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ANALYSIS OF RCC AND COMPOSITE STRUCTURE WITH G+20 STOREY BUILDING

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ABSTRACT

India is the fastest growing and developing country. The Structural engineers are facing challenges in fulfilling the demand of effective and economical design solution for high rise structures. In India RCC construction seems to be the best design solution for low rise building structure. But in case of high rise structure RCC members are no longer suitable because of their increased dead load, limitation of span length and less stiffness. To overcome such defects structural engineers are using different materials to their best utilization. The composite section using steel encased with concrete is effective solution in major civil structures. This paper presents the comprehensive analysis of G+20 building. A true attempt is made to study the behavior of Composite Structure by using E-tab 2015 software. The result proves that performance of composite model is not only habitable, stable, safe but also cost and time saving. A qualitative better change is seen in the structural members of slab, beam and FEC column which indicate less bending, twisting moment, displacement and reduce shear force, axial force resulting into high strength, stiffness, speedy erection and efficient use of concrete and steel model of composite designing.

Keywords - *Comprehensive Model, Fully Encased Composite (FEC), Profile Sheet Decking , RCC(Reinforced Cement Concrete), Weight of Structure,*

I. INTRODUCTION

The conventional system of RCC modeling is unable to meet huge demand of shelter in short space of present time. To provide the shelter in available space in metropolitan cities in India, the construction industry is looking forward to a newly developed and economic system of composite steel-concrete modeling for high rise structures more than 15 stories –a vertical progress in short area .A population 125 million, out of which 35% peoples are living in big 25 metro-cities or semi metro cities of India. The fact that horizontal expansion of these cities is impossible due to non availability of land and other compulsions hence only vertical progress is to be made by adopting a modern approach of composite steel-concrete modeling in all further tall buildings above 15 stories. However structural community should keep in mind that this composite designing system is well established and followed by U.S.A., European Countries and Australia since 1965, whereas we still neglecting the same despite our huge domestic demand .In nutshell on the part of Government, Privet institutions and as a society should promote ,encourage and boost this modern approach of tall composite structures at least from

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now onwards so as to achieve efficient use of material, reduction of concrete work and labor cost, stiffness, strength, longevity and time saver speedy development of shelter /business of our society.

II. COMPOSITE STRUCTURE

Composite structure can be defined as the structures in which composite sections made up of two different types of materials such as steel and concrete are used for beams and columns. Two different materials are tied together by the use of shear studs at their interface having lesser depth in composite construction. General composite slab-beam arrangement is shown in Fig 1. A steel concrete composite beam consists of a steel beam, over which a reinforced concrete slab is cast with shear connectors. The composite action reduces the beam depth. It saves the material cost considerably. Composite construction combines the better properties in both, concrete in compression and steel in tension. The coefficient of thermal expansion of both concrete and steel is being nearly the same. Therefore, there is no induction of different thermal stresses in the section under variation of temperature. Structural components use in composite construction consists of the following elements.

- Composite Profile Deck Slab
- Composite Beam
- Composite Column
- Shear Connector

