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A Review on the Comparative Study of Steel, RCC and Composite Building

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ABSTRACT: In India concrete is very popular material of construction especially in case of medium and low rise buildings. And in case of high rise buildings steel is generally used and the composite construction is not such popular but it is possible that composite construction can be more beneficial in case of medium and high rise buildings. Steel-concrete composite construction can be built in place of RCC structures to get maximum advantage of steel and concrete and to produce efficient and economic structures. It is the decision of contractor or owner that which type of properties they require in the field and according to those properties the type of material can be chosen. This paper shows comparison of various aspects of building construction for steel, RCC as well as composite buildings considering various researches acted on this topic.

KEYWORDS: Comparative Study, Composite, Comparison Aspects, Storey Drift, Lateral Acceleration, Base shear, Mass irregularity, Overturning Moment

I. INTRODUCTION

Low rise buildings were generally selected in India as common option but now a days in India population is rapidly increasing and due to that the requirement of construction of medium and high rise buildings is also increasing. Reinforced concrete members are mostly used in framing system because this system is most convenient and economical for low rise buildings.

But for medium and high rise buildings this type of structures are no longer economical because of hazardous form work, less stiffness, span restriction, and increased dead load. Composite structure can be suitable in that case. Composite construction is having wide range of scope. It is very necessary to select suitable type of building as per requirement of owner as well as construction site. ^[3]

As compared to other developing countries the use of steel for construction purpose is very less in India. Steel structural members are prone to local and lateral buckling. Concrete structural members are generally thick and less likely to buckle but they are subjected to creep and shrinkage with time. Steel is more ductile material and so it can absorb more shocks and impact loadings. Thus composite structure is made to take the benefit of both of the materials.

It is shown that the performance of building during an earthquake depends upon several factors like stiffness, ductility, lateral strength and simple and regular configuration. So to come on a final decision of comparison all three types of buildings should be compared by displacement, base shear, storey drift and lateral force. ^[1]

II. LITERATURE REVIEW

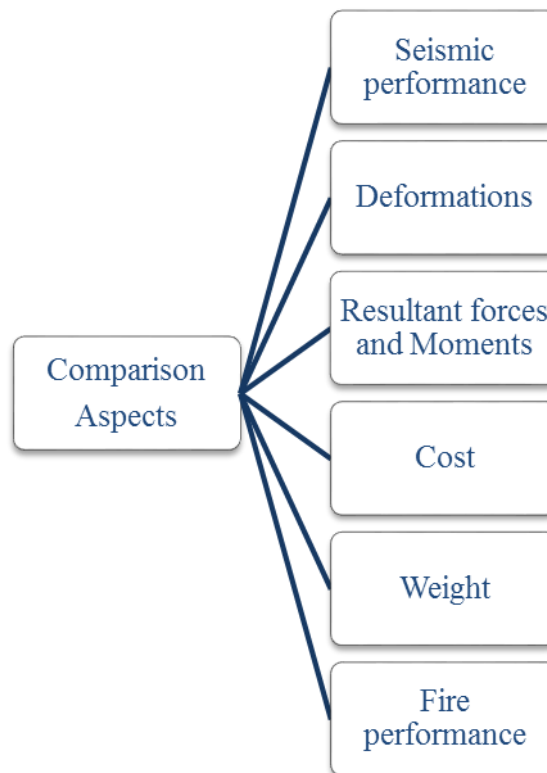
There is a considerable research work has been done in the direction of comparative study of steel, RCC and composite structures.

It can be seen from the studied research work that to judge the suitability of construction material, it is very necessary to compare the steel, RCC, and composite buildings for the following aspects.

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After this comparison, one can be able to come to a decision that which structure should be constructed under various respective conditions.

[1] Seismic Performance

A large amount of the research work has been done in the direction of Seismic behaviour under dynamic performance. Critical issues related with seismic behaviour are **storey drift, Base shear and Mass irregularity**. Structural engineer have to deal will all these critical issues for making the structure safe under the seismic effect.

Following Research work has been done in the direction of making the structure safe under seismic action.

[a] Storey Drift

Rahul Pandey has submitted his thesis “**Comparative seismic analysis of RCC, Steel and Steel-concrete composite frame**”^[10] in which he had compared the performance of a (G+7) storey RCC, Steel, and Composite building frame situated in earthquake zone 5 using SAP2000 software. And the results were compared and the conclusion about the storey drift was made that storey drift in X-direction was more for steel frame as compared to composite and RCC frame.

