ISSN:2348-2079

Volume-5 Issue-1

International Journal of Intellectual Advancements and Research in Engineering Computations

Analytical investigation on RCC and steel-concrete composite multistorey building

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Abstract: **Steel-concrete composite systems for buildings are formed to act as a single unit by connecting the steel beam to the composite deck slab or profile deck sheet with the help of shear connectors. For the cases of high rise building RCC building is found no longer economical due to its larger dead load, lower stiffness and poor performance in Earthquake conditions.**

In this paper, G+9 multistorey building is modelled and analysed using ETABS-2016 under Seismic Zone 3 and Seismic Zone 4. Three different types of model is made in this research one for RCC, and remaining two for Steel Concrete Composite Structure with two different types of columns such as encased column and Concrete filled tubes. Comparison of parameters like Joint displacement, Story drifts and Story Shear is carried over and results are being compared.

Keywords: **ETABS-2016, Profile deck sheet, Joint displacement, Story drifts, Story Shear**

I.INTRODUCTION

In recent days, Steel concrete construction have been become quite popular due to its various advantages. It takes an advantage of Steel and Concrete together, as Steel is rich in tension and concrete is rich in compression .In the area of urban region to overcome the growing population Medium to High rise building is the only option. However, RCC building is superior for low rise building but in cases of high-rise building Steel Concrete Composite building were the greater option because of its lesser dead load, increased room size and speedy construction.

A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel. Formwork for the columns is not necessary by using concrete filled tubular section. The load carrying capacity of composite columns is more than that of the bare reinforced column and the structural steel column included in the system.

II.ELEMENTS OF COMPOSITE STRUCTURE

1) Steel Concrete Composite Deck Slab:

It comprises of profile steel deck which act as the permanent formwork as well as the transverse reinforcement.Embossments are provided in order to make bond between the concrete and the profile sheet deck.

2) Composite Beam:

Steel Concrete Composite beam is generally of structural steel member over the concrete slab or profile deck slab is placed. Shear connectors provides the adequate connection to the slab and the structural steel.

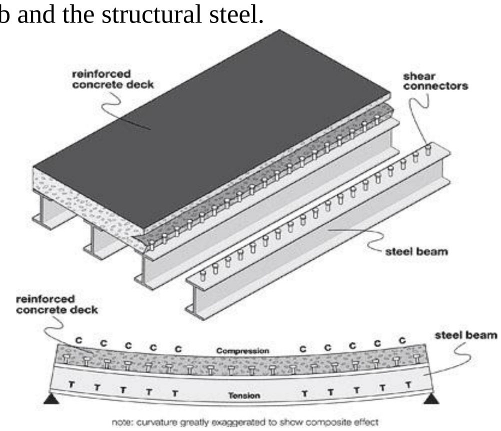

Fig. 2.2 Typical Composite beam

C) Composite column:

The Steel Concrete Composite Column is a compression member by which the steel element is a structural member. There are three types of composite columns used in practice which are Concrete Encased, Concrete filled, Battered Section.

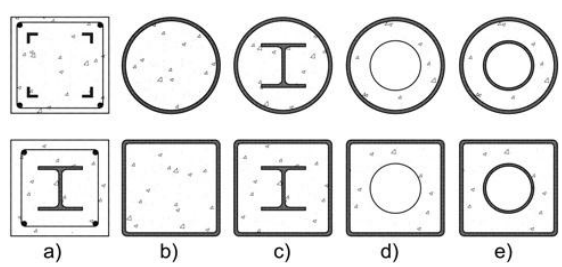

Fig. 2.3 Various types of composite columns: concrete encased steel (CES) (a), CFST (b), combination of CES and

CFST (c), hollow CFST sections (d) and double skin sections (e).

III. STRUCTURE DETAILS

The building considered here is a commercial building. The plan dimension is 20mx20m. The study is carried out on the same building plan and of same storey height for RCC and Steel Concrete Composite building with Encased Column and with Filled Tubes under Seismic Zone 3 and Seismic Zone 4. The basic loading on all types of structures are kept same.

