STUDY ON SEISMIC BEHAVIOR OF MULTI-STORIED RCC BUILDING CONSIDERING CFST COLUMNS

[1]Gopi Deepak Ghadvir, [2] Proffessor M.V.Nagendra

[1] *PG student,* [2]Associate Proffessor
[1]Department of Civil Engineering,
[1]PVPIT, Budhgaon, India

Abstract : This dissertation work is mainly focused on seismic behavioral study of RCC building structures with Concrete Filled Steel Tube (CFST) columns. In this chapter some introductory information about CFST is summarized. Also, objectives of dissertation are given along with outline of dissertation report.

***IndexTerms* - Component,formatting,style,styling,insert.**

1.Introduction

A concrete filled steel tubular (CFST) column is steel tubular section filled with concrete and has composite performance. Combination of steel and concrete mix advantages of these two materials and compensate disadvantages. The steel tube have longitudinal and lateral reinforcement role for helping concrete core to resist against bending moment, shear and tension. Steel tube also creates confinement in concrete and increase compressive strength and prevents concrete from spalling. Concrete core increases stiffness of column and reduces capability of inward local buckling. Interaction between steel and concrete provide high strength, ductility and energy absorption capacity and led to better seismic performance of structures built with these columns.

Behaviors of CFST columns are influenced by loading, characteristics of materials and geometric of cross section such as nonlinear behavior and ultimate strength of material, shape and width-to-thickness ratio of steel tube section.

Concrete filled steel tubular columns have been extensively used in modern construction owing to that they utilize the most favorable properties of both constituent materials. It has been recognized that concrete filled tubular columns provide excellent structural properties such as high load bearing capacity, ductility, large energy-absorption capacity and good structural fire behavior. Composite members are made up of two different materials such as steel and concrete which are used for beams and columns. The steel and concrete structures have wide applications in multistory commercial buildings and factories as well as in case of bridges. Steel and concrete have almost the same thermal expansion, concrete is efficient in taking compression loads and steel is subjected to tensile loads. Composite structures are becoming popular and preferred choice of structural Engineers as disadvantages of using purely steel or purely concrete structures can be minimized. In a composite column both the steel and concrete would resist the external loading by interacting together by bond and friction.

2.Review of Previous Studies

Following different studies are reviewed during this dissertation work.

Baochun CHEN in July 2008, The Concrete Filled Steel Tubular (CFST) structure has been applied prevalently and rapidly to arch bridges since 1990 and this trend is continued with more and more long span CFST arch bridges been built since 2000. This paper briefly introduces the present situation of CFST arch bridges, their five main structure types and the construction methods. Many selected CFST arch bridges built since 2000 and some still under construction are presented.

B. R. Niranjan, Eramma H. (2014), studied the compressive behavior of triangular and rectangular fluted reinforced circular CFST column with varying length to width (L/D) ratio. The compressive strength of CFST columns were obtained by experimentally and analytically. Analytical results of CFST column calculated using codes EC-4, ACI-318 and AISC. The study shows experimental strength results of CFST columns were higher than the analytical strength results calculated from methods given in above codes; hence the researchers had suggested that the equations given in above codes cannot be directly used to calculate the compressive strength of the fluted CFST column.

Burak Evirgen et al. (2014), investigated the compressive behaviour of CFST section considering various cross-sectional shapes like circular, hexagonal, rectangular and square. Experimental study was carried out by varying B/t (Breadth to thickness) ratio and grades of concrete. The obtained results of experimental study were compared with software results calculated by developing finite element model using ABAQUS software. From this study, researchers had been stated that the concrete core of CFST resists the inward buckling of steel tube and steel tube provides better confinement to concrete core which increases the strength of CFST.

X. H. Dai et al. (2014), investigated the compressive behavior of elliptical slender CFST section. A Complete behavioral study carried out by developing a finite element model using ABAQUS software and these software results of elliptical CFST sections compared with several test results for validation and accuracy. The researchers have also calculated the buckling load of elliptical section according to the specification given in Euro Code – 4 for rectangular and circular CFST section and it is concluded that the design method given in EC-4 for finding the axial compression behavior of circular and rectangular CFST section may be used for the elliptical CFST section.

