Chicago is the example of braced tube structure.

Tube in tube consists of inner and outer tube. Tube in tube structures are also called as hull and core structures ie inner tube is the 'core' and the outer tube is called as 'hull'. The inner tube is a shear wall and the purpose of this inner tube is for the transportation of the lifts and the outer tube consists of columns. The outer tube of tube of tube structure plays an important role since it have high structural depth. Tube in Tube structures are better for high rise buildings because it in this system more than 50 stories buildings can be made. Bundled tube structure is a structural system having a group of tubes forming a bundle type structure. The advantage of bundled tube structure is that it provides large floor area and since the columns are present on the outer perimeter it is helpful in interior planning. The Sears tower in chicago is the example of bundled tube structure.

II. LITERATURE REVIEW

1) Archana J et.al. (2016) studied tube in tube structures and tube mega frames. This study was done to obtain the best structural system against lateral loads. In this study a G+15 building for frame tube, tube in tube structure with centre, edge and inner tube, tube mega frame system was analysed on etabs software. The methods used in this analysis were response spectrum analysis and Equivalent static analysis. All the three models were compared on the basis of results of three parameters i.e.storey displacement,storey drift, storey shear. From this study it is concluded that tube in tube structures with centre tube showed lesser values of storey displacement, storey drift, storey shear than bare frame and tube mega frames.

2) Bipin H Naik et.al. (2017) analysed tube in tube structure and conventional moment resisting frame. This analysis is was done to see the behavior of tube in tube structure with variation in the column spacing,tube in tube structure with X bracing and tube in tube structure with moment reisisting frame.The column spacing was 3m and 6m.The number of stories in the building was G+49 i.e.50 storied building.The parameters used in this study were base shear,Time period, Stiffness, Displacement, Drift. The methods used in this analysis were Equivalent static and dynamic time history analysis and base shear,Time period, Stiffness, Displacement, Drift were compared for each model. From this study it is concluded that stiffness was increased in firmly distributed columns and expansion of bracing results in decrease in time period. Base shear gets expanded when column dispersing is diminished and lessening the column dispersing helps in better constraining of displacement and drifts.

3) Mohan K T et.al. (2017) analysed tube in tube structures with different forms subjected to lateral loads**.**The purpose of this research was to analyse different forms of tube in tube structures.In this study tube in tube structure with different geometry like square,rectangular,triangular and hexagonal tube in tube structure.This four models of 60 stories were modeled and analysed on SAP 2000 software.Response Spectrum analysis was used to compare time period, displacement, drift and base shear.From this study it is concluded that square geometry showed least values of drift,displacement and time period was less in comparison with rectangular,triangular and hexagonal.Base shear value was highest in square geometry and least in hexagonal geometry.

4 Shubhangi V Pawar et.al. (2017) carried the earthquake and wind analysis of different plans of braced tube structure.The main objective of this research was to see the effects of earthquake and wind force on different plan shapes of braced tube structure.Comparative analysis of 60 storied braced tube structure with different plan shapes like Circular, Square,rectangular was done by linear static method on etabs software.The three models were compared on the basis of displacement,storey drift,base shear.From this analysis it is concluded that the storey drift and storey displacement values in circular and square braced tube structure was less as compared to rectangular braced tube structure. the storey drift and storey displacement values in circular braced tube structure was less as compared to square braced tube structure.

5 Mostafa Moghadasi et.al (2017) studied the effect of geometry on shear lag of frame tube tall buildings which is subjected to earthquake loads.The main purpose of this study was to see the effect of geometry on shear of frame tube structures.In this study two groups of 40 stories and 60 stories was analysed.To check effect of geometry on shear lag both the groups were analysed by linear elastic method.The values of shear lag was observed in different shapes like rectangular,triangular and hexagonal.In this study they observed that rectangular geometry is not suitable because axial force distribution in column was not good and shear lag value was more compared to triangular and hexagonal geometry.In hexagonal plan the amount of shear lag was minimum. From this analysis it is concluded that rectangular geometry not a suitable against shear lag and hexagonal geometry is better against shear lag.