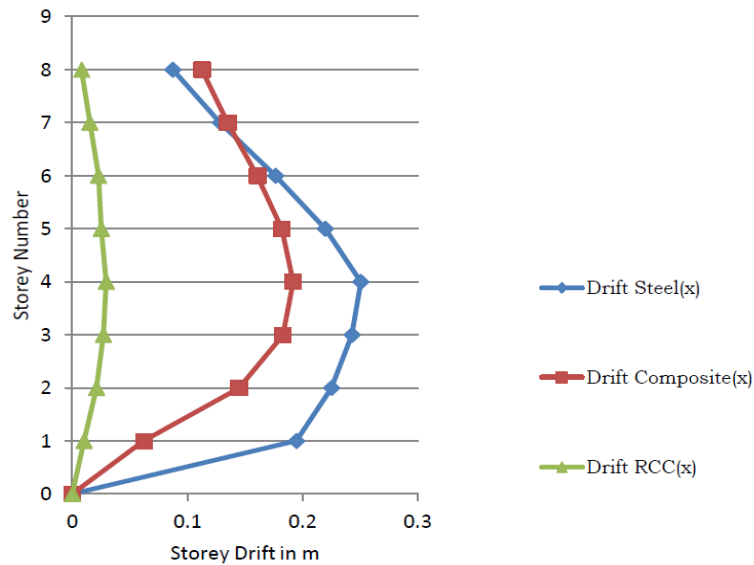
And RCC frame has the lowest value of storey drift because of its high stiffness, which indicates that as the value of stiffness increases, storey drift values decreases with it.

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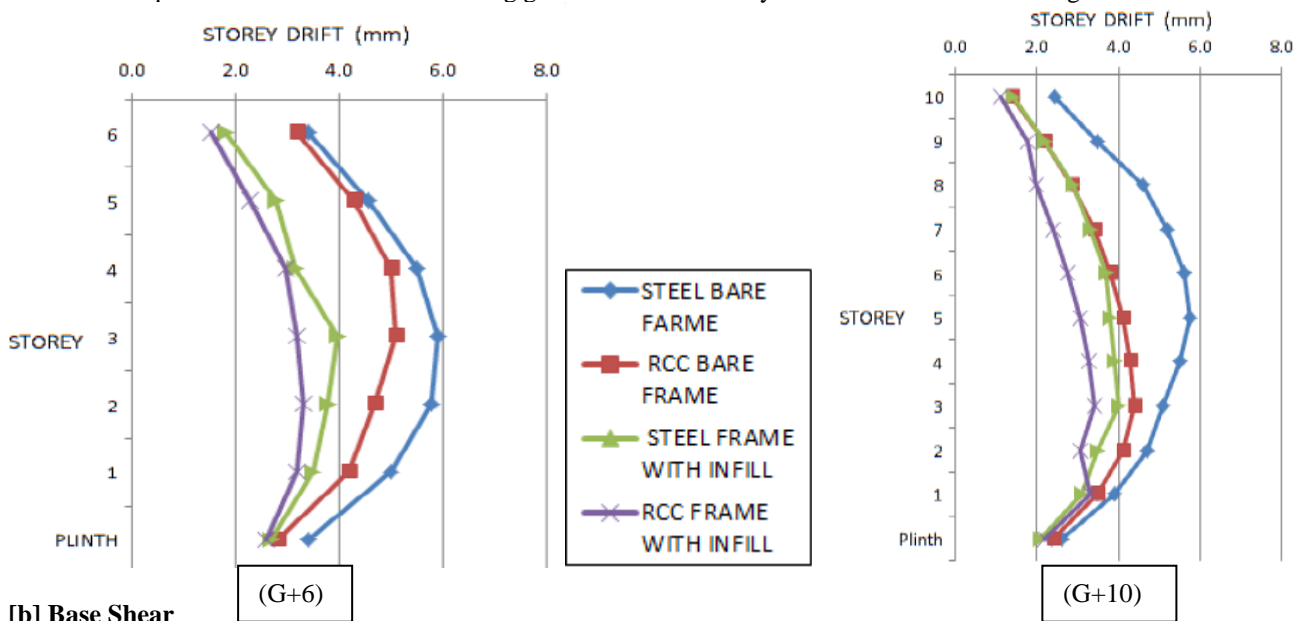
The following graph was made for the results. The graph show us that RCC frame is having the less value of storey drift and up till the 7th storey, storey drift is less for composite frame and maximum storey drift is of steel frame. So here RCC frame is better than rest of two frames in case of storey drift.



