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Comparative Analysis of CFST and RCC Structures Subjected to Seismic Loading

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Abstract : 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.
Keywords : Composite; CF Seismic Analysis; Drift; Equivalent Static Analysis.

1.0 Introduction

The composite construction has been in practice since early nineteenth century but still it has not become a very common construction technique. It also has a lot of advantages over our traditional construction techniques[1,2]. The main reason for this is lack of knowledge on its behavior and construction techniques. Codes like AISC, 2005; ACI-318, 2008; EC-4, 2004; AIJ, 2001 provide information on their design but still certain details are lacking. Many research works have been done experimentally in case of encased columns but CFST sections have gained little attention. Their behavior in a structure should be studied. This paper thus focuses on a comparative analysis of a conventional (G+9) storey reinforced concrete structure with a composite structure having CFST columns subjected to seismic loading. It is performed using ETABS software.

The concrete filled steel tube sections have a lot of advantages. The steel provides a permanent formwork for concrete. The confinement effect in these sections also helps the concrete to attain increased strength[3,4]. In this paper circular concrete filled steel tube section is chosen because it gives highest confinement effect compared to rectangular and square concrete filled steel tube sections. Fig 1 shows a concrete filled steel tube.

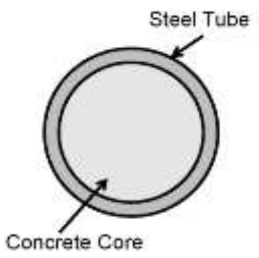

Fig-1 Concrete filled steel tube section

2.0 Methodology

In this study the seismic analysis for a G+9storey structure is performed for both R.C.C and composite structures using ETABS software. The structure is located in Coimbatore of seismic zone III. The plan dimensions of the structure are 42m X 24m. Equivalent static method of analysis is performed as per IS 1893[5,6]. After analysis the seismic performance of both the structures are compared from the results using ETABS software.

2.1 Modeling in ETABS

A 3-D model of the structure analyzed drawn in ETABS is shown in figure 2. The following table gives the details used in modeling of the R.C.C and Composite structures.

Table 1 Modelling Details

	RCC Building	**CFT Building**
MATERIAL PROPERTIES		
Grade of Concrete [fck]	M30	M30
Grade of Reinforcing Steel [fy]	Fe 415	Fe 415
SECTIONAL PROPERTIES		
Column size	D=750mm	D=800mm t=9mm
Beam size	550x250mm	ISMB 250
Slab thickness	150mm	150mm
LOAD ASSIGNMENT		
Live Load on roof slab	1.5 KN/m	1.5 KN/m
Live Load on floor slab	3KN/m	3KN/m
Floor finishing	1 KN/m	1 KN/m
SEISMIC DATA		
Seismic Zone	III	III
Importance Factor	1.5	1.5
Zone Factor	0.16	0.16
Soil Type	Medium Soil	Medium Soil
Response Reduction Factor	3	3

Using the above details the model was formed in ETABS. Both R.C.C and Composite structures were modeled as per codal provisions. The composite structure was designed as per AISC Standards. The R.C.C structure was designed as per IS 456:2000[7,8]. The seismic design was performed based on IS 1893. Same grid for both structures as per plan was formed. After analysis data like Storey Drift, Storey Shear, Storey Stiffness and Storey Displacement were obtained and the results were tabulated and graphs were plotted for comparison of seismic performance of both Composite and R.C.C Structures[9,10,11].

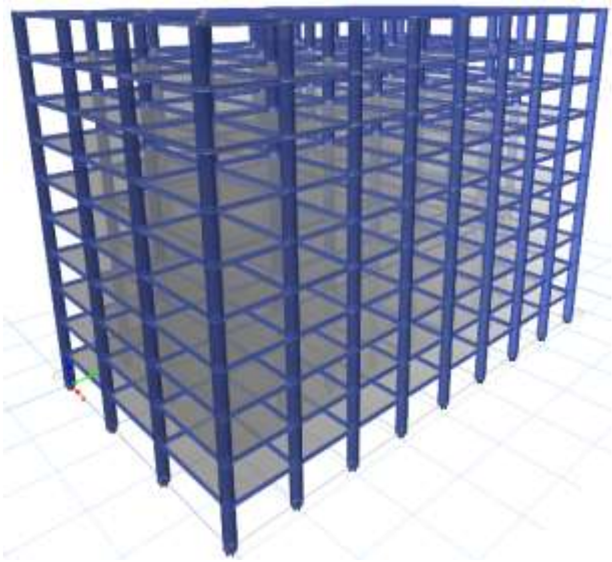

Fig.2 3 D view of the Structure

3.0 Results and Discussion

The results obtained on comparing parameters like Storey Drift, Storey Displacement, Storey Shear and Storey Stiffness for both R.C.C and Composite structures are shown below in tables and graphs.

