Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 10, October : 2023

Comparative analysis of G+30 Composite and RCC structures using ETABS

V.Muni Kumar[1], Dr. C. Sashidhar M.Tech,Ph.D[2]

[1]M. Tech (Computer Aided Structural Engineering), Civil Engineering Department, JNTUA College

[2]Professor in Civil Engineering Department, JNTUA College of Engineering, Ananthapuramu, India.

munikumar.gkce@gmail.com[1], sashidhar.civil@jntua.ac.in[2]

Abstract The widespread use of reinforced concrete in building construction is determined by several factors, including the accessibility of the necessary raw materials, the level of expertise required for construction, and the viability of design codes. Composite building, however, is a novel idea in the construction sector. It may not be cost-effective to wait to build each floor until the concrete columns are built when contemporary composite methods enable the assembly of multi-story structural frames feasible. But in Japan, where the composite beam-columns' better earthquake resistant qualities have been known for a long time and where they are widely employed for building, they have become the standard. To promote the adoption of this effective type of mixed construction, it was important to define seismic design requirements for commonly used Indian structural systems. Different construction-related factors are compared in this project.

In this project, a composite structure and an RCC structure of a 30-storey residential building are modeled in ETABS, and RSA (Response Spectrum Analysis) is run on both. In order to compare metrics like storey displacement, storey drift, and base shear, an analysis is performed on the assumption that the material property is linear.

KEY WORDS: ETABS, Response Spectrum Analysis, Linear Static Analysis.

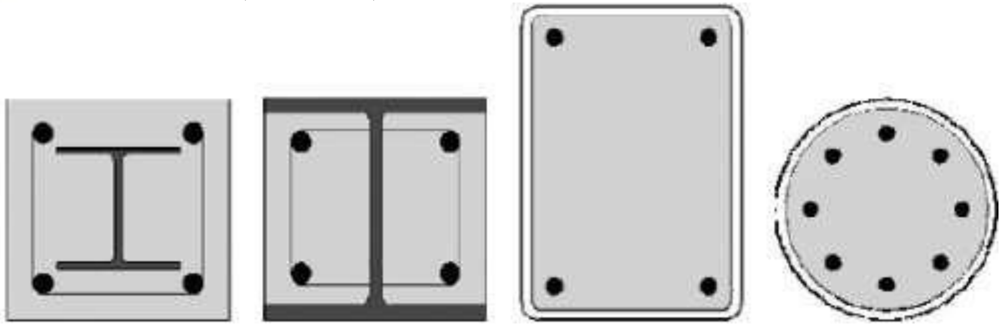
1. Introduction

The advantages of composite systems over traditional construction have led to their increased popularity in recent years. Composite building uses the best features of both concrete and steel, allowing for rapid construction. In this study, we use Etabs to model a R.C.C building and a composite building of 30 storeys. The performance of the models under static and dynamic loads was analyzed and compared.

Composite columns are commonly used because they are easy to install, strong, and safe in the event of a fire. When concrete is poured into steel tubes at the construction site, we say that the tubes are "concrete filled." The reinforced concrete inside the column does most of the work under normal conditions, but in a fire it does all the work. These columns have been the subject of numerous essays, but all of them take a simplistic view of the topic. The neutral axis of circular columns is especially important to calculate. It is also typical to ignore the shear resistance of the column.

1.1 Composite columns

Different configurations of composite columns are depicted in the following illustration. Like other composites, their allure stems from the fact that they make use of the best qualities of its constituent parts. In this case, steel and concrete. As a result, you can get the most out of your square footage while yet maintaining a high level of resistance. They also work admirably under extreme heat and flames.



Typical composite column cross sections

The British Standard (BS) EN 1994 provides guidance for the design of composite columns in structural frames. Given that this is the first time such information has been included in a code for use in the UK, it's possible that composite columns have been underutilized until now. Composite H sections, both fully encased and 'partially encased' (web infill only), and concrete filled hollow sections all have their own sets of guidelines. The diagram depicts typical cross sections. Composite columns that necessitate formwork during construction are not widely considered economical in the United Kingdom.

