International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 04 | Apr 2022 www.irjet.net p-ISSN: 2395-0072

Comparative Study on CFST and RC Column in the RC Frame Structure

Abdul Baqui Ansari[1], Sandhya Sahani[2]

[1]M.Tech, Civil Engineering, Suyash Institute of Information Technology, Gorakhpur, Uttar Pradesh
[2]Assistant Professor, Civil Engineering, Suyash Institute of Information Technology, Gorakhpur, Uttar Pradesh

---***---

Abstract - *In this research study, we studied the response of the different composite columns in the multistorey building by using dynamic analysis. In this paper, we created three models which have different composite columns. In the model-01, we provided the general RCC column; in the model-02, we provided the column in which the tube is provided; in the model-03, we provided the I-section steel with the reinforcement, where the purpose of the using the reinforcement in the model-03 is that proper joint can be created between the beam and column. These three models will be analyzed with the help of the ETABS software by using the Indian standard Seismic code 1893 part-1:2016. The method used for the analysis of these models is the Time History Method and data of the time history was taken from "Andaman" whose magnitude was 7.8. After the analysis of these three models, we will compare the result based on the seismic parameter such as Storey acceleration, Mode shape, Column force, Storey Overturning moment, Base reaction and then we will compare the stability of these three models with the help of this seismic parameter.*

Key Words: Dynamic analysis, time history analysis, CFST column, Composite Section, ETABS.

1. INTRODUCTION

The CFST column is a structural element made of steel tubes with a concrete core. The outer tube of the CFST column not only limits the concrete core but also prevents the steel tube from collapsing inward [1]. Because of its excellent load carrying capacity, cheap cost, and labour efficiency, this type of composite element has recently been popular in many load-bearing structures. Existing design standards such as Japanese standard [6], American code AISC 360-16 [7], Eurocode 4 [8], allow for maximum yield stresses of 440 MPa, 525 MPa, 460 MPa, and 690 MPa, respectively, for the steel grade used in CFST columns. Steel with high yield stress has a much higher yield strain than concrete, which is one of the main reasons for these limitations. As a result, the concrete core usually crushes before the high-tensile steel yields [10]. The construction of multistory RCCs is now expanding day by day, and as the structure's height rises, so does the numerical value of lateral pressures such as seismic and wind forces. To withstand the lateral force on a multistory building, we must construct a more robust structure that can withstand the lateral force easily. We know that steel is needed to support the structure's tensile force and that the nature of the lateral load is tensile, therefore we give a steel tube in model 02 and an I-section with reinforcement in model 03 that can withstand that lateral load.

1.1. CFST Column

Concrete Filled Steel Tube column is defined as the column in which the tube of the steel is placed and has no use of the reinforcement bar. The main advantage of the CFST column is that it can resist the higher lateral force as compared to the reinforcement bar, and the drawback of the CFST column is that we cannot provide the proper joint between the beam and column. The figure of the CFST column is given below:

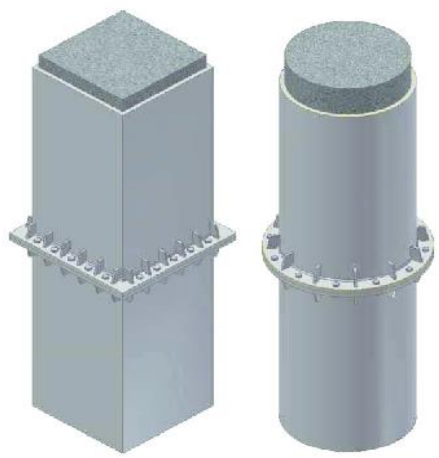

Figure-01: CFST Column

1.2. Composite Material

Composite material is defined as the combination of two or more materials for one purpose is known as a composite material. In this paper, we used the composite material in model-02 and model-03. Here Steel and concrete are used in the multistory building for the resisting load of the structure. The figure of the composite material is given below:

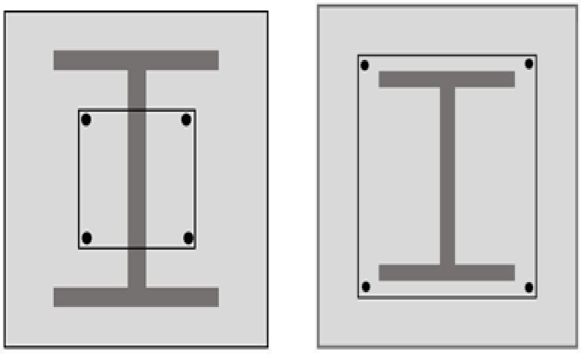

Figure-02: Composite Material

2. METHODOLOGY

In the methodology, we studied the method which is used for the analysis of these models, Indian Standard Code, Software, load combination, load case, building parameter, seismic parameter, etc.

2.1. Method of the Analysis

In this research paper, we used the dynamic analysis of the CFST column in the multistoried building by using the Time History Analysis. The dynamic analysis is used when the variation of the lateral force concerning the time is high, or the study of the structure in the moving condition. In the Static Method, we study the structure when that structure is in the rest or equilibrium condition, or variation of the lateral force concerning the time is low.

2.2. Software

The software used for creating and analysis of these models is ETABS software, which was developed by the CSI Company. ETABS software is used for the analysis and designing of the structure with the various type of load. In this software, the Standard code is almost uploaded which is used for analyzing the structure by using particular that standard code.

2.3. Indian Standard Code

In this research paper, we used mainly four Indian Standard codes such as IS 456:2000, IS 875-part-1, IS 875-part-2, and Indian Standard 1893 part-1:2016.

2.3.1. IS Code 456:2000

IS 456-2000 Plain and Reinforced Concrete - Code of Practice is an Indian Standard code of practice for general structural use of plain and reinforced concrete. ... It gives extensive information on the various aspects of concrete. Load Combination. In this Indian standard code, the minimum reinforcement area of the column, beam and slab is given; based on which we check the minimum reinforcement area.

2.3.2. IS Code 875 part-1

IS 875 (Part 1) Code of Practice for Design Loads (Other than Earthquake) For Buildings and Structures. Part 1: Dead Loads--Unit Weights of Building Materials and Stored Materials. In this Indian standard code, the value of the unit weight of the materials is given.

2.3.3. IS Code 875 part-2

This standard (Part 2) covers imposed loads (live loads) to be assumed in the design of buildings. The imposed loads, specified herein, are minimum loads that should be taken into consideration for the structural safety of buildings. This Indian standard code gives the value of the live load according to the type of the structure.

2.3.4. IS Code 1893: Part-1: 2016

This Indian standard code is used for the Earthquake Resistant Design of the Structure, in this code, the seismic parameter is given such as the seismic zone, importance factor, etc; when we analyzed static or dynamic analysis of the structure.

2.4. Load Case

In these three models, we took some load cases such as the dead load of the structure, live load on the slab or roof, wall load, and seismic force.

2.5. Building Parameter

In this parameter, we will study the size of the beam, column, thickness of the slab, plan area of the building, the total height of the structure, etc. The table of the building parameter is given below:

Table-01: Building Parameter

S.No	Building Parameter	Dimension
1	Beam	350mm X 450mm m40
2	Column	440mm X 550mm m40
3	Slab	150mm m30
4	Bottom storey height	Bottom storey height
5	Height of every floor	Height of every floor
6	The total height of the building	The total height of the building
7	Area of the building	Area of the building
8	Span of beam	4m

2.6. Material Parameter

The material used in the analysis of these three models such as concrete, reinforcement, etc is given below in the form of the table:

Table-2: Material Parameter

S.No	Material Name	Grade
1	Concrete	M40 for beam & Column
2	Concrete	M30 for Slab
3	Mild Steel (Fe250)	I section & Tube Section

2.7. Load Parameter

The load which applies on the structure such as dead load or self-weights live load on the slab or roof, live load on the beam is given below in the form of the table:

Table-3: Load Parameter

S.No	Load parameter	Value
1	Dead load	6.9 KN/m
2	Live load	2.5 KN/m
3	Live load	4KN/m²

