SEISMIC ANALYSIS OF RC STRUCTURES WITH DIFFERENT COMPOSITE COLUMNS IN BUILDINGS WITH MASS IRREGULARITIES

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Abstract – *High storied buildings and apartments are becoming more essential in the metropolitan, sub-urban areas due to its dense population and scarcity of land for building constructions. The design and construction of tall structures should be effectual, such that it should be proficient in resisting the adverse effect of earthquake and wind forces .So, composite construction are adopted which exhibits the advantages of two materials i.e., concrete and light weight steel, used both in buildings and bridges over many spans. The external loading in composite columns are withstood by bonding and friction between steel and composite structures. The objective of this paper is to evaluate the comparison of RCC, composite columns with concrete filled steel tube and composite encased I section column on buildings with mass irregularities. Buildings are modelled using ETABS 2016. G+10 story building is selected for analysis. Seismic analysis is followed using IS 1893:2002. The results are obtained from various parameters such as base shear, story displacement, story drift etc.,*

Key Words: Base shear, Story Drift, Story Displacement

1.INTRODUCTION

The constructions of multi-storey buildings are rapidly increasing due to the limitation of lands. In such a situation building will have to be designed in various shapes and it should be capable to withstand heavy seismic loads. Composite construction is one of the most effective methods that satisfy this requirement. And it is necessary to check the behaviour of Concrete filled steel tubes (CFST) columns and Encased I Section composite column instead of reinforced cement concrete (RCC) columns used in high rise buildings.

CFST and Encased I Section composite column structure is a type of the composite steel-concrete structures used presently in civil engineering field. In this type of composite members, the advantages of both hollow Structural Steel and concrete is utilized. Due to excellent static and earthquake resistant properties of CFST and Encased I Section composite column, they are being used widely in real civil engineering projects. They possess properties such as high strength, high ductility and large energy absorption capacity. They are widely used in high-rise and multi storey buildings as columns and beam-columns, and as beams in low-rise industrial buildings where a robust and efficient structural system is required. There are a number of different advantages related to such structural systems in both terms of structural performance and construction sequence. The inherent buckling problem related to thin-walled steel tubes is either prevented or delayed due to the presence of the concrete core. Furthermore, the performance of the concrete in-fill is improved due to confinement effect exerted by the steel shell. The distribution of materials in the cross section also makes the system very efficient in term of its structural performance. The steel lies at the outer perimeter where it performs most effectively in tension and bending. It also provides the greatest stiffness as the material lies farthest from the centroid. Concrete Filled Steel Tube (CFST) Structural System high-strength concrete is used for filling steel tubes. These members are ideally suited for all applications because of their effective usage of construction material. CFST and Encased I Section composite column are also used extensively in other modern civil engineering applications. Application of the Concrete filled steel tubes (CFST) concept may lead to 60% total saving of steel in comparison to conventional structural steel system. Steel tubes were also used as permanent formwork and the well distributed reinforcement located at most efficient position.

Due to large shear capacity of concrete filled steel tubular members, they predominantly fail in flexure in a ductile manner. Confinement effectiveness may be reduced to a bit if rectangular or square tubes are filled up with high strength concrete but it provides advantage against flexure. A steel concrete composite column is a compression member, comprising either of a concrete encased hot rolled steel section or a concrete filled hollow section of hot rolled steel. It is generally used as a load bearing member in a composite framed structure. Composite columns with fully and partially concrete encased steel sections concrete filled tubular section are generally used in composite construction.

2. OBJECTIVE OF THE WORK

The main intent of the study is to find the behaviour of composite columns with concrete filled steel tubes and composite encased I section column and to study the effect of composite columns in building with mass irregularities. The objectives formulated for the study are:

1. To evaluate the comparison of composite columns with concrete filled steel tubes and composite encased I section column.

2. To find the structural behaviour of multi-storey building with mass irregularities.
3. To find out the storey displacement, storey drift and base shear in each cases.

2. SELECTION OF GEOMETRY

The study majorly focuses on analyzing G+10 storied building with concrete filled steel tubes and composite encased I section column under mass irregularities. The problem is analyzed with the help of ETABS software and the results so obtained are discussed in this chapter.

This study includes the analysis of G+10 storied building with Reinforced concrete columns, concrete filled steel tubes and composite encased I section column under mass irregularities. The parameters such as base shear, story displacement and story drift are compared. The selection of building geometry is one of the most important aspect which leads to the modelling of the building in ETABS software.

2.1 Preliminary Data

- Plan of the Building – 20m x 30m
- Grade of the concrete – M30
- Number of stories – G+10
- Floor Height – 3m
- Column Size -500mm x 500mm
- Beam Size – 300mm x 500mm
- Slab Thickness – 150mm
- Density of concrete – 25 kN/m^2
- Live Load on floor – 2kN/m^2
- Live Load on 3^{rd} ,6^{th} ,9^{th} floor – 5kN/m^2
- Seismic Zone – IV
- Importance Factor – 1
- Type of soil – Medium soil
- Response Reduction Factor – 5(SMRF)
- Type of Analysis – Equivalent Static Analysis

The loads considered in the analysis of G+10 storied building with concrete filled steel tubes and composite encased I section column under mass irregularities are:

- Dead load has been taken as 2kN/m2 as per (IS: 875 (Part 2) – 1987).
- The live load has been taken as 3.5kN/m2 as per (IS: 875 (Part 2) – 1987).
- Seismic loads are calculated as per IS: 1893 (Part 1)-2002.