III. STRUCTURAL MODELLING

a) Objectives of the study:-

1. To compare the response of braced and unbraced structure against lateral loads in seismic zone III.
2. To obtain a better bracing system for tube in tube structure.
3. To compare Maximum values of Storey Displacement, Storey drift, Storey Shear by response spectrum analysis for different bracing types.

b) Model types:-

1. Tube in Tube structure without bracings i.e. base model.
2. Tube in Tube structure with diagonal bracings.
3. Tube in Tube structure with X bracings.
4. Tube in Tube structure with V bracings**.**

c) Building details:-

Number of stories	30
Story height	3m
Length of the building	60m
Width of the building	40m
Spacing between grids	5m
Grade of the concrete	M30
Size of beam	400mmx700mm
Size of column	700mmx700mm

Thickness of Slab	200mm
Thickness of Shear wall	250mm
Bracing Steel grade	Fe345
Seismic zone	III
Live load	3kN/m
IS Code	IS 456:2000, IS 1893:2002

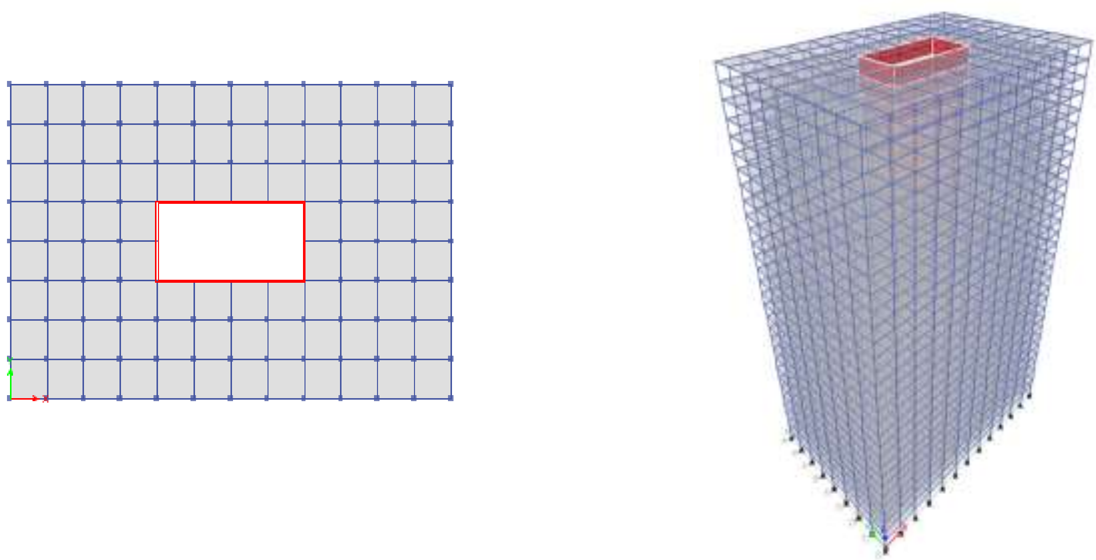

Fig 1.1 Plan and 3D view of tube in tube structure without bracing

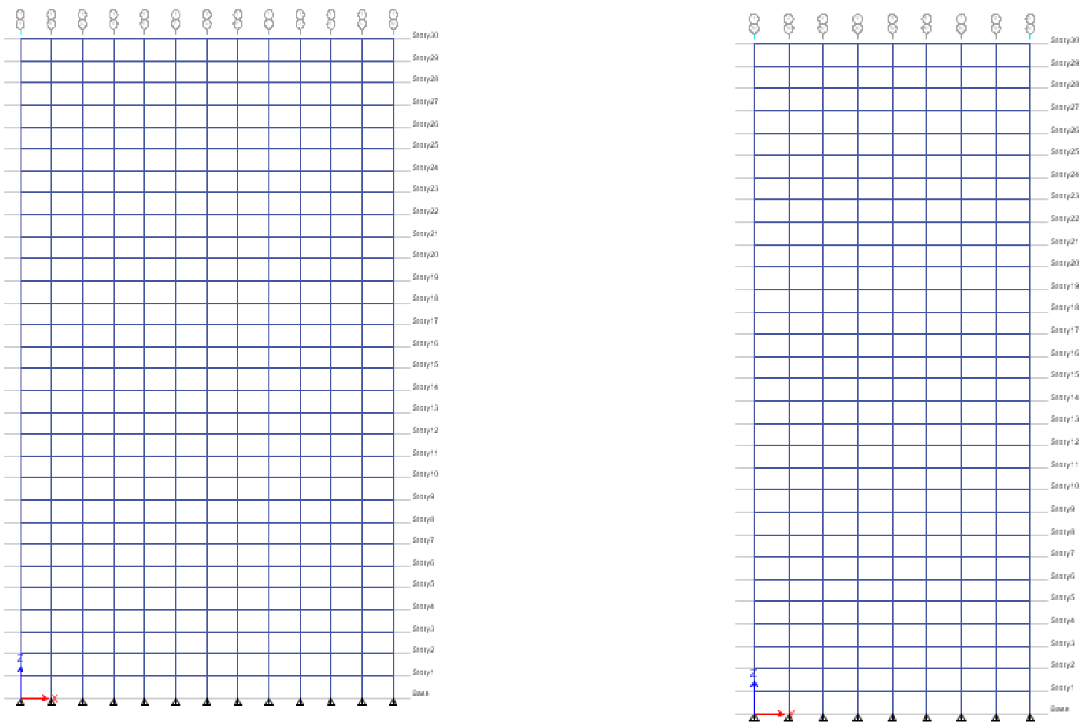

Fig 1.2 Elevation of tube in tube structure without bracing in X and Y direction

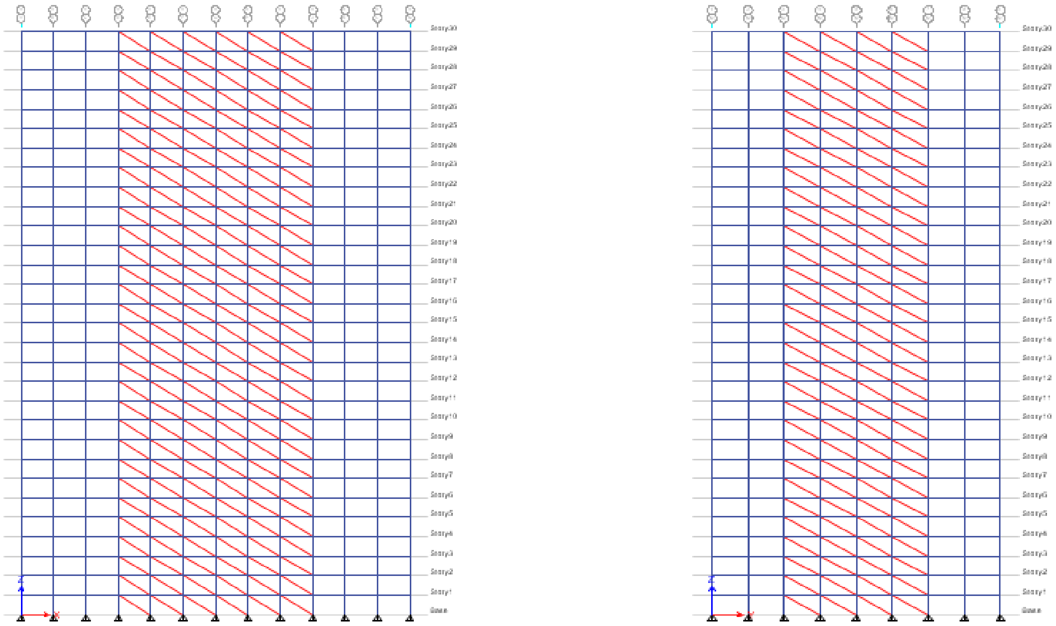

Fig 1.3 Elevation of tube in tube structure with diagonal bracing in X and Y direction

