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Seismic Performance of Building with Different Concrete Encased Steel Composite Columns

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***Abstract*—Presently Earthquakes are most frequent natural hazard occurred in India and as a result lots of life and property damage due to sudden failure of the structure, therefore it's important to give special attention to design and to improve the seismic performance of multi-storey buildings. Use of structural steel in RCC building make building more ductile and earthquake resistant. Composite structure are advance structure over RCC structure and Steel structure. In composite structure both concrete and structure steel were used and work as a single unit under gravity and seismic forces. In this paper seismic response of composite structures are presented, Response spectrum method is used for the analysis of (G+14) residential multi-storey building with different composite column located in zone IV using ETABS(2017) software. In this paper analysis results studied and compare their seismic parameters with ordinary RCC building as per IS 1893:2016 (Part I). It is found that building with composite column (concrete encased steel tube composite column) perform better than ordinary RCC building under seismic loading.**

***Index Terms*—Concrete Encased Steel-tube Composite Column,Response Spectrum Method,Seismic Performance ETAB-2017**

1. INTRODUCTION

Steel concrete composite structure are structure in which structural steel used as reinforcement with concrete. Steel is highly ductile material and when steel with this property is combined with concrete, both materials turn into a single unit and provide sufficient ductility as well as stiffness to the structure. Presently earthquake is most frequent natural hazard occurred in India and it became the reason of lots of life and property loss due to sudden failure of the structure, that's why need of more ductile structure arises which provided sufficient ductility to the structure so that structure gives resistance to the lateral or earthquake forces. Use of steel-concrete composite columns instead of RCC columns provide ductility to the member so that it could bear earthquake forces without any failure. Steel concrete composite column are currently being increasingly used in the construction of building due to their excellent static and earthquake resisting properties.

In this paper residential (G+14) storey building with RCC column and steel concrete composite column is considered. The variation in parameter of steel-concrete composite column and RCC column studied with the help of finite element analysis method using ETABS (2017) software. For analysis two type of steel concrete composite columns considered shown in **fig 1.1**

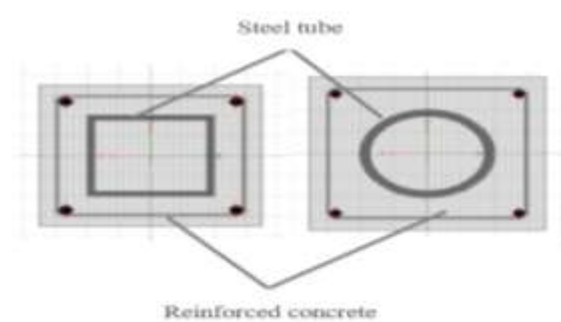

Fig 1.1 concrete encased steel tube column section

2. OBJECTIVE OF WORK

The main aim of this work is to study the behavior of different concrete encased steel tube column and their performance under seismic and gravity loading. Also compare their seismic parameters with RCC column as per IS 1893:2016(1).

3. BUILDING DESCRIPTION

(G+14) Storey Residential building situated in zone IV is considered for the analysis and their geometric parameters are given in table 3.1

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Table 3.1 Geometrical Properties

S.NO	Structural Part	Dimension
1.	Length in X-direction	**25m**
2.	Length in Y-direction	**20m**
3.	No of bays in X-direction	**5No@5m**
4.	No of bays in Y-directions	**5No@4m**
5.	Floor to floor height	**3m**
6.	Total height of buildings	**45 m**
7.	Slab thickness	**150mm**
8.	Column size	**350X350mm (Inner Column) 300X350mm (Outer Column)**
9.	Beam size	**250X300 mm**

Table 3.2. Material Properties

S. No	Material	Grade
1.	Concrete (beam, slab) Concrete (Column)	M25 M30
2.	Grade of steel section	Fe250
3.	Steel tube section thickness	t =15mm
4.	Rebar	HYSD-500

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

1.	Earthquake Zone	IV
2.	Zone factor (Z)	0.24 (Table 3, clause 6.4.2)
3.	Damping Ratio	5% (clause 7.2.4)
4.	Important Factor	1.2 (Table 8, clause 7.2.3)
5.	Type of soil	Medium soil (clause 6.4.2.1)
6.	ResponseReduction Factor	5(SMRF)(Table-9, clause 7.2.6)

Table 3.4. Loading

1.	Live load	3 KN/m2 as per IS 875 Part II
2.	Earthquake load	as per IS 1893:2016Part-I
3.	Dead load	Self-calculated

4. PROBLEM DESCRIPTION

- Model 1-Building provided with RCC column.
- Model 2 -Building provided with concrete encased rectangular steel tube composite column.
- Model 3 -Building provided with concrete encased circular steel tube composite column.

