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Seismic Response of Tall Buildings with Different Types of CFST Columns

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***Abstract*—Concrete filled steel tube columns are the columns in which concrete is filled into the steel tube. Concrete filled steel tube (CFST) is gaining more popularity in present time in construction area, mainly due to its simple construction sequence and superior structure performance. The concrete filled steel tube (CFST) members are ideally suited for all application because of their effective usage of construction material. In tall buildings these CFST columns performed excellently when building is subjected to lateral loading. In this paper we study the seismic behaviour of (G+19) storey tall building situated in Zone IV through Response spectrum analysis method using ETAB-2017 software. The main focus of the study is to evaluate the performance of building with CFST (concrete filled steel tube) columns under seismic loading considering two different models i.e RCC building with rectangular CFST columns and RCC building with circular CFST columns. For this analysis structural members considered in both models are of same cross section area and both structures are designed for same loading conditions. The main objective of this paper is to find out the best among the two considered sections of concrete filled steel tube(CFST) columns in terms of seismic response and compare their seismic parameters (stiffness, storey displacement etc)**

***Index Terms*— Concrete Filled Steel Tubular Column, Seismic Behavior, Response Spectrum Method, ETAB-2017**

1. INTRODUCTION

Construction of Tall Buildings has widely increased in the recent age due to deficiency of land. The design of such tall structures demand for large sized components, especially colums causing reduction in functional area of buildings which affects economy of construction due to higher dead loads. This problem can be minimized by replacing the RCC colums with CFST colums in RCC Structures. CFST column is a composite section formed by filling concrete into a hollow steel tube and it resists the applied load through the composite action of concrete and steel, concrete filled steel tubular (CFST) sections possesses high strength, high ductility, large energy absorption capacity, stiffness, fire performance along with easy construction ability etc. The main focus of the study is to evaluate and comparing the performance of buildings with Rectangular and Circular CFST columns (fig.1.1) under seismic and gravity loading. In this study, the finite element (FE) technique is used to investigate the seismic response of CFST column framed structure.

Fig.1.1 Types of CFST

2. OBJECTIVES OF WORK

- To study the seismic behaviour of Rectangular and Circular CFST columns in tall buildings.
- To evaluate the performance of different cross sections (Rectangular and Circular) and compare with the following seismic parameters i.e Time period, stiffness, storey drift, storey displacement.

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3. BUILDING DESCRIPTION

Commercial building with G+19 storey located in Zone IV are given below:

3.1. Geometrical Properties:

S.NO	Structural Part	Dimension
1.	Length in X-direction	25 m
2.	Length in Y- direction	20 m
3.	No. of bay in X-direction	5 No@5 m
4.	No. of bay in Y-direction	5 No@4 m
5.	Floor to floor height	3 m
6.	Total height of building	60 m
7.	Slab thickness	150 mm
8.	Rectangular column size	450x350mm
9.	Circular Column size	450 mm dia
10.	Beam size	350x250mm

3.2. Material Properties:

S. No	Material	Grade
1.	Concrete (column)	M30
2.	Concrete(slab)	M25
3.	Concrete (beam)	M25
4.	Rebar	Fe500
5.	Steel tube	Fe250
6.	Thickness of steel tube	15mm

3.3. Seismic Data (IS Code 1893: 2016 Part-1)

1.	Zone	IV
2.	Zone Factor	0.24 (clause 6.4.2)
3.	Damping ratio	5% (clause 7.2.4)
4.	Importance factor	1.2 (clause 7.2.3)
5.	Types of soil	Type(II) (clause6.4.2.1)
6.	Response reduction factor	5 (SMRF) (clause7.2.6)

3.4. Loading:

- Dead load-self weight of building
- Live load 4 KN/m^2 as per IS 875 Part II
- Earthquake load as per IS 1893:2016 Part-I

4. PROBLEM DESCRIPTION

- Model 1-Multistorey RCC building with Rectangular CFST columns.
- Model 2-Multistorey RCC building with Circular CFST column.

