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Seismic Performance of Concrete Filled Steel Tubular Column Building

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***Abstract**: Steel-Concrete composite construction has become prevalent in recently due to their various benefits over conventional RC and steel construction. Concrete filled steel tubular members are the composite members which utilizes the advantages of both steel and concrete. This study aims at evaluation of seismic performance of concrete filled steel tubular column building by combined use of CFST columns along with RC columns. A G+30 storey residential building is analyzed by response spectrum method using software package ETABS 2015. Seismic response of building with peripheral CFST columns along with interior RC columns has been observed in this study. Results for building with conventional RC columns, building with circular CFST columns and building with peripheral CFST columns were compared in this study. It was concluded that, combined use of CFST columns and RC columns gives the midway results than that of conventional RC column building and CFST column buildings.*

***Keywords** -Composite column, Concrete-filled steel tubular column, Seismic performance, Time period*

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I. Introduction

Steel-Concrete composite construction has become popular in recent years due to their various advantages over conventional RC and steel construction. In urban areas, due to increased population and unavailability of land, engineers prefers to construct multistorey high-rise buildings. Concrete filled steel tubular members are the composite members which utilizes the advantages of both steel and concrete. They consist of hollow steel section of circular, square and rectangular shape filled with plain or reinforced concrete. The concrete-filled steel tubular (CFST) column offers various structural benefits such as high compressive strength, fire resistances, high ductility and effective energy absorption capacity.

The comparison of design codes for CFST columns shows that Brazilian code provides the most conservative design and Euro code shows values nearer to experimental results [1]. High rise SMRF with thin walled CFST columns are capable of improving collapse margin for more than 60% [2]. CFST columns are significant in load carrying capacity with small cross section as compared to Conventional RC concrete [3].CFST frame becomes economical when number of storey becomes greater than 15 storey [4].

According to research papers, CFST columns have good resistance against lateral load as well as axial load with higher ductility and energy absorption capacity. [5, 6]. Frames with CFST columns have better seismic performance as compared to conventional RC framed structure [7]. The cost of CFST framed structure is higher than RC framed structure but lower than steel framed structure [8].

In this study, detailed analysis of G+30 storey building with CFST columns of circular cross section placed at peripheral positions in plan is being carried out using Etabs 2015 to understand the behavior of structure subjected to earthquake and to check effective position of CFST columns.

II. Structural Modelling and Analysis

Plan of building for study of three systems viz. conventional RC column building, circular CFST column building and peripheral CFST column building was 17.1m X 19.1m as shown in Figure 1, Figure 2 and Figure 3. Beam size and column size considered for analysis are as given in Table 1. M1-RCC denotes building with conventional RC columns, M2-CCC denotes building with circular CFST columns and M3-PCC denotes building with peripheral CFST columns and interior RC columns.

Table 1 – Structural Member Sizes

Models	Beams		Columns		
	Secondary Beams	Primary Beams	Ground to 10th	11th to 20th	21st to 30th
M_1-RCC	250mm X 400mm	250mmX500mm, 250mmX650mm	400mmX800mm, 450mmX950mm	350mmX650mm 400mmX800mm	300mm X 450mm 350mm X 500mm
M_2-CCC	ISWB 150	ISWB 450, ISWB 500	CHS 355.6X12.5, CHS 406.4X10	CHS 355.6X8	CHS 244.5 X 8
M_3-PCC	ISWB 150	ISWB 450, ISWB 500	CHS 355.6X12.5, CHS 406.4X10, 450 mmX850mm	CHS 355.6X8, 350 mmX650 mm	CHS 244.5X8, 350 mmX500 mm

Following parameters were considered for analysis of G+30 storey building,

- Frame type - Special moment resisting frame
- Type of building – Residential
- Floor to floor height = 3.0 m
- Grade of concrete= M40
- Grade of Steel = Fe500
- Grade of structural steel = Fe 410
- Thickness of external and internal walls = 150 mm
- Slab thickness = 110 mm
- Deck slab thickness= 120 mm
- Corus profiled steel decking = ComFlor 46 [9]
- Shear Wall thickness = 250 mm
- Dynamic analysis method – Response spectrum analysis[as per clause 7.7.5 of IS 1893 (part 1) – 2016]

By using above data, the analysis of G+30 building was carried out. Also following are the loading conditions considered for the structure:

1.1Dead Load Conditions.

This includes the self-weight of all structural members along with partition walls. These calculations are considered as per IS 875 (Part – I) 1987.

1.2 Live Load Conditions

Live load conditions are considered according to IS 875 (Part 2) – 1987.