Compression members made from concrete-filled hollow sections save on formwork and material compared to an equivalent H section. When compared to a bare steel segment, concrete infill greatly improves compression resistance by distributing the load and reducing local buckling. The improvement in fire resistance might be just as beneficial, especially if it allows the column to be left exposed or with minimal protection. The latent heat of evaporation from the infill concrete greatly reduces the rate at which the temperature rises.

The primary goals of this research are to assess the buildings in ETABS software using seismic analysis, and to examine the G+30 storied structure in accordance with the code (IS1893:2002) requirement by employing various columns, including RCC and composite columns. RSA was used to analyze factors like modal frequency and time period.

2. Literature Studies

Baldev D. Prajapati, D. R. Panchal et., al. (2013) The purpose of this research was to analyze and design a symmetric 30-story building's susceptibility to wind and earthquake stresses. In addition to eliminating the need for costly testing, the new method makes it simpler to build with a wide range of steel sections and shear connectors while still guaranteeing their efficacy.

Anirudh Gottala, Kintali Sai Nanda Kishore et., al. (2015) This study explores the premise that the analysis and design of structures for static pressures has become commonplace due to the widespread availability of low-cost computers and specialized applications. For this study, we picked a nine-story framed structure (G+9) as our target. In the analyzed beams, this study found that the tensile stresses were roughly proportional to the compressive stresses.Nodal displacements and bending moments in beams and columns were much greater during the seismic stimulation than under the static loads.

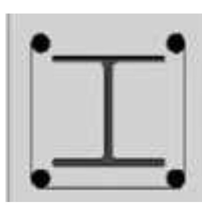
Pardeshi sameer, Prof. N. G. Gore et., al. (2016) In this research, symmetric and asymmetric models of a G+15 building were developed and analyzed with the use of ETABS. The mass and stiffness of a structural system are the major determinants of its dynamic response. Project objectives include RSA on regular and irregular RC frames, THA on regular frames, and ductility-aware design utilizing the equivalent RSA algorithm, IS 13920. Results from examinations of both regular and irregular structures are compared.

3. Model Specifications and models in ETABS

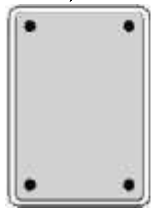
In the present study, analysis of G+ 30 stories building in Zone V is carried out in ETABS.

Basic parameters considered for the analysis are

1. Grade of concrete : M40
2. Grade of Reinforcing steel : HYSD Fe500
3. Dimensions of beam : 230mmX460mm
4. Dimensions of column : 690mmX690mm
5. Thickness of slab : 180mm
6. Steel column :ISWB500
7. Composite column :0.69X0.69 with angle section
8. Height of bottom story : 3m
9. Height of Remaining story : 3m
10. Live load : 5 KN/m^2
11. Dead load : 2 KN/m^2
12. Density of concrete : 25 KN/m^3
13. Seismic Zone : Zone IV
14. Site type : II
15. Importance factor : 1.5
16. Response reduction factor : 5
17. Damping Ratio : 5%
18. Structure class : B
19. Basic wind speed : 44m/s
20. Risk coefficient (K1) : 1.08
21. Terrain size coefficient (K2) : 1.14
22. Topography factor (K3) : 1.36
23. Wind design code : IS 875: 1987 (Part 3)
24. RCC design code : IS 456:2000
25. Steel design code : IS 800: 2007
26. Earth quake design code : IS 1893 : 2002 (Part 1)
27. Column C/S of Composite structure