In research paper “**Comparative study of analysis and design of R.C. and steel structures**”^[6]

a 3-D model was prepared for the frame analysis of building in ETABS for the earthquake zone 5 and the results were indicating the same thing that the storey drifts of steel structures are comparatively more than RC structures within the permissible limit.

And the following graphs were made for (G+6) and (G+10) stories. From the graphs it can be clearly observed that RCC frame is having lesser values of storey drift than steel frame due to its greater weight. And if bare frame and infill frame are compared then bare frames are having greater values of storey drift due to their lesser weights.



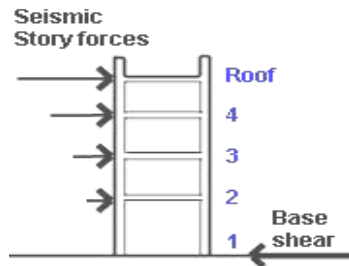
[b] Base Shear

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Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure, which is shown in the figure.

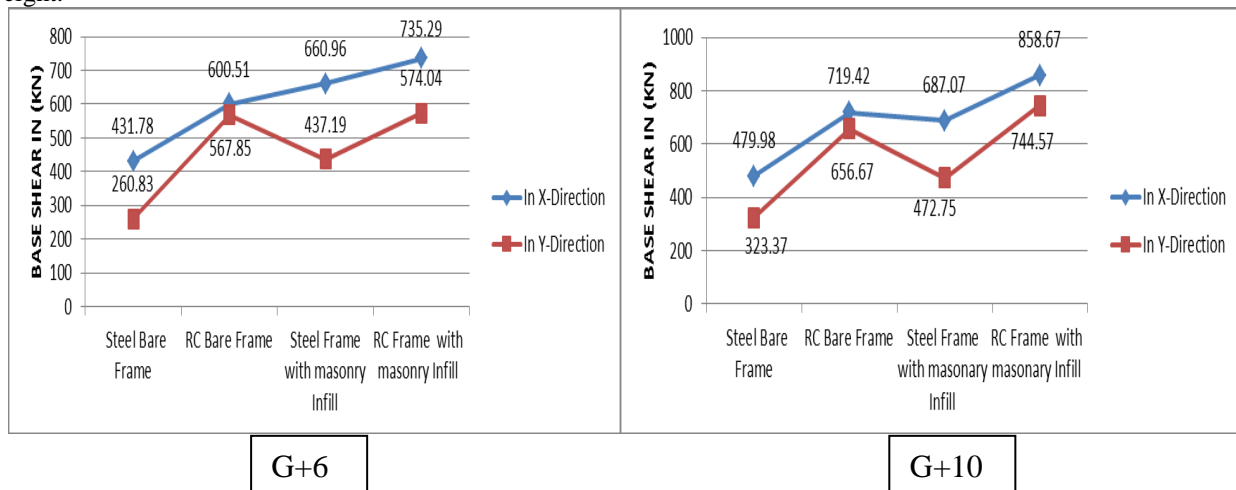


Nitin M. Warade and P.J. Salunke submitted a research paper “Comparative Study of Analysis and Design of Composite Structure.”^[11]

In which five models (G+6,G+7,G+8,G+9,G+10) were modelled and analysed using ETABS software. And in the results they have noticed that base shear of composite building was decreased than normal RCC building and increased than steel building, which indicates that with increase in the stiffness base shear also increases.

In research paper “Comparative Study of Analysis and Design of R.C. and Steel Structures”^[6] it is concluded that base shear in steel structure is less than the R.C. structure because of the less seismic weight which gives better seismic response during earthquake. In this paper for the frame analysis a 3-D model was prepared in ETABS for the earthquake zone 5.

The graphs for that are given below which show us that steel frame is having lesser values of base shear than RC frame due to its lesser weight. And bare frame is having lesser values of base shear than masonry infill frame due to its lesser weight.