2.8. Seismic Parameter

According to the Indian Standard Code, we have taken the value of the seismic parameter based on the location of the structure, type of frames such as OMRF or SMRF, etc is given below:

Table-4: Seismic Parameter

S.No	Seismic Parameter	Value
1.	Importance Factor (I)	1.2
2.	Response Reduction Factor (R)	3
3.	Zone Factor (z)	0.24
4.	Type of the Soil	2^{nd}
5.	Eccentric ratio	0.05
6.	magnitude	7.8
7.	Time history data	Andaman, 10/08/2009 19:55:35 UTC

2.9. Plan, Elevation and 3D view of Model-01

In the model-01, we provided the normal RCC column, the details figure of the model-01 is given below:

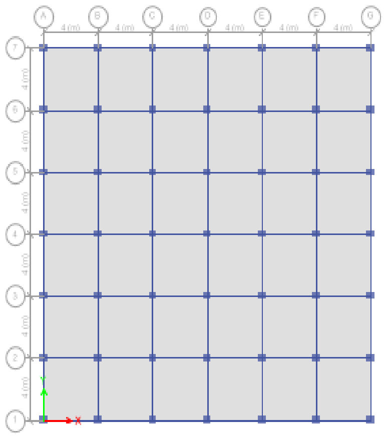

Figure-03: Plan of Model

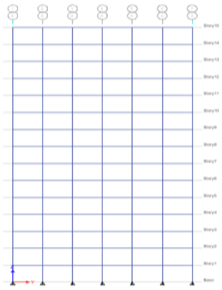

Figure-04: Elevation of Model

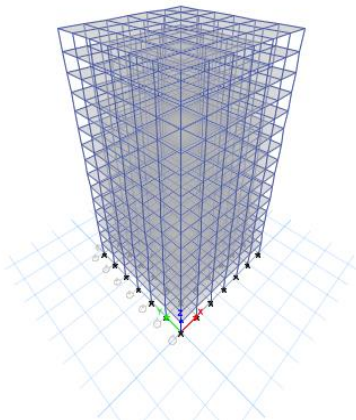

Figure-05: 3D View of Model

2.10. Plan, Elevation and 3D view of Model-02

In model-02, we provided the CFST column means providing the tube of the steel in the column. The plan, elevation and 3D view of the model-02 are the same as model-01, but the cross-section of the column in the model-02 is different from the model-01. The figure of the cross-section of the column of the model-02 is given below:

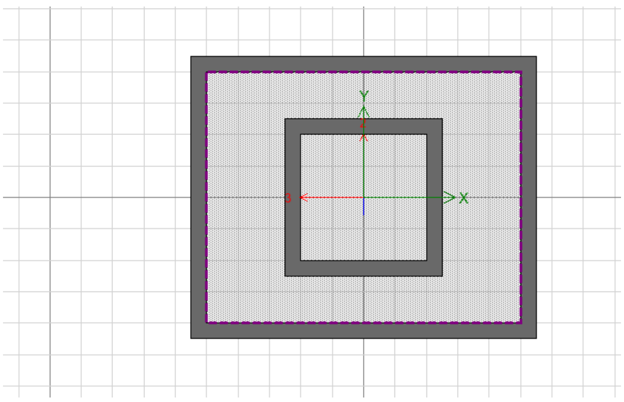

Figure-06: Section of tube Column of Model-02

2.11. Plan, Elevation and 3D view of Model-03

In model-03, we provided the I-section steel with reinforcement in the column. The plan, elevation and 3D view of the model-03 are the same as model-01, but the cross-section of the column in the model-03 is different from the model-01. The figure of the cross-section of the column of the model-03 is given below:

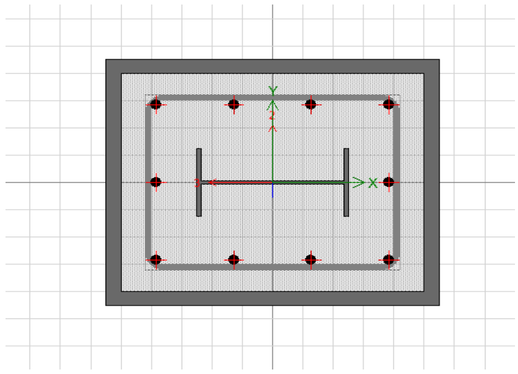

Figure-07: Section of Column of Model-03

3. RESULT AND ANALYSIS

In the result and analysis, we will study the result which comes out after the analysis of three models, and then compare all results of each model will be compared with other models in the form of a graph. After analyzing all data concerning each other, we will see which model is more stable and durable as compared to other models. The parameter taken for the analysis of the models is:

i. Design Reaction
ii. Storey Acceleration
iii. Mode Shape
iv. Column Force
v. Storey Overturning Moment

3.1. Design Reaction

Design reaction is defined as the vertical force which is developed at the base of the structure, the design reaction resists all the forces or load which is acting on these models. The value of the design reaction is taken due to load case EX which is a seismic force in the X-direction. The graph of the design reaction is given below of these three models along the FZ (vertical load along Z-direction):

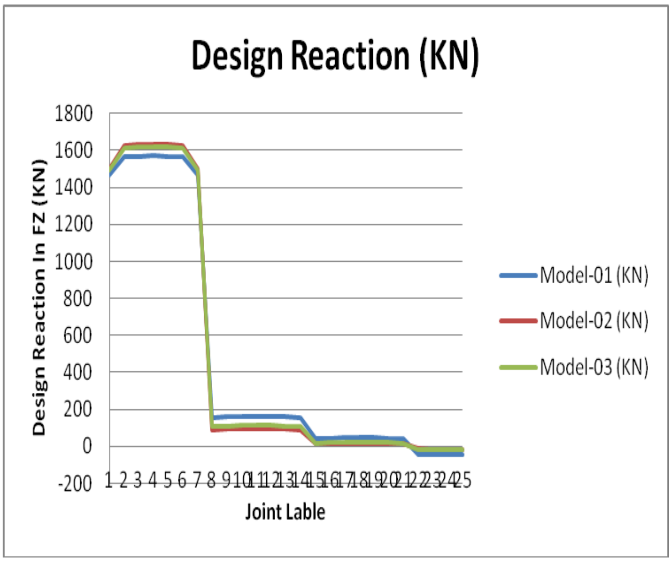

Chart-1: Design Reaction

From the above graph, we can analyze the maximum value of the design reaction at the joint label 06 which is present at the base of the model.

3.2. Storey Acceleration

Storey acceleration is defined as the acceleration of each storey of the structure due to applying the lateral load on the structure. The effect of the storey acceleration is high in the case of the lateral load and minimum in the case of the vertical load. The value of the storey acceleration is taken along the load case EX which is applied in the model, and a graph of the storey acceleration along UX is given below:

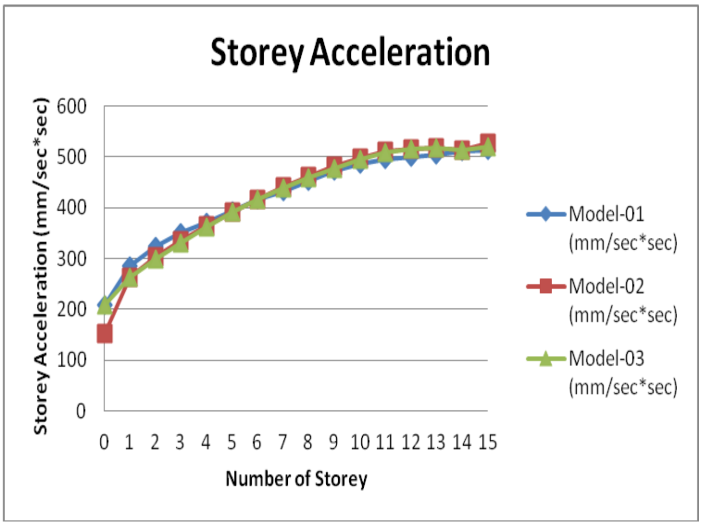

Chart-2: Storey Acceleration

From the above graph of the storey acceleration, we can analyze the maximum response of the storey acceleration in model-02.