28. Column C/S of RCC structure



Models in ETABS

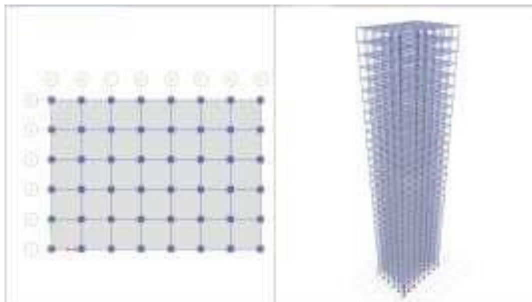


Fig 01: RCC Column Building

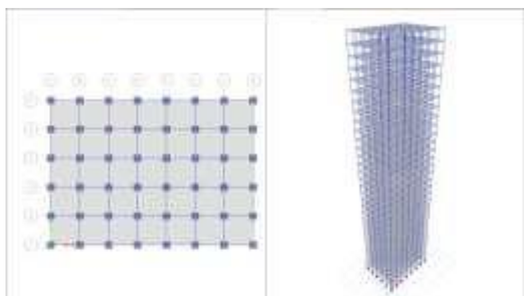


Fig 02: Composite column Building

4. Results and Analysis

Maximum Storey Displacement

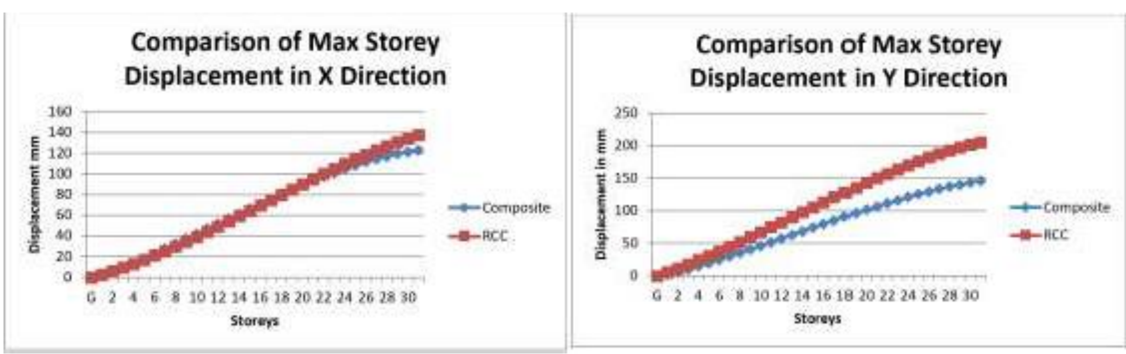


Fig 03: Comparision of max storey displacement in X & Y Direction

As can be seen in the aforementioned graphs, when comparing composite structure to RCC, the maximum storey displacements are lower in composite structure. The increased strength from the composite's added reinforcing results in a decreased displacement value. When comparing Composite Structure to RCC Structure, it is revealed that storey displacements are reduced by 14% in the X-Direction. In the Y-direction, however, the disparity is 25%.

