International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Issue-08, Nov 2022

Analysis and Design of commercial building with Concrete Filled Steel Tube (CFST) column (composite structure) and its comparison with RCC structure

Kalash R. Gangwal, Post Graduate Student in Structural Engineering, MGM University, Jawaharlal Nehru Engineering College, Aurangabad, MS, India. gangwalkalash919@gmail.com

J.R Ramchandani, Assistant Professor, Civil Engineering Department, MGM University, Jawaharlal Nehru Engineering College, Aurangabad, MS, India. jramchandani@mgmu.ac.in

ABSTRACT - Concrete filled steel tubes (CFST) column systems consist of steel tubes filled in concrete. The CFST columns have many advantages compared to the RCC or steel structures. This paper presents work done on analysis and design of G+5 building for conventional RCC and Composite structure by E-tabs software. The axial force, shear force, bending moment and story drift are compared for both the structures.

Keywords – Concrete, Steel Tube, Composite Structure.

I. INTRODUCTION

A structural member composed of two or more dissimilar materials is known as composite members. Composite structures have better properties than its individual elements. Composite member consisting steel and concrete is one of the mostly used composite members in the construction industry. Concrete has better resistance towards compression forces; it has relatively low resistance towards tension forces. Whereas, steel performs well in tension and is required in smaller quantities. The combination of steel-concrete composite members utilizes the concrete's compressive strength and steel's resistance to tension thereby making it very efficient for the construction industry. Concrete-filled steel tube composite structures have benefits of both hollow structural steel and concrete core. It is structural system is based on filling the steel tube with high strength concrete. The composite action between the constituent elements present in the CFST column enhances its structural system behaviour.

Due to the high strength, ductility and good energy absorption capacity CFST members show good resistance towards seismic vibrations. Under axial compression load, concrete in the steel tube is confined sue to which the load resistance and ductility of CFST members increases. CFST materials fail more favourably by a ductile fracture mechanism due to the high shear capacity of concrete-filled steel tubular members. Moreover, the steel tube provides a permanent framework for the members.

Concrete filled steel tubes (CFST) are increasingly used in the world of construction, especially in the construction of the high-rise buildings and the high-rise buildings with increased grid of columns**.** CFT has been used in China for almost 50 years and now in Japan and USA use of CFT has increased from last few years. Research and development work has been done in many countries to increase practical use of CFT due its many advantages.

INRODUCTION TO MEMBERS OF COMPOSITE STRUCTURE

1) Composite Beam

The beam used in composite structure is steel beam. Concrete slab is rested on this beam and is supported by it. In this form the steel beam and concrete slab together act as composite beam. The beam is mainly subjected to bending and under load beam and slab start to act independently and if any connection is not provided between them a relative slip occurs in them. This slip is needed to be minimised or eliminated, in order for these two components to act together as a composite member. For this purpose shear connectors are provided between them.

Advantages of composite beams

- Comparatively beams of lesser depth can be used for the same loading and span of beam.
- It is much better for earthquake prone areas because of more resistance and ductility.
- Provides better fire resistance.
- Composite sections have higher stiffness than RCC sections and thus deflection is less.

 DOI : 10.35291/2454-9150.2022.0471

- It has comparatively less self weight than RCC structure which is much better for designing high rise buildings.

2) Shear Connector

Shear connectors are provided to connect steel beam and concrete slab. They provide sufficient strength and stiffness to both and also minimises slip between them. The total shear force at the interface between steel beam and concrete slab is almost seven times more than the total load carried by the beam. They are mainly provided for two reasons a) transmit longitudinal shear along interface, b) avoid separation of steel beam and concrete slab. There are mainly three types of connectors; flexible shear connector, rigid shear connector and anchorage shear connector.

3) Composite Column

Composite column comprises of either concrete encased hot rolled steel section or concrete filled steel tubes. The section used in our project is concrete filled steel tube. Composite column is generally used as load bearing member in composite framed structure.