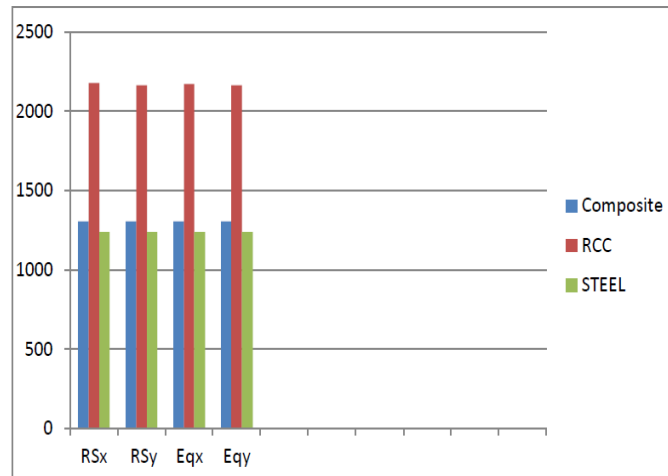
Rahul Pandey has described in his thesis^[10] that, Base shear for RCC frame is maximum because the weight of RCC frame is more than steel and composite frame. So, Base shear gets reduced for composite frame and for the steel frame as compared to RCC frame.

The graph for that is given below which show us that steel frame is having lesser values of base shear, concrete frame is having higher value of base shear, and base shear of composite frame is lesser than concrete frame and greater than steel frame. Which indicates that greater value of weight indicates greater value of base shear.

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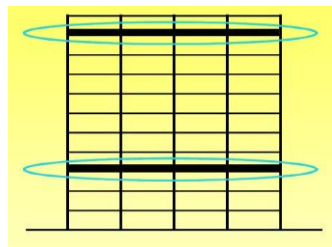


[c] Mass Irregularity

Prof. Swapnil B. Cholekar and **Basavalingappa S.M.** had described that the Mass Irregularity can affect all the parameters of storey drift, base shear, dead weight, shear force and joint displacement during earthquake. They were compared for RCC and composite structures in this paper.

For the stability of the structure and less damage of the structure it is very important to have uniform mass, stiffness, simple-regular configuration. ^[1]

Mass irregularity is given in the figure. Mass irregularity is an important factor which is to be considered while designing multistorey building. It is formed due to uneven distribution of mass, strength, and stiffness. Seismic



performances of this type of irregular structures become very important. Mass irregularity should be considered to exist where the seismic weight of storey is more than 200% of that of its adjacent storey. With increase in the difference of mass between two stories, mass irregularity also increases.

Mass irregularity results from this research paper can be summarized as below ^[1]

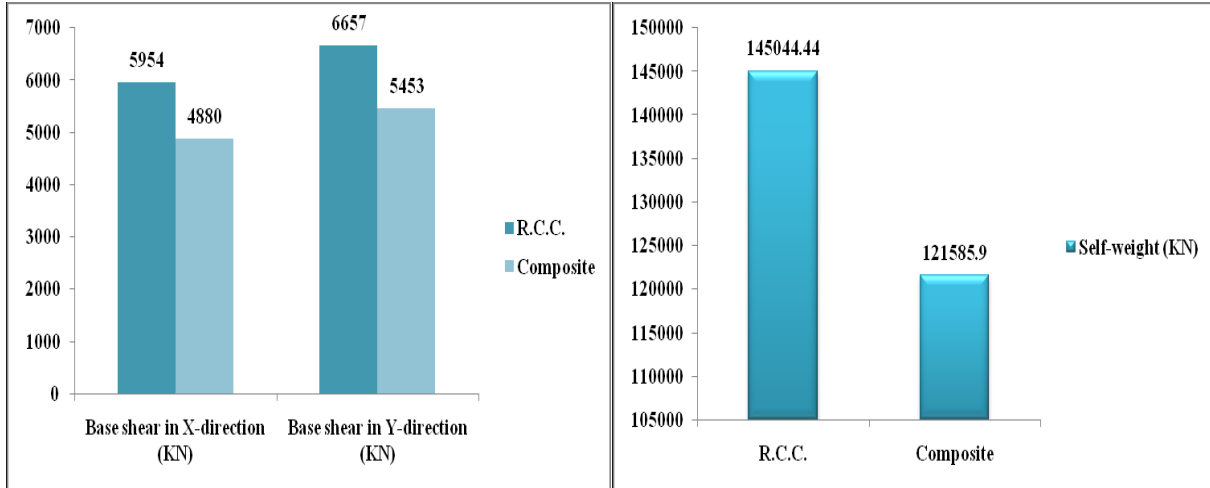
- Under mass irregularity composite structure shows reduction of storey drift values in both X- and Y- direction.
- Under mass irregularity composite structure shows reduction of base shear.
- Under mass irregularity dead weight of composite structure is less.
- Under mass irregularity shear force in composite structure is also less.
- Under mass irregularity joint displacement values are less in composite structure.