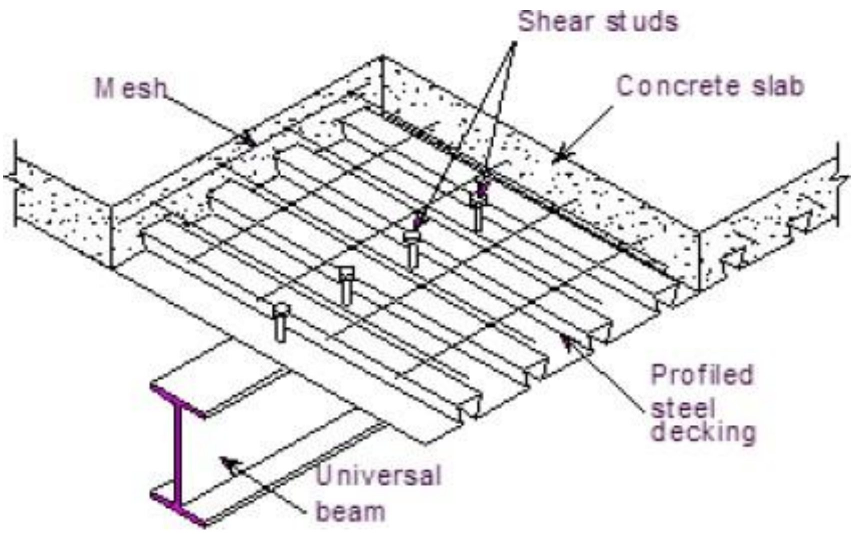

Figure 1 Typical Profile Deck Slab Beam Arrangement

A steel concrete composite beam consists of a steel beam, over which a reinforced concrete slab or Profile Sheet Deck Slab is cast with shear connectors. The composite action reduces the beam depth. A steel concrete composite column is traditionally a compression member in which a steel element is structural steel-I section. There are three types of composite columns in practice, Concrete encased, concrete filled tubes and batter

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section. Shear connections are essential for steel concrete construction as they integrate the compression capacity of supported concrete slab with supporting steel beams to improve the load carrying capacity as well as overall rigidity.

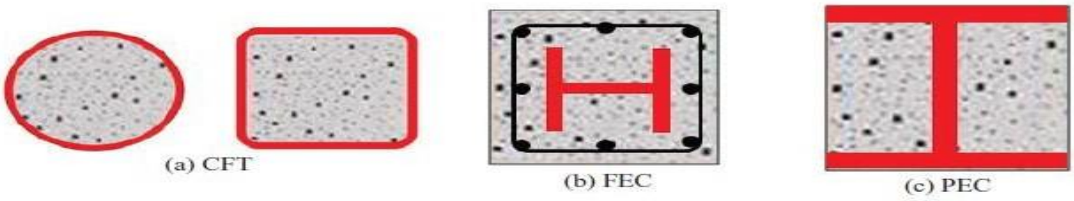

Figure 2 Different Types of Composite Columns

III. OBJECTIVES OF STUDY

- To check whether the steel-concrete composite (FEC) sections are the best alternative to RCC sections used in high rise building.
- To checked the cost efficiency of Composite Structure.
- To check the resistance of steel concrete composite structure to the seismic loading
- To check whether the steel encased concrete composite sections are best economic and time effective solution for high rise structure.

To satisfy these Four above mentioned objectives the comparative study has been carried out on a G+20 storey structure and comparison is done on the results of Base Shear, Storey Displacement, Axial Force, Bending Moment, Shear Force and Weight of structure and the cost of structure.

IV. BUILDING DETAILS

To complete this study a G+20 storey residential building is considered for analysis. As the normal structure will not require a composite section's study purpose high rise structure is selected. The plan dimensions are 30m X 12m. The building is located in Earthquake zone II and having zone factor equal to 0.24. Wind velocity is 44 m/sec. In preliminary attempt of an analysis the RCC structure is analyzed and designed accordingly to finalize the column sizes, subsequently the sections are finalized for composite structure. Static loading is considered as per IS-875 Part II. For composite structure analysis the AISC 360-10 code provisions are considered. The conventional R.C.C structure is design according to IS 456-2000. The figure 3 shows the details of column beam position in Architectural plan and 3 Dimensional View of Building.

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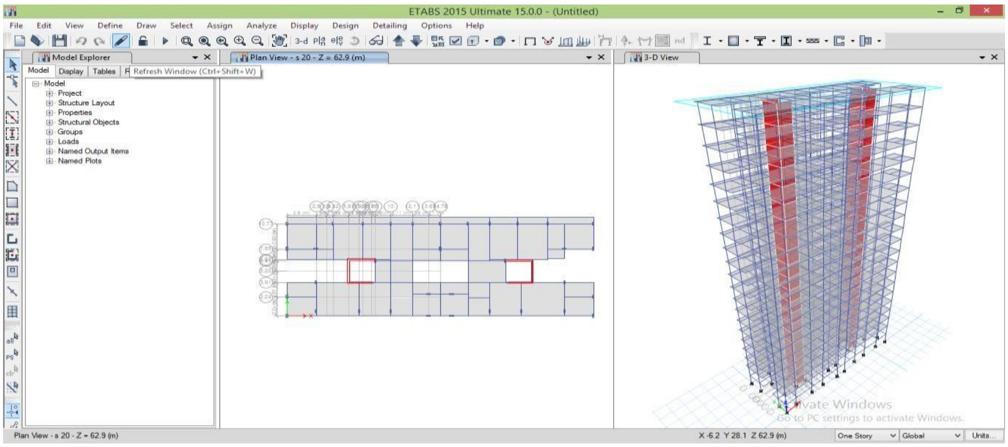