4.1 Plan Of Building For Different Models (Shown in figure 4.1 & figure 4.2)

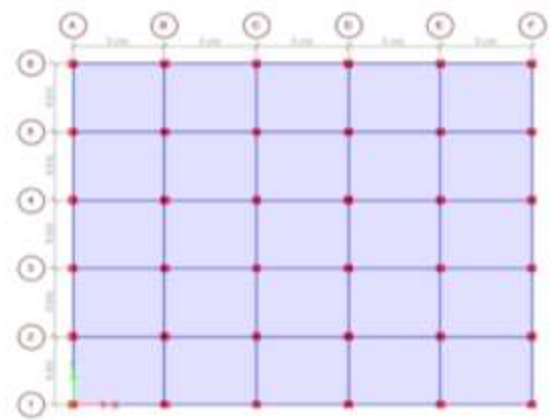

Fig.4.1 Building with Rectangular CFST columns

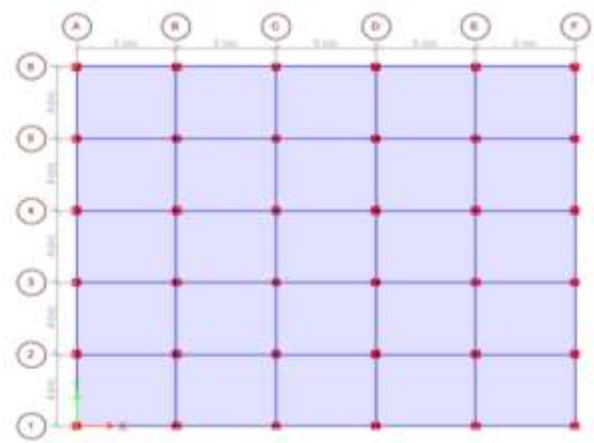

Fig.4.2 Building with Circular CFST columns

5. ANALYSIS AND RESULTS

Results obtained after the analysis of G+19 storey RCC building considering Rectangular and Circular CFST columns by response spectrum method are represented in the form of graphics and tables.

5.1 Natural Time Period-

Time period 'T' of a structure is the time taken by it to undergo one complete cycle of oscillation.

$$T=2\pi\sqrt{\frac{m}{k}}$$

The time period for both models is shown in **table 5.1** and the time period variation with different modes is shown in **fig.5.1**

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 4, Issue 6, June 2019

Table 5.1 Natural Time Period

Mode	Rectangular CFST	Circular CFST
1	4.765	4.547
2	4.482	4.251
3	4.007	3.917
4	1.563	1.487
5	1.469	1.39
6	1.315	1.284
7	0.906	0.857
8	0.848	0.798
9	0.764	0.746
10	0.625	0.587
11	0.587	0.549
12	0.526	0.512

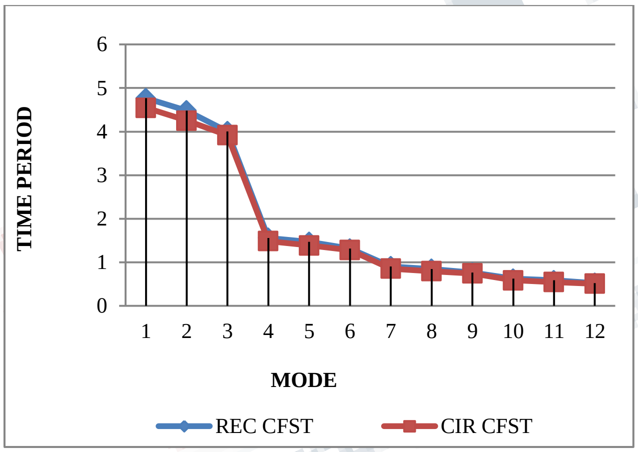

Figure 5.1 Variation of Natural Time Period

Natural time period is mainly proportional to the square root of stiffness. Maximum time period is observed in RCC building with Rectangular CFST columns and minimum value is observed in Circular CFST column building shown in **table 5.1** and corresponding graph shown in **fig 5.1.**

5.3. Storey Displacement

According to IS Code, allowable displacement is calculated as H/250, where 'H' is total height of storey above the ground level. The variation of storey lateral displacement for Rectangular CFST and Circular CFST column buildings are shown below in **table 5.2 and fig.5.2**

Table 5.3 Storey displacement

Storey	As per IS CODE (mm)	Rect. CFST (mm)	Circular CFST (mm)
1	12	4.97	4.254
2	24	14.316	12.568
3	36	24.905	22.183
4	48	35.849	32.214
5	60	46.873	42.357
6	72	57.87	52.489
7	84	68.776	62.541
8	96	79.53	72.453
9	108	90.069	82.165
10	120	100.322	91.613
11	132	110.214	100.725
12	144	119.659	109.424
13	156	128.565	117.624
14	168	136.834	125.234
15	180	144.36	132.158
16	192	151.03	138.29
17	204	156.728	143.527
18	216	161.34	147.769
19	228	164.786	150.953
20	240	167.127	153.145

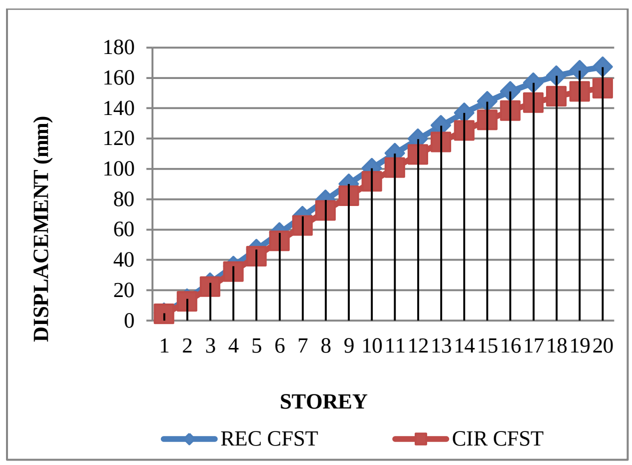

Fig 5.3 Storey displacement V/S Storey

Above figure shows that lateral displacement are minimum in building with Circular CFST column as compared to Rectangular CFST column building which indicates the stiffness of building with Circular CFST column is more.