A. Structural Data For R.C.C Building & Steel-Concrete Composite Building.

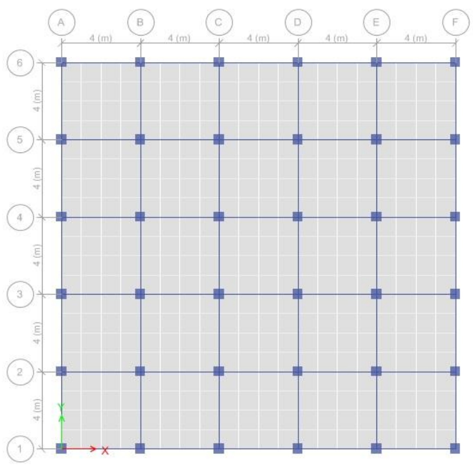

Fig. 3.1Plan for R.C.C building

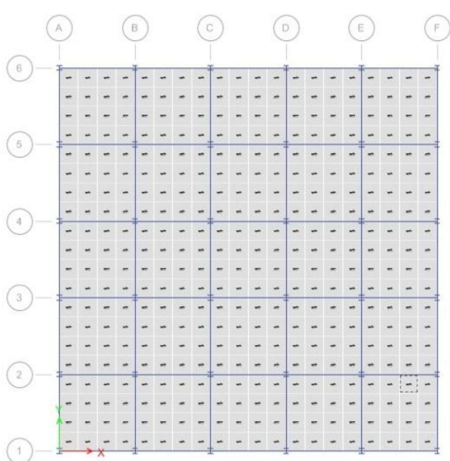

Fig. 3.2 Plan for Composite Encased Column building

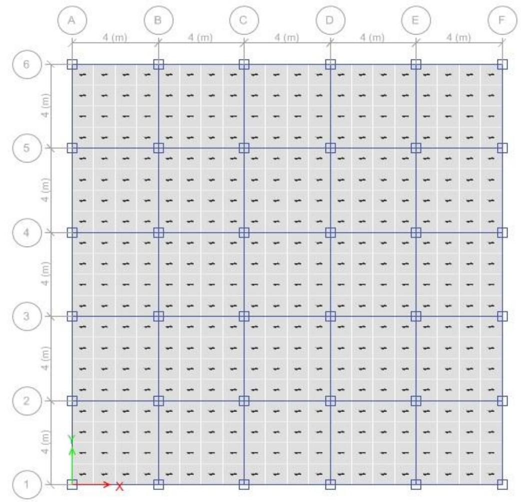

Fig. 3.3 Plan for Composite Filled Tube building

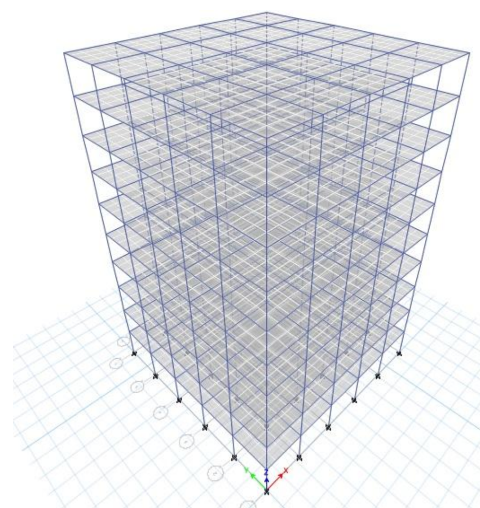

Fig3.2 Model of building

Table 1: Description of the RCC model

SI. NO.	Description of the RCC model	
1	No. of Storey	G+9
2	Typical Floor height	3m
3	Ground Floor height	3m
4	Plan dimension	20 m x 20 m
5	Beam size	200x 300 mm
6	Column size	350x350 mm
7	Thickness of slab	125 mm
8	Concrete grade	M 30
9	Rebar Grade	Fe 415
10	Dead load on slab	1 kN/m^2

11	Live load on slab	3 kN/m^2
12	Seismic load	As per IS 1893:2002
13	Load Combinations	As per IS 1893:2002
14	Seismic Zone	Zone 3
		Zone 4
15	Type of Soil	Medium Soil
16	Importance Factor (I)	1
17	Response Reduction Factor (R)	5

Table 2: Description of the Composite Encased Column model

SI. NO.	Description of the Composite Encased Column model	
1	No. of Storey	G+9
2	Typical Floor height	3m
3	Ground Floor height	3m
4	Plan dimension	20 m x 20 m
5	Beam	ISHB150-1
6	Column size	350x350 mm
7	Encased Steel section	ISHB 250-1
8	Composite Profile Deck Slab thickness	125 mm
9	Thickness of concrete above Profile Sheet	60 mm
10	Depth of Profile Sheet	65 mm
11	Thickness of Profile Sheet	1 mm
12	Diameter of Shear Stud	18 mm
13	Height of Shear Stud	80 mm
14	Concrete grade	M 30
15	Rebar Grade	Fe 415
16	Dead load on slab	1 kN/m^2
17	Live load on slab	3 kN/m^2
18	Seismic load	As per IS 1893:2002
19	Load Combinations	As per IS 1893:2002
20	Seismic Zone	Zone 3
		Zone 4
21	Type of Soil	Medium Soil
22	Importance Factor (I)	1
23	Response Reduction Factor (R)	5