2.2 Models for Analysis

- Model 1- G+10 Building with Reinforced concrete column
- Model 2- G+10 Building with Concrete filled steel tubular column
- Model 3- G+10 Building with composite encased I section column

3. RESULTS AND DISCUSSION

The analysis of G+10 stories of rectangular building with RCC, CFST and composite encased I section columns are carried out using ETABS 2016 software. The rectangular structure with RCC column is analyzed with the seismic loads. The maximum story displacement and story drift of the structure were determined by the observations and corresponding graphs.

3.1 Story Displacement

The story displacement is the total displacement of a building with respect to its base.

Story	Elevation (m)	Location	X-Dir Max (mm)	X-Dir Min (mm)	Y-Dir Max (mm)	Y-Dir Min (mm)
Story11	33	Top	17.229	1.877	18.966	2.557
Story10	30	Top	16.527	1.626	18.12	2.204
Story9	27	Top	15.554	1.409	17.012	1.906
Story8	24	Top	14.223	1.207	15.516	1.624
Story7	21	Top	12.633	1.012	13.761	1.358
Story6	18	Top	10.852	0.816	11.798	1.092
Story5	15	Top	8.907	0.639	9.663	0.843
Story4	12	Top	6.866	0.469	7.441	0.616
Story3	9	Top	4.79	0.309	5.179	0.397
Story2	6	Top	2.753	0.17	2.965	0.205
Story1	3	Top	0.959	0.065	1.024	0.064
Base	0	Top	0	0	0	0

Table -1: Story displacements in X and Y directions for Rectangular-RCC model

The displacements of each story levels in X and Y directions due to seismic loads are given in the Table 1. The story displacement value increases with the increase in story height and the maximum story displacement obtained in X direction and Y directions are 17.229mm and 18.966mm.

Story	Elevation (m)	Location	X-Dir Max (mm)	X-Dir Min (mm)	Y-Dir Max (mm)	Y-Dir Min (mm)
Story11	33	Top	17.682	2.126	19.335	2.931
Story10	30	Top	16.962	1.857	18.488	2.571
Story9	27	Top	16.05	1.613	17.459	2.256
Story8	24	Top	14.892	1.386	16.158	1.956
Story7	21	Top	13.523	1.167	14.645	1.671
Story6	18	Top	11.986	0.95	12.953	1.39
Story5	15	Top	10.316	0.753	11.118	1.128
Story4	12	Top	8.544	0.566	9.186	0.883
Story3	9	Top	6.688	0.392	7.164	0.646
Story2	6	Top	4.734	0.242	5.041	0.425
Story1	3	Top	2.604	0.131	2.738	0.226
Base	0	Top	0	0	0	0

Table-2: Story displacements in X and Y directions for CFST column model

The displacements of each story levels in X and Y directions due to seismic loads are given in the Table 2. The story displacement value increases with the increase in story height and the maximum story displacement obtained in X direction and Y directions are 17.682mm and 19.335mm.

Story	Elevation (m)	Location	X-Dir Max (mm)	X-Dir Min (mm)	Y-Dir Max (mm)	Y-Dir Min (mm)
Story11	33	Top	17.534	2.106	19.3	2.871
Story10	30	Top	16.786	1.84	18.47	2.518
Story9	27	Top	15.861	1.599	17.453	2.208
Story8	24	Top	14.711	1.376	16.158	1.913
Story7	21	Top	13.354	1.159	14.649	1.633
Story6	18	Top	11.831	0.945	12.96	1.357
Story5	15	Top	10.175	0.751	11.129	1.099
Story4	12	Top	8.412	0.566	9.201	0.859
Story3	9	Top	6.561	0.394	7.184	0.626
Story2	6	Top	4.61	0.245	5.067	0.409
Story1	3	Top	2.5	0.133	2.763	0.215
Base	0	Top	0	0	0	0

Table-3: Story displacements in X and Y directions for concrete encased composite column model

The displacements of each story levels in X and Y directions due to seismic loads are given in the Table 3. The story displacement value increases with the increase in story height and the maximum story displacement obtained in X direction and Y directions are 17.534mm and 19.3mm respectively.

3.2 Story Drift

Story	Elevation (m)	Location	X-Dirn	Y-Dirn
Story 11	33	Top	0.000244	0.000287
Story 10	30	Top	0.000327	0.000037
Story 9	27	Top	0.000447	0.000501
Story 8	24	Top	0.000533	0.000587
Story 7	21	Top	0.000595	0.000654
Story 6	18	Top	0.000652	0.000713
Story 5	15	Top	0.000683	0.000742
Story 4	12	Top	0.000693	0.000755
Story 3	9	Top	0.000680	0.000739
Story 2	6	Top	0.000604	0.000652
Story 1	3	Top	0.00032	0.000341
Base	0	Top	0	0

Table-4: Story drifts in X and Y directions for Rectangular-RCC model

The story drift values increase up to the fourth story and then decreases. The maximum story drift obtained is 0.000755.