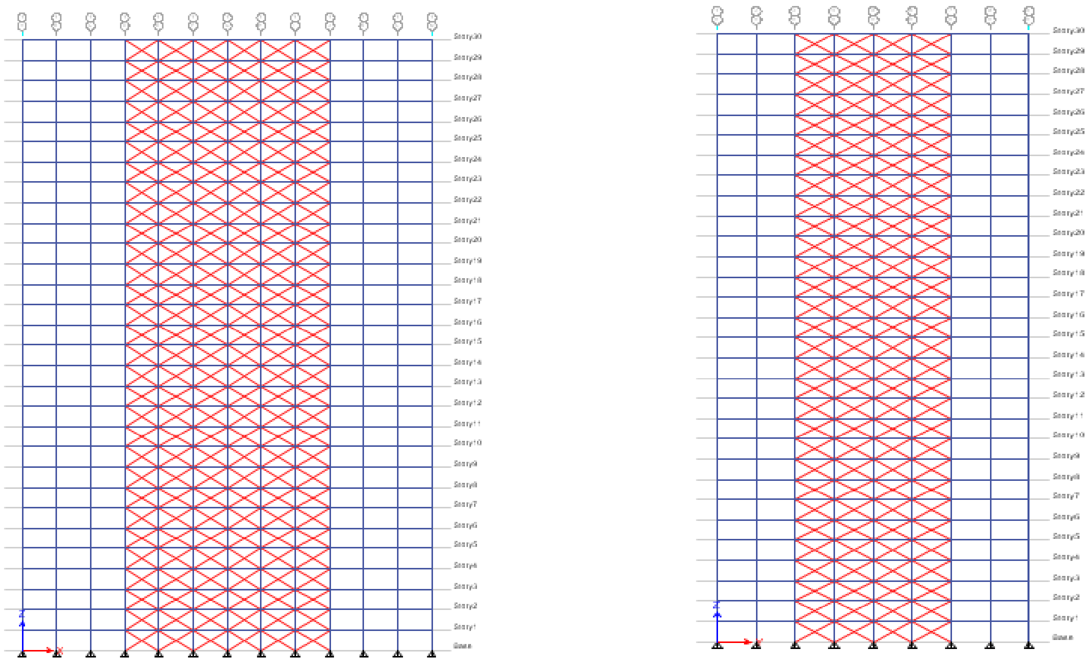

Fig 1.4 Elevation of tube in tube structure with X bracing in X and Y direction

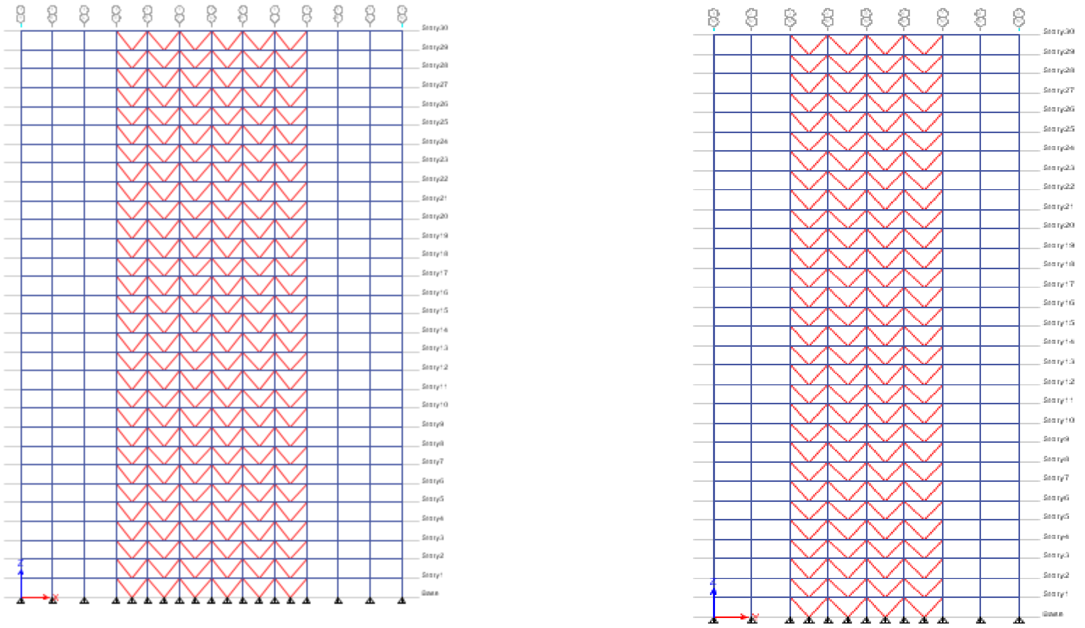

Fig 1.5 Elevation of tube in tube structure with V bracing in X and Y direction

IV. RESULTS

The following are the results of tube in tube structures with different type of bracing.

i) Table showing comparison of maximum values of storey displacement storey drift and storey shear in X direction for different bracings.