Advantages of Concrete filled steel tube column

- Higher load caring capacity permits more floor space area.
- Due to restraining effect of concrete the occurrence of local buckling of steel tube is delayed.
- The strength of concrete is increased due to confining effect provided from steel tube.
- CFT is used as to avoid having large size of columns in buildings due to which we get more carpet area of floor.
- Good ductility and energy absorption.
- The system is excellent earthquake resistant as compared to RCC and steel construction.
- It shows more stiffness in horizontal plane.
- There is no need of formwork as the steel tube itself acts as formwork.
- The speed of construction is very fast which is more useful for bigger projects.
- The system is more fire resistant than other types.
- Steel tube reinforces the concrete to resist tensile forces.

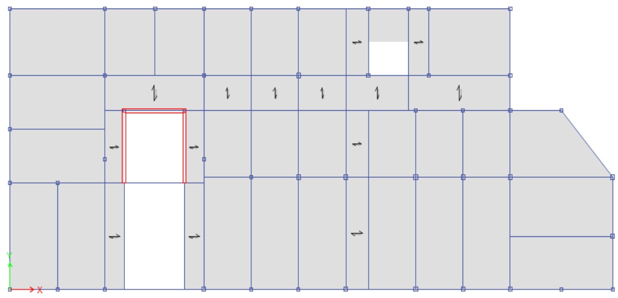
OBECTIVE

The salient objectives of the present study are as follows:

- To perform analysis using E-tabs software for G+5 multi-storeyed building for both RCC and composite structure.
- To compare behaviour of structure using both RCC and composite columns.
- To find out best option among RCC column and composite column for multi-storeyed building.

II. STRUCTURAL DETAILS

We have considered a commercial building. The dimension of the building is 46.499mx19.27m. The analysis is done for both RCC and composite structure for the same plan. Loading for both the structures is kept same.



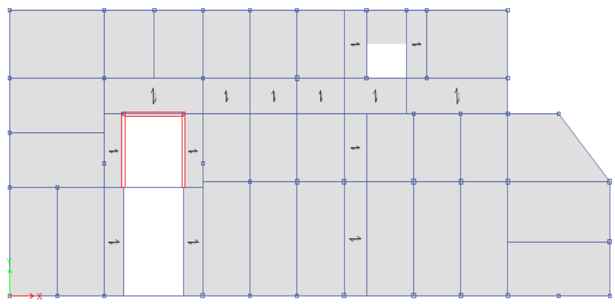


Figure 1 Typical RCC floor

Figure 2 Typical Composite floor

Table 1 : Structural Data for RCC and Composite Structure

Comparing factor	R.C.C	Composite Structure
Plan Dimension	46.499m x 19.27m	46.499m x 19.27m
No. of Storeys	6	6
Ht. of each storey	3.35m	3.35m
Ht. of Parapet	1.5m	1.5m
Total ht. of building	21.6m	21.6m
Type of beams		
	230mm x 450mm 230mm x 530mm 230mm x 750mm	ISMB 350 ISMB 400 ISMB 500 ISMB 550
Size of columns		
	300mm x 600mm 230mm x 530mm 230mm x 600mm 350mm x 700mm	CFST 230mm x 230mm CFST 300mm x 300mm
Slab thickness	140mm (two way) 125mm (one way)	140mm (two way) 125mm (one way)
Wall thickness	230mm	230mm
Grade of steel	Fe 500 (longitudinal bars)	Fe 500 (longitudinal bars)

 DOI : 10.35291/2454-9150.2022.0471

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Issue-08, Nov 2022

	Fe 415 (confinement bars)	Fe 415 (confinement bars) Fe 345 (steel sheet for columns)
Grade of concrete	M25	M25
Loading conditions		
Dead Load	1.3 kn/m2 for slabs 12 kn/m2 for beams	1.3 kn/m2 for slabs 12 kn/m2 for beams
Live Load	4 kn /m2	4 kn /m2
Seismic Zone	2	2
Wind Speed	44 m/s	44 m/s
Zone factor	0.36	0.36
Importance factor	1	1
Soil Condition	Medium soil	Medium soil

ANALYSIS

The above models are analysed using E-tabs software. Different parameters such as axial force, shear force and bending moment are studied for the models. Wind force is calculated using IS-875 (PART-3) and SP64 whereas IS-1893:2002 is used for seismic design force.

