Comparative Study on Seismic Analysis of Multi Storied Buildings with Composite Columns

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Abstract: **Due to large population and small per capita area, need of tall buildings becomes more essential in the society. The limitations of the available land frequently restrict the freedom of an engineer to create a perfect structure. In such situations s the buildings will have to be designed in various shapes even with oblique corners so as to utilize the maximum benefits of available land. As earthquakes are one of the greatest damaging natural hazards to the building, the design and construction of tall structures which is capable of resisting the adverse effects of earth quake forces is the most important. Concrete-filled steel tubular columns have excellent earth-quake resistant properties such as high strength and ductility and large energy absorption capacity. The objective of this paper is to evaluate the comparison of composite columns with concrete filled steel tubeand composite encased I section column. This paper mainly emphasizes on structural behavior of multi-storey building for different plan configurations like Rectangular, C, L and H-shape with two different column property . It is also to compare and find which building with composite column is more effective against lateral loads.Modeling of 15- storey buildings are analysed using ETABS 2015. The results are tabulated, compared and final conclusions are framed. From the output of ETABS, various results are obtained. And these results are evaluated by preparing various graphs.**

Keywords: Concrete Filled Steel Tube , Encased I Section Column, Regular And Irregular Buildings, ETABS, Response Spectrum Analysis, Base Shear, Storey Drift, Storey Displacement

I.INTRODUCTION

Concrete Filled Steel Tubular (CFST) members utilize the advantages of both steel and concrete. They comprise of a steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. They are widely used in high-rise and multi storey buildings as columns and beam-columns, and as beams in low-rise industrial buildings where a robust and efficient structural system is required. There are a number of different advantages related to such structural systems in both terms of structural performance and construction sequence. The inherent buckling problem related to thin-walled steel tubes is either prevented or delayed due to the presence of the concrete core. Furthermore, The performance of the concrete in-fill is improved due to confinement effect exerted by the steel shell. The distribution of materials in the cross section also makes the system very efficient in term of its structural performance. The steel lies at the outer perimeter where it performs most effectively in tension and bending. It also provides the greatest stiffness as the material lies farthest from the centroid. Concrete Filled Steel Tube (CFST) Structural System high-strength concrete is used for filling steel tubes. These members are ideally suited for all applications because of their effective usage of construction material. CFST structure is a type of the composite steel-concrete structures used presently in civil engineering field. In this type of composite members, the advantages of both Hollow Structural Steel (HSS) and concrete is utilized. Due to excellent static and earthquake resistant properties of CFST,they are being used widely in real civil engineering projects. They possess properties such as high strength, high ductility and large energy absorption capacity. Concrete filled steel tubes (CFST) are also used extensively in other modern civil engineering applications.. Application of the CFST concept may lead to 60% total saving of steel in comparison to conventional structural steel system. Steel tubes were also used as permanent formwork and the well distributed reinforcement located at most efficient position. Due to large shear capacity of concrete filled steel tubular members, they predominantly fail in flexure in a ductile manner. Confinement effectiveness may be reduced to bit if rectangular or square tubes are filled up with high strength concrete but it provides advantage against flexure. A steel concrete composite column is a compression member, comprising either of a concrete encased hot rolled steel section or a concrete filled hollow section of hot rolled steel. It is generally used as a load bearing member in a composite framed structure. Composite columns with fully and partially concrete encased steel sections concrete filled tubular section are generally used in composite construction.

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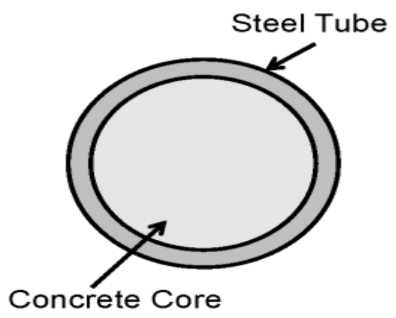

Fig 1: Concrete filled tube steel section column

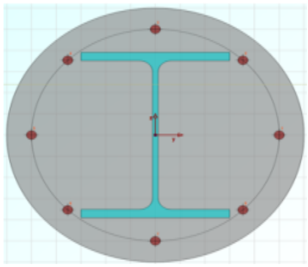

Fig 2: Composite encased I section Column

II. OBJECTIVES

- To evaluate the comparision of composite columns with concrete filled steel tubes and composite encased I section column
- To find the structural behavior of multi-storey building for different plan configurations like Rectangular, C, L and I-shape with two different composite columns
- To find out which building is performed good in each cases