Parameters	**Base model**	**Diagonal bracing**	**X bracing**	**V bracing**
Storey Displacement (in mm)	13.142	12.320	11.820	11.920
Storey Drift	0.000177	0.000166	0.000158	0.000160
Storey Shear (in kN)	9745.757	10739.103	11266.256	11080.453

i) Table showing comparison of maximum values of storey displacement storey drift and storey shear in Y direction for different bracings.

Parameters	**Base model**	**Diagonal bracing**	**X bracing**	**V bracing**
Storey Displacement (in mm)	15.304	14.871	14.230	14.313
Storey Drift	0.000209	0.000202	0.000192	0.000193
Storey Shear (in kN)	7732.404	8411.307	8717.941	8602.119

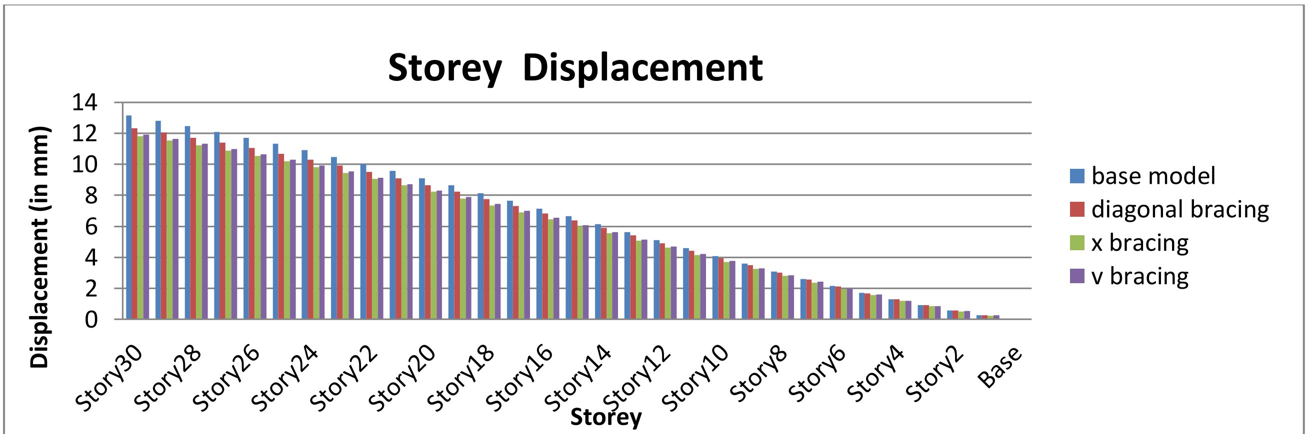

Fig 1.6 Graph showing comparison of storey displacement in X direction for different bracings