3.3. Column force

Column force is defined as the vertical force in the compressive nature which come from the above structure to the column. Design the column to resist that particular load of the column force. The value of the column force due to load case EX, the graph of column force is given below:

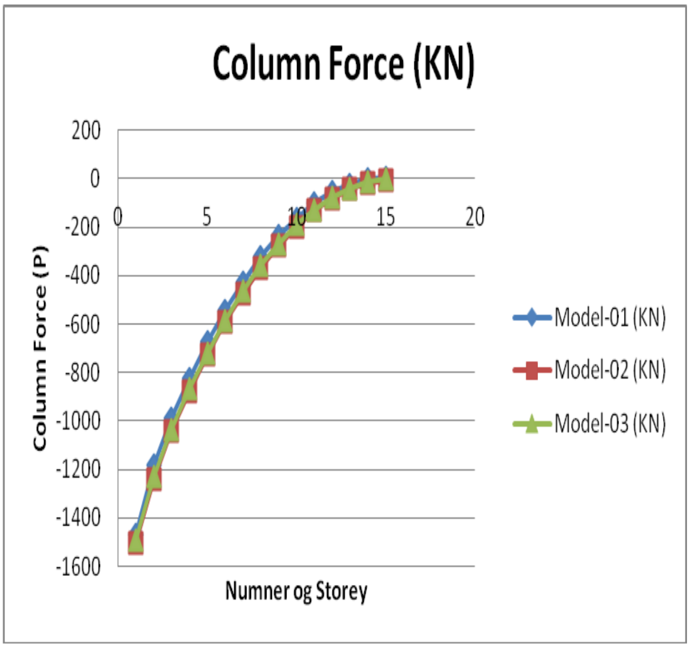

Chart-3: Column Force

From the above graph of the column forces of the models, the maximum value of the column force in the mode-02, where the tube of the steel provided in the column.

3.4. Storey Overturning Moment

Storey overturning moment is defined as the moment which acts on every top layer of the storey of the structure. The effect of the overturning moment is maximum due to applying the lateral load on the structure as compared to the vertical load on the structure. The value of the maximum overturning moment is produced at the base of the structure. The graph of the overturning moment is given below:

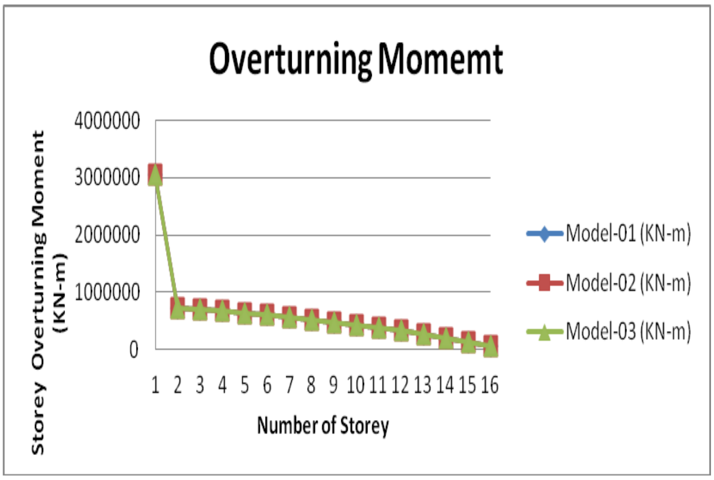

Chart-4: Storey Overturning Moment

From the above graph of the storey overturning moment, we can analyze that from storey-01 to storey-02 maximum change occurs.