III. LITERATURE REVIEW

Faizulla Z Shariff et al.(2015) presented a paper on "Comparative study on rcc and CFT multi-storied buildings" Use of composite material is of particular interest, due to its significant potential in improving the overall performance through rather modest changes in manufacturing and constructional technologies. Steel-concrete composite columns are used extensively in modern buildings. Extensive researches on composite columns in which structural steel section are encased in concrete have been carried out. In-filled composite columns, however have received limited attention compared to encased columns. In this study E-Tabs nonlinear software is used for simulation of steel concrete composite (CFT) with steel reinforced concrete structures (RCC) of G+14, G+19 and G+24 stories each are considered for comparative study. Comparison of parameters like base shear, axial force and bending moment is done.

S. Varadharajan et al.(2013) conducted a study on "Review of different Structural irregularities in buildings". The present study summarizes the research works done in the past regarding different types of structural irregularitiesi.e. Plan and vertical irregularities. Criteria and limits specifi ed for these irregularities as defi ned by different codes of practice (IS1893:2002, EC8:2004 etc.) have been discussed briefl y. It was observed that the limits of both Plan and vertical irregularities prescribed by these codes were comparable. Different types of modeling approaches used have also been discussed briefly. The review of previous research works regarding different types of plan irregularities justified the preference of multistorey building models over single storey building models and concept of balanced CV (Center of strength) – CR (Center of rigidity) location was found to be useful in controlling the seismic response parameters. Regarding the vertical irregularities it was found that strength irregularity had the maximum impact andmass irregularity had the minimum impact on seismic response. Regarding the analysis method MPA (Modal pushover analysis) method even after much improvement was found to be less accurate as compared to dynamic analysis.

Shilpa Sara Kurian et al.(2016) presented a paper on " Study On Concrete Filled Steel Tube" study is an attempt to understand the behavior of Concrete filled steel tubular column under axial load. A concrete-filled steel tubular (CFST) column is formed by filling a steel tube with concrete. It is well known that concrete-filled steel tubular (CFST) columns are currently being increasingly used in the construction of buildings, due to their excellent static and earthquake-resistant properties, such as high strength, high ductility, large energy absorption capacity, bending stiffness, fire performance along with favorable construction ability etc. Recently, the behavior of the CFST columns has become of great interest to design engineers, infrastructure owners and researchers, therefore to understand the load deformation characteristics of composite columns critically, numerical finite element analysis using software package ANSYS is carried out in this paper. This paper focuses on modeling of concrete filled steel tube (CFST) column under axial loading.

Wakchaure et al.(2012) presented a paper on "study of plan irregularity on high-rise structures" aims at studying description of different plan irregularities by analytical method during seismic events. In all the studied systems from which dual system is chosen for analysis and studying its effects on different irregularities in which analysis is based on the variation , with respect to structural systems. Analyses have been done to estimate the seismic performance of high rise buildings and the effects of structural irregularities in stiffness, strength, mass and combination of these factors are to be going to be considered. The work describes to the irregular plan geometric forms that are repeated more in the metro city areas such as Mumbai like T-section and Oval Shape plan geometry. These irregular plans were modelled in ETABS 9.7 considering 35 and 39 storied buildings, to determine the effect of the plan geometric form on the seismic behaviour of structures with elastic analyses. Also, effects of the gust factor are considering in T-shape and Oval Shape plans. Although these affects mainly on the architectural plan configuration, plan irregularity find

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better structural system solution such as dual system has been use for structural analysis. In structural configuration shear wall positions located are located in the form of core and columns are considered as gravity as well as lateral columns

Abhay Guleria et al.(2014) conducted a study on "Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations" The case study in this paper mainly emphasizes on structural behavior of multi-storey building for different plan configurations like rectangular, C, L and I-shape. Modelling of 15- storeys R.C.C. framed building is done on the ETABS software for analysis. Post analysis of the structure, maximum shear forces, bending moments, and maximum storey displacement are computed and then compared for all the analyzed cases. The analysis of the multi-storeyed building reflected that the storey overturning moment varies inversely with storey height. Moreover, L-shape, I-shape type buildings give almost similar response against the overturning moment. Storey drift displacement increased with storey height up to 6th storey reaching to maximum value and then started decreasing. From dynamic analysis, mode shapes are generated and it can be concluded that asymmetrical plans undergo more deformation than symmetrical plans.
All of the above journals have done their study by finding out displacement , story drift ,base shear ,axial force etc. A concrete-filled steel tubular (CFST) column is formed by filling a steel tube with concrete. It is well known that concrete-filled steel tubular (CFST) columns are currently being increasingly used in the construction of buildings, due to their excellent static and earthquake-resistant properties, such as high strength, high ductility, large energy absorption capacity, bending stiffness, fire performance along with favorable construction ability etc. So my aim is to compare the concrete filled steel tube column and Composite encased I section Column in different irregular rc buildings.