Y. F. Yang, L. H. Han (2012), have examined the behaviour of CFST under partial compression by considering different parameters, namely cross sectional shape, length to diameter ratio and partial compression area ratio. The study was carried out by testing twenty-six specimens of CFST by varying the above parameters and their behaviour was also verified by developing a finite element model using ABAQUS software. The study shows that the behaviour of partially compressed CFST section was similar to that of fully compressed CFST section.

3.Objectives of the present work

Objectives of the dissertation work are given as follows.

1. To validate the results of seismic analysis of a G+2 RCC structure obtained by software and manually using Equivalent Static Method of analysis.
2. To compare the behavior of RCC multi storey (G+10) building structure considering conventional RCC and CFST column.
3. To investigate the seismic behavior of multi storey (G+10) RCC building structure by CFST column.

4. Methodology

4.1 General

This chapter describes various methods and approaches used for analysis and design of structure. In the present work, comparative study of seismic behaviour of RCC multi-storied building considering CFST columns using ETABS 2015 has been carried out. Seismic analysis of building is required to carry out for the determination of seismic responses so as to understand the realistic behavior of the structure. This can be done either by dynamic or simple static analysis method. In this study seismic analysis of structure is carried out by Response Spectrum Analysis method of dynamic analysis. After analysis, design of RCC building is done by according to IS 456:2000 and for designing CFST columns AISC 360:10 is used.

4.2 Selection and validation of software

The present study is carried out on analysis and design of multi-storied building considering CFST columns using ETABS 2015 software since, ETABS 2015 is the only software which has the facility of analyzing and designing of CFST columns. It designs the CFST sections as per specification of AISC 360-10. To know the competency of ETABS 2015 software for analyzing and designing CFST sections, a G+2 building structure provided with CFST columns has been analyzed (Seismic) and designed by software as well as manually as per codal provisions and their results are compared. Seismic analysis of structure is carried out using Equivalent Static method of seismic analysis which is described in section(3.3.2) and design of CFST section is carried out as per specifications of AISC 360-10 which are summarized in section (3.4)

4.3 Methods of analysis of structure

4.3.1 Response Spectrum Analysis method

In this study seismic analysis of building structure is carried out by Response Spectrum Method and for validation Equivalent static analysis method is used. These both methods are chosen according to the type and specifications of building structure. Generally for high rise building structure, dynamic method of seismic analysis is preferred as specified in IS: 1893 (Part I)-2002, clause 7.8.

4.3.2 Equivalent Static Analysis method

This method is also called as Linear Static Analysis method is used to estimate the demand for the building whose response is particularly dominated by the first mode and expected to behave in elastic range. In this method the lateral loads on building are calculated based on the fundamental period of structure and applied at the each floor level. The magnitude of this lateral force has been selected with the intension that when applied to the linearly elastic model of the building, it will results in design displacement expected during the design earthquake. This Equivalent static analysis is based on some assumptions which are listed below.

- Assume that the structure is rigid.
- During motion of ground, each point on structure experience same acceleration.
- It gives approximate values of total horizontal force on the structure
- Assume that there is perfect fixity in between the structure and its foundation

5. Design of multistoreyed building using CSI ETABS 2015

5.1 For the validation of analytical results of ETABS 2015 software, a G+2 building provided with CFTS columns of rectangular shape is analyzed manually as per IS code specifications as well as using ETABS 2015.