- Live load on passage/staircase = 3 kN/m^2
- Live load on roof = 1.5 kN/m^2
- Live load on other rooms = 2 kN/m^2

1.3 Seismic Load Parameters

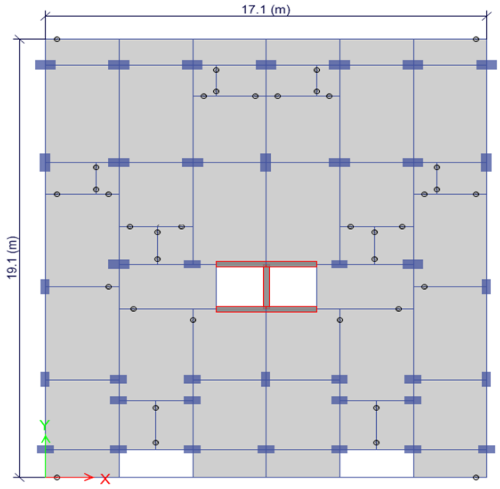
Seismic load parameters are considered according to IS 1893 (part1) – 2016. All models are analysed by Response spectrum method of Dynamic analysis.

- Zone - III
- Soil type - Medium soil [Clause 6.4.2, IS 1893 (Part I) – 2016
- Importance factor - 1.2 [Clause 7.2.3, Table 8, IS 1893 (Part – I) – 2016
- Seismic zone factor - 0.16 [Clause 6.4.2, Table 3, IS 1893(Part I) – 2016
- Damping ratio - 5 %

1.4 Wind Load Parameters

Following wind load parameters are considered for analysis of models. Wind load parameters are considered as per IS 875 (Part 3) – 2015.

- Basic wind speed = 44 m/s
- Terrain category = III
- Probability Factor k1 = 1
- Topography Factor k3 = 1
- Importance Factor k4 = 1



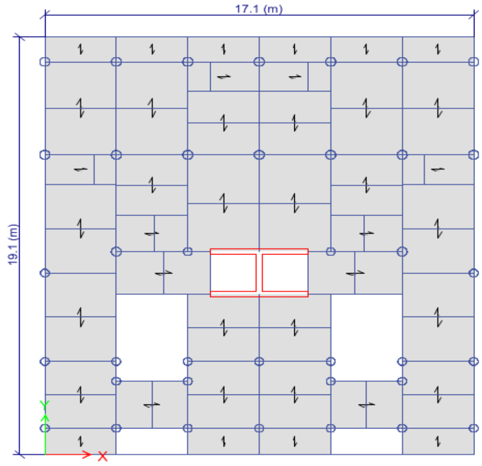


Figure 1- : Plan View of RC Building (M_1-RCC
Figure 2: Plan View of Building with circular CFST columns (M2-CCC)

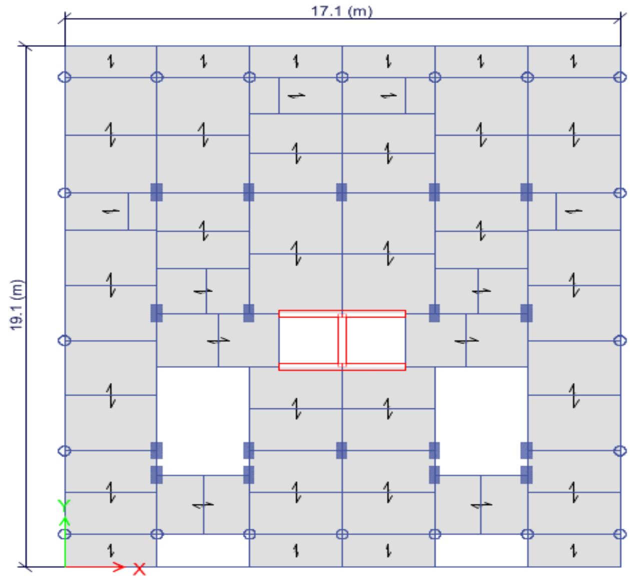


Figure 3: Plan View of Building with peripheral CFST columns (M3-PCC)

Figure 1 shows the plan view of G+30 storey building with conventional RC columns and Figure 2 shows the plan view of G+30 storey building with circular CFST columns. Figure 3 shows the plan view of G+30 storey building with peripheral CFST columns and interior columns as RC columns.

III. Results and Discussion

In this section, results are obtained under seismic conditions for conventional RC column building, building with circular CFST columns and building with CFST columns at periphery along with interior RC columns in the form of base shear, maximum lateral displacement and time period. Results obtained in present study are discussed. Also, results obtained for all six building models are compared.