IV .METHODOLOGY

Methodology employed is response spectrum method

A. Modelling of Building

Here the study is carried out for the behaviour of G+15 storied R.C frame buildings with Rectangular,L shape,C shape,H shape plan. Floor height provided as 3m. And also properties are defined for the frame structure. 8 models are created in ETABS software with concrete filled steel tube columns and concrete filled encased I section columns in rectangular ,L shape, C shape ,H shape buildings . post analysis of the structure, maximum shear forces, bending moments, and maximum storey displacement are computed and then compared for all the analyzed cases. modelling of rcc frames includes an RCC framed structure is basically an assembly of slabs, beams, columns and foundation inter-connected to each other as a unit. The load transfer mechanism in these structures is from slabs to beams, from beams to columns, and then ultimately from columns to the foundation, which in turn passes the load to the soil. In this structural analysis study, we have adopted four cases by assuming different shapes for the same structure, as explained below.

1. Rectangular Plan
2. L-shape Plan
3. H-shape Plan
4. C-shape Plan

The Building is 42m x 25m in plan with columns spaced at 4m from center to center. A floor to floor height of 3m is assumed.The following models are created on ETAB ,plan and 3d view of rectangular,L shape ,C shape,H shape buildings are given below

B.ETABS

ETABS is a program for linear, nonlinear, static and dynamic analysis, and the design of building systems. From an analytical standpoint, multistoried buildings constitute a very special class of structures and therefore deserve special treatment. The concept of special program for building type structures was introduced over 40 years ago and resulted in the development of the TABS series of computer program. The input, output and numerical solution techniques of ETABS are specifically designed to take advantage of the unique physical and numerical characteristics associated with building type structures. As a result, this analysis and design tool expedites data preparation, output interpretation and execution throughput. The need for special purpose program has never been more evident as Structural Engineers put non-linear dynamic analysis into practice and use the greater computer power available today to create larger analytical models. Over the past two decades, ETABS has numerous mega-projects to its credit and has established itself as the standard of the industry. ETABS software is clearly recognised as the most practical and efficient tool for the static and dynamic analysis of multistoried frame and shear wall buildings

C. Building Plan Dimension Details

This analysis mainly deals with the study of a rectangular, L, C and H shaped plan using ETABS. A 42m x 25m 15-storeys structure modelled using ETABS. The height of each storey is taken as 3m, making total height of the structure 45m.

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PROPERTIES OF BUILDING	BUILDING WITH COMPOSITE COLUMNS OF CFST	BUILDING WITH COMPOSITE COLUMNS OF ENCASED I SECTION
MATERIAL PROPERTIES		
Grade of concrete	M-30	M-30
Gradeof reinforcing steel	Fe-415	Fe-415
Unit wt of concrete	25 kN/m^3	25 kN/m^3
SECTIONAL PROPERTIES		
Column type	Circular	Circular
Column size	D=800 & t=9mm	D=800 & t=9mm
Beam Size	ISWB600	ISWB600
BUILDING DETAILS		
No of bays in x direction	7	7
No of bays in y direction	5	5
Width of bay in x direction	6m	6m
Width of bay in y direction	5m	5m
Height of storey	3m	3m
Type of support	Fixed	Fixed
SEISMIC DATA		
Earthquake zone	III	III
Damping ratio	5%	5%
Importance factor	1	1
Type of soil	Medium soil	Medium soil
Response reduction factor	5(SMRF)	5(SMRF)
Poisson's ratio	0.15	0.15

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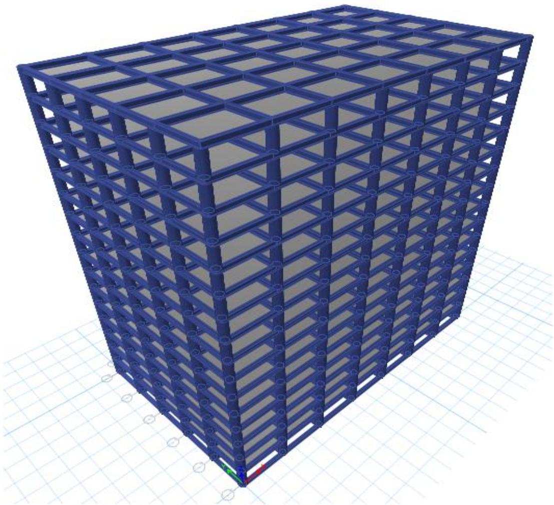