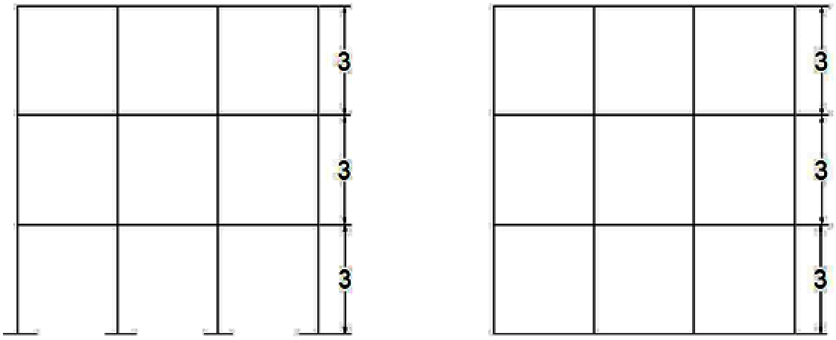

Fig. No.5.1: Plan and Elevation of G+2 Storied RCC Building (Validation)

5.2 Preliminary data of structure for analysis:

Sr. No.	Particulars	Details
1	Type of Structure	Multistoried Special Moment Resisting Frame
2	Type of building	Residential building
3	Seismic Zone	V (IS:1893-2002)
4	Number of Stories	Three (G+2)
5	Floor Height	3000 mm
6	Wall	150 mm
7	Imposed load	2 kN/m^2
8	Materials	Concrete M20, Reinforcement Fe500 & Structural steel (Fy-250)
9	Size of Columns	230 mm X 450 mm, t = 13m(Rectangular) 300 mm X 600 mm, t = 13m(Rectangular)
10	Size of Beams	230 mm X 450 mm
11	Depth of slab	145mm thick
12	Type of Soil	Medium
13	Damping	5%

5.3Basic Loading considered on building

The basic loading on building provided with RCC and CFST columns are kept same. Following are the different loadings are considered on buildings. Dead load and live load on building are taken as per IS: 875-1987 (Part-1and Part-2)

5.3.1 Dead Load [as per IS : 875 – 1987(Part-1)]

1)Floor load:-

a) Assume slab thickness
Load = 0.1450X 1 X 25 = 3.625 kN/m^2

b)Floor finish = 1.5 kN/m^2

c)Water proofing load on terrace = 2.5 kN/m^2

2)Wall load (Assume wall thickness 150mm):-

a)Load of external and partition walls

Load = 0.15 X 20 X (3-0.45) = 7.65kN/m

b) Load of parapet walls

Load = 1 X 20 X 0.15 = 3 kN/m

c)Load of Head room walls

Load = 0.15 X 20 X (2.75-0.45) =6.90kN/m

3) Staircase load:- 20 kN/m

5.3.2 Live Load [as per IS: 875-1987 (Part-2)]

1) Live load on all rooms including bathrooms and toilets = 2 kN/m^2
2) Live load on corridors, passages and balconies = 3 kN/m^2

5.3.3 Load cases, load combinations and earthquake parameters.

5.3.3.1 Load cases

1) Dead Load
2) Live Load
3) Wind force in X- direction
4) Wind force in Y- direction
5) Earthquake force in X-direction
6) Earthquake force in Y-direction

5.3.3.2 Load combinations [as per IS 1893:2002 (Part-I) & (IS 875-Part-V)]

Table No. 5.3.3.2: loading combinations considered for analysis of structure

Sr. No.	Load Combinations	Case
1	Combo 1	1.5(DL + LL)
2	Combo 2	1.5(DL+EL)
3	Combo 3	1.2 DL+0.3LL+1.2EL
4	Combo 4	1.5(DL+WL)
5	Combo 5	1.2(DL+LL+WL)
6	Combo 6	0.9DL + 1.5EL
7	Combo 7	0.9DL + 1.5WL