III. RESULTS

Analysis of both the structures is done and following results are obtained.

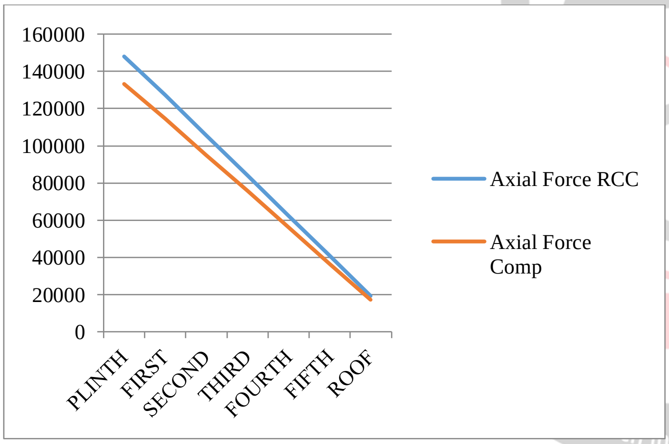


Figure 3: Comparison of Axial Force

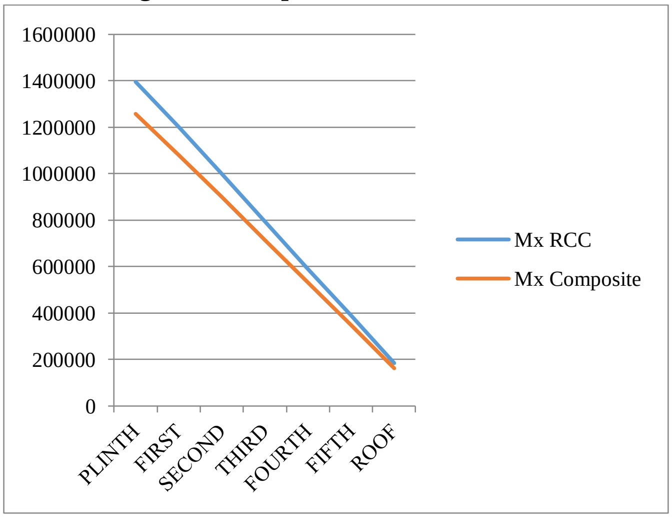


Figure 4: Comparison of Bending Moment in x-direction

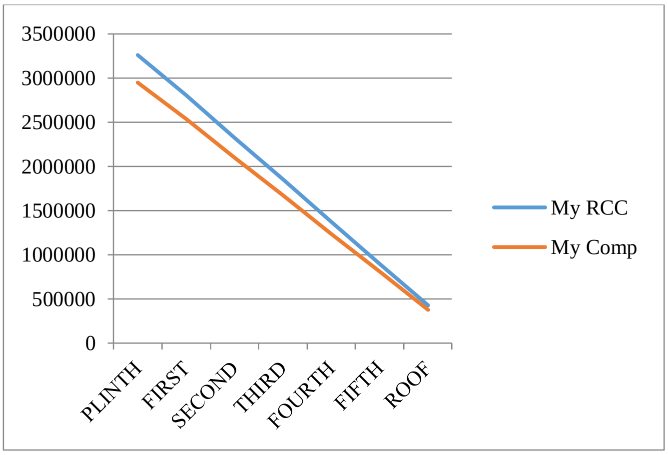


Figure 5 Comparison of Bending Moment in y-direction

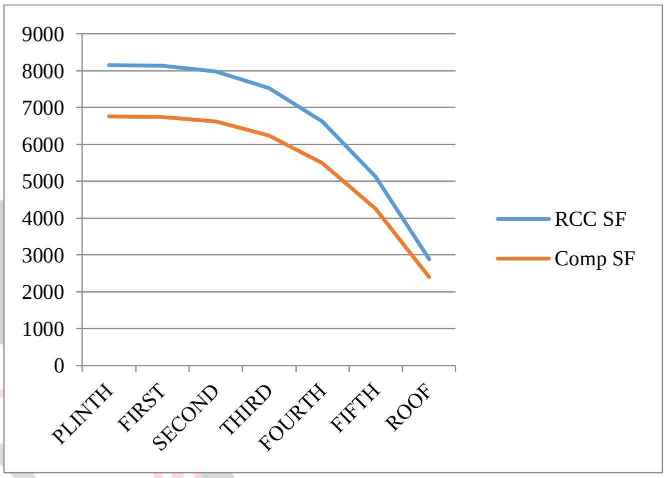


Figure 6 Comparison of Shear Force X-dir

1. Figure 3 shows that axial force in RCC structure is more than that of Composite structure. The axial force in RCC structure is approximately more than 10% than composite structure.
2. Figure 4 and figure 5 shows that bending moment in x and y direction of composite structure is relatively less than that of RCC structure.
3. Figure 6 shows that shear force in RCC structure is more than Composite structure.

IV. CONCLUSION

Analysis of G+5 building is done for both types of structure i.e. RCC structure and Composite structure using concrete filled steel tubes and comparison is done for both the structures. Following conclusions drawn are as follows –

1. For the same loading conditions where in RCC structure column section of 300mm x 750mm is required, in composite structure CFST section of 300mm x 300mm is required. Thus size of column required in composite structure is less than in RCC structure.
2. For the same loading conditions where in RCC structure 230mm x 450mm section of beam is required, in composite structure ISMB 300 section

 DOI : 10.35291/2454-9150.2022.0471

is required. So the size of beam required in composite structure is less than in RCC structure.

3. As steel section is used for beams in composite structure and column size is smaller in composite structure, lesser volume of concrete is used in composite structure which results in less use of reinforcement steel.
4. When compared axial force, shear force and bending moment is less in composite structure than RCC structure by 10% to 15%, thus smaller foundation size is required in composite structure.
5. As steel concrete composite structure has better ductility than RCC structure it is suggested to use composite structure in earthquake prone areas.