Figure 3 Architectural plan and 3 Dimensional View of Building

Table 1 Details of R.C.C and Composite G+20 Building

Details	RCC Structure	Composite Structure
Plot Aera	30 m X 12 m	30 m X 12 m
Height of Building	62.9 m	62.9 m
Height of Each storey	3 m	3 m
Height of Parapet	1 m	1 m
Depth of Foundation	2.9 m	2.9 m
Size Of Beam	230 mm X 600 mm	ISMB 350, ISHB 350-1, ISHB 150-3, ISHB 400
Size of column	300 x 700 mm, 230 x 600 mm 230 x 530 mm, 230 x 450 mm	450 X 300 @ ISHB 150-3
Thickness of Slab	125 mm	
Thickness of Wall	150 mm	150 mm
Seismic zone factor	II	II
Zone Factor	0.24	0.24
Soil Condition	Hard soil	Hard soil
Importance factor	1.0	1.0
Wind speed	44 m/sec^2	44 m/sec^2
Floor Finish	1 KN/m^2	1 KN/m^2
Live Load	2 KN/m^2	2 KN/m^2
Grade Of Concrete	30 N/mm^2	30 N/mm^2
Grade Of Steel	415 N/mm^2	415 N/mm^2 250 N/mm^2
UDL on beam	7.65 KN/m	7.65 KN/m
Density Of Brick	Density Of Brick	Density Of Brick

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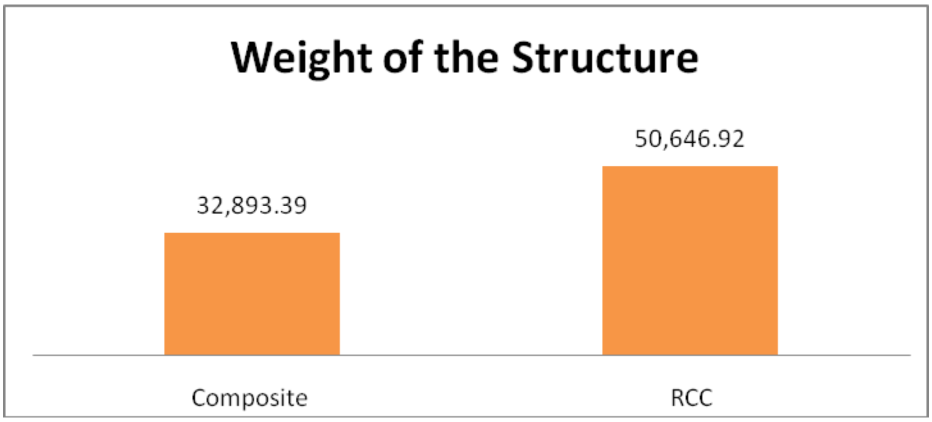
V. ANALYSIS OF STRUCTURE

The building model is analyzed using Equivalent Static Method. The building models are analyzed by the E-tab 2015 software. As study primarily focuses on the seismic assessment and comparison between the RCC and composite structure, different parameters such as bending moment, shear force, Base shear, Cost of structure, Time Period and Weight of structure are studied for the models. Seismic codes are unique to a particular region of country. In India, Indian standard criteria for earthquake resistant design of structures IS 1893: 2002 are the main code that provides outline for calculating seismic design force. Response spectrum analysis is carried out for knowing seismic performance of both the structure. For the composite structure analysis AISC 360-10 code provisions are considered.

VI. RESULTS AND DISCUSSION

6.1 Weight of structure

Weight of any structure is depends upon its components and material used in construction. Weight should be kept as low as possible to reduce the earthquake effect. In order to find out dead weight and make it a lighter structure we have studied the weight of all structural members in composite steel concrete and RCC building. From the following figure it is seen that composite structure is having less weight by 35.05 % comparing to RCC.



Graph 1 Comparison of Weight of Structure

6.2 Time Period and Frequency

It is observed that for both the structures time period continuously decreases and correspondingly the frequency increases from 1st node to 12th node. The time period of composite structure is more than RCC structure and at the same time frequency is more in RCC structure than Composite structure. The time period of composite structure is increased by 19 % to 25% and on the other hand frequency is decreased by 22% to 24%. The reduction in stiffness of composite structure results in increase of time period and decrease in frequency.