6.CFST

A concrete-filled steel tubular (CFST) column is formed by filling a steel tube with concrete. It is well known that concrete-filled steel tubular (CFST) columns are currently being increasingly used in the construction of buildings, due to their excellent static and earthquake-resistant properties, such as high strength, high ductility, large energy absorption capacity, bending stiffness, fire performance along with favorable construction ability etc. Recently, the behavior of the CFST columns has become of great interest to design engineers, infrastructure owners and researchers, Concrete-filled steel tube (CFST) columns combine the advantages of ductility, generally associated with steel structures, with the stiffness of a concrete structural system. The advantages of the concrete-filled steel tube column over other composite systems include: The steel tube provides formwork for the concrete, the concrete prolongs local buckling of the steel tube wall, the tube prohibits excessive concrete spalling, and composite columns add significant stiffness to a frame compared to more traditional steel frame construction. While many advantages exist, the use of CFTs in building construction has been limited, in part, to a lack of construction experience, a lack of understanding of the design provisions and the complexity of connection detailing. Consequently, a joint was needed that could utilize the favorable strength and stiffness characteristics of the concrete-filled tube column yet be constructible.

6.1 Structural modeling, analysis and design

Modeling of building structure is done by using ETABS 2015. The complete modeling, analysis and design of structure is done in three phase namely preprocessing, processing and post processing