6. Construction of composite structure requires less time than RCC construction, so i.

FUTURE SCOPE

- Cost estimation can be done in order to find more economical type of construction.
- Both the structures can be compared for different type of seismic zones to find a suitable one.
- Different sections of columns for composite structures can be analysed and compared to find more suitable one.

REFERENCES

[1] Han LH, Li W. (2014) Seismic Performance of Concrete-Filled Steel Tubular (CFST) Structures. In: Klinkel S., Butenweg C., Lin G., Holtschoppen B. (eds) Seismic Design of Industrial Facilities. Springer Vieweg, Wiesbaden. https://doi.org/10.1007/978-3-658-02810-7_30

[2] KVEDARAS, A. K. Theory and practice of concrete filled steel tubes. Habilitation thesis, Vilnius Gediminas Technical University, Vilnius, 1999. 82 p. (in Lithuanian).

[3] FURLONG, R.W. Design of Steel-Encased Concrete Beams Columns. Journal of the Structural Division, 1968, 94(1), p. 267–281.

[4] Suliman Hassan Abdulla, “Behaviour of concrete filled steel tube (CFST)” Sharjah, American University of Sharjah College of Engineering United Arab Emirates, p. 19-24.

[5] A.L. Krishnan, Concrete filled steel tube columns for high-rise buildings, Structural Mechanics of Engineering Constructions and Buildings. 4 (2009) 75-80.

[6] C.-J. Gong, X. Lin, S.-H. Cai, Application of concrete-filled steel tubular columns in tall buildings in earthquake area, in: Proceeding of Structures Congress XII, Proceedings of the ASCE Structures Congress 94, Atlanta, GA. 1 (1994) 146-151.

[7] Gupta, P. K., Sarda, S. M., and Kumar, M. S. (2007). Experimental and computational study of concrete filled steel tubular columns under axial loads. J. Constr. Steel Res. 63, 182–193. doi: 10.1016/j.jcsr.2006.04.004.

[8] IS: 456(2000) Indian Standard Code of Practice for Plan and Reinforecement.

[9] IS: 800, "Code of practice for general construction in steel, Bureau of Indian Standards, New Delhi, 2007.

[10] IS: 11384, "Code of practice for composite construction in structural steel and concrete", Bureau of Indian Standards, New Delhi, 1985.

 DOI : 10.35291/2454-9150.2022.0471