

# Comparison of Seismic Behaviour of a Multi - Storey Structure with Different Shapes of CFST and Steel Column

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**ABSTRACT:** The present work seeks to investigate the seismic behavior of a typical ordinary moment resisting framed structure with composite columns and conventional Steel columns and examine the key design issues involved. The present study deals with seismic behavior of a typical (G+12) storied framed structure assessed through equivalent static method of analysis as per IS: 1893-2002 for moderate seismic zone III using ETABS software package. The analyses are performed on a suite of ordinary moment resisting framed 3D space models with different column types – Steel, and CFST. The analysis is carried out and the results are compared in terms of critical earthquake response parameters such as base shear, storey drifts, storey displacements, and storey stiffness.

**KEY WORDS:** CFST, Moment resisting framed structure

## I. INTRODUCTION

In recent days, due to the expansion of cities it is required to construct the high storey buildings. Composite buildings prove to be promising for multi storey building. As a result, composite columns have recently undergone increased usage throughout the world, which has been influenced by the improvement of high strength concrete enabling these columns to be considerably economized. The composite construction has been in practice since early nineteenth century but still it has not become a very common construction technique. 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. CFST columns are used in buildings, bridges, electric transmission lines and offshore structures due to their abundant properties. Steel sections with concrete infill are being widely used as structural members, since filling the steel section with concrete increases both its strength and ductility without increasing the section size. Many researchers found that the CFST column system has numerous advantages compared with the ordinary steel or the reinforced concrete system due to its high-strength, stiffness, ductility, and better seismic performance.

## II. RELATED WORK

Raghavendra Yadav et al.(2017) studied that one of the main problems that Civil Engineers face today is to construct a structure that has the ability to withstand heavy seismic forces with overall cost of construction being less. Composite construction is one of the methods that satisfy this requirement. Steel has excellent resistance to tensile loading while concrete is good in compression. Steel gives ductility to structure while concrete is resistant to corrosion. Composite construction uses the greatest possible advantages of both steel and concrete. In this paper a comparison of the seismic performance of a G+9 Storey reinforced concrete and composite building having same plan configuration located in seismic zone III is done. In the composite building the columns are made of concrete filled steel tube section (CFST). ETABS software is used for seismic analysis of the reinforced concrete and composite structures. The structural behavior of both the structures under equivalent static method is compared and the results show that composite structure performs better under seismic loading. Atul K Desai et al.(2017) presented a paper on “Comparative Performance Evaluation of Steel Column Building and Concrete Filled Tube Column Building under Static and Dynamic Loading” CFST (especially square) performed better in terms of lateral displacement and fulfils the serviceability criteria better than the steel frame for the selected study frame. A concrete-filled steel tubular (CFST)

column is formed by filling a steel tube with concrete. In this paper, an attempt has been made to check the feasibility of Concrete-Filled Steel Tube column in terms of both performance and cost. An actual building was selected as the study frame and designed for steel sections as per IS800:2007. All the Columns of the study frame were then replaced by equivalent Concrete-Filled Steel Tube columns (both square and circular). The seismic performance evaluation of both the frames was then carried out & compared. The seismic performance of the Concrete-Filled Steel Tube (CFST) column frame was found better than steel frame under both the static and dynamic loading and it also proved to be economical than the steel frame.

### III. OBJECTIVE

To find out the seismic behaviour of multi-storey framed structures with CFST and steel structures and to find out the economic cross section for CFST.

#### IV. SCOPE

- ❖ (G+12) framed multi-storey and concrete of grade M 30 and steel of grade Fe 250
- ❖ Analysis is carried out in zone III and Equivalent static lateral force method is used

### IV. METHODOLOGY

The methodology of this study includes:

1. Selection of geometry
2. Modelling of buildings
3. Analysis (equivalent static lateral force method)
4. Comparison (steel and CFST buildings)

The building considered here is a commercial building. The plan dimension is 35m x 25m. Floor height provided as 4 m. And also properties are defined for the frame structure.