Fig 3: 3D view of rectangular building

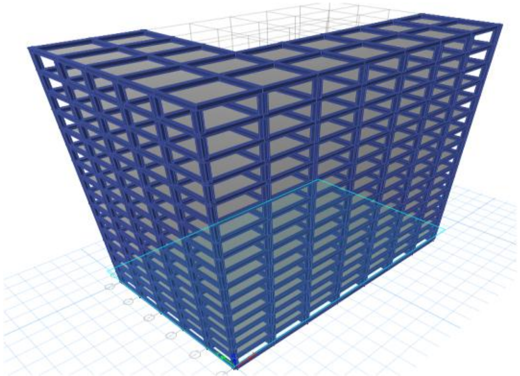

Fig 4: 3D view of L shape building

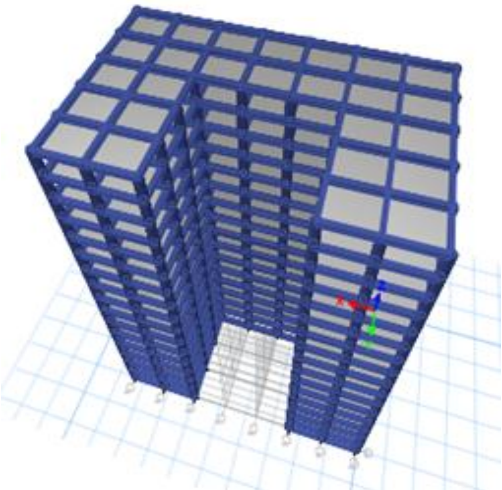

Fig 5: 3D view of C shape building

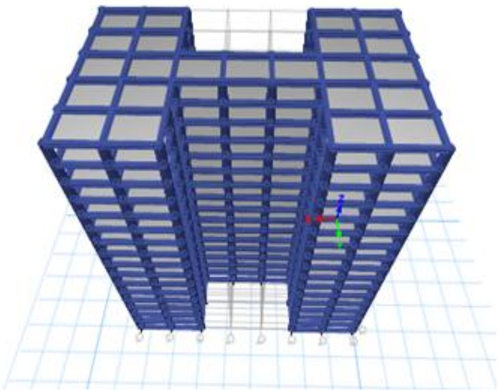

Fig 6: 3D view of H shape building

D. Load Formulation

Various types of load considered are discussed in succeeding sections.

- Dead load on each floor = 1.5 kN/m^2(IS :875 (Part 1) – 1987).
- Live load had been taken as 4 kN/m^2 (IS : 875 (Part 2) – 1987)
- Live Load at roof level =1.5 kN/m^2
- Seismic loads are calculated as per IS: 1893 (Part 1)- 2002.

E.Response Spectrum Analysis

The response spectrum represents an envelope of upper bound responses, based on several different ground motion records. For the purpose of seismic analysis, the design spectrum given in figure 1 of IS:1893 (Part 1): 2002 is used. This spectrum is based on strong motion records of eight Indian earthquakes. This method is an elastic dynamic analysis approach that relies on the assumption that dynamic response of the structure may be found by considering the independent response of each natural mode of vibration and then combining the response of each in same way. This is advantageous in the fact that generally only few of the lowest modes of vibration have significance while calculating moments, shear and deflections at different levels of the building.

VI.RESULTS AND DISCUSSION

A..Base Shear

The base shear at each storey level for both concrete filled steel tube column and encased I section column buildings of regular and irregular 15 storeys are obtained for both X and Y directions presented in charts by response spectrum analysis below.The maximum base shear values are plotted against number of storeys in X direction and Y direction