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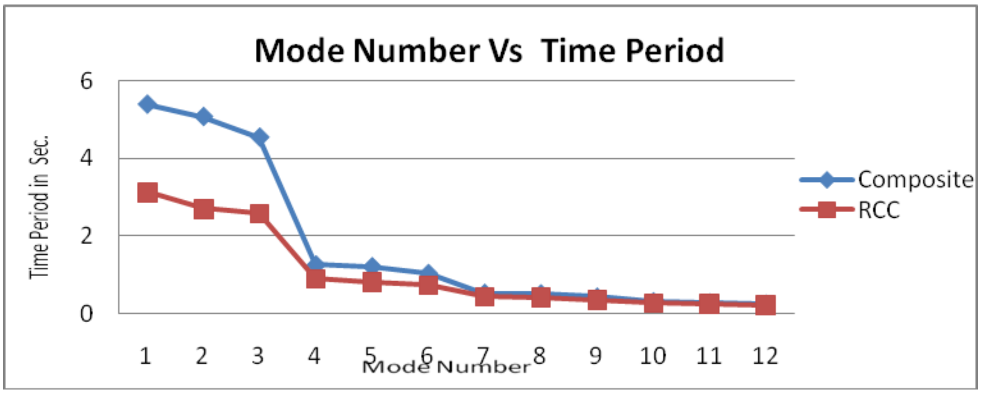
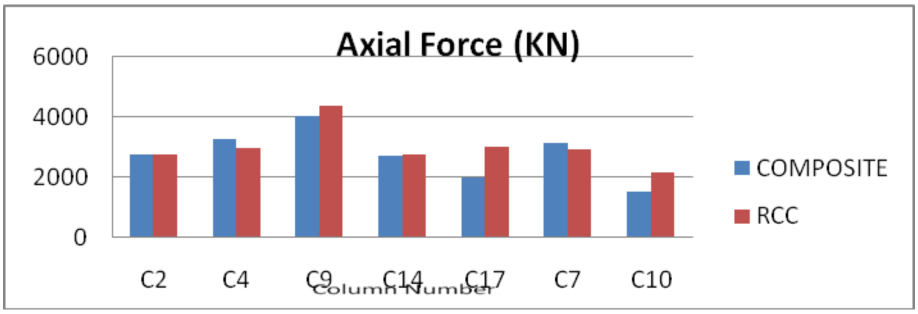


Graph 2 Comparison of Time Period

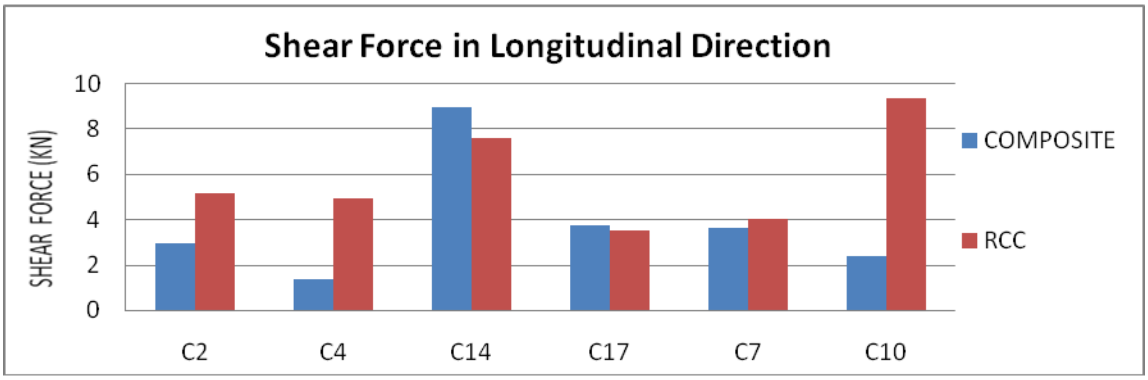
6.3 Axial Force in column, Shear Force in Column and Bending Moment

The result shows that the axial force in maximum composite column is less than RCC column. An average reduction of 10% to 12% is seen in axial force of composite column.



