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# COMPARISON OF RCC, STEEL AND COMPOSITE STRUCTURES SUBJECTED TO VARIOUS LOAD COMBINATIONS

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***Abstract**:The composite construction of steel and concrete indicates a section of steel enclosed in concrete. For structural elements such as, the column & the concrete slab is connected to the steel beam with the aid of mechanical shear connectors so that they act as a distinct unit. In this report, the steel and concrete composite is considered for the comparative study of a residential building G + 12 floors located in the area of earthquake III and with a wind speed of 33 m / s. For the modeling, analysis and design of structures. ETABS And STADPRO are used and the performance of composite, steel, RCC w.r.t different parameters different stories as storey drift, storey displacement, base shear, shear force etc. results are compared. It is found that composite structures aremorecheaper than RCC.***

***Keywords: ETABS 2015,STADPRO,Seismic Analysis,*storey *drift, storey displacement.***

## 1. INTRODUCTION

In India most of the building structures are low rise buildings. So,for these structures reinforced concrete members are used extensively for the reason that the construction becomes quite suitable and reasonable in nature. But since the inhabitants in urban areas are increasing exponentially and the land is limited, there is a need of vertical growth of buildings in those places. So, for the ulfillment of this purpose a large number of intermediate to high rise buildings are being constructed these days. For these high rise structures it has been noted out that use of composite members in construction are more effective and cost-effective than using reinforced concrete members. The popularity of steel-concrete composite construction in cities can be owed to its benefits over the usual reinforced concrete construction. Reinforced concretes frames are used in low rise buildings because loading is insignificant as compared with high rise structures. But in intermediate and high rise buildings, the conventional reinforced concrete construction cannot be used as there is increased dead load along with span limitations, less stiffness and framework which is quite susceptible to hazards.
In construction industry in India use of steel is very less as compared to other developing nations like China, Latin America etc. Seeing the development in India, there is a appalling need to explore more in the field of construction and work out new improved techniques to use Steel as a construction material wherever it is inexpensive to use it.composite frames use more steel than RCC and tends to be most reasonable approach in terms of cost, and act as solution for problems which are generally faced in low to high rise structures.

*1.1 The objectives of the present research work are:*

- Seismic analysis of R.C.C ,Steeland Steel-Concrete Composite frame conforming to IS: 1893-2002 code.
- Comparing the results of R.C.C,Steel and Steel-Concrete Composite frame conforming to IS 1893-2002 code for the following parameters.

❖ Lateral displacement
❖ Storey shear
❖ Storey drift
❖ Axial force
❖ shear force
❖ Bending moments.
❖ Time period and frequency
❖ Base shear.
❖ Cost comparisons.

 

*1.2 Scope of the Study:*

To carry out seismic and wind analysis of R.C.C, Steeland Steel-Concrete Composite frames. The following methods are adopted.

- Modelling is done for different frames of RCC,Steel,Steel-concrete composite. The models are primarily prepared in line diagram by taking material property and column and beam sections in ETABS 2015 and STADPRO.
- Number of columns and beams are same throughout the all frames.

## 2. LITERATURE REVIEW:

Some of the research papers have been reviewed to decide the objectives for this present work. The observations of research papers are mentioned as below.

Akram S Shaikh (2017) selected an institutional building with a G + 5 plan located in the IV seismic zone. The size of their work was 24 x 15 m, and the overall height of the building is 20.5 m. The study was conducted to compare R.C.C and Composite. With respect to different parameters while analysing models in computer software. They are Storey drift, displacement, storey shear and concluded that floor displacement was maximum for composite building as compared to RCC building. Story drift is more for Composite building as compare to RCCbuilding.

K. Mukesh Kumar (2016) conducted comparative study in the seismic zone V, and considered RCC and low-level composite structures (5, 10 and 15 floors). Carried out linear and non-linear dynamic analysis using ETABS. Parameters considered were , the time history, the axial force of the column, the shearing forces in beams and bending moments, the time period the structure and the dead weight of the structure. Dimensions of their plan consisted of compartments equal to the 4X4 length of 5 m. And found that the time period of the structures were reduced from composite to RCC , as well as a dead weight, axial forces, shear forces were reduced from composite structure to RCC.