Story	Elevation(m)	Location	X-Dir	Y-Dir
Story11	33	Top	0.00025	0.000287
Story10	30	Top	0.000305	0.000344
Story9	27	Top	0.000389	0.000436
Story8	24	Top	0.000459	0.000506
Story7	21	Top	0.000513	0.000564
Story6	18	Top	0.00056	0.000613
Story5	15	Top	0.000593	0.000646
Story4	12	Top	0.000619	0.000674
Story3	9	Top	0.000653	0.000708
Story2	6	Top	0.000722	0.000774
Story1	3	Top	0.000868	0.000913
Base	0	Top	0	0

Table-5: Story drifts in X and Y directions for CFST column model

The story drift values decreases from bottom story to top story. The maximum story drift obtained is 0.000913.

Story	Elevation(m)	Location	X-Dir	Y-Dir
Story11	33	Top	0.000259	0.000281
Story10	30	Top	0.000309	0.00034
Story9	27	Top	0.000387	0.000434
Story8	24	Top	0.000455	0.000505
Story7	21	Top	0.000508	0.000563
Story6	18	Top	0.000555	0.000612
Story5	15	Top	0.00059	0.000645
Story4	12	Top	0.000618	0.000673
Story3	9	Top	0.000652	0.000706
Story2	6	Top	0.000715	0.000774
Story1	3	Top	0.000833	0.000921
Base	0	Top	0	0

Table-6: Story drifts in X and Y directions for concrete encased composite column model

The story drift values decreases from bottom story to top story. The maximum story3 drift obtained is 0.000921.

3.3 Base Shear

Model	Max Base shear (X- dirn) kN/m²	Max Base Shear (Y-dirn) kN/m²
RCC	342.13	330.88
CFST	314.93	303.41
Encased I section	319.43	302.45

Table-7: Maximum Base shear in X and Y-dirn for three models

Maximum displacement obtained for RCC column building with mass irregularity is 18.966mm. Maximum story drift obtained for RCC column building with mass irregularity is 0.000755. Base shear of building with RCC column in X direction is 342.1357 kN. Base shear of building with RCC column about Y-direction is 330.8825kN. Maximum displacement for rectangular shaped building with CFST column is 19.335 mm. Maximum storey drift obtained for CFST column building with mass irregularity is 0.000913.

Base shear of building with CFST column in X direction is 314.93 kN. Base shear of building with CFST column in Y-direction is 303.41kN. Maximum displacement for rectangular shaped building with concrete encased composite column is 19.3 mm. Maximum storey drift obtained for concrete encased composite column building with mass irregularity is 0.000913. Base shear of building with concrete encased composite column in X direction is 319.43 kN. Base shear of building with concrete encased composite column in Y direction is 302.45 kN. Base shear for buildings with different columns are shown in chart 1.

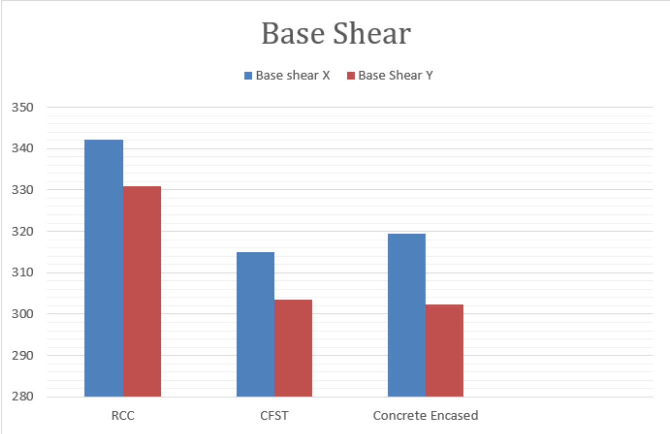

Chart -1: Variation of base shear in different columns

3. CONCLUSIONS

This study mainly focuses on the seismic analysis of G+10 building with concrete filled steel tubes and composite encased I section column under mass irregularities as per the selected geometry in ETABS software. Following conclusions were observed from the present study ;

- Conventional RCC columns were replaced by CFST and concrete encased steel composite columns and results were studied for building with mass irregularities.
- Story displacement was found to be almost similar on RCC , CFST and concrete encased steel composite columns in building with mass irregularities.
- Base shear for buildings with CFST columns were reduced about 8-9% compared to buildings with RCC columns and were found effective for buildings with mass irregularities.
- Base shear for buildings with concrete encased I section columns were reduced about 7-9% compared to buildings with RCC columns and were found effective for buildings with mass irregularities.
- Lateral forces on story with mass irregularity is much larger compared to other stories.
- CFST columns are thereby more appropriate to be used in buildings with mass irregularities compared to concrete encased columns.

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