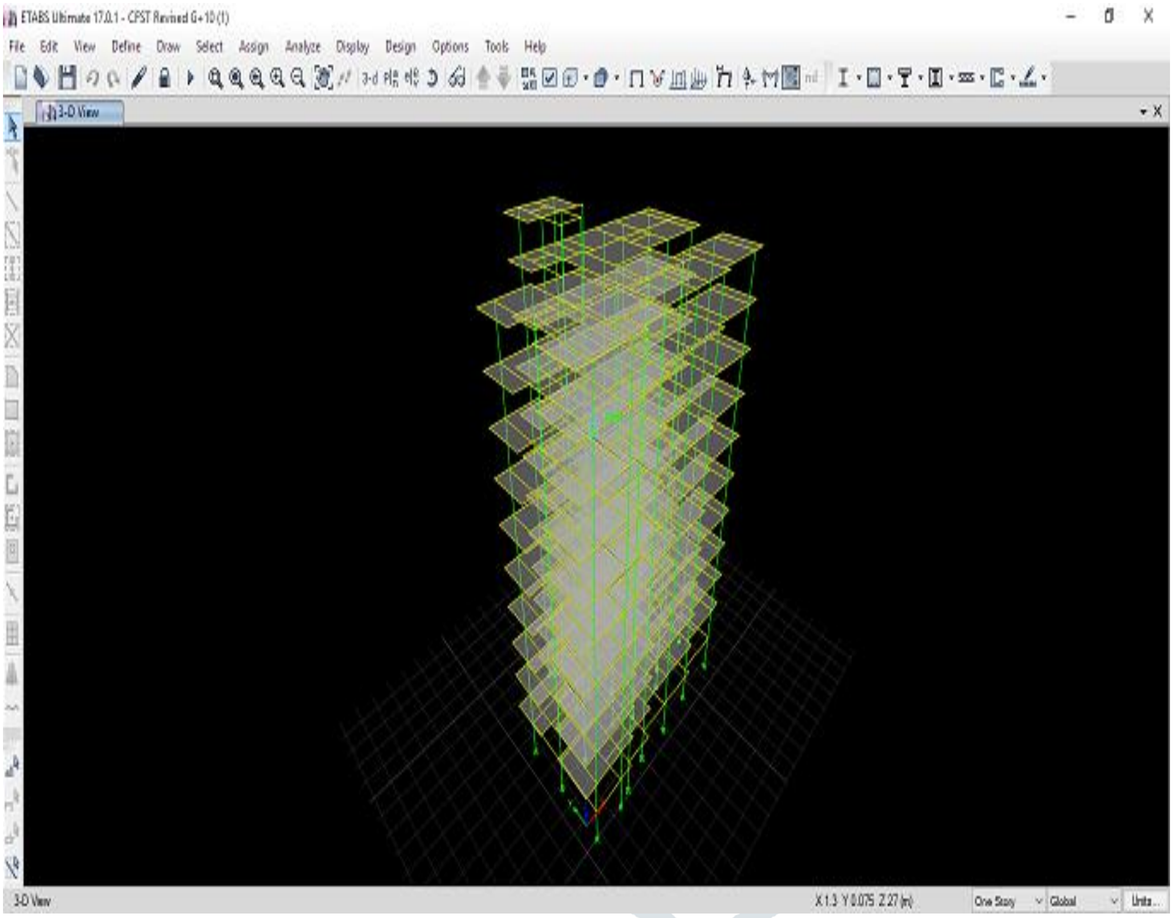

Fig.No.4.5: 3D model of building in ETABS 2015

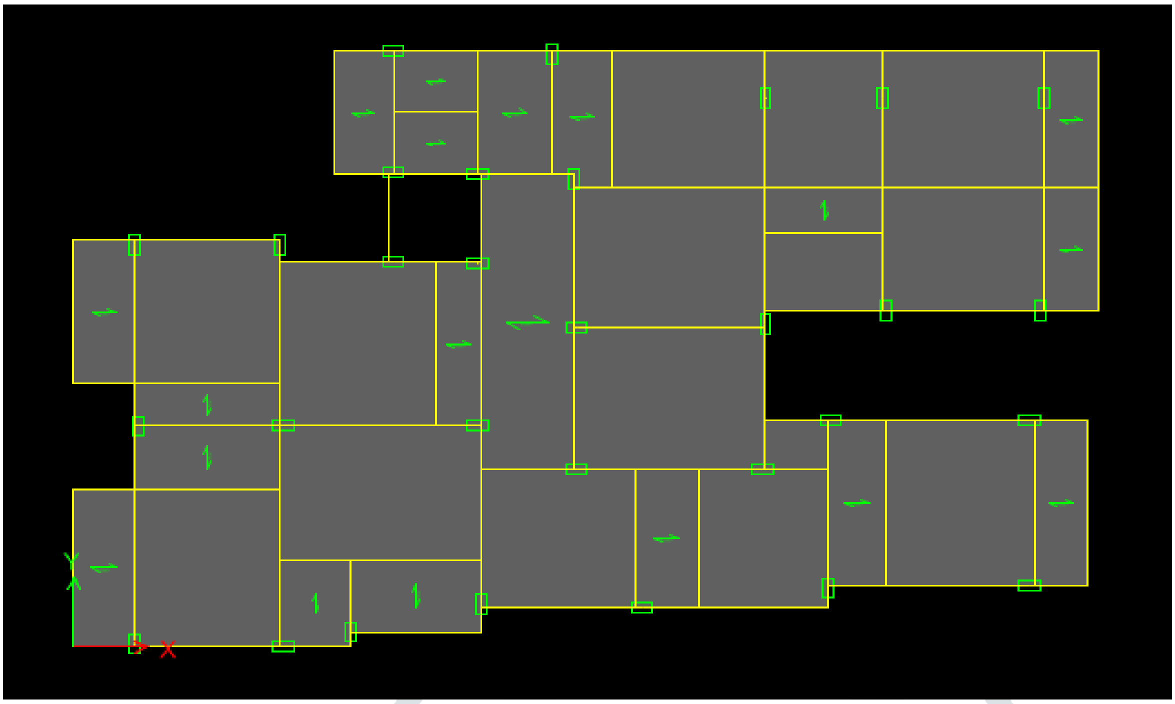

Fig.No.4.6: Plan of building for modeling in ETABS 2015

7.Results

The results of analysis and design of a G+10 RCC multistoried building provided with rectangular CFST columns using response spectrum method are presented and discussed in the following manner:

1) Verification of analysis results of G+2 storied building by manually with the results of ETABS 2015 software using Equivalent Static Analysis method.

2) Lateral displacement of building provided with CFST and RCC columns.