5.4. Storey Drift

As per IS 1893:2016 (I) the storey drift should not be more than 0.004h, where 'h' is the storey height. The calculated storey drift is given in **table 5.4** and variation of storey drift shown in **fig. 5.4.**

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Table 5.4 Storey drift

Storey	As per IS CODE(mm)	Rect. CFST (mm)	Circular CFST(mm)
1	12	4.97	4.254
2	12	9.346	8.314
3	12	10.589	9.616
4	12	10.943	10.03
5	12	11.024	10.143
6	12	10.998	10.132
7	12	10.906	10.052
8	12	10.754	9.912
9	12	10.539	9.712
10	12	10.254	9.448
11	12	9.891	9.112
12	12	9.445	8.698
13	12	8.907	8.2
14	12	8.269	7.61
15	12	7.526	6.923
16	12	6.67	6.133
17	12	5.697	5.237
18	12	4.613	4.242
19	12	3.446	3.184
20	12	2.342	2.192

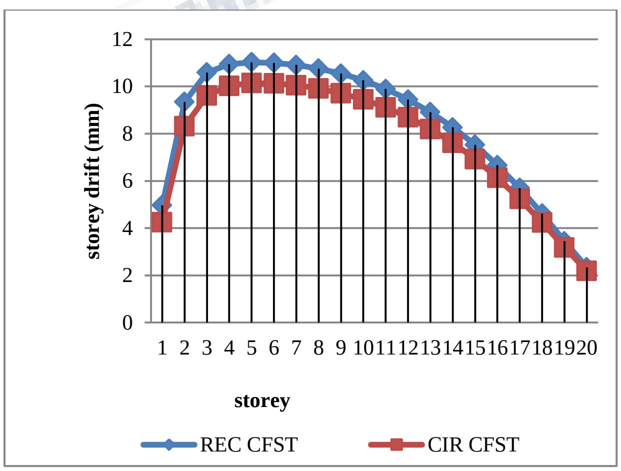

Figure5.4 Variation of storey drift

Above shows that the storey drift are minimum in building which is provided with Circular CFST columns as compared to Rectangular CFST building.

5.5. Storey Stiffness

Stiffness refers to the rigidity of a structural element.

Table5.5 Storey Stiffness

Storey	Rec CFST(KN/m)	Cir CFST(KN/m)
1	499145.8	595799.688
2	266371.2	305415.971
3	234585.9	263015.63
4	225760.3	250389.923
5	222706.5	245883.883
6	221538.9	244304.316
7	220797.2	243506.486
8	219815	242443.798
9	218599.3	241057.878
10	217587	239946.759
11	217057.6	239528.159
12	216699.9	239397.674
13	215900.4	239114.526
14	214494.2	238711.13
15	214417.8	238487.557
16	214416.6	237227.033
17	213225.3	236381.05
18	213216.3	235943.429
19	206686.8	229939.739
20	163947.8	179969.26

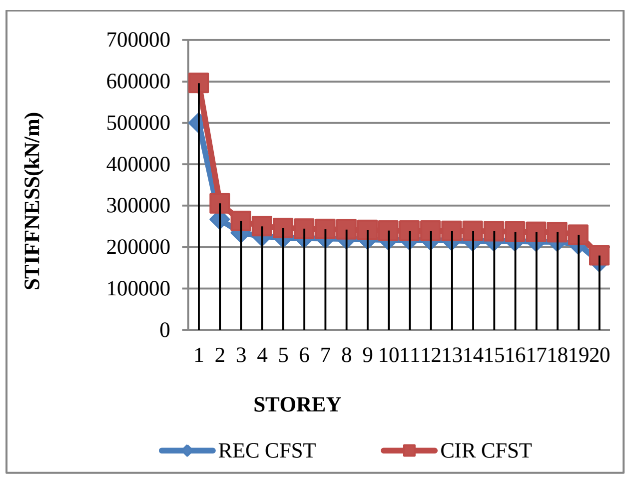

Figure 5.5 Variation of storey stiffness

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 4, Issue 6, June 2019

From above **table 5.5** and corresponding **fig 5.5**, we can conclude that model 2 i.e Circular CFST column building is more stiffer than Rectangular CFST column building.

6. CONCLUSIONS

Following conclusions are drawn from analysis of G+19 storey RCC building considering Rectangular and Circular CFST columns.

1- The natural time period value of the building with Circular CFST columns reduces by 5% compared to building with Rectangular CFST column which indicates that model-1 building provided with Rectangular CFST column is more flexible.

2- The Storey Displacement value of the building with Circular CFST columns reduces by 8.37% compared to building with Rectangular CFST columns. This indicates that the building becomes more stiffer when provided with Circular CFST columns.

3- The Storey Drift value of the building with Circular CFST columns reduces by 15% compared to building with Rectangular CFST columns.

4- The Storey Stiffness value of the building with Circular CFST columns increases by 19.37 % compared to building with Rectangular CFST columns. Hence, building with Circular CFST columns is less prone to damages.

Circular CFST Building is found to Perform Better than Rectangular CFST Column Buildings Mainly Due to Higher Moment of Inertia and Confining Effect in Circular CFST column as Compared with Rectangular CFST column.

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