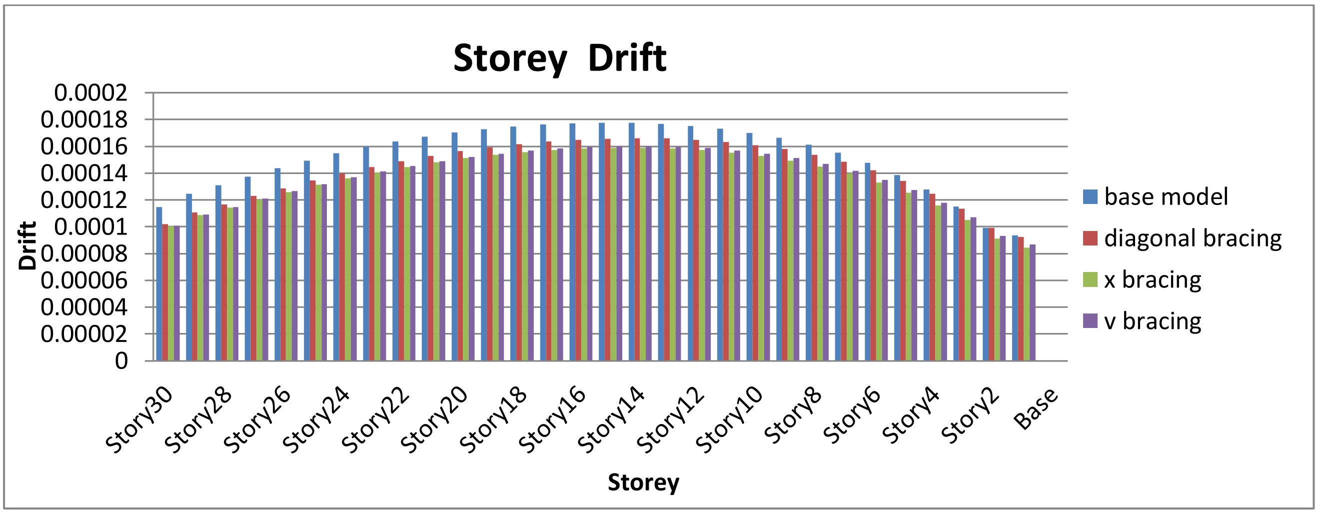

Fig 1.7 Graph showing comparison of storey drift in X direction for different bracings

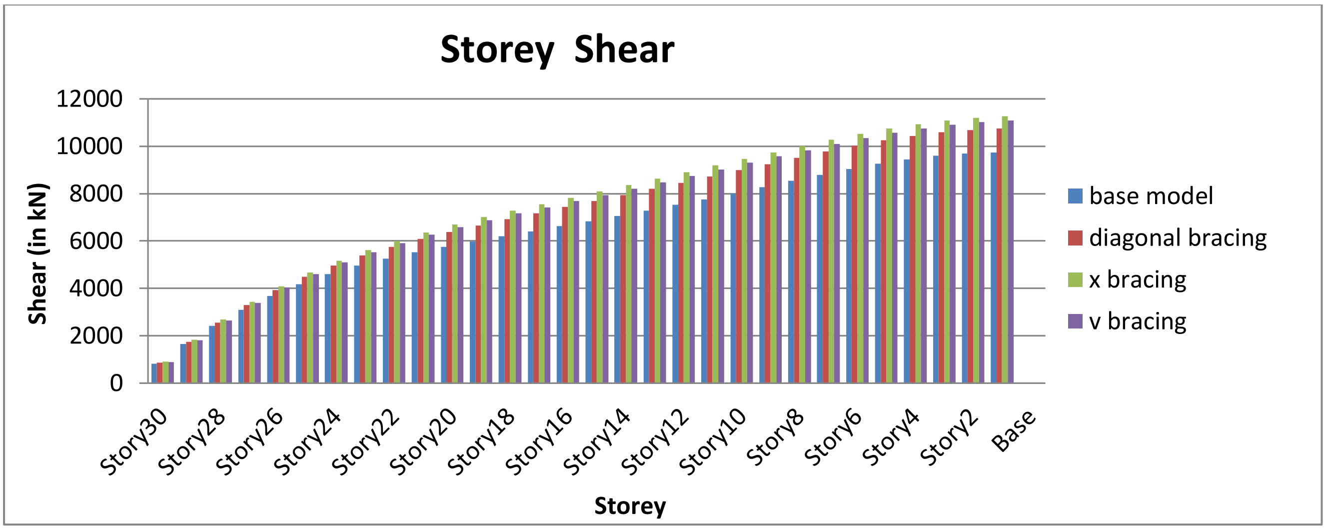

Fig 1.8 Graph showing comparison of storey shear in X direction for different bracings