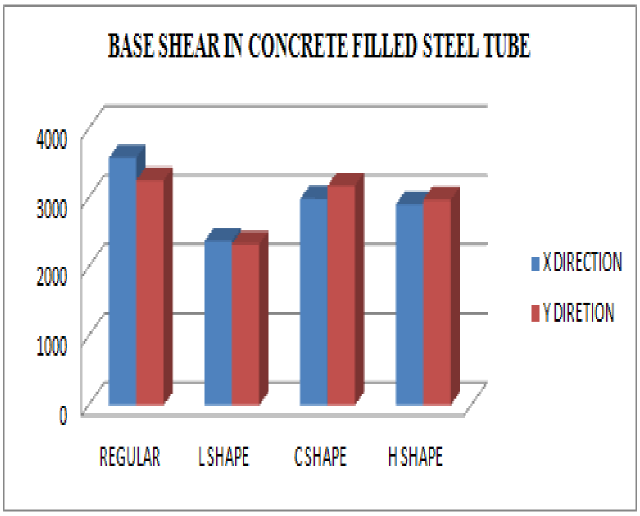

Fig 7:Base shear (kN) in CFST column

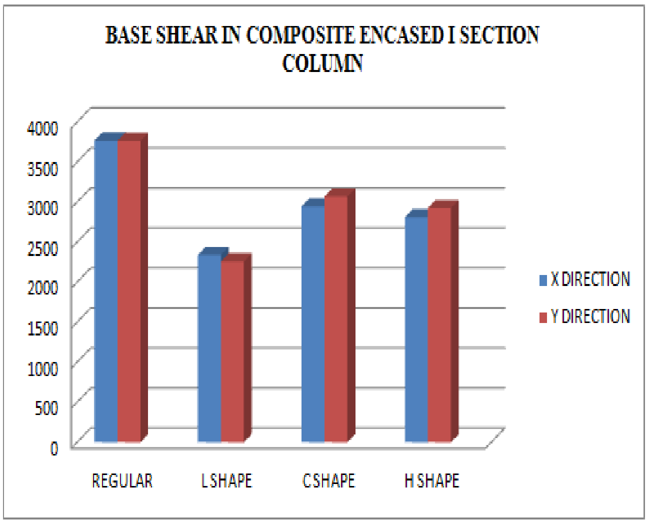

Fig 8:Base Shear in composite encased I section column(kN**)**

On the basis of base shear regular building with concrete filled steel tube is performed well.In irregular buildings concrete filled encased I section buildings are performed well in L then H and C shape buildings .It can be seen from above charts, In regular buildings base shear in case of concrete filled steel tube column is less compared to encased I section column. Storey shear value at base will be greater than that of top storeys. In regular buildings with Concrete Filled steel tube buildings show greater storey shear value when compared with other building.

B. Storey Drift

The maximum storey drift values are plotted against number of storeys in X direction and Y direction.

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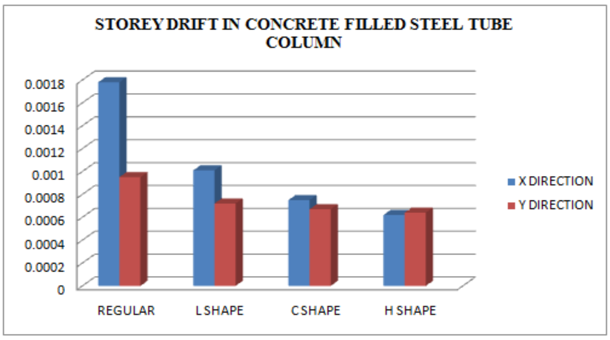

Fig 9 storey drift in concrete filled steel tube column

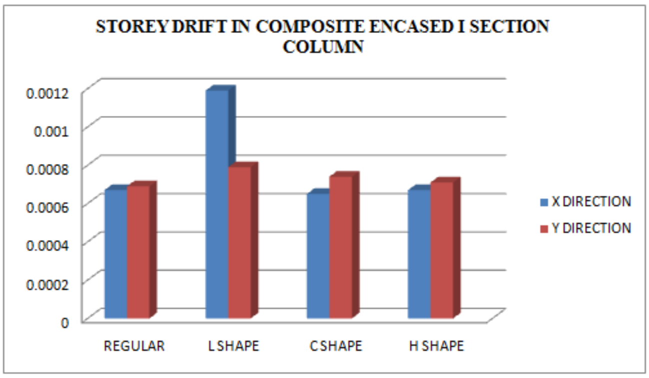

Fig 10 Storey drift in composite encased I section column(kN)

On the basis of storey drift regular building with concrete filled encased I section column is performed well, but in irregular buildings encased I section buildings are performed well in L shape building only and building with concrete filled steel tube column is performed good in H and C shape buildings

