COMPERATIVE STUDY ON SEISMIC BEHAVIOUR OF BUILDING PROVIDED WITH RCCAND COMPOSITE (CONCRETE ENCASED STEEL COMPOSITE) COLUMN

[1] Shobha Yadav, [2] Dr Kailash Narayan, [3]KumarVanshaj

[1] PG Student (M.Tech Structural Engineering), [2]Professor, [3]Phd Scholar

[1][2][3]Civil Engineering Department, Institute of Engineering & Technology, lucknow-226022 (India)

[1] shobha456yadav@gmail.com,[3]vanshaj10@gmail.com

Abstract:*Because of huge population and limited per capita area, multi-storey buildings become high priority in the society.Nowadays earthquakes are very often and considering earthquake as one of the major natural hazards for multi-storey building, RCC structure are not much resistant to earthquake and therefore they fail to bear the earthquake forces. It gives rise to the use of composite structure. Composite structures are basically a structure that combine structural steel with concrete where hot rolled steel section are used as structural member. Composite structures utilize the advantages of both steel and concrete and have excellent earthquake resistant properties such as high strength, ductility, and large energy absorption capacity. In this paper it is observed, the seismic behavior of G+14 Storey composite building situated in Zone IV and compare their seismic parameters with RCC building by using ETABS 2017 Software through Time History analysis. The main objective of this paper is to spread out the advantage of composite structure over RCC structure. The main focus of the study is to evaluate the performance of building provided with concrete encased steel composite columns under seismic loading. Building with concrete encased steel composite columns performs better against seismic forces.*

Keyword: *Concrete Encased Steel Composite Column, Seismic Performance, Time History Method, ETAB-2017*

1. Introduction

Nowadays earthquake are very often all over the world and when a building is subjected to lateral deflections under the action of seismic loads, resulting oscillatory movement can induce a wide range of response in the building occupants from mild discomfort to acute nausea. As a result, lateral stiffness is a major consideration in the design of multi-storey building. Composite structure are basically a structure combining structural steel with concrete where hot rolled steel section are used as structural member and has great lateral stiffness.

In India the use of composite structure is very low in construction industry compared to other developing or developed countries. In India population increases very rapidly during past two decades and there is limited free space available for construction, so in that case need of multi-storey building arises, they save space and accommodate more residents as compared to low rise building. Use of composite structure in multi-storey building make construction faster, economical, make building more flexible, increase its strength and lastly it make building lateral load resistance because of ductile property of steel. Composite structure are admired for their advantages over RCC structures and Steel structures, the combination of steel and concrete is better than the individual properties of either steel or of concrete. Composite structure having the properties of both steel and concrete as steel provide more deflection and ductility to the structure which is beneficial in resisting earthquake or seismic forces on the other hand concrete will have the advantages of high strength, fire resistance, economic, easy to place, easily available material and also it is able to reduce the slenderness to the steel, so it can take larger loads.

1.1 Concrete Encased Steel Composite Column Used For Analysis **(shown in fig 1.1**)

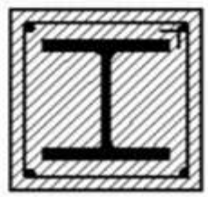

Fig 1.1(composite column cross-section)

2. Objective of research

i. To study the behaviour of RCC and composite building under seismic and gravity loading.

ii. To determine the various parameters i.e Time period, Story drift, Story displacement, Storey shear and Stiffness to evaluate the performance of building.

3. Building description

Residential building with (G+14) storey located in Zone IV are given below:-

3.1Geometrical 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	3 m
6.	Total height of buildings	45 m
7.	Slab thickness	150mm
8.	Column size	350X350mm (Inner Column) 300X350mm (Outer Column)
9.	Beam size	250X350 mm

3.2. Material Properties

S. No	Material	Grade
1.	Concrete (beam, slab) Concrete (Column)	M25 M30
2.	Grade of steel section	Fe250
3.	Steel section (H-shape)	ISHB 225
4.	Rebar	HYSD-500

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.	Response Reduction Factor	5(SMRF) (Table-9, clause 7.2.6)

3.4. Loading

i. Live load 3 KN/m^2 as per IS 875 Part II
ii. Earthquake load as per IS 1893:2016Part-I

4.Problem Description

- Model 1-Building with RCC column.
- Model2-Building with concrete encased I-Shape steel section composite column.