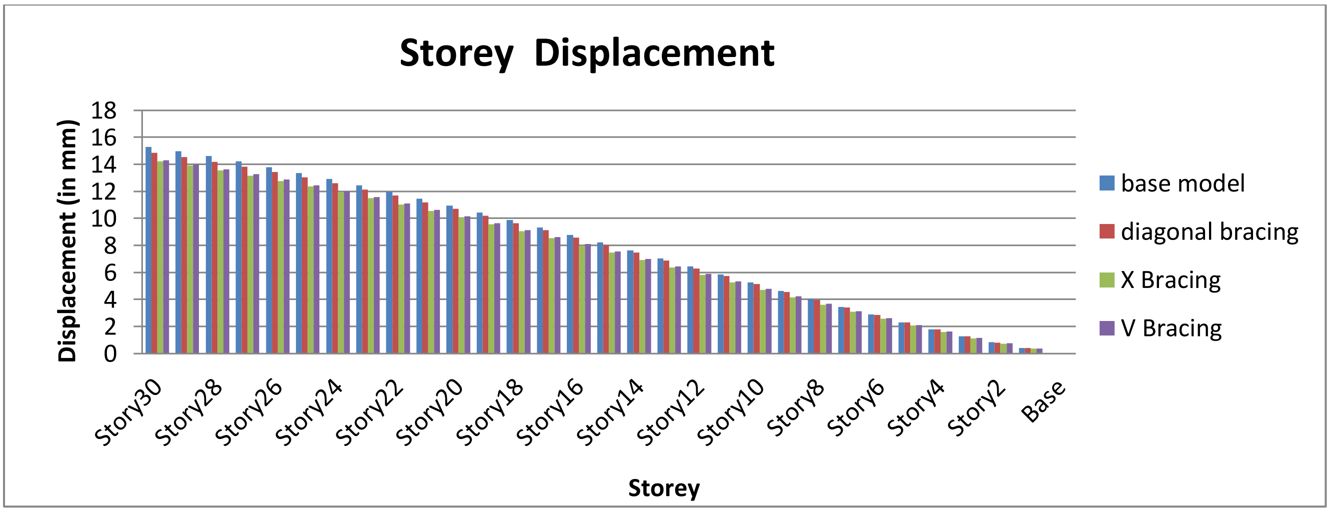

Fig 1.9 Graph showing comparison of storey displacement in Y direction for different bracings

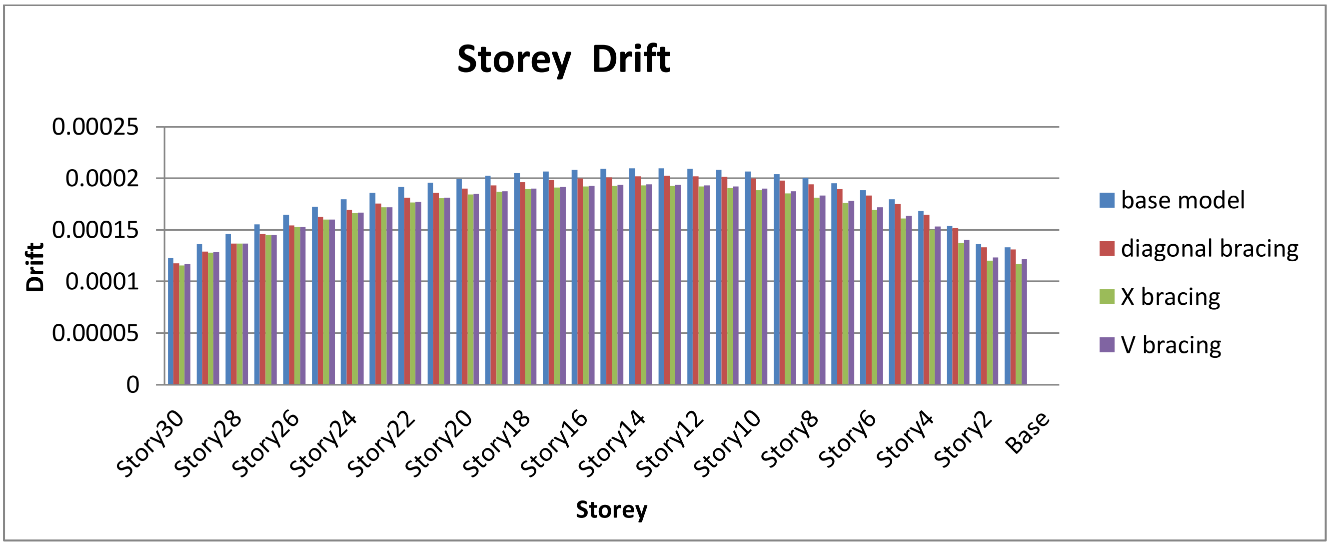

Fig 1.10 Graph showing comparison of storey drift in Y direction for different bracings