Table3: Description of the Composite Filled tubes model

SI. NO.	Description of the Composite Filled Tubes model		
1	No. of Storey		G+9
2	Typical Floor height		3m
3	Ground Floor height		3m
4	Plan dimension		20 m x 20 m
5	Beam		ISHB150-1
6	Column size		350x350 mm
7	Concrete Filled Steel tube	Flange Thickness	18 mm
		Web Thickness	18 mm
8	Composite Profile Deck Slab thickness		125 mm
9	Thickness of concrete above Profile Sheet		60 mm
10	Depth of Profile Sheet		65 mm
11	Thickness of Profile Sheet		1 mm
12	Diameter of Shear Stud		18 mm
13	Height of Shear Stud		80 mm
14	Concrete grade		M 30
15	Rebar Grade		Fe 415
16	Dead load on slab		1 kN/m^2
17	Live load on slab		3 kN/m^2
18	Seismic load		As per IS 1893:2002
19	Load Combinations		As per IS 1893:2002
20	Seismic Zone		Zone 3
			Zone 4
21	Type of Soil		Medium Soil
22	Importance Factor (I)		1
23	Response Reduction Factor (R)		5

IV.RESULTS AND DISCUSSION

The model was analysed by Equivalent Static Method. The building model was then analysed by using Etabs-2016 for

RCC, Steel-Concrete Composite Structure with Encased Column and with Filled tubes . In India, IS 1893 (PART-1): 2002 is the main code that governs the outline for Seismic design force. The parameters such as Joint Displacement, Storey Drift, and Storey Shear are analysed.

A . Joint Displacement:

The Joint Displacements for each storey level for RCC and Steel Concrete Composite building with Encased and Concrete Filled Steel tubes (CFST) are tabulated.

Table 4:Joint Displacement for Seismic Zone 3

Storey No.	RCC	Encased Column	CFST
10	27.441	51.064	49.546
9	26.359	48.031	45.612
8	24.584	44.105	41.067
7	22.206	39.207	35.827
6	19.354	33.448	29.972
5	16.156	27.041	23.696
4	12.721	20.262	17.282
3	9.145	13.467	11.106
2	5.529	7.167	5.664
1	2.108	2.192	1.641

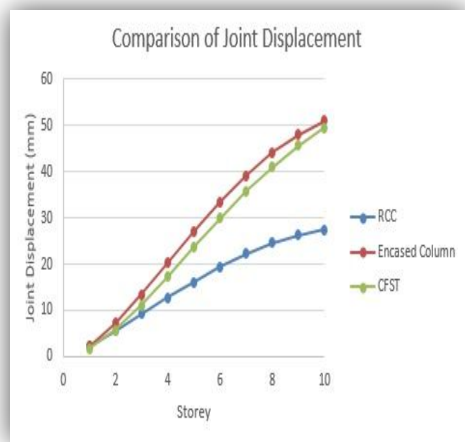

Fig.4.1 Comparison of Joint Displacement for Earthquake Zone 3.

Table 5:Joint Displacement for Seismic Zone 4

Storey No.	RCC	Encased Column	CFST
10	41.154	76.587	74.311
9	39.536	72.043	68.415
8	36.877	66.157	61.601
7	33.308	58.81	53.741
6	29.031	50.172	44.958
5	24.234	40.562	35.543
4	19.081	30.393	25.923
3	13.717	20.201	16.659
2	8.293	10.751	8.496
1	3.161	3.285	2.46

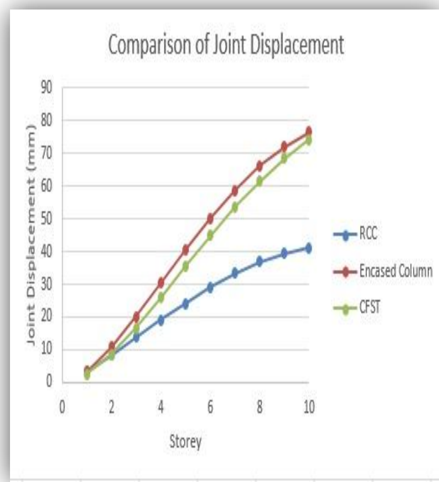

Fig.4.2 Comparison of Joint Displacement for Earthquake Zone 4.

B.Storey Drift:

The Storey Drift for each storey level for RCC and Steel Concrete Composite building with Encased and Concrete Filled Steel tubes (CFST) values are tabulated.