Following are the graphical comparisons of their results, which show us that under mass irregularity due to greater weight of RCC frame its base shear will also be more as compared to composite frame and that result will be same for both X and Y direction earthquakes.

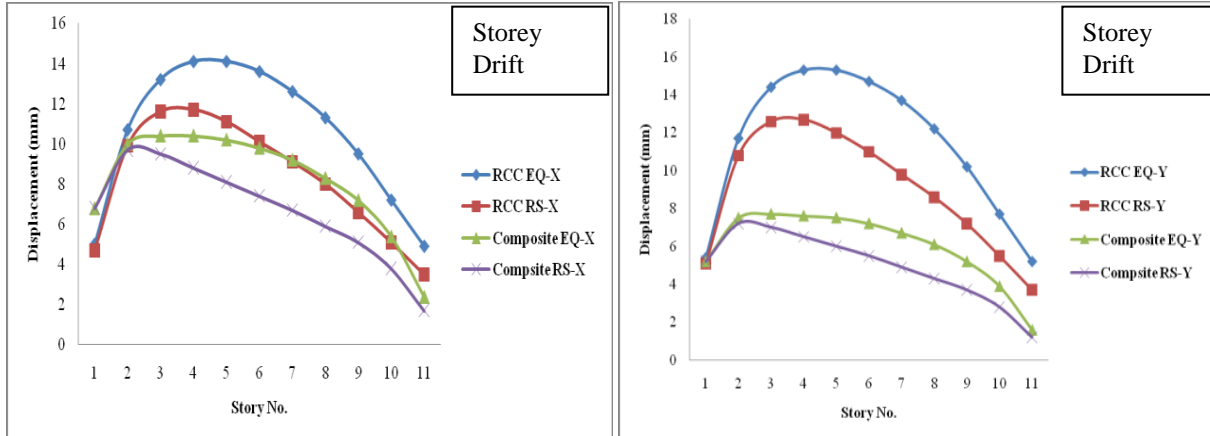
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Following graphs show us that, under mass irregularity RCC frame is having higher values of storey drifts as compared to composite frame.



[2] Displacements

Under the application of various loads the displacement of nodes can occur. Less nodal displacement indicates safe structure.

Shashikala Koppad and **Dr. S.V. Itti** had published “Comparative study of RCC and Composite Multi Storeyed Buildings”^[3] in which they took a 3-D model in seismic zone 3 and analysed it in STAAD.Pro V8i software. In this research paper they had concluded that node displacement in composite structure is more as compared to RCC structure. This is because the composite structure is more flexible as compared to RCC structure.

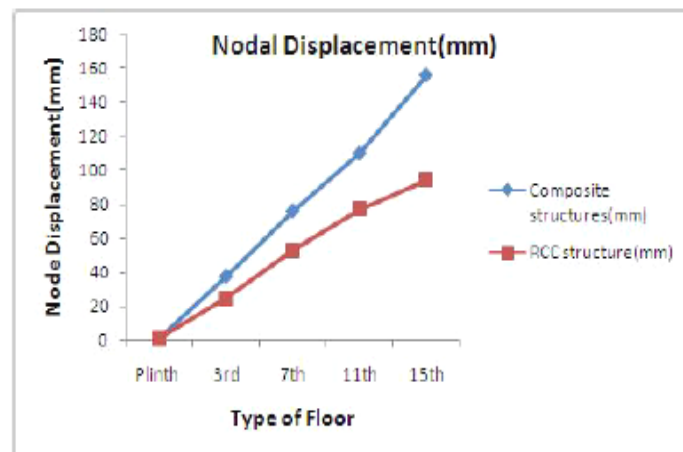
The results are shown in graph and the table. It is shown that values of nodal displacements of composite frame are higher than RCC frame. The observations are the same for plinth, 3rd, 7th, 11th and 15th floors and graph is also plotted according to these results.