4.1 Plan of Building for Different Models- Plans of building with different columns are show in **fig 4.1.1 and fig 4.1.2.**

Fig 4.1.1 Building with RCC Column

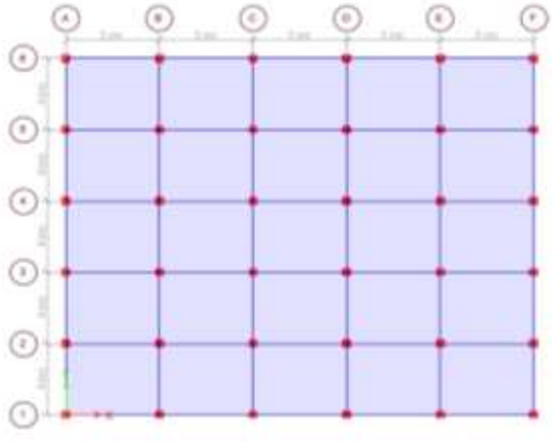

Fig 4.1.2Building with I-Shape steel section

5. Analysis and Results

All the models with different columns hasbeen analysed and their results shown below. The various parameters which were studied are on the performance of building during seismic disturbance are evaluated in terms of Time period, Base Shear, Storey drift, Storey displacement and Stiffness.

5.1 Time Period-Time taken by the structure to complete one cycle of oscillation is define as time period 'T'.

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

Results obtained from the analysis shows, maximum time period of model 2 is 14% less than the model 1. It indicates that model 2 is stiffer as compare to model 1. The time period for both modelsare shown in **table 5.1** and their variation with different modes are shown in **fig 5.1.**

Table 5.1 Time Period

Mode No	Model 1 (sec)	Model 2 (sec)
Mode 1	4.781	4.094
Mode 2	4.55	3.971
Mode 3	4.278	3.63
Mode 4	1.576	1.351
Mode 5	1.499	1.31
Mode 6	1.412	1.2
Mode 7	0.921	0.791
Mode 8	0.873	0.766
Mode 9	0.829	0.706
Mode 10	0.643	0.553
Mode 11	0.611	0.538
Mode 12	0.578	0.495

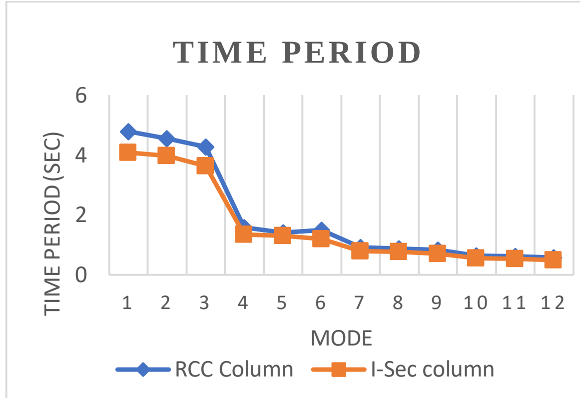

Fig 5.1 Natural time period V/S Mode

5.2 Base shear- Base shear is directly proportional to weight of structure.

Base shear, $\mathbf{V_B= A_h W}$

Results obtained from the analysis shows, maximum base shear of model 2 is 5% less than model 1. Base shear for both the models is shown in **table 5.2**

Table 5.2 Base Shear

Direction	Model	Base Shear (KN)
X+Ecc.Y	1	1270.9923
Y+Ecc.X	1	1270.9923
X+Ecc.Y	2	1210.1441
Y+Ecc.X	2	1219.0913

5.2.1 Storey shear: Distribution of base shearat each story is defined as story shear, story shear increases as story is increase,storey shear for both models are shown in **table5.2.1**and their variation shown in**fig 5.2.1.**