3.1 Base Shear

Figure 4 shows the base shear of all three G+30 storey building models under seismic load in X and Y-direction. It is observed that, M1-RCC building shows maximum base shear as 1384.99 kN and 1445.15 kN in X and Y-direction respectively which is greater than M2-CCC and M3-PCC. M2-CCC building shows lower base shear and M3-PCC building shows intermediate base shear between M1-RCC and M2-CCC.

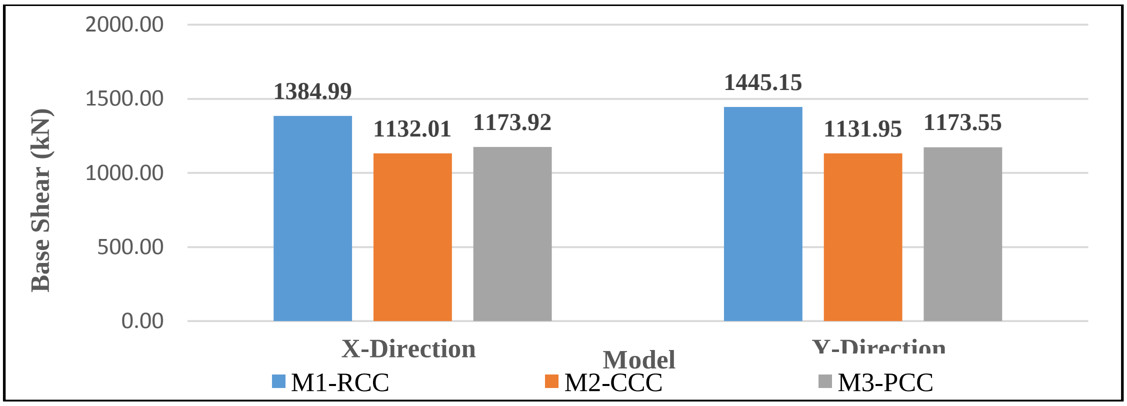


Figure 4: Comparison of base shear in X-direction

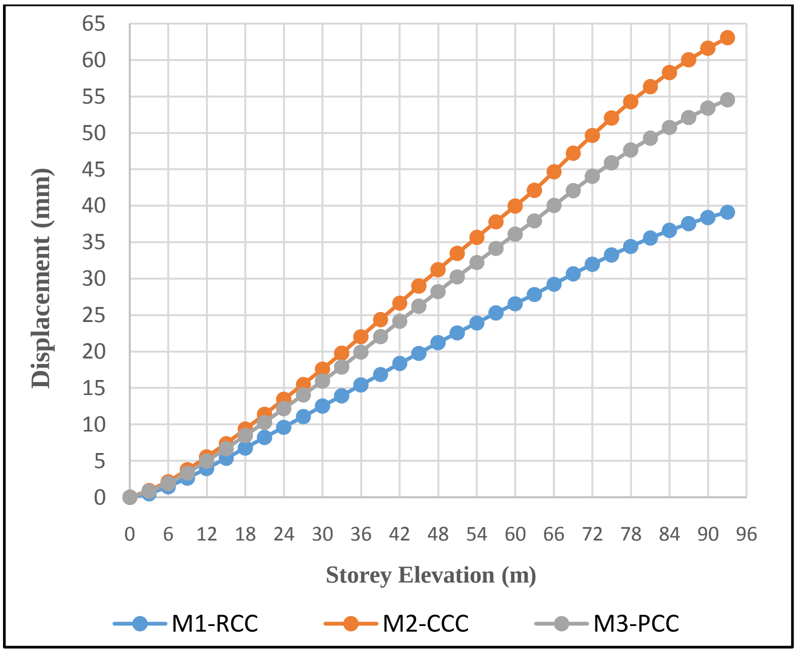


Figure 5: Maximum lateral displacement in X-Direction

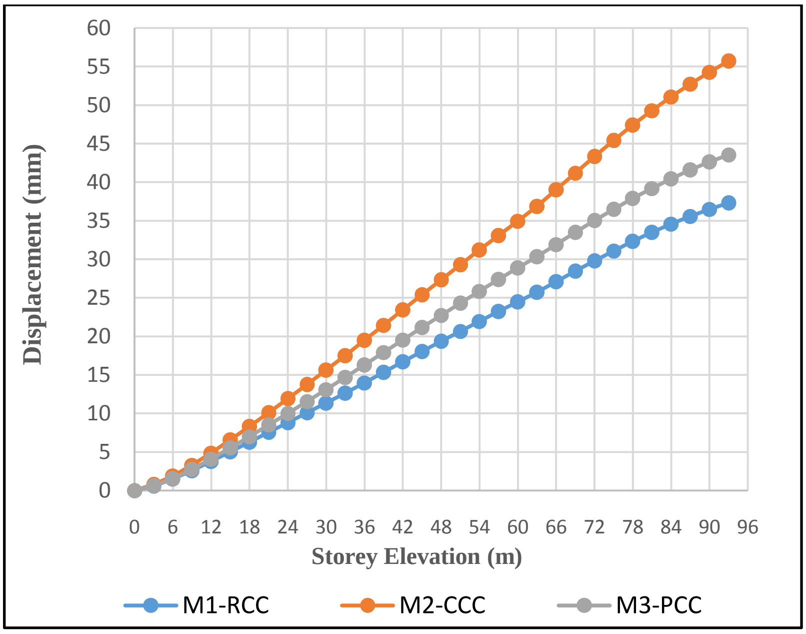


Figure 6: Maximum lateral displacement in Y-direction

3.2 Maximum Lateral Displacement

Figure 5 and Figure 6 shows the maximum lateral displacement for three building models of G+30 storey buildings under dynamic loading conditions in X and Y-direction. It is found that, M2-CCC building shows highest lateral displacement as 63.039 mm and 55.714 mm in X and Y-direction respectively. While M1-RCC building shows lower lateral displacement as 39.131 mm and 37.306 mm in X and Y-direction respectively. M3-PCC building shows intermediate base shear between M1-RCC and M2-CCC.

3.3 Time Period