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Type of floor	Composite structures (mm)	RCC structures (mm)
Plinth	1.2	1.1
3rd	37.821	24.475
7th	76.2	52.571
11th	110.15	76.989
15th	156.177	93.937



[3] Resultant Forces and Moments

D.R. Panchal and P.M. Marathe had published “Comparative study of R.C.C, Steel and Composite (G+30 storey) building” [5]

- Shear forces in the secondary beams are increased in steel structure and reduced in composite structure as compared to RCC.

In main beams, shear forces are increased in steel structure and reduced in composite structure upto large extent as compared to RCC framed structure.

This result can be observed from the table given below which show us the comparison of RCC, Steel and Composite frames for three categories which are ground floor to 10th floor, 10th floor to 20th floor and 20th floor to 30th floor. Here the results of Steel and Composite are compared with respect to the results of RCC. And all the tables are given in the same pattern.

SHEAR FORCE IN SECONDARY BEAM IN KN

	RCC	STEEL	COMPOSITE
Ground floor to 10 th floor	159.16	276.31 73% increase	165.88 4% reduction
10 th floor to 20 th floor	190.44	338.18 77.5% increase	165.88 12.8% reduction
20 th floor to 30 th floor	186.07	372.42 100% increase	165.88 11% reduction

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SHEAR FORCE IN MAIN BEAM IN KN

	RCC	STEEL	COMPOSITE
Ground floor to 10 th floor	390.35	1169.86 200% increase	554.96 42% increase
10 th floor to 20 th floor	332.7	557.63 67% increase	631.19 89% increase
20 th floor to 30 th floor	233.86	534.73 128% increase	634.88 171% increase

- Bending moments in secondary beams are increased in steel structure and reduced in composite structure as compared to RCC structures.
In main beams bending moments are increased in steel and composite both of the structures upto large extent as compared to RCC structure.

BENDING MOMENTS IN SECONDARY BEAM IN KN M

	RCC	STEEL	COMPOSITE
Ground floor to 10 th floor	393.2	978.4 73% increase	236.38 40% reduction
10 th floor to 20 th floor	498.7	1345.3 77.5% increase	236.38 52.6% reduction
20 th floor to 30 th floor	506.7	1538.46 100% increase	236.38 53.3% reduction

BENDING MOMENTS IN MAIN BEAM IN KN M

	RCC	STEEL	COMPOSITE
Ground floor to 10 th floor	704.3	1839.8 161% increase	1322.9 87% increase
10 th floor to 20 th floor	585.5	2127.1 263% increase	1217.0 108% increase
20 th floor to 30 th floor	474.5	2119.0 346% increase	1227.2 158% increase

- Axial forces in column have been reduced in steel as well as composite structure as compared to RCC structure.

COLUMN AXIAL FORCES IN KN

	RCC	STEEL	COMPOSITE
Ground floor to 10 th floor	22051.9	11668.3 47% reduction	17365.0 21.5% reduction
10 th floor to 20 th floor	14061.1	7665.2 45.4% reduction	17360.0 23% increase

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20 th floor to 30 th floor	6970.7	3850.7	5625.0
		44.8% reduction	20% reduction

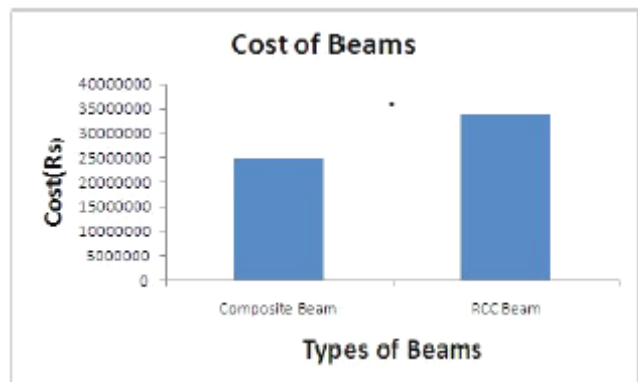
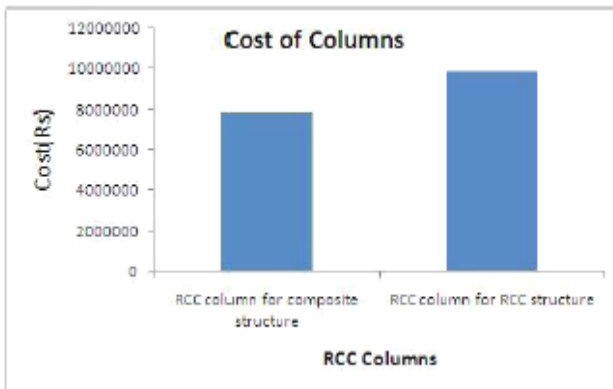
[4] Cost

Cost is a major aspect of comparison of steel, RCC and composite buildings. Because costly structures are generally neglected in construction if another cheaper option is available in front of it. Research work in case of cost comparison of buildings has been done in the direction of RCC and Composite buildings. Cost results from various research papers can be summarized as below.