Table 5.2.1Storey Shear

Storey	Model 1 kN	Model 2 kN
Storey 15	221.3032	215.8597
Storey 14	202.6986	191.9998
Storey 13	174.7758	165.5508
Storey 12	148.9214	141.061
Storey 11	125.1354	118.5305
Storey 10	103.4176	97.9591
Storey 9	83.7683	79.3468
Storey 8	66.1873	62.6938
Storey 7	50.6746	47.9999
Storey 6	37.2304	35.2653
Storey 5	25.8544	24.4898
Storey 4	16.5468	15.6734
Storey 3	9.3076	8.8163
Storey 2	4.1367	3.9184
Storey 1	1.0342	0.9796

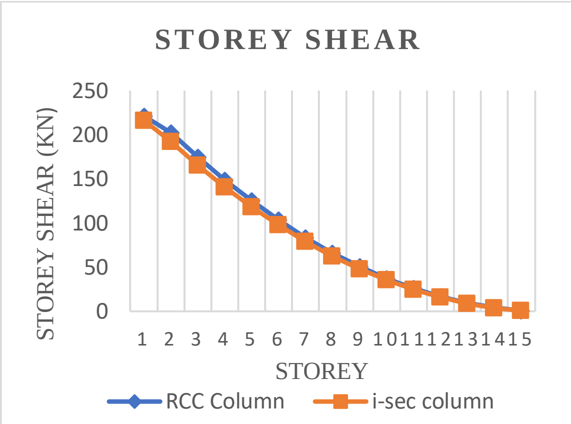

Fig 5.2.1 Storey shear V/S Storey

5.3 StoreyDisplacement- Total displacement of i^th storey with respect to ground is define as storey displacement. As per IS code, allowable displacement is H/250, where 'H' is total height of building. Results obtained from the analysis shows, maximum storey displacement of model 2 is 38% less than the model 1.storey displacement for both modelsare shown in **table 5.3**and their variationsare shown in **fig 5.3**

Table 5.3: -Storey Displacement

Storey	Model 1 mm	Model 2 mm	As Per IS Code
Storey 15	197.66	122.112	180
Storey 14	192.366	119.688	168
Storey 13	184.957	115.712	156
Storey 12	175.59	110.311	144
Storey 11	164.541	103.689	132
Storey 10	152.081	96.043	120
Storey 9	138.463	87.556	108
Storey 8	123.916	78.395	96
Storey 7	108.647	68.711	84
Storey 6	92.841	58.636	72
Storey 5	76.66	48.289	60
Storey 4	60.244	37.771	48
Storey 3	43.721	27.173	36
Storey 2	27.268	16.614	24
Storey 1	11.547	6.542	12

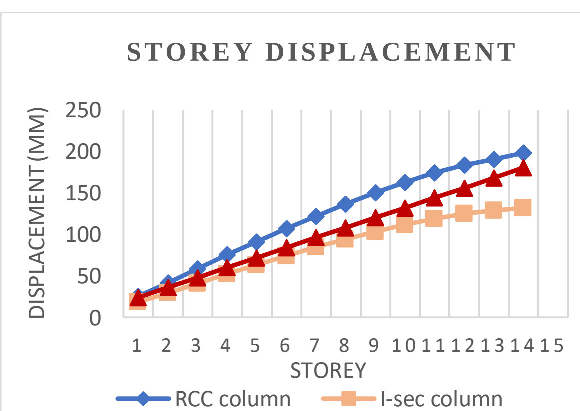

Fig5.3 Storey displacement V/S Storey

5.4 StoreyDrift- It is defined as ratio of displacement of two consecutive floor to height of that floor. As per IS 1893:2016(I) the storey drift is not be more than 0.004h, where 'h' is the storey height. Results obtained from the analysis shows, model 1 failed, as value gets exceed the maximum allowable values and model 2 passed, within the permissible limits.Storey drift for both modelsare shown in **table 5.4**and their variation are shown in **fig 5.4**