Mahesh Kumawat(2014) examined steel concrete composites with RCC and comparative studies of G + 9 stories. a commercial building located in the earthquake-III zone , IS IS 1893 (Part 1) -2002 considered. 3D modeling and structural analysis is done using SAP 2000 software. For composite structure analysis and RCC, equivalent static analysis methods and reaction spectrum analysis were used and concluded that the dead weight of the composite structure is lower than the RCC structure and therefore seismic strength is reduced. It was also noted that for composite structures, lateral displacements have been reduced.

## 3. METHODOLOGY

In our present study we have used the CQC method to combine the modes. The Building is considered here is a residential building of plan dimension 16.3mX18.25m situated in seismic zone III confirming to IS1893 2002, with wind velocity 33m/s. Building plan is shown in fig 1 and description is mentioned in table no 3.2. Shape of column considered are square. As square shape of columns are more suitable for earthquake resistant structures. The study is carried out for Steel, RCC, Steel-Concrete composite on same plan with certain basic assumptions for deciding the preliminary dimensions of all the three structures. Other data are tabulated in table 3.2

Load combinations considered for the study have been mentioned in table 3.1. for concrete , steel, composite structures confirming to IS875 1987 (part 5) and IS 800 2000.

Table.3.1. Load combinations for RCC, steel structures.

| **Load combinations as per IS 1839 2002:** | **Load combinations as per IS 800 2000:** |
|---|---|
| 1.5(DL+LL) | 1.5(DL + EQx) |
| 1.5(DL+EQx) | 1.5(DL + EQ-x) |
| 1.2(DL+LL+EQx) | 1.5(DL + EQz) |
| 1.2(DL+LL+WLx) | 1.5(DL + EQ-z) |
| 1.5(DL+WLx) | 0.9DL + 1.5EQx |
| 0.9 DL+1.5WLx | 0.9DL + 1.5EQ-x |
| 0.9DL+1.5EQx | 0.9DL + 1.5EQ-z |
| 1.5(DL+EQz) | 1.5(DL + LL) |
| 1.2(DL+LL-EQz) | 1.2(DL + LL) + 0.6WLx |
| 1.2(DL+LL-WLz) | 1.2(DL + LL) + 0.6WL-x |
| 1.5(DL-WLz) | 1.2(DL + LL) + 0.6WLz |
| 0.9 DL-1.5WLz | 1.2(DL + LL) + 0.6WL-z |
| 0.9DL-1.5EQz | 1.2(DL + LL +WLx) |
| 1.5(DL-EQz) | 1.2(DL + LL +WL-x) |

| | |
|---|---|
| 1.2(DL+LL-EQz) | 1.2(DL + LL +WLz) |
| 1.2(DL+LL-WLz) | 1.2(DL + LL +WL-z) |
| 1.5(DL-WLz) | 1.5(DL + WLx) |
| 0.9 DL-1.5WLz | 1.5(DL + WL-x) |
| 0.9DL-1.5EQz | 1.5(DL + WLz) |
| 1.5(DL-EQx) | 1.5(DL + WL-z) |
| 1.2(DL+LL-EQx) | 0.9DL + 1.5WLx |
| 1.2(DL+LL-WLx) | 0.9DL + 1.5WL-x |
| 1.5(DL-WLx) | 0.9DL + 1.5WLz |
| 0.9 DL-1.5WLx | 0.9DL + 1.5WL-z |
| 0.9DL-1.5EQx | 1.2(DL + LL) + 0.6EQx |
| | 1.2(DL + LL) + 0.6EQ-x |
| | 1.2(DL + LL) + 0.6EQz |
| | 1.2(DL + LL) + 0.6EQ-z |
| | 1.2(DL + LL +EQx) |
| | 1.2(DL + LL +EQ-x) |
| | 1.2(DL + LL +EQz) |
| | 1.2(DL + LL +EQ-z) |