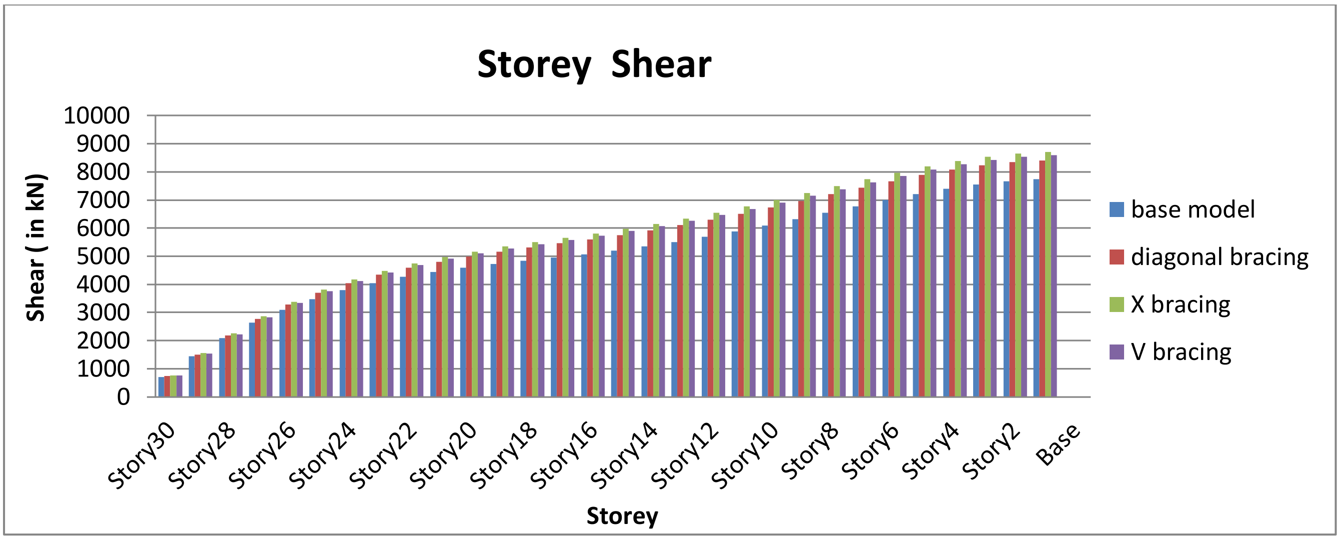

Fig 1.11 Graph showing comparison of storey shear in Y direction for different bracings

V. DISCUSSIONS AND CONCLUSION

1. Tube in tube structure with X bracings showed 11.18 % reduction in x direction and 7.55 % reduction in y direction in storey displacement. In case of storey drift 11.8 % reduction in x direction and 8 % reduction in y direction is observed in comparison with unbraced tube in tube structure.

2. In case of storey shear X bracings showed 15.6 % increment in x direction 7.55 % increment in y direction in comparison with unbraced tube in tube structure.

3. Tube in tube structure with V bracings showed 10.25 % reduction in x direction and 7 % reduction in y direction in storey displacement. In case of storey drift 10.88 % reduction in x direction and 7.8 % reduction in y direction is observed in comparison with unbraced tube in tube structure.

4. In case of storey shear V bracings showed 13.7 % increment in x direction 11.24 % increment in y direction in comparison with unbraced tube in tube structure.

5. Tube in tube structure with diagonal bracings showed 6.6 % reduction in x direction and 3 % reduction in y direction in storey displacement. In case of storey drift 6.62 % reduction in x direction and 3.4 % reduction in y direction is observed in comparison with unbraced tube in tube structure.

6. In case of storey shear diagonal bracings showed 10.2 % increment in x direction 8.7 % increment in y direction in comparison with unbraced tube in tube structure.

7. On comparing X bracing showed lesser values of storey displacement, storey drift than V bracing and diagonal bracing in x and y direction. In X bracing value of storey shear was more compared to V bracing and diagonal bracing in both x and y direction.

8. The storey drift and storey displacements values of braced structure was found to be lesser compared to unbraced structure.

9.The storey shear values of braced structure is greater compared to the storey shear values of unbraced structure and storey shear was maximum in X bracing which shows increase in stiffness of the building.

10.Tube in Tube structure with X Bracings showed better results. compared to diagonal and V Bracings.

11.In further studies time history analysis can be used to check the behaviour tube in tube structures with different bracings.

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