4. CONCLUSION

i. The value of the storey acceleration of the Model-02 in UX is maximum as compared to the other models, so we can say that model-02 is more flexible as compared to model-1 and model-3, because of the effect of the lateral force is high in the model-2.

ii. The value of the axial force in the column due to seismic forces in X-direction in the Model-01 is minimum as compared to the model-02 and model-03. The value of the torsion and moment at the storey-01 is zero so its means that we do not need the extra reinforcement in the models at the storey-01. We only need to design the column according to the effect of the load on the Z-direction.

iii. After comparing the result of the mode shape of the three models, then we find that the mode shape of model-01 at mode-01 is developed at 2.058 seconds, which is maximum as compared to the model-02 and model-03.

iv. Concerning the above graph of the storey overturning moment, the summation of the total overturning moment in model-02 is maximum which is equal to 9750343 KN-m. The value of the storey overturning moment of the model-01 and model-03 is 0.000102% and 0.00002051 % less as compared to the model-02.

v. From the above table of the design reaction, we can see that value of the design reaction of the model-01 is maximum as compared to model-02 and model-03, so the cost of the constructing the foundation to resist the design reaction is more as compared to other models, but the model-02 have a low value of the design reaction so it is more economical as compared to other models.

REFERENCES

[1]P. Fajfar, A nonlinear analysis method for performance based seismic design, Earthquake Spect. 16 (3) (August 2000) 573–592.

[2]Ketan Patela, Sonal Thakkarb* ANALYSIS OF CFT, RCC AND STEEL BUILDING SUBJECTED TO LATERAL LOADING, ScienceDirect, 2012, 51 (2013) 259 – 265

[3]Konstantinos Daniel Tsavdaridis, Seismic Analysis of Steel–Concrete Composite Buildings: Numerical Modeling.2014, ScienceDirect, DOI 10.1007/978-3-642-36197-5_125-1

[4]Sameh A. El-Betar, Seismic performance of existing R.C. framed Buildings.2015, Elsevier

[5]Pramodini Naik1, Satish Annigeri2, Performance Evaluation of (storey RC building located in North Goa. ScienceDirect. 2016, Procedia Engineering 173 (2017) 1841 – 1846

[6]IS: 1893-2016, Criteria for earthquake resistant design of structures, Bureau of Indian Standard, New Delhi.

[7]IS 456-2000, Plain and Reinforced Concrete Code of Practice, Bureau of Indian Standard, New Delhi.

[8]IS 800-2007, Code of practice for general construction in steel, Bureau of Indian Standard, New Delhi.

[9] AS/NZS 2327, Composite Steel-Concrete construction for buildings, Australia/Standard New Zealand Standard, 2017.

[10] C.-S. Kim, H.-G. Park, K.-S. Chung, I.-R. Choi, Eccentric axial load capacity of highstrength steel-concrete composite columns of various sectional shapes, J. Struct. Eng. 140 (4) (2014), 04013091, .

[11] F. Aslani, B. Uy, Z. Tao, F. Mashiri, Predicting the axial load capacity of high-strength concrete filled steel tubular columns, Steel Compos. Struct. 19 (4) (2015) 967–993.

[12] W.-M. Gho, D. Liu, Flexural behaviour of high-strength rectangular concrete-filled steel hollow sections, J. Constr. Steel Res. 60 (11) (2004) 1681–1696.

[13] D.M. Lue, J.-L. Liu, T. Yen, Experimental study on rectangular CFT columns with highstrength concrete, J. Constr. Steel Res. 63 (1) (2007) 37–44.

[14] D. Liu, Behaviour of high strength rectangular concrete-filled steel hollow section columns under eccentric loading, Thin-Walled Struct. 42 (12) (2004) 1631–1644.

[15] D. Liu, Tests on high-strength rectangular concrete-filled steel hollow section stub columns, J. Constr. Steel Res. 61 (7) (2005) 902–911.

[16] L.-H. Han, G.-H. Yao, X.-L. Zhao, Tests and calculations for hollow structural steel (HSS) stub columns filled with self-consolidating concrete (SCC), J. Constr. Steel Res. 61 (9) (2005) 1241–1269.

[17] J.M. Portolés, E. Serra, M.L. Romero, Influence of ultra-high strength infill in slender concrete-filled steel tubular columns, J. Constr. Steel Res. 86 (2013) 107–114.

[18] Z. Tao, L.-H. Han, Z.-B. Wang, Experimental behaviour of stiffened concrete-filled thin-walled hollow steel structural (HSS) stub columns, J. Constr. Steel Res. 61 (7) (2005) 962–983.