C. Storey Displacement

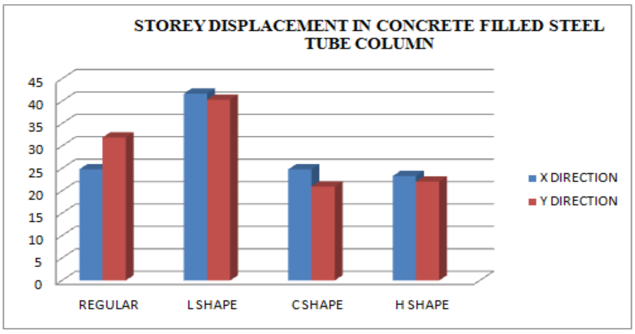

Fig 11 storey displacement in concrete filled steel tube column

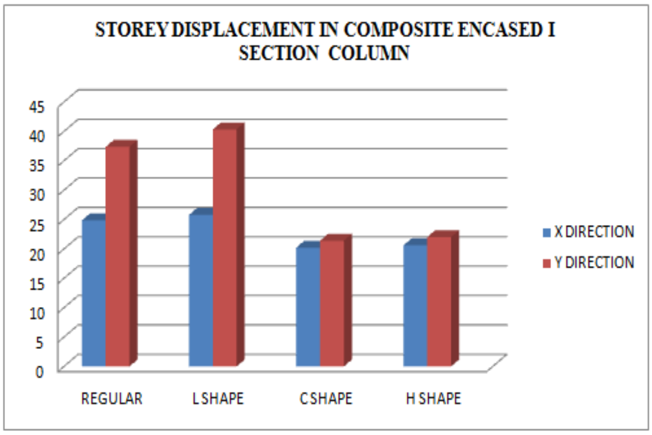

Fig 12.Storey displacement in composite encased I section column(kN)

VII. CONCLUSIONS

In the present study, an attempt is made to find which type of composite column is effective to resist lateral deformation in a multistoried building by Response Spectrum Analysis. The seismic analysis is carried out taking into consideration that all the buildings are located in zone III i.e. Thiruvananthapuram region as per code. The base shears, storey drift and storey displacement are plotted and compared for each model. The mode shapes corresponding to each time period are obtained.

The following conclusions are drawn based on the analysis:

- In case of G+15 regular building with concrete filled steel tube column is performed well in terms of base shear (percentage reduction of 4.9% in X direction and 13.64% in Y directions compared to concrete filled encased I section columns)and storey displacement (percentage reduction of 1.8% in X direction and 14.5% in Y directions compared to concrete filled encased I section columns) in both X and Y directions.But on the basis of storey drift ,regular building with concrete filled encased I section column performed well in X and Y directions, (percentage reduction of 6.17% in X direction and 27% in Y directions compared to concrete filled steel tube columns).
- In case of G+15 L shape building, on the basis of base shear building with concrete filled encased I section column is performed well in X and Y directions, (percentage reduction of 1.68% in X direction and 3.21% in Y directions compared to concrete filled steel tube columns) and storey displacement (percentage reduction of 3.8% in X direction and 4.9% in Y directions compared to concrete filled steel tube columns) in both X and Y directions.But on the basis of storey drift L shape building with concrete filled steel tube columns performed well in X and Y directions, (percentage reduction of 1.5% in X direction and 8.8% in Y directions compared to concrete filled encased I section columns).
- In case of G+15 C shape building,on the basis of base shear building with concrete filled encased I section column is performed well in X and Y directions, (percentage reduction of 1.5% in X direction and 3.36% in Y directions compared to concrete filled

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steel tube columns) and storey displacement (percentage reduction of 18.3% in X direction and 2% in Y directions compared to concrete filled steel tube columns) in both X and Y directions.But on the basis of storey drift L shape building with concrete filled steel tube columns performed well in X and Y directions, (percentage reduction of 1.3% in X direction and 16.8% in Y directions compared to concrete filled encased I section columns).

- In case of G+15 H shape building, on the basis of base shear building with concrete filled encased I section column is performed well in X and Y directions, (percentage reduction of 3.3% in X direction and 1.58% in Y directions compared to concrete filled steel tube columns) and storey displacement (percentage reduction of 11.5% in X direction and 1.3% in Y directions compared to concrete filled steel tube columns) in both X and Y directions.But on the basis of storey drift L shape building with concrete filled steel tube columns is performed well in X and Y directions, (percentage reduction of 7.4% in X direction and 5.6% in Y directions compared to concrete filled encased I section columns).

From the analysis result ,it was concluded that concrete filled steel tube columns performed better in regular buildings and composite column with encased I section columns performed well in irregular buildings.

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