Table 3.2. Building details

| Building details | | | |
|---|---|---|---|
| particulars | RCC | STEEL | COMPOSITE |
| Plan Dimensions | 16.3m*18.25m | 16.3m*18.25m | 16.3m*18.25m |
| Total Height | 38.5m | 38.5m | 38.5m |
| Storey Height | 3m | 3m | 3m |
| Depth of Foundation | 2.5m | 2.5m | 2.5m |
| size of beams | 230mmX400mm | ISMB300,ISMB600,IS350 | ISMB300,ISMB600,ISMB350, |
| size of Columns | 600mmX600mm | ISWB600,ISMB600,ISHB450, | ISHB300 encased column size 550X550mm |
| Thickness of wall | 230mm | 230mm | 230mm |
| Thickness of slab | 150mm | 150mm | 150mm |
| seismic zone | III | III | III |
| Reduction factor | 5 | 5 | 5 |

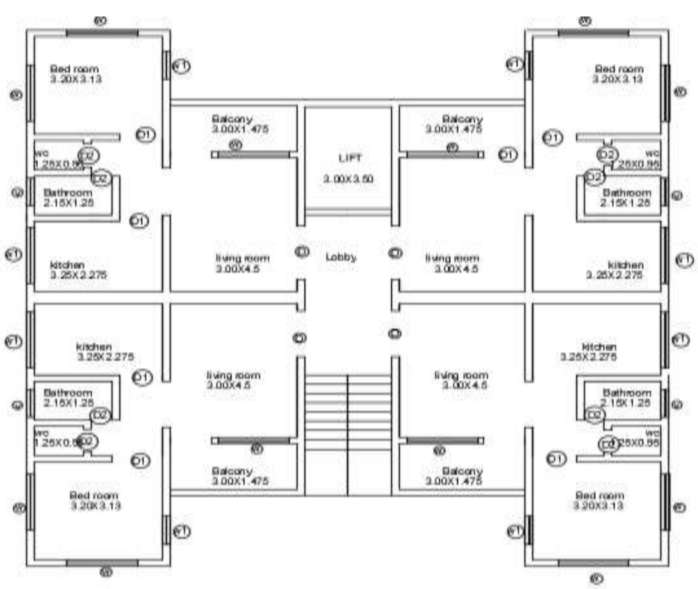


*Fig.1 plan of building considered*

**Modeling of Building**: modeling of building was done using STADPRO and ETABS 2015. These analytical models included all the important components which influence mass, stiffness. The structural members like columns, beams, slabs are modeled. The non-structural elements which do not have much effect on the analysis of structures are not modeled. The slabs are assumed to act as a diaphragm which ensureintegral actions of all the vertical load-resisting elements.

*Fig.2. Modelling of building in STADPRO* *Fig.3. Modelling of building in ETAB*

## 4. ANALYSIS :

Analysis of building was done as per IS codes, IS 1893 2002, IS 875 1987 (part 3) for earthquake and wind calculations respectively. And the structure was analysed using STADPRO, ETABS software. The results obtained from both the software are almost same. Hence , validation of project was done.

## 5. RESULTS AND DISCUSSIONS:

A)Equivalent Static Method : Equivalent Static method analysis was carried as per IS 1893 2002 on all the structures. loads are calculated and distributed results obtained are compared in contrast with following parameters.

i)Storey Stiffness: It can be observed from fig.4 that composite structure has more stiffness than Rcc, steel. It is observed that the storey stiffness of composite structure has increased 6% to 7% than RCC and 20% to 28% to than steel in transverse direction. .It is observed that the storey stiffness of composite structure has increased 7% to 10% than RCC and 43% to 48% to than steel in longitudinal shown in fig 5.

ii) Lateral Displacements : Its observed that lateral displacements reduced in composite frame is from 24% to 29% than RCC and 70% than steel and about composite structure is from 9% to 20% than RCC & 26% to 48% than Steel in longitudinal direction. As shown in fig.6 and fig 7 respectively.

iii) StoreyDrifts :It can be seen that composite structure has less drift ,due to more stiffness than RCC and Steel structure. storey drifts in composite structure has been reduced from 11% to 30% than RCC & 9% to 35% than Steel. As shown in fig 8.

iv) Axial force, shear force: It can be seen that composite column have less axial force than RCC. Axial forces in composite column reduced from 1.5% to 5.5% RCC and increased from 11% to 13% than steel, Shear forces reduced by 38% to 41% than steel. Shear force has found to be increased up to 14% than RCC as shown in fig 9 & fig 10 respectively.