Figure 7 shows the time period for three building models of G+30 storey buildings obtained by response spectrum method. From Figure 7 it is observed that, M2-CCC has highest time period as 4.91 sec and M3-PCC shows time period as 4.578 sec. M1-RCC building shows lowest time period as 3.568 sec.

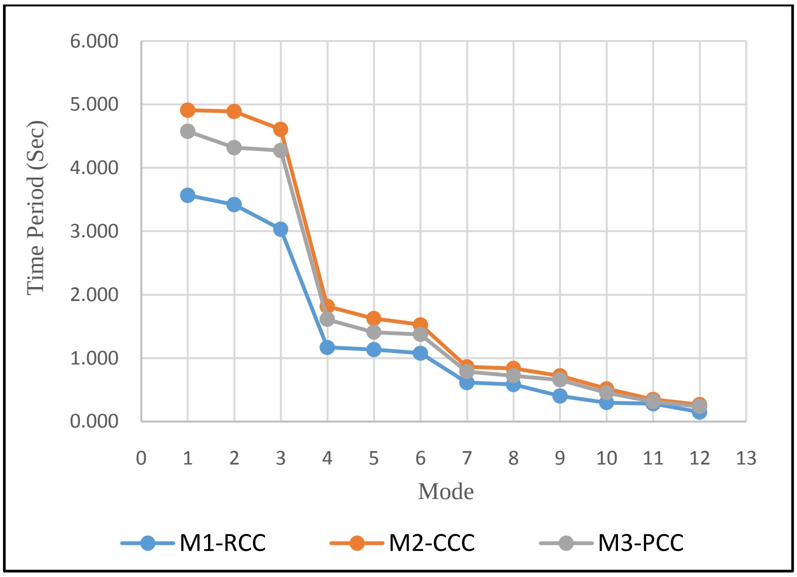


Figure 7: Comparison of time period

IV. Conclusions

1 Up to 20% and 14% reduction in base shear is observed in M2-CCC and M3-PCC as compared to M1-RCC. The use of steel beams, composite deck slabs and CFST columns in M2-CCC and M3-PCC reduces the self-weight of the structure as well as base shear.

2 Approximately 30% reduction in column sizes in M2-CCC and M3-PCC is found as compared to M1-RCC.

3 M2-CCC and M3-PCC shows 30% increase in lateral displacement as compared to M1-RCC. Use of CFST columns increases the ductility if the overall structure leading to rise in lateral displacement.

4 Rise in ductility increases the time period of M2-CCC building. Combined use of CFST and RC columns in M3-PCC leads to reduction in ductility of building as well as time period.

From the obtained results it can be concluded that, building with peripheral CFST columns and interior RC columns is the most suitable building model which provides the high resistance against seismic loading as well as economy due to combined use of RC columns with smaller section sizes.

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