Storey drift

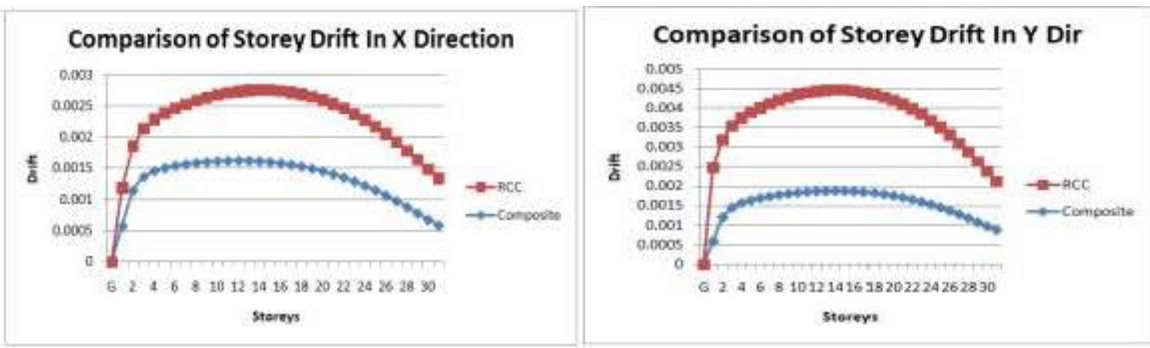


Fig 04: Comparision of storey drift in X & Y Direction

Drift refers to the horizontal movement of a structure caused by factors such as gravity or lateral loads. The preceding figures show that the effect of seismic load on a composite building is reducing with storey drifts decreasing in both the X and Y directions when compared with RCC model. The rate of increase in storey drift is rapid upto storey 6 and beyond this there is a gradual increase.

Base shear

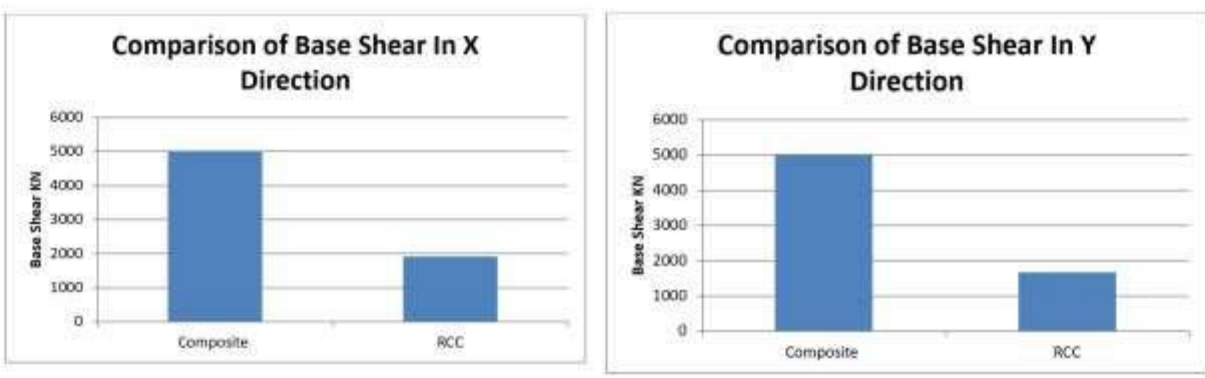


Fig 05: Comparision of base shear in X & Y Direction

From the above graphs it is observed that for composite structure model, the intensity of maximum base shear is more than the RCC model. The increased base shear values can be attributed to extra load from the additional reinforcement in the composite structure. The Composite structure has a maximum base shear value of 5017KN, whereas in RCC Structure it is 1918KN.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 10, October : 2023

Over turning moments

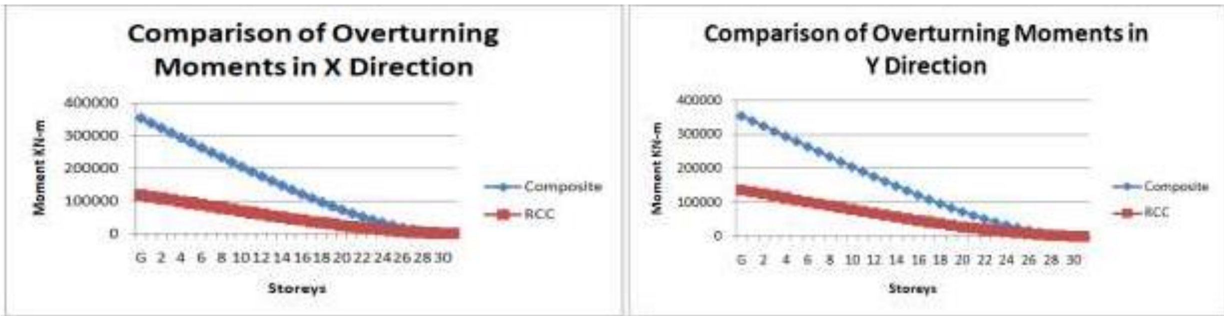


Fig 06: Comparision of Overturning moments in X & Y Direction

From the above results, it was observed that the overturning moments for both X & Y directions in Composite structure is 353573.5 KN-m and in case of RCC model it is 117599.4KN-m. It shows that Composite Structure can sustain higher overturning moments compared to RCC under similar loading conditions.