4.1 Plan of Building For Different Models-Plans of building provided with different type of columns are show in **fig 4.1.1-4.1.3**

Fig 4.1.1 Building provided with RCC Column

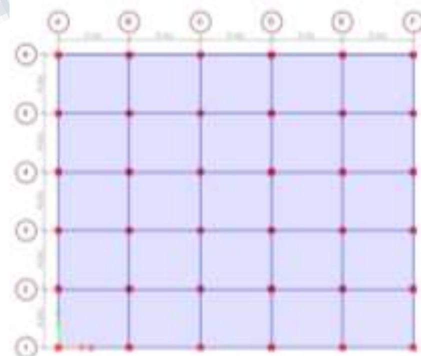

Fig 4.1.2 Building provided with concrete encased rectangular steel tube composite column

Fig 4.1.3 Building provided with concrete encased circular steel tube composite colum

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5. ANALYSIS AND RESULTS

Seismic analysis of all the models provided with RCC column, concrete encased rectangular steel tube composite column and concrete encased circular steel tube composite column has been carried out and their results on various seismic parameters such as time period, storey displacement and building stiffness studied on the bases of their performance and shown below.

5.1 Time Period-

Time taken to complete one oscillation cycle by the structure is define as time period 'T'. It is an inherent property of a building controlled by its mass 'm' and stiffness 'k'.

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

Analysis results shows, in model 3 the maximum time period is 3.869 and in model 2maximum time period is 4.019 which is 19% and 16% respectively less than the time period of model 1. It shows that stiffness of model 3 is more than the stiffness of model 1 & model 2. Table 5.1 shows time period of all models & fig 5.1.1 shows variation in time period of all model.

Table 5.1 Time Period

Mode No	Model 1 sec	Model 2 sec	Model 3 sec
Mode 1	4.781	4.019	3.869
Mode 2	4.55	3.825	3.656
Mode 3	4.278	3.563	3.443
Mode 4	1.576	1.325	1.274
Mode 5	1.499	1.176	1.135
Mode 6	1.412	1.26	1.204
Mode 7	0.921	0.775	0.744
Mode 8	0.873	0.735	0.703
Mode 9	0.829	0.691	0.665
Mode 10	0.643	0.541	0.517
Mode 11	0.611	0.514	0.49
Mode 12	0.578	0.482	0.462

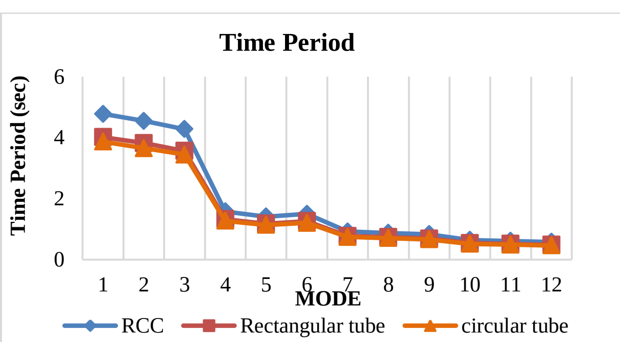

Fig 5.1.1 Variation in Time Period

5.2Storey Displacement

Storey displacement is the absolute value of displacement of the storey under the action of the lateral forces. Analysis results shows, in model 3 the maximum displacement is 112.96 and in model 2 maximum displacement is 118.059 which is 42% and 40% respectively less than the maximum displacement of model 1.Displacement of all three models are shown in table 5.2 and their variation in displacement are shown in fig 5.2.1