The present work follows equivalent static method of analysis. The concept employed in equivalent static lateral force procedures is to place static loads on a structure with magnitudes and direction that closely approximate the effects of dynamic loading caused by earthquakes. Concentrated lateral forces due to dynamic loading tend to occur at floor and ceiling/roof levels in buildings, where concentration of mass is the highest. Thus, the greatest lateral displacements and the largest lateral forces often occur at the top level of a structure (particularly for tall buildings). These effects are modeled in equivalent static lateral force procedures by placing a force at each story level in a structure.

#### 4.1. MODELLING USING ETABS

ETABS is a programme for linear, nonlinear, static and dynamic analysis, and the design of building systems. From an analytical standpoint, multi-storeyed buildings constitute a very special class of structures and therefore deserve special treatment. The concept of special programmes for building type structures was introduced over 40 years ago and resulted in the development of the TABS series of computer programme. 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.

SL. NO.	Description of the model	
1	No. of Storey	G+9
2	Typical Floor height	3m
3	Ground Floor height	3m
4	Plan dimension	24 m x 24 m
5	Column	ISHB 400
6	Thickness of slab	150 mm
7	Steel grade	Fe 250
8	Concrete grade	M30
9	Live load on slab	1.5 kN/m <sup>2</sup> (On roof)
10	Seismic load	4 kN/m <sup>2</sup> (Intermediate floors)
11	Load Combinations	As per IS 1893:2002
12	Seismic Zone	Zone 3
13	Type of Soil	Medium Soil
14	Importance Factor (I)	1
15	Response Reduction Factor (R)	5
16	Plan area CFST	490000mm <sup>2</sup>

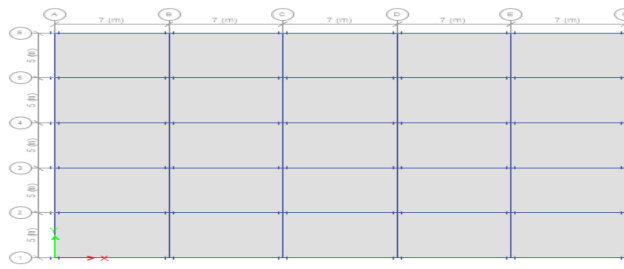


fig 5.1 Plan of the Building

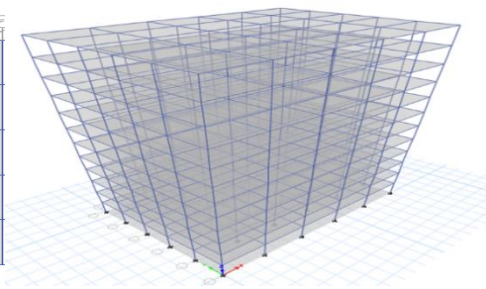


fig 5.2 3D Model of the Building

For the analysis, the dimension of column section considered for the composite structure is same as that in steel structure. The cross section of columns considered for the composite building having different shapes are shown below.

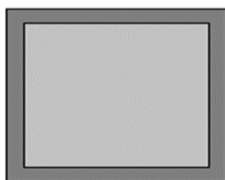


fig 5.3 Rectangular Steel Section Column

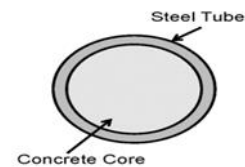


fig 5.4 Circular Steel Section Column

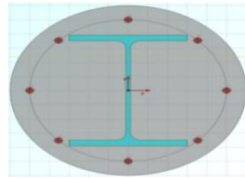


fig 5.5 Composite Encased I Section Column

#### 4.2 ASSIGNING LOADS

Dead load, live load, seismic load are assigned and their different load combination have been considered for the analysis. Live load on roof and intermediate floor is taken as 1.5 kN/m<sup>2</sup> and 4 kN/m<sup>2</sup> respectively. Seismic loads are calculated as per IS 1893: ( Part I ) - 2002

#### IV. RESULTS AND DISCUSSION

The results obtained on comparing parameters like Storey Drift, Storey Displacement, Storey Shear and Storey Stiffness for both steel and Composite structures are shown below in the form of graphs.