Table 5.4:-Storey drift

Storey	Model 1 mm	Model 2 mm	As Per IS Code
Storey 15	5.3	2.424	12
Storey 14	7.409	3.976	12
Storey 13	9.367	5.401	12
Storey 12	11.049	6.542	12
Storey 11	12.46	7.646	12
Storey 10	13.618	8.487	12
Storey 9	14.547	9.161	12
Storey 8	15.269	9.685	12
Storey 7	15.806	10.073	12
Storey 6	16.181	10.347	12
Storey 5	16.416	10.518	12
Storey 4	16.523	10.598	12
Storey 3	16.453	10.558	12
Storey 2	15.721	10.074	12
Storey 1	11.747	6.622	12

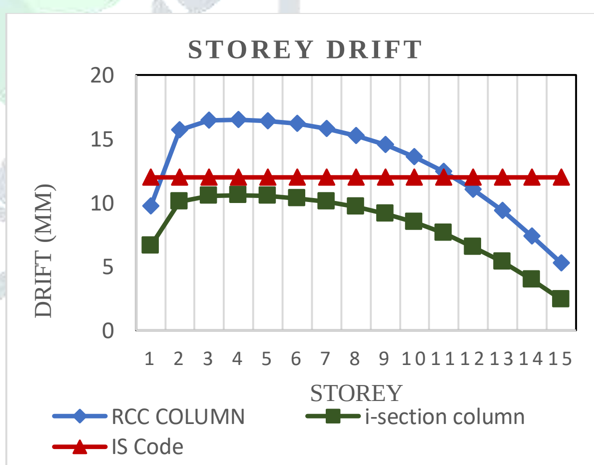

Fig 5.4Storey Drift V/S Storey

Table 5.4 & Figure 5.4 shows that the storey drift are minimum in building which is provided with composite(concrete encasedI-Shape steel composite) column as compared to ordinary RCC column building.

5.5 Storey stiffness-Stiffness refers to the rigidity of a structural element. Results obtained from the analysis shows, model 2 is 29% more stiffer than model

2.Storey stiffness for both models are shown in **table 5.5** and their variation in stiffness are shown in **fig 5.5**

Table 5.5:-StoreyStiffnessV/S Stiffness

Storey	Model 1 KN/m	Model 2 KN/m
Storey 15	111047.537	143544.434
Storey 14	126121.306	165847.681
Storey 13	126182.632	171871.695
Storey 12	126655.681	174771.57
Storey 11	126866.689	176553.575
Storey 10	127751.458	177818.993
Storey 9	128397.424	178817.454
Storey 8	128738.55	179680.387
Storey 7	129392.971	180487.244
Storey 6	130282.565	181293.571
Storey 5	130947.488	182154.372
Storey 4	131561.301	183206.869
Storey 3	133382.157	185303.396
Storey 2	141926.994	194962.295
Storey 1	229074.898	300720.653

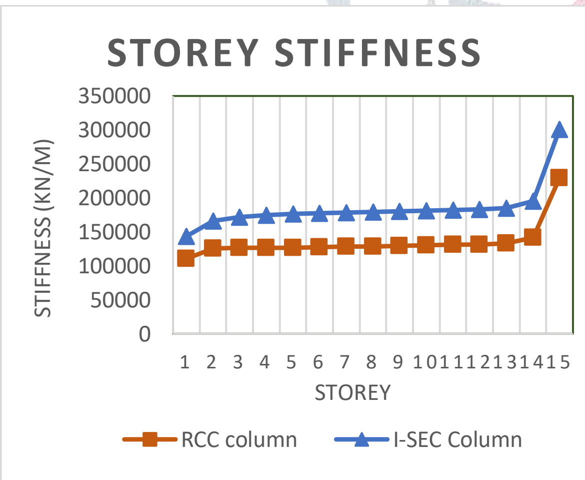

Fig5.5 Stiffness V/S Storey

6.Conclusions

Following conclusions are drawn from analysis of G+14 storied building considering RCC and concrete encased steel composite columns.

1. Composite column with I-Section perform better than RCC column.

2. Natural time period is inversely proportional to the square root of stiffness. The value of maximum time period was observed in model 1 and minimum value observed in model 2. Because composite column provides large stiffness to the building so the value of natural time period is decreases from model 1 to model 2Which indicates that model-1 building provided with RCC column is more flexible.