Graph 3 Comparison of Axial Force

The comparison of shear force is shown in Graph 4. It can be observed that the shear force in maximum composite column is less than RCC column in both the direction. Accept in column C17 in transverse direction and in column C14 in longitudinal direction shear forced is more in composite structure. In longitudinal direction the shear force is reduced by 25% to 29% and in transverse direction shear force is reduced by 33% to 37%



Graph 4 Shear Force in Column (longitudinal Direction)

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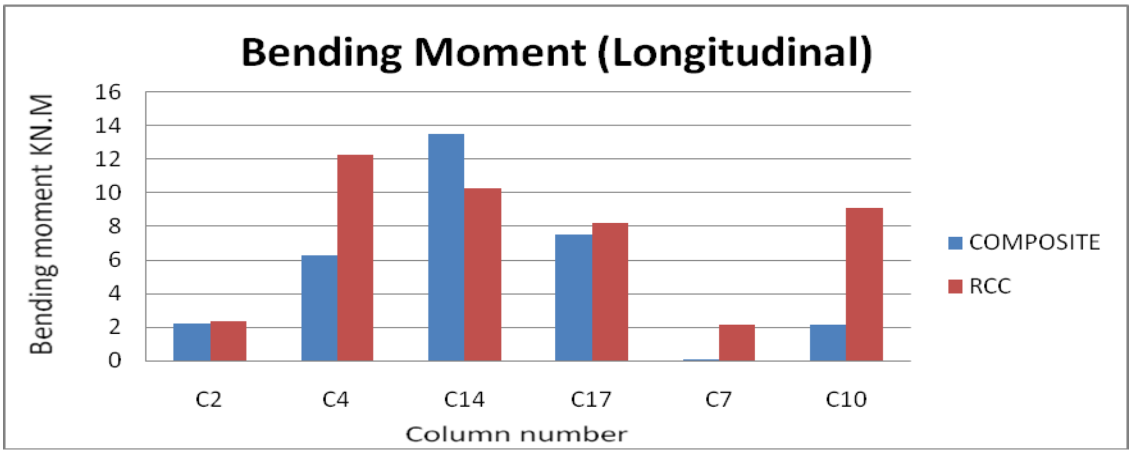
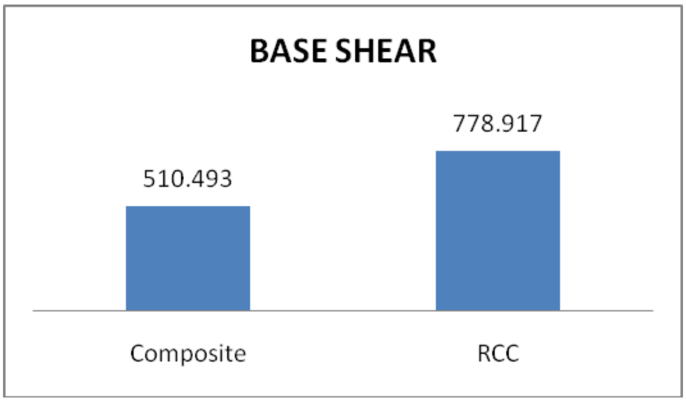
Analysis result shows that the bending moment in composite column section is less than RCC column section. In column C14 in longitudinal and C17 in transverse the bending moment is increased by 24% and 18% respectively. An average reduction of 35% to 45% is seen in bending moment of composite column than R.C.C. column in longitudinal direction.



Graph 5 Comparison of bending moment (Longitudional Direction)

6.5 Base Shear

As the base shear is the horizontal reaction to the earthquake forces and horizontal forces results from the storey weight. Storey weight includes the self-weight of the structure also; hence in the reinforced cement concrete model the self-weight is seems to be the more and hence maximizing the earthquake forces which results in the maximum base shear. As we have the static formula for base shear and base shear is the direct function of the seismic weight therefore naturally base shear is more in the case of RCC structure. The analysis is carried out as per code IS:1893-2002 and the results of base reactions directly shows that base shear in longitudinal and in transverse direction is less in composite structure than RCC structure. The base shear is the basic parameter for deciding the earthquake resistant structure. To make the structure safe, the base shear should be kept as low as possible. The base shear in Composite structure is reduced by 34.46% in X Direction and 46.6% in Y direction.