For multistorey buildings,

- Cost of composite beams is less than RCC beams because composite beams do not require any formwork.^[3]
- As axial forces and reactions are less in composite columns as compared to RCC columns, so cost of composite columns is less.^[3]

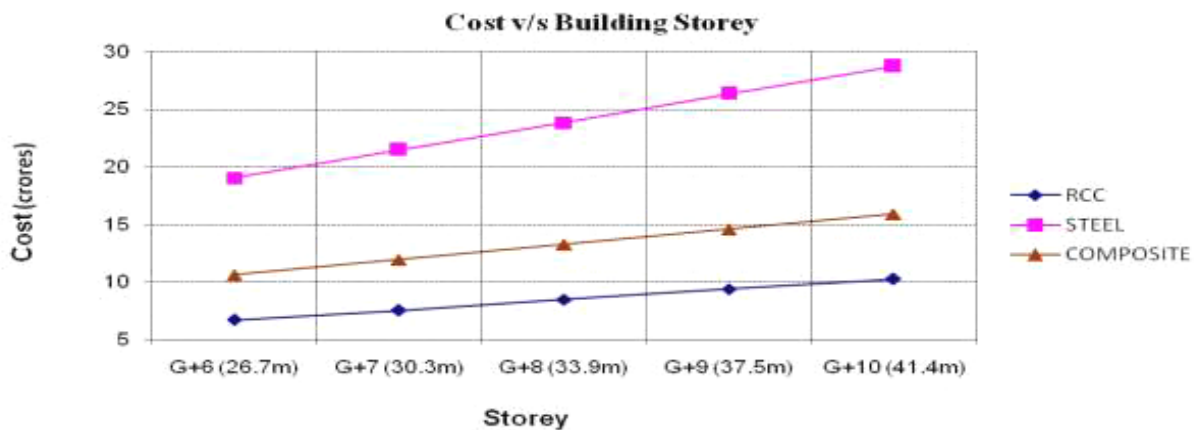
These both results are shown in the graphs.



- Composite buildings are more economical than RCC.^[3]

For low rise buildings,

- Cost of composite buildings is more than RCC and less than steel^[11], which is shown in the graph.



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[5] Weight

Weight of various types of structures is very important to know because it will affect the cost of foundation as well as the cost of ground improvement.

Weight results from various research papers can be summarized as below.

- Weight of the composite structure is quite low as compared to RCC structure, which helps in reducing foundation cost. ^[3]
- Dead load of composite is less than RCC and more than steel, which is shown in graph given below. ^[11] These results are shown in the graph given below.



[6] Fire performance

Fire performance of the building is considered more seriously when building is Industrial. In case of an industrial building to construct a steel structure can be risky. So in place of steel structure, composite or RCC structure is preferred. Fire performance is the ability of a particular structural element (as opposed to any particular building material) to fulfil its designed function for a period of time in the event of a fire.

Because of concrete's inherent material properties, it can be used to minimize fire risk for the lowest initial cost while requiring the least in terms of ongoing maintenance. In most cases, concrete does not require any additional fire-protection because of its built-in resistance to fire. It is a non-combustible material (i.e. it does not burn), and has a slow rate of heat transfer. Concrete ensures that structural integrity remains, fire compartmentation is not compromised and shielding from heat can be relied upon.

In case of composite structures numerous studies have been conducted on the fire performance of CFST columns. In CFST the filled concrete can significantly increase the fire resistance. Because the heat is absorbed by the core concrete the temperature of the steel tube will increase more slowly. The outer tube provides a confinement to the core concrete during the fire exposure, the spalling of the core concrete thus can be prevented. Confinement to the steel casing can also be provided by providing concrete cover around it. ^[12]

III. CONCLUDING REMARKS

Following general points can be discussed from the study of various research papers.