3. Base shear increases with the increase in mass and stiffness of structure. From the analysis maximum value of base shear observed in model 1 and minimum in model 2. It means during earthquake model 1 is subjected to higher lateral forces.

4. From the analysis, we found that lateral displacements are minimum in model 2 and maximum in model 1 so there are more chances of failure of building with RCC column compare to building with composite column, which indicates the stiffness of building provided with composite column is more.

5. The minimum value of Storey Drift is obtainedin model 2and maximum drift in model1. It shows building with composite column gives less lateral displacement during earthquake.

6. Storey stiffness of model 2 is more than the storeystiffness of building with RCC column. Hence, building provided with composite columns is less prone to damages.

REFERENCES

[1] Cheng-chihchen,Jian-Ming Li (2005) “Experimental behaviour and strength of concrete-encased composite beam-column with T-Shape steel section under cyclic loading” (ELSEVIER) Vol-61, pp 863-881

[2] L.Cheng,Chun-Man Chan (2009) “ Optimal lateral stiffness design of composite steel and concrete tall frameworks” (ELSEVIER) Vol-31,pp 523-533.

[3] Yu-feng An, Lin-Hai Han (2014) “Behaviour of concrete-encased column under combined compression and bending” (ELSEVIER) Vol-101, pp 314-330.

[4] Cristina Camoian, Zsolt Nagy (2015) “Behaviour of fully encased steel-concrete composite columns subjected to monotonic and cyclic loading” (ELSEVIER) Vol-117, pp 439-451.

[5] Wei-Wu Qian, Wei Li, Lin-Hai Han (2016) “Analytical behavior of concrete-encased CFST columns under cyclic lateral loading” (ELSEVIER) Vol-120,pp 206-220.

[6] D.Datta (2016) "Steel composite construction-New Trend in India" (IOSR-JMCE) ISSN:2278-1684, pp 2320-334X

[7] Georgios S. Papavasileiou ,DimosC.Charmpis (2016) "Seismic design optimization of multi-storey steel-concrete composite buildings" (ELSEVIER) Vol-170,pp 49-61.

[8] Dona Chacko, George M Varghese (2016) "Non-Linear behaviour of RCC core steel composite column" (ELSEVIER) Vol-5,pp 2278-0181

[9] Rakesh Abrol, SK Kulkarni (2017) "Seismic analysis of RCC and Composite structures" (IJARD) Vol-2, pp 288-296.

[10] Rajendra R.Bhoir, Vinay Kamble (2017) "Analysis and design of Composite structure & its comparison with RCC Structures" (IJRASET) Vol-5, pp 2321-9653.

[11] Shuai Li, Lin-Hai, Chao Hou (2018) "Concrete-encased CFST column under combined compression and torsion:Analyticalbehaviour"(ELSEVIER) Vol-144,pp 236-252.

[12] Chengxiang Xu, Jie Deng, Sheng Peng (2018) "Seismic analysis of steel reinforced concrete frame structures based on different Engineering Demand Parameters(Journal of building Engineering) pp S2352-7102(18)30512-6

[13] Jingming Cai, Jinlong Pan (2018) "Behaviour of ECC-encased CFST columns under axial compression" (ELSEVIER) Vol-171, pp 1-9.

[14] Binglin Lai, J.Y.RichardLiew,Tongyun Wang (2019) "Buckling behaviour of high strength concrete encased steel composite columns" (ELSEVIER) Vol-154,pp 27-42

[15] IS:456-2000 "Code practice forplane and reinforced concrete"

[16] IS 11384:1985 "Code of Practice for Composite Construction in structural Steel Concrete"

[17] IS:1893(Part 1): 2016 "Criteria for Earthquake Resistant Design of Structures"

[18] IS:13920-2016 "Code of Practice For Ductile Design and Detailing of ReinforcedConcrete Structures Subjected to Seismic Forces

[19] IS: 875(Part 2)-1987 "Code of Practice for design loads for buildings and structures"

[20] IS:808-1989 "Dimensions for Hot Rolled Steel, Column, Channel and Angle Sections"

[21] IS:800-2007 "Code for General Construction in Steel for practice, Bureau of Indian Standard, New Delhi