Graph 6 Base Shear Comparison

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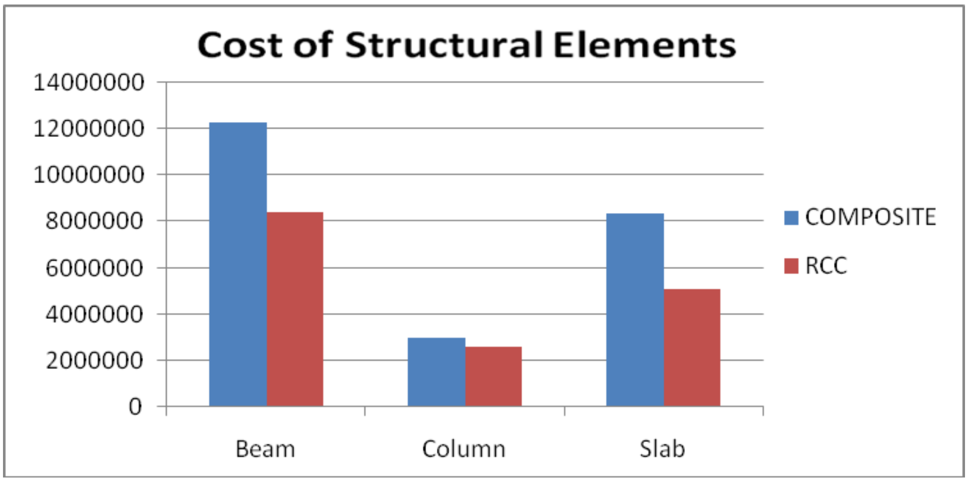
6.6 Cost of Structure

The cost comparison is made on the basis of material cost and results shows that the cost of composite structural elements is more than RCC structural elements. Material cost of composite structure is increased by 31.63 %. On the other hand the construction process of composite structure is much faster than conventional RCC structure. So when we consider the time required for construction, the composite structure is always preferable than conventional RCC structure. Speedy construction facilitates quicker return on the invested capital and benefits in terms of rent.



Graph 7 Comparison of Cost in terms of Structural Element

7.0 CONCLUSION

- The dead weight of Composite structure is found to be 30 % to 35% less than RCC structure and hence the seismic forces are reduced by 30% to 35%. As the weight of the structure reduces it attract comparatively less earthquake forces than RCC structure. This will add to further reduction in axial forces, shear forces and bending moment as compared to RCC structure.
- As the weight of structure is reduces the size of foundation also reduces which leads to saving in foundation cost.
- The axial force in composite column is found to be 7% to 9% less than RCC columns in linear static analysis. This reduction in axial force reduces the size of column and ultimately saves the material and its cost.
- The shear force in composite column is reduced by 25% to 29% in longitudinal direction and 33% to 37% in transverse direction at 1st storey. A significant reduction in shear force in both the direction is seen in composite column member.
- The bending moment in composite column in linear static analysis reduces by 58 % to 68% in longitudinal direction. The reduction in bending moment reduces the size of column.

- According to the Response spectrum analysis method, the time period of composite structure is more than RCC structure and at the same time frequency is more in RCC structure than Composite structure. The time period of composite structure is increased by 19 % to 25% and on the other hand frequency is decreased by 22% to 24%. The reduction in stiffness of composite structure results in increase of time period and decrease in frequency of composite structure.
- It is also seen that if the secondary beams are provided below the composite slab, then the composite structure gives more stiffness than RCC structure. Increased stiffness of composite structure results in reduction of lateral of lateral displacement of composite structure.
- The schedule of design of composite and RCC structure shows that the composite members requires much reduced dimensions than that of RCC members. The reduction in dimension of composite column results in providing more usable area.
- The results obtained by equivalent static analysis and the response spectrum analysis methods are nearly matching. The results obtained by Response spectrum analysis method are slightly less than that by equivalent static analysis. It is well known that response spectrum analysis method is more accurate than equivalent static analysis method.
- In composite structure due to high ductile nature of steel it leads to increase the seismic resistance of the composite section steel component can be deformed in a ductile manner without premature failure and can withstand numerous loading cycles before fracture.
- Due to high rates of steel one may find composite construction a little bit costly at the initial stage, but due to its speedy construction work the project can be completed as early as possible than RCC construction. In addition to this, reduced dimensions of beams and columns in composite construction leads to reduction in dead weight of the structure which ultimately helps in reduction of the cost of foundation.

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