Table 5.2:-Storey Displacement

Storey	Model 1 mm	Model 2 mm	Model 3 mm	As Per IS 8 Code
Storey 15	197.866	118.059	112.961	180
Storey 14	190.566	115.818	110.897	168
Storey 13	183.157	112.077	107.398	156
Storey 12	173.79	106.927	102.532	144
Storey 11	162.741	100.563	96.48	132
Storey 10	150.281	93.182	89.432	120
Storey 9	136.663	84.965	81.562	108
Storey 8	122.116	76.076	73.031	96
Storey 7	106.847	66.667	63.983	84
Storey 6	91.041	56.869	54.545	72
Storey 5	75.86	46.8	44.83	60
Storey 4	58.444	36.56	34.936	48
Storey 3	41.921	26.261	24.954	36
Storey 2	25.468	15.998	15.03	24
Storey 1	11.547	6.22	5.707	12

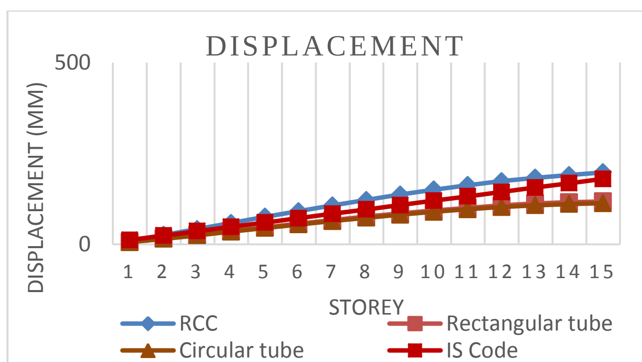

Fig 5.2.1 Variation in Displacement

5.3 Storey stiffness

Stiffness define as a rigidity of a structure, it means the extent to which the structure is able to resist defection or deformation due to aplication of force. Analysis results shows, model 3 is 18 % and model 2 14% stiffer than model 1. Storey stiffness of all models are shown in table 5.3 and stiffness variation graph are shown in fig 5.3.1.

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Table 5.3:- StoreyStiffnessV/S Stiffness

Storey	Model 1 KN/m	Model 2 KN/m	Model 3 KN/m
Storey 15	121047.54	120526.2	133383.4
Storey 14	136121.31	137277.3	150020.8
Storey 13	136182.63	137310.5	150473.8
Storey 12	136655.68	137833.2	150632.4
Storey 11	136866.69	138243.1	150893.7
Storey 10	137751.46	138456	150922.9
Storey 9	138397.42	138794.4	151268.7
Storey 8	138738.55	138998.5	151932.9
Storey 7	139392.97	139578.5	152289.4
Storey 6	140282.57	140466	152300.7
Storey 5	130947.49	141081	152320.7
Storey 4	131561.3	141609	152670.5
Storey 3	133382.16	143449.8	154929.9
Storey 2	141926.99	152109.2	166160.3
Storey 1	229074.9	238399.2	271459.7

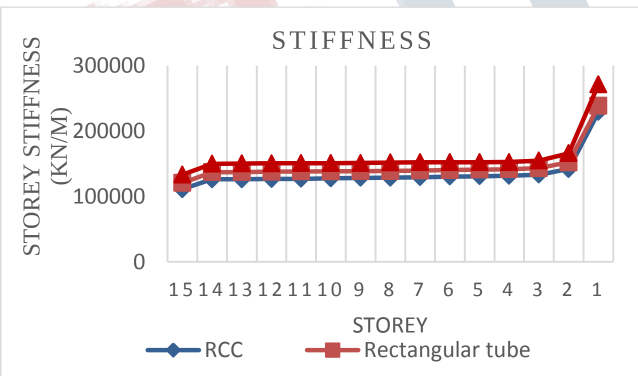

Fig 5.3.1 Stiffness V/S Storey

6. CONCLUSIONS

Following conclusions obtained from the analysis of (G+14) storey Residential building provided with RCC and concrete encased steel-tube composite columns.

1. Building provided with concrete encased circular steel tube column perform better than other building with RCC column.
2. .The natural time perrio depends on two things, stiffness and mass of the system. It is found that model 1 has maximum time period value and model 3 has minimum time period value. Composite column provide large stiffness to the building because of that natural time period decreases from model 1 to model 3 Which indicates that model-3 building with concrete encased circular steel tube composite column is more flexible.
3. It is found that model 1 has maximum displacement and model 3 has minimum displacement, so thereismore chances of failure of building provided with RCC column compare to building provided with concrete encased circular tube column. It shows that building provided with concrete encased steel composite column is stiffer than building with RCC column.
4. Storey stiffness of model 3 is more than the storeystiffness of building with RCC column. Hence, building provided with concrete encased steel composite columns is less prone to damages.

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