B) Response spectrum method: Response spectrum method analysis was carried as per IS 1893 2002 on all the structures. loads are calculated and distributed results obtained are compared in contrast with following parameters.

i) Time period: It can be seen that time period is more for composite structure than RCC, it observed that time period in composite structure is increased by 3.17% than RCC and reduced by 29% than steel. The maximum time period is for composite structures, it means it is more flexible to oscillate back and forth when lateral force act on the building and RCC structures has least time period which says that it is less flexibleAs shown in fig 11.

ii) Frequency: It can be noted that composite structure has increased frequency than the RCC and Steel. Its because stiffness of the structure is directly proportional to its natural frequency and inversely proportional to its time period. As shown in fig.12.

C) Cost comparisons: The concrete, material take off obtained from STADPRO, when multiplied with its rate it was found that reduction in cost of composite frame is 22% and steel frame is 14% compared with cost of RCC frame. This includes material cost only and doesn’t include, transportation cost, labour cost etc. as shown in fig 13.


*Fig 4 stiffness along transverse direction.*

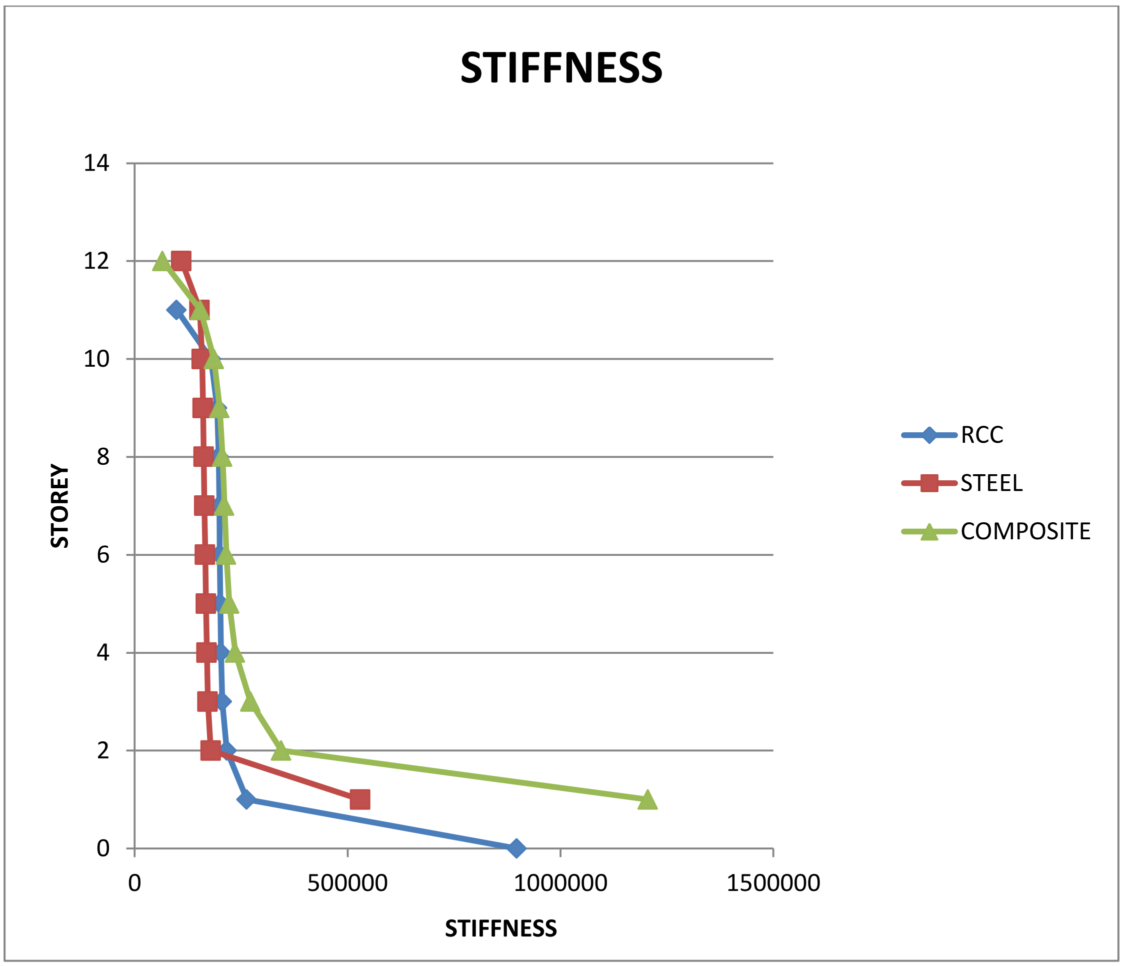


*Fig 5 stiffness along longitudinal direction.*

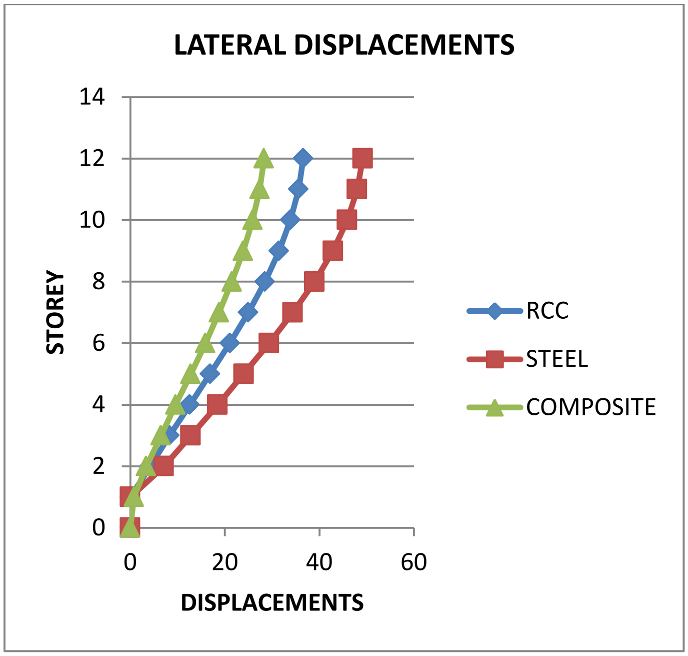


*Fig 6 lateral displacements along transverse direction.*

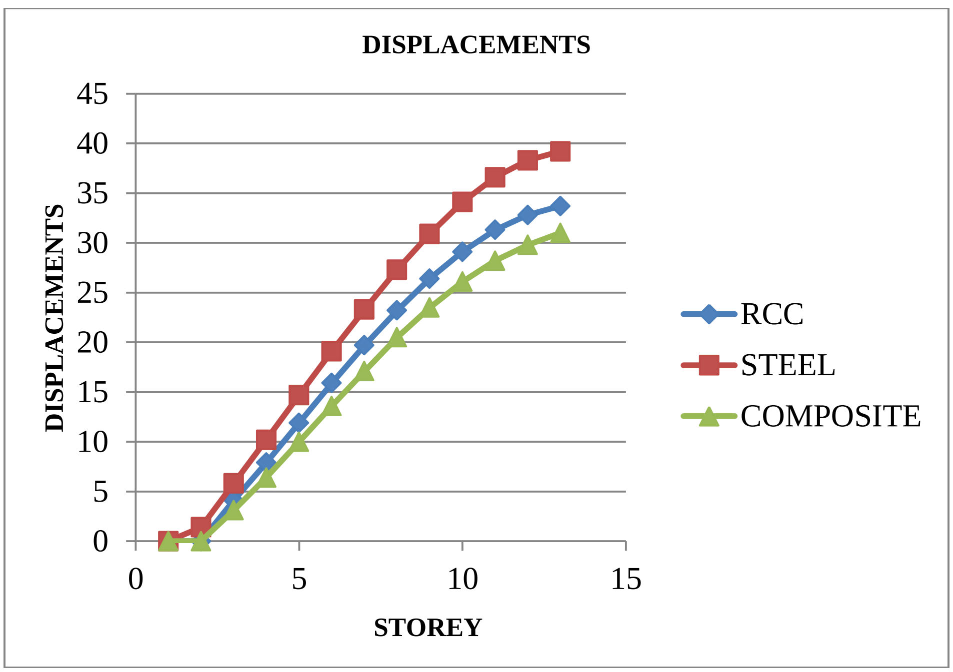


*Fig 7 lateral displacements along longitudinal direction*

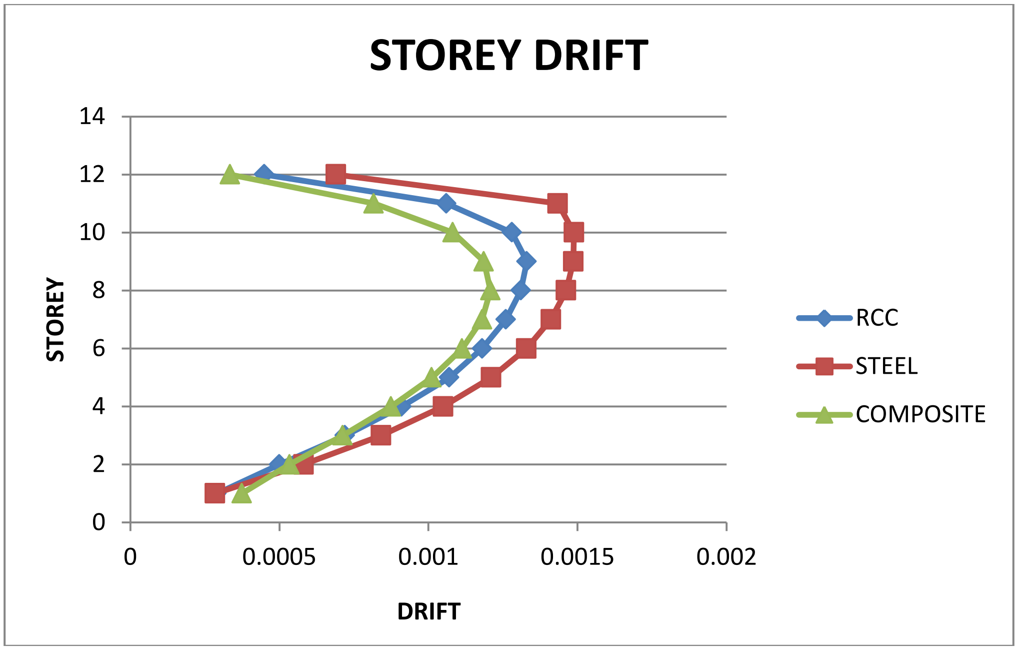


*Fig 8 Inter Storey Drifts.*

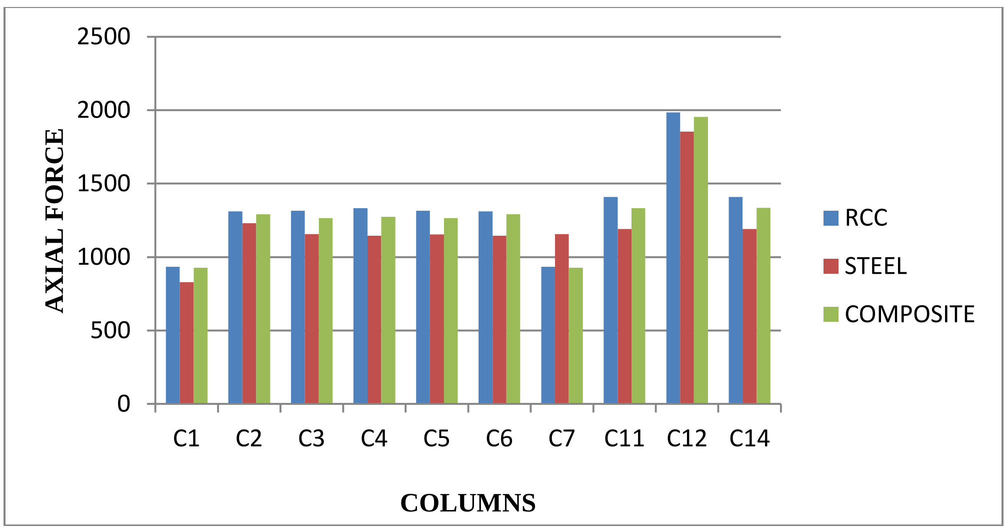


*Fig.9 Axial Forces in columns*