3.1 Storey Drift

The Storey drift at each storey level for both R.C.C and Composite structures in X direction are presented below

Table 2 Drift in X direction

Storey	R.C.C x 10^{-3} mm	Composite x 10^{-5} mm
9	0.23	0.2
8	0.36	0.3
7	0.48	0.3
6	0.57	0.4
5	0.65	0.4
4	0.7	0.4
3	0.74	0.5
2	0.79	0.4
1	0.92	0.4
Base	1.3	0.2

The above results can be depicted in the form of graph as in figure 3

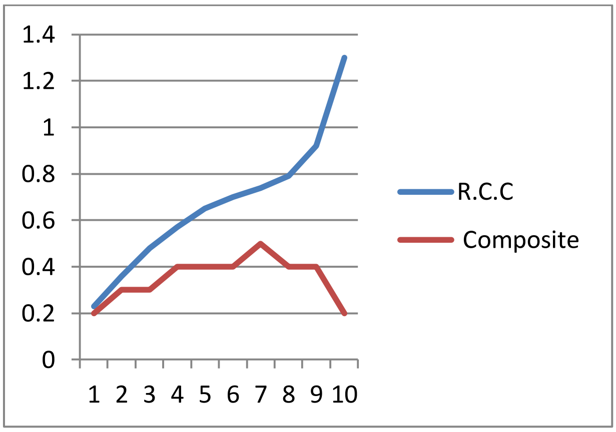

Figure 3 Storey Drift in X direction

The Storey drift at each storey level for both R.C.C and Composite structures in Y direction are presented below.

Table 3 Drift in Y direction

Storey	R.C.C x 10^{-3} mm	Composite x 10^{-5} mm
9	0.41	0.4
8	0.6	0.4
7	0.8	0.5
6	0.98	0.5
5	1.12	0.6
4	1.23	0.6
3	1.33	0.6
2	1.44	0.6
1	1.67	0.6
Base	2.17	0.3

The above results can be depicted in the form of graph

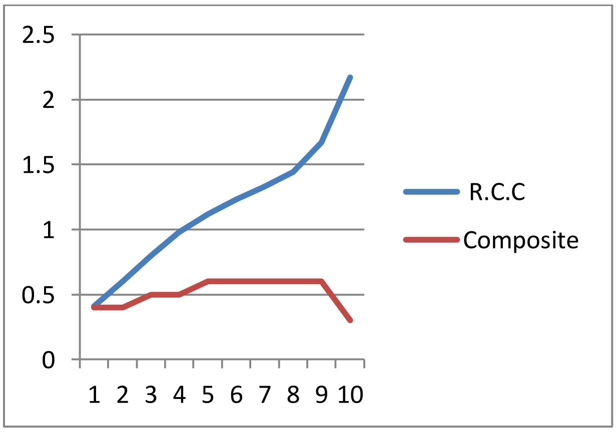

Figure 4 Storey Drift in Y direction

3.2 Storey Displacement

The Storey Displacement at each storey level for both R.C.C and Composite structures in X direction are presented below

Table 4Displacement in X direction

Storey	R.C.C mm	Composite x 10^{-2} mm
9	20.96	10.7
8	20.25	10
7	19.15	9.2
6	17.68	8.3
5	15.91	7.2
4	13.91	5.9
3	11.74	4.6
2	9.45	3.1
1	7.01	1.8
Base	4.19	0.6

The above results can be depicted in the form of graph

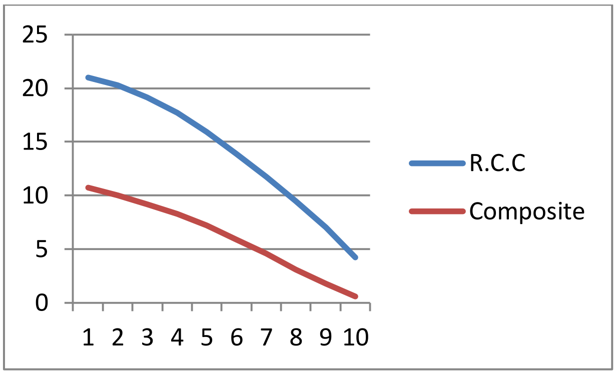

Figure 5 Storey Displacement in X direction

The Storey Displacement at each storey level for both R.C.C and Composite structures in Y direction are presented in table 5. From storey displacement of both the R.C.C and composite structures it is found that the storey displacements in case of composite is less compared to R.C.C structure.