Time period

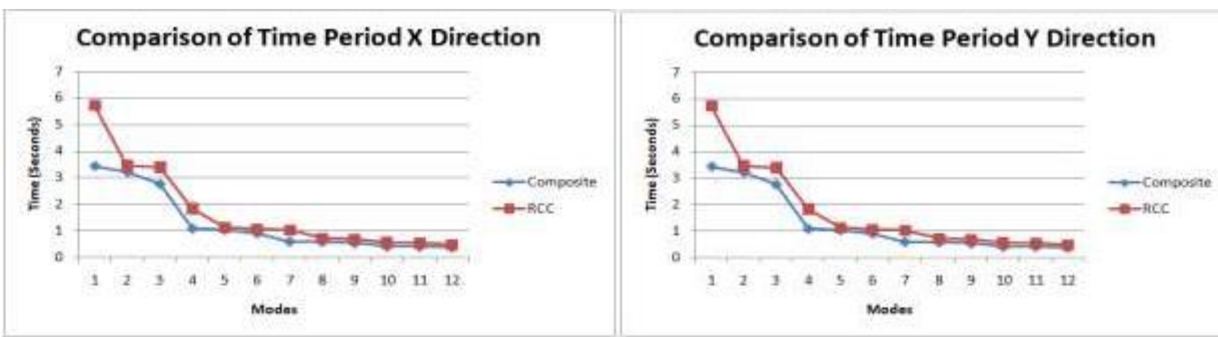


Fig 07: Comparision of Time periodin X & Y Direction

The values of time period are decreasing from mode 1 to mode 12 in both X and Y directions for RCC and as well as composite structue with time periods being higher in the RCC building model.

Modal Frequency

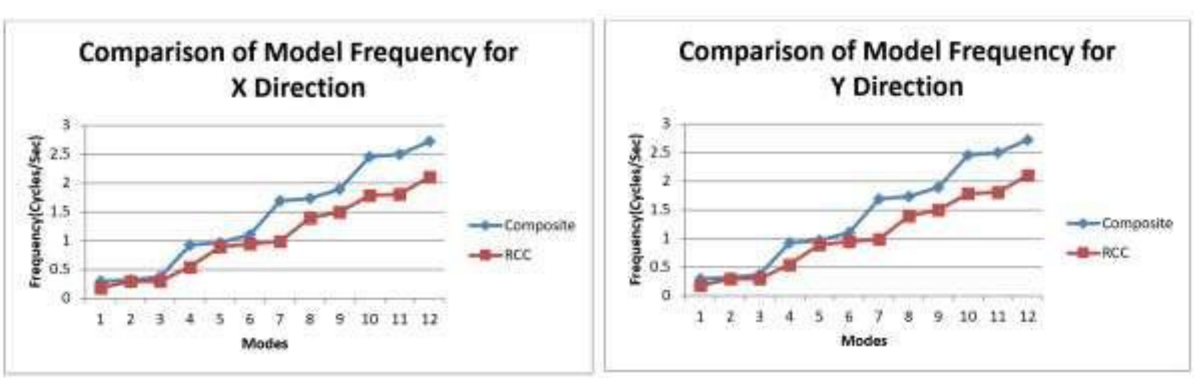


Fig 08: Comparision of model frequencyin X & Y Direction

The values of model frequency are increasing from mode 1to mode 12 in both X and Y directionsfor RCC and as well as composite structue. Higher values of the modal frequencies values are observed in the case of the composite building model.