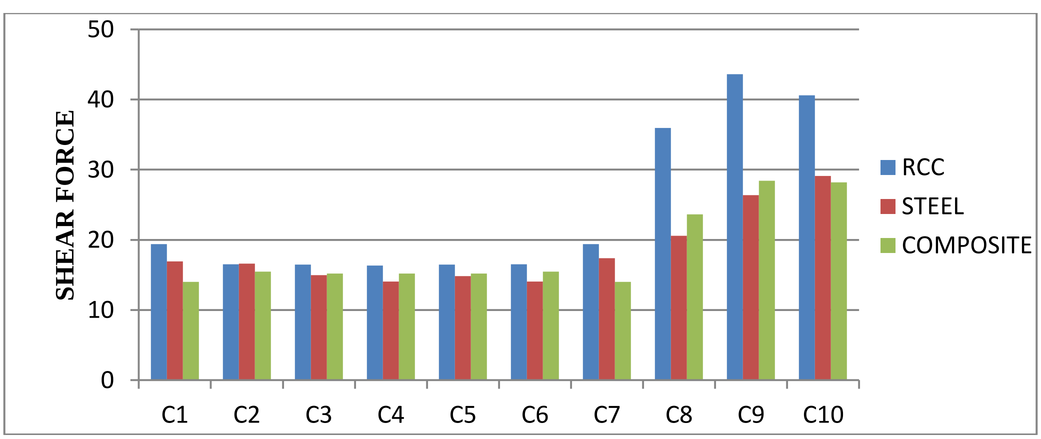


*Fig10 Shear Forces in columns*

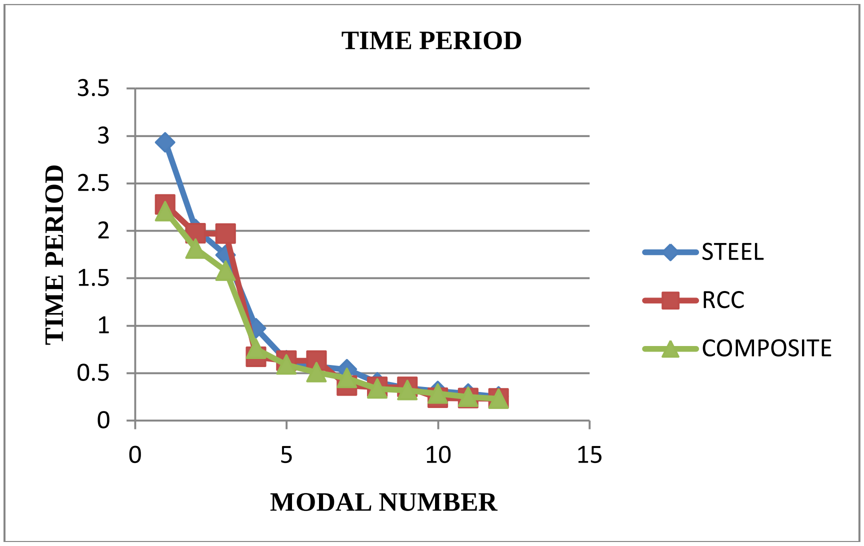


*Fig 11.Time Period.*

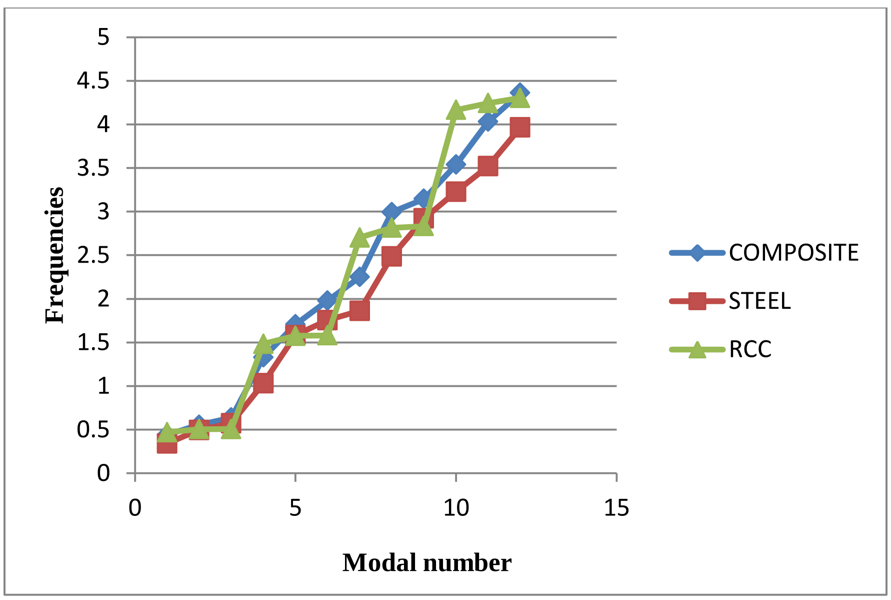


*Fig 12.Frequencies*

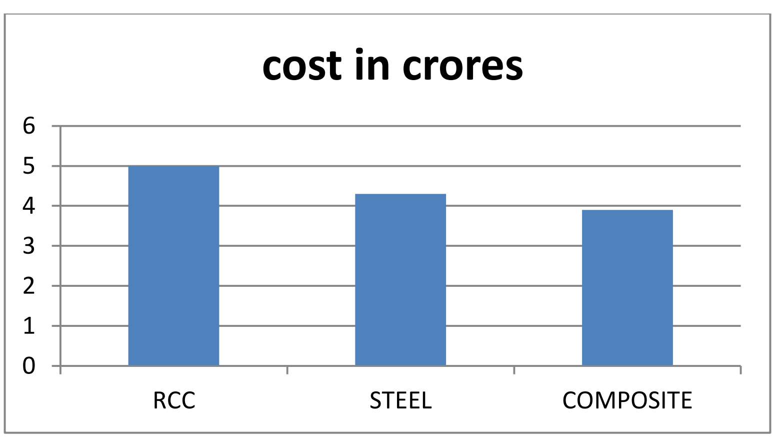


*Fig 13 Cost Comparisons.*

## Conclusion

Analysis and design results of G+12 storied building with R.C.C, steel & composite structure are concluded as follows.

1) The dead weight of composite structure is observed to be less than that of RCC structure and thus the seismic loads are diminished.
2) It is observed that Storey drift is more for Steel frame as compared to Composite and RCC frames.
3) It is observed that Storey displacement is more for Steel frame as compared to Composite and RCC frames.
4) It is watched that stiffness in composite structure is increased in transverse and longitudinal direction when contrasted with R.C.C structure.
5) In composite structure due to high ductilenature of steel it leads to increased seismic resistance of the composite section.
6) The analysis is done in Staadpro and Etabs which have shown same results. hence, validation of the analysis is completed

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