Table 5 Displacement in Y direction

Storey	R.C.C mm	Composite x 10^{-2} mm
9	36.35	15.2
8	35.09	14
7	33.22	12.8
6	30.73	11.3
5	27.7	9.7
4	24.24	7.9
3	20.43	5.9
2	16.32	4
1	11.86	2.2
Base	6.73	0.8

The above results can be depicted in the form of graph

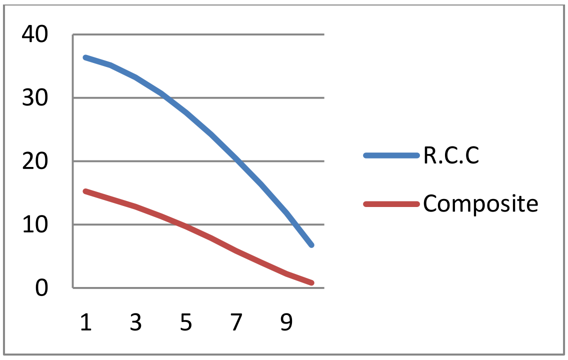

Figure 6 Storey Displacement in Y direction

3.3 StoreyStiffness

The Storey stiffness at each storey level for both R.C.C and Composite structures in X direction are presented below

Table 6Storey stiffness in X direction

Storey	R.C.C x 10^6 KN/m	Composite x 10^6 KN/m
9	1.059	0.111
8	1.326	0.208
7	1.372	0.267
6	1.39	0.306
5	1.381	0.336
4	1.376	0.37
3	1.362	0.417
2	1.311	0.5
1	1.143	0.685
Base	0.776	1.403

The above results can be depicted in the form of graph as below

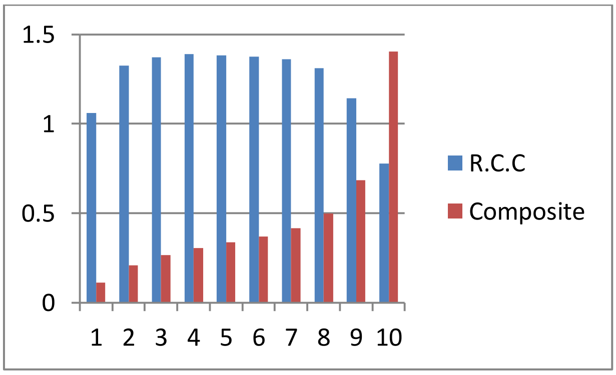

Figure 7 Storey Stiffness in X direction

The Storey stiffness at each storey level for both R.C.C and Composite structures in X direction are presented below

Table 7Storey stiffness in Y direction

Storey	R.C.C x 10^6 KN/m	Composite x 10^6 KN/m
9	0.591	0.065
8	0.781	0.127
7	0.81	0.172
6	0.808	0.204
5	0.797	0.233
4	0.783	0.265
3	0.76	0.309
2	0.716	0.382
1	0.628	0.541
Base	0.483	1.14

The above results can be depicted in the form of graph as below

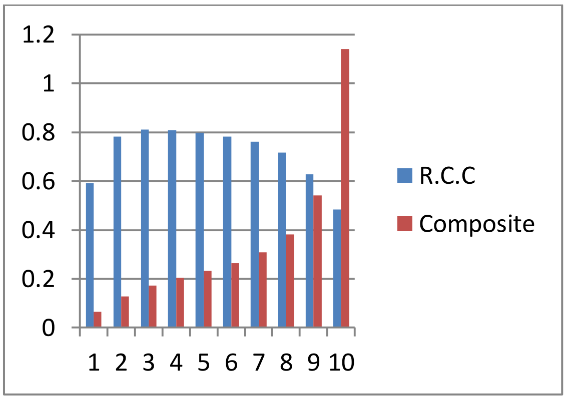

Figure 8 Storey Stiffness in Y direction

3.4 Storey Shear

The Storey Shear at each storey level for both R.C.C and Composite structures are presented below

Table 8Storey Shear

Storey	R.C.C KN	Composite KN
9	746.89	0.7354
8	1456.23	1.6123
7	2016.7	2.4892
6	2445.801	3.3661
5	2761.06	4.2429
4	2979.99	5.1198
3	3120.11	5.9967
2	3198.92	6.8736
1	3233.95	7.75
Base	3242.71	8.6274

4.0 Conclusion

The Composite structure drifts very much lesser when compared to R.C.C structure[12,13]. Also the displacement has reduced drastically in composite structure compared to R.C.C structure. In case of storey stiffness, compared to R.C.C the stiffness of the Composite increases gradually from ground floor.From the results it can also be inferred that storey shear in composite is very much smaller than in R.C.C structure. From the results it can be concluded that composite structure performs better under seismic loading compared to R.C.C structure. It can be considered as an alternative to conventional structures in seismic prone regions.

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