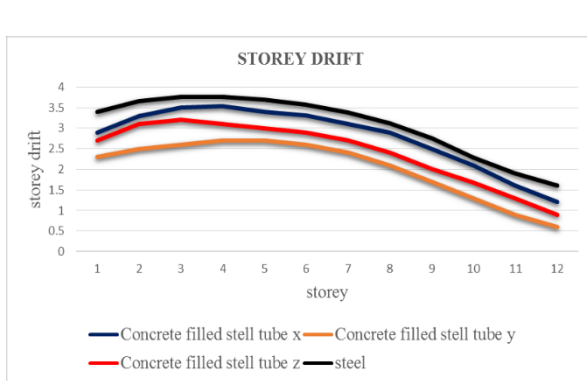


fig 6.1 Storey Drift

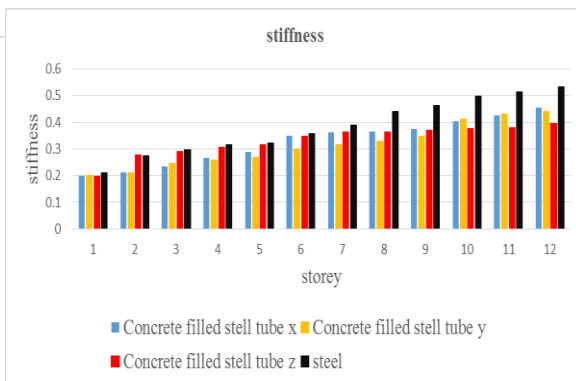


fig 6.2 Storey Stiffness

Composite structure having column drifts very much lesser when compared to steel structure. Hence, composite structure performs better in storey drift as compared to steel structure.

In case of storey stiffness compared to CFST, the stiffness of the steel increases gradually from ground floor due to the ductile behaviour of steel

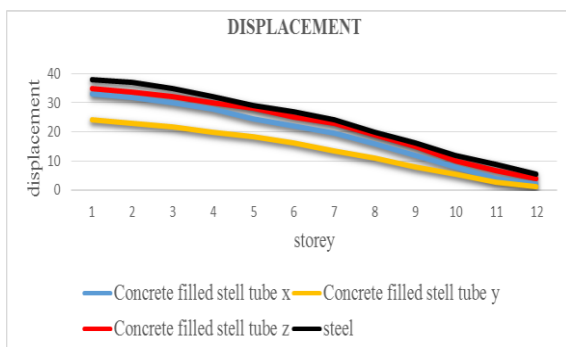


fig 6.3 Storey Displacement

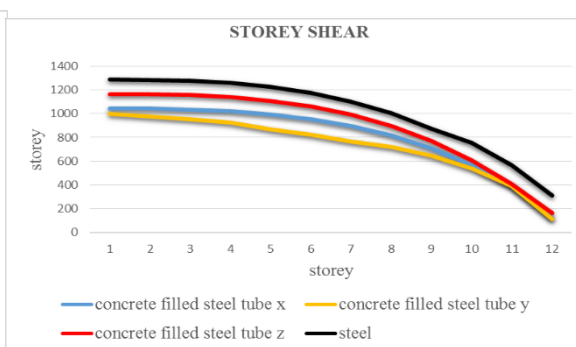


fig 6.4 Storey Shear

Displacement has reduced drastically in composite structure having CFST than steel structure. The reduction of storey displacement of composite structure results in increased stiffness. The structure having steel column has large storey displacement.

Storey shear in composite structure having lesser than in steel which is good for the structures located in seismic prone regions. For the analysis, the dimension of column section considered for the composite structure is same as that in steel structure.

## VII. CONCLUSIONS

The Composite structure having CFST column drifts very much lesser when compared to steel structure due to their excellent static and earthquake resistant properties. In case of storey stiffness, compared to CFST, the stiffness of the steel structure increases gradually from ground floor. Because the ductile behavior of steel is more than CFST. Also the displacement has reduced in composite structure compared to steel structure. The storey shear in composite is lesser than steel which is good for the structures located in seismic regions. From the results, it can be concluded that composite structure performs better under seismic loading compared to steel structure. Composite structures can be considered as an alternative to conventional structures in seismic prone regions. From the output composite column is more effective against lateral loads. Best cross section of CFST is “Concrete filled tube steel section”.

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