Table 6:Storey Drift for Earthquake Zone 3

Storey No.	RCC	Encased Column	CFST
10	0.000364	0.001016	0.001316
9	0.000592	0.00131	0.001516
8	0.000793	0.001633	0.001747
7	0.000951	0.00192	0.001952
6	0.001066	0.002136	0.002092
5	0.001145	0.00226	0.002138
4	0.001192	0.002265	0.002059
3	0.001205	0.0021	0.001814
2	0.001143	0.001662	0.001344
1	0.000703	0.000731	0.000547

Table 7:Storey Drift for Earthquake Zone 4

Storey	RCC	Encased	Filled
10	0.000543	0.00152	0.00197
9	0.000887	0.001963	0.002272

8	0.00119	0.002449	0.00262
7	0.001426	0.002879	0.002928
6	0.001599	0.003204	0.003138
5	0.001717	0.00339	0.003207
4	0.001788	0.003397	0.003088
3	0.001808	0.00315	0.002721
2	0.001714	0.002491	0.002015
1	0.001054	0.001095	0.00082

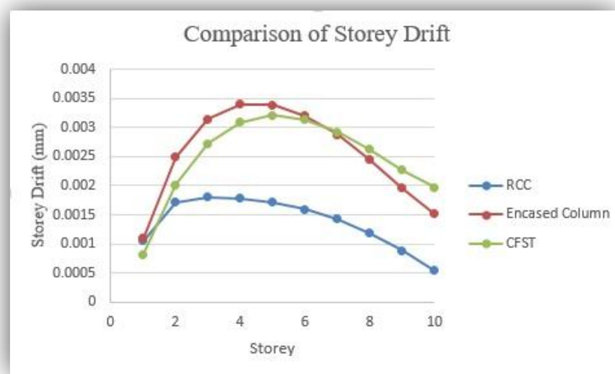

Fig.4.4 Comparison of Storey Drift for Earthquake Zone 4

C.Storey Shear:

The Storey Shear for each storey level for RCC and Steel Concrete Composite building with Encased and Concrete Filled Steel tubes (CFST) values are tabulated.

Table 8:Storey Shear for Earthquake Zone 3

Storey No.	RCC	Encased Column	CFST
10	127.0278	56.7814	63.5181
9	236.1211	106.7464	120.4715
8	322.3183	146.2249	165.4718
7	388.313	176.4507	199.9251
6	436.7989	198.6574	225.2377
5	470.4696	214.0787	242.816
4	492.0189	223.9483	254.066
3	504.1404	229.5	260.3942
2	509.5277	231.9674	263.2067
1	509.5277	232.5842	263.9098

Fig.4.5 Comparison of Storey Shear for Seismic Zone 3

Table 9:Storey Shear for Seismic Zone 4

Storey No.	RCC	Encased Column	CFST
10	190.5418	85.1721	95.2771
9	354.1817	160.1196	180.7073
8	483.4774	219.3374	248.2077
7	582.4695	264.676	299.8876
6	655.1983	297.986	337.8566
5	705.7044	321.118	364.2239
4	738.0284	335.9224	381.099
3	756.2106	344.2499	390.5913
2	764.2916	347.951	394.8101
1	766.3118	348.8763	395.8648

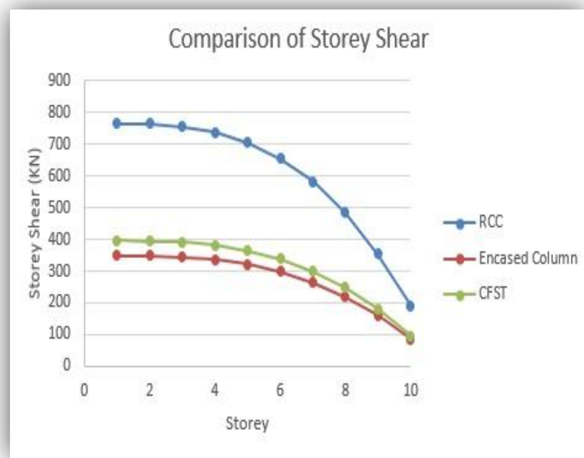

Fig.4.6 Comparison of Storey Shear for Seismic Zone 4

V CONCLUSION

The seismic performance evolution of building is studied based on the parameters such as joint displacement, storey drift and storey shear. The following conclusions are analysed.

1.Joint Displacement is on the higher side for the Steel-Concrete Composite Structure but within the Permissible limit.

2.Storey Drift is lower for the RCC structure than the Steel-Concrete Composite Structure because of its high stiffness.

3.Storey shear is minimum for the steel-concrete composite structure because of its lower self weight.

4.Among the two seismic zone, zone 4 has higher of these values for joint Displacement, Storey Drifts and Storey Shear.

5.Steel Concrete Composite structure is best suited for high-rise building due to its decreased self weight of the structure.

6.Steel Concrete Composite structures have higher ductile in nature and hence more suited during Earthquake consideration.

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