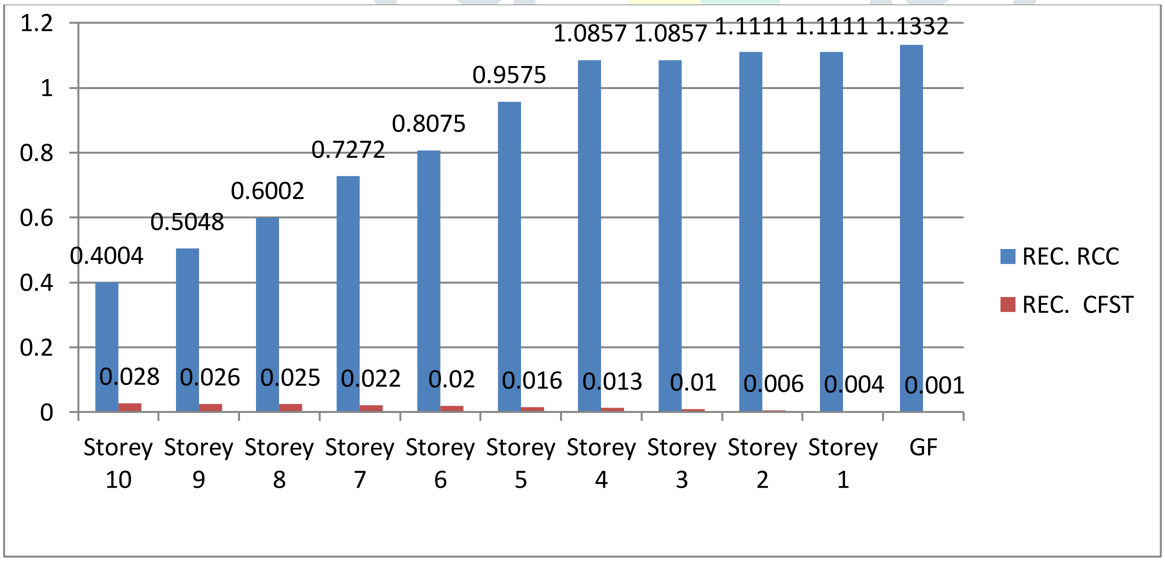

Fig. No. 5.4: lateral displacement of building

8.Conclusions

1. The results of analysis as obtained by Equivalent Static Analysis method (manual analysis) and ETABS 2015 software for G+2 storied building provided with CFST columns are found to be almost same (error 1.5%) and therefore, it can be concluded that the analysis and design of the building gets validated.

2. The storey shear and lateral displacement values obtained in the seismic analysis of a G+10 storied building provided with rectangular CFST columns are found to be approximately less than 10% as compared to the values obtained for the buildings with RCC columns of similar c/s section. Also, storey shear and lateral displacement values are found to be approximately less than 8% columns compared to the rectangular CFST columns respectively.

9.References

1. .Aaron D. Probst, Thomas H.-K. Kang, Chris Ramseyer and Uksun Kim, "Composite Flexural Behavior of Full- Scale Concrete-Filled Tubes withoutAxial Loads", Journal of Structural Engineering, ASCE, Vol. 136, No. 11, p 1401-1412 (2010).
2. Charles W. Roeder, Dawn E. Lehman and Erik Bishop "Strength and Stiffness of Circular Concrete-Filled Tubes" Journal of Structural Engineering, ASCE, Vol. 136, No.12, p 1545–1553 (2011).
3. Dawn E. Lehman; Katherine G. Kuder, Arni K. Gunnarrson; Charles W. Roeder and Jeffrey W. Berman, "Circular Concrete-Filled Tubes for Improved Sustainability and Seismic Resilience" Journal of Structural Engineering, Vol. B4014008 p 1-12 (2014).
4. IS11384 (1985), "Code of Practice for Design of Composite Structure," Bureau of Indian Standards (BIS), New Delhi.
5. K. Chithira and K. Baskar, "Experimental and Numerical Investigation on Circular CFT Columns under Eccentric Load Condition with and without Shear Connectors" International Journal of Earth Sciences and Engineering Vol. 5, No. 01, p 169-179 (2012).