Storey stiffness

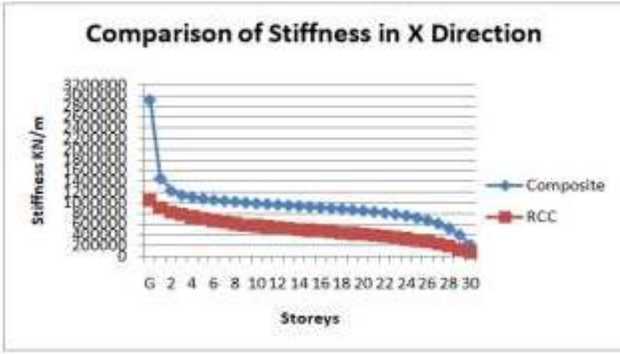


Fig 09: Comparison of Storey Stiffness in X & Y Direction

When comparing composite and RCC models, the stiffness values are greater in the X and Y directions for composite structure model because of the increased resistance offered by the column members.

5. Conclusions

The following are the conclusions were made

1. Upon comparing storey drift of both models, the Composite structure has experienced lesser storey drifts than the R.C.C model. The percentage reduction of drift in composite model is 14%.
2. Incase of Maximum Storey Displacement, the Composite structure performed better with lower storey displacements when compared with RCC. In X-Direction, it is observed that Composite structure experienced 14% lesser displacements when compared to RCC structure. Whereas, In Y-Direction, the difference is 25%.
3. When Over-turning moments of the models are considered,they start decreasing with increasein storey height for both the models.
4. The Over-turning moments are 353573.5 KN-m in X-Direction and 117599.4 KN-m in Y-Direction for composite structure model. The Composite structure have experienced 66% higher overturning moments than RCC structure.
5. Comparing the Base Shear values of both models, the Composite structure has experienced higher base shear value compared to R.C.C Structure.
6. Storey stiffness in both the X and Y direction are higher for the composite member than RCC building models.
7. The values of time periods are decreasing from mode 1 to mode 12 in both X and Y directions. Higher values of the time period values are obtained in the case of the RCC building model.
8. The values of modal frequencies are increasing from mode 1 to mode 12 in both X and Y direction case. Higher values of the modal frequencies values are obtained in the case of the composite building model.

After considering all the parameters, the structure modeled as Composite Structure exhibited better performance than the R.C.C Model.

6. References

1) IS 1893 (Part1): (2016), “Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions and Buildings”, Bureau of Indian Standards.
2) CSI Computers and Structures INC. “Introductory Tutorial for E-TABS: Linear and Nonlinear Static and Dynamic Analysis and Design of Three-Dimensional Structures” 2011
3) CSI (2009).“E-TABS: Static and Dynamic Finite Element Analysis of Structures” Nonlinear Version 14, Computers and Structures.
4) B.C. Punmia, A.K. Jain, 2006, “R.C.C Designs”, Laxmi publications New Delhi.
5) IS-456 2000plain and reinforced concrete code of practice.
6) P. Agarwal, M. Shrikhande, Earthquake resistance design of structures, PHI learning Pvt. 2012.
7) Theory of Structures by Ramamrutham for literature review on kani′s method
8) Reinforced and slab.concrete Structures by A.K. Jain and B.C. Punmia for design of beams, columns
9) ETABS Version 9.70 (1997), Computers and Structures, Inc., Berkeley, California. International Code Council, Inc. (2000). International Building Code.
10) B. K. Sanghani and P. G. Patel, “Behaviour of Building Component in Various Zones,” International Journal of Advances in Engineering Sciences, Vol. 1, Issue 1(Jan. 2011).
11) Simu, E and Miyata, T. (2006), “Design of buildings and bridges for wind a practical guide for ASCE-7 standard users and designers of special structures, John Wiley & Sons.
12) Sinha, S.N., Handbook of reinforced concrete design, 1996, Tata McGraw-Hill Publishing Company limited, New Delhi 110 008.