- Following factors should be considered to decide structural suitability.
 - Seismic performance of the structure

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Deformations
Resultant Forces and Moments
Cost
Weight
Fire performance

- Overall response of composite structure is better than RCC structure i.e. composite structure produces less displacement and resists more structural forces.
- Composite structures are best solution for high rise buildings and they are resulted in speedy construction.
- Steel option is better than RCC but the composite option for high rise building is best.
- Steel has excellent resistance to tensile loading but prone to buckling and concrete gives more resistance to compressive force. Steel can be used to induce ductility and concrete can be used for corrosion and fire protection.
- Composite structures are resulted into lighter construction than traditional concrete construction as well as speedy construction. So completion period of composite building is less than RCC building.

IV. SCOPE OF WORK

In this review paper it is shown that Steel, RCC and Composite structures can be compared in various aspects under various conditions. But soil conditions can be changed other than hard soil and can be compared for worst conditions. And in India generally these aspects are not considered fully. But practical applications of these comparison can make structure more safe and more economical. And more accurate comparison processes and aspects can be developed.

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REFERENCES

- [1] Prof. Swapnil B. Cholekar, Basavalingappa S. M., "Comparative Analysis of Multistoried RCC and Composite Building due to Mass Irregularity", International Research Journal of Engineering and Technology, (IRJET) e-ISSN: 2395 -0056 , Volume: 02 Issue: 04, p- 603-608, July-2015
- [2] Mr. Nitish A. Mohite, Mr. P.K.Joshi, Dr. W. N. Deulkar, "Comparative Analysis of RCC and Steel Concrete composite (B+G+11 storey) Building", International Journal of Scientific and Research Publications, ISSN 2250-3153 , Volume 5, Issue 10, p- 1-6, October 2015
- [3] Shashikala. Koppad, Dr. S.V.Itti, "Comparative study of RCC and composite multistoreyed Buildings", International Journal of Engineering and Innovative Technology (IJEIT), ISSN: 2277-3754 ,p- 341-345, Volume 3, Issue 5, November 2013
- [4] Sattainathan.A, Nagarajan.N, "Comparative study on the behavior of R.C.C., Steel and composite structure", International Journal on Applications in Civil and Enviornmental Engineering, ISSN (Online) : 2395 – 3837 Volume 1: Issue 3, , pp 21-26, March 2015
- [5] D. R. Panchal and P. M. Marathe, "Comparative Study of R.C.C., Steel and Composite (G+30) storey building", Institute of Technology, Nirma University, Ahmedabad – 382 481 , pp- 1-6, December, 2011
- [6] Prof. Prakarsh Sangave, Mr. Nikhil Madur, Mr. Sagar Waghmare, Mr. Rakesh Shete, Mr. Vinayak Mankondi, Mr. Vinayak Gundla, "Comparative study of Analysis and design of R.C. and Steel Structures", International Journal of Scientific & Engineering Research, ISSN 2229-5518, Volume 6, Issue 2,pp- 256-267, February-2015
- [7] Prasad Kolhe, Prof. Rakesh Shinde, "Time History Analysis Of Steel And Composite Frame Structure", IJREAT International Journal of Research in Engineering & Advanced Technology, ISSN: 2320 – 8791, Volume 3, Issue 2, April-May, 2015.
- [8] Ketan Patel, Sonal Thakkar, "Analysis of CFT, RCC and Steel Building Subjected to Lateral Loading", Chemical, Civil and Mechanical Engineering Tracks of the 3rd Nirma University International conference on engineering, Elsevier, pp- 259 – 265, year 2013
- [9] Varsha Patil, Shilpa kewate, "Comparative Study on Dynamic Analysis of Composite, RCC and Steel structure", International Journal of Engineering Technology, Management and Applied Sciences, ISSN 2349-4476, Volume 3, Issue 8,pp- 135-142, August 2015
- [10] Rahul Pandey, "Comparative Seismic Analysis of RCC, Steel & Steel-Concrete Composite Frame", Department of Civil engineering National Institute of technology Rourkela ,2014
- [11] Nitin m. Warade, P. J. Salunke, "Comparative study on Analysis and Design of Composite Structure", International Journal Of Advance Research In Science And Engineering IJARSE, ISSN-2319-8354(E), Vol. No.2, Issue No.12, pp- 41-50, December, 2013
- [12] Lin-Hai Han , Wei Li , Reidar Bjorhovde , "Developments and advanced applications of concrete-filled steel tubular (CFST) Structures:Members",Elsevier, Journal of Constructional Steel Research 100 , pp- 211–228, 2014

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