COMPARATIVE STUDY OF RCC, STEEL AND COMPOSITE STRUCTURES FOR INDUSTRIAL BUILDING

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ABSTRACT

Steel Concrete Composite construction has gained wide acceptance world wide as an alternative to RCC construction. However, this system is relatively new concept for the construction industry. Reinforced concrete members are used in the framing system for most of the buildings since this is the most convenient & economic system for one storey buildings. However, for multi storeyed building this type of structure is no longer economic because of increased dead load, less stiffness,, span restriction and hazardous formwork. And steel structure is also good for low load but Steel concrete composite frame system can provide an effective and economic solution to most of these problems in medium to high rise buildings. In the present work Concrete composite with RCC, Steel structure options are considered for comparative study of G+2 storey of Industrial building which is situated in earthquake zone-3 of IS 1893-2002 earth quake loading. Equivalent static method of analysis is used for modeling of composite, Steel and RCC structures; STAAD-pro V8i Finite element software is used. In the composite structure Steel column is encased in PCC and RCC slab on steel girder are employed. The dead load and live load are considered as per IS-875(part-1&2) and wind load is considered as per IS-875(part-3). The result of this work shown that, the cost of the composite is less than the RCC structure as well as steel structure. The critical bending moment and Shear force values are less in composite structure compared to RCC structure and more than steel structures due to decreased dead load. Composite structure is best solution for the multi storeyed Structure compared to RCC and Steel structure.

Keyword : - *Industrial Building, Cost Difference, Axial Force, Node Displacement, Max Bending Moment and shear Force etc….*

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1. INTRODUCTION

In past structural engineer has d the choice of masonry building and multi stories building with RCC framed structure or steel structure. Recently trend of going towards composite structure has started and going [1]. Now a days in India to fulfill the requirements and needs of high rise buildings the composite is best suited for infrastructural growth other than the RCC and steel structures, and steel concrete composite system have become quite popular in recent time because of their advantages against convention construction, composite construction combines the better properties of both material such as concrete and steel [2].

1.1 Advantages of Composite structure

i. Increased strength for a given cross sectional dimension.
ii. Increased stiffness, leading to reduced slenderness and increased buckling resistance.
iii. Good fire resistance in the case of concrete encased.
iv. Corrosion protection in encased member.

v. Superior seismic performance for lateral load.
vi. Significant economic advantages over either pure structural steel or reinforced concrete alternatives.
vii. Identical cross sections with different load and moment resistances can be produced by varying steel thickness, the concrete strength and reinforcement. This allows the outer dimensions of a column to be held constant over a number of floors in a building, thus simplifying the construction and architectural detailing.
viii. Erection of high rise building in an extremely efficient manner.
ix. Formwork is not required for concrete filled tubular sections
x. Economical for High rise buildings

1.2 Components of Composite structure

Composite deck slab- Composite floor system consists of steel beams metal decking and concrete. They are combined in very efficient way so that the best properties of each material can be used to optimize construction techniques. The most common arrangement found in composite floor systems is a rolled or build up steel beam connected to a formed steel deck and concrete slab. The metal deck typically span unsupported between steel members, while also providing a working platform for concreting work. The composite floor system produce a rigid horizontal diaphragm, providing stability to the over all building system, while distributing wind and seismic shear to the lateral load-resisting system

Composite beams- In conventional composite construction, concrete slabs rest over steel beams and are supported by beam. Under load these to components act independently and a relative slip occurs at the interface if there is no connection between them. With the help of a deliberate and appropriate connection provided between them can be eliminated. In this case the steel beam and the slab act as a "composite beam" and there action is similar to that of a monolithic Tee beam. Though steel and concrete are the most commonly used materials for composite beams, other materials such as pre-stressed concrete and timber can also be used. Concrete is stronger Compression than in tension, and steel is susceptible to buckling in Compression. By the composite action between the two, We can utilize there respective advantage to the fullest extent. General in steel concrete composite beams, steel beams are integrally connected to pre fabricated or cast in situ reinforced concrete slabs.

Composite columns- A steel concrete composite column is a Compression member, Comprising either of a concrete incased hot rolled steel section or a concrete filled hallow section of hot rolled steel. It is generally used as a load bearing member in a composite framed structure. Composite members are mainly subjected to compression and bending. At present there is no Indian standard code covering design of composite column. The method of design in this report largely fallows EC4, Which incorporate latest research on composite construction. Indian standard for composite construction IS 11384-1985 does not make any specific reference to composite column. This method also adopt the European buckling curve for steel column as a basic of column design

Shear connector- The total shear force at the interface between concrete slab and steel beam is approximately 8 times the total load carried by the beam. There for, mechanical shear connector is required at the steel concrete interface. These connector are designed to (a) transmit longitudinal shear along the interface, and (b) prevent separation of steel bean and concrete slab at the interface. Commonly used types of shear connector as per IS:11384-1985. There are three main types of shear connectors., rigid shear connector, flexible shear connector and Anchorage shear connectors.

2. METHODOLOGY

1) In the present work it is proposed to prepare a finite element models of G+2 Storey Industrial building using STAAD Pro V8i with fixed base at ground level.
a) R.C.C structure
b) Steel Structure
c) Composite Structure
2) Apply Dead load, Live load and Wind load/Earth quake load as per IS 875-1987and IS 1893-2002 and Carry out the equivalent Static method of analysis.
3) Carry out Designs by Limit state method using IS 456-2000 and SP16-1980
4) Carry out quantity surveying for all the three type of buildings.
5) Estimate the cost using Karnataka State Schedule Rate – 2018 Book
6) Compares the result of all three types of structures.

3. MODELING AND ANALYSIS

The study has been carried out with some basic assumption in design criteria/parameters for (G+2) storied industrial building for RCC, Steel as well as Composite including relevant soil parameters, wind speed, landscape class and topography, earthquake zone and value of coefficient and acceleration based on available local data and stipulations of bureau of Indian standards and euro codes. The dead burden and live burden has been consider dependent on the IS 875(part-1 and 2), wind load depends on IS-875(Part-3). For tremor stacking, the arrangement of IS-1893:2002 was considered.

The study has been carried out for the three variant

i. G+2 RCC, 4.5m height.
ii. G+2 Steel Structure, 4.5m height.
iii. G+2 Steel concrete Composite, 4.5m height

3.1 Building Detail

The building considered here is an Industrial building having G+2 storied located in seismic zone 3 and for earthquake loading, the provisions of IS:1893(Part1)-2002 is considered. The wind velocity 39m/s. The line diagram plan of building is shown in fig.1 the building is planned to facilitate the basic requirements of an Industrial building. he plan dimension of the building is 12X42 m. Height of each storey for Composite, RCC and steel structure is 4.5 m. The study is carried out on the same building plan for RCC, steel and composite construction with some basic assumptions made for deciding preliminary sections of both the structures. The basic loading on all three type of structure types of structures are kept same, other relevant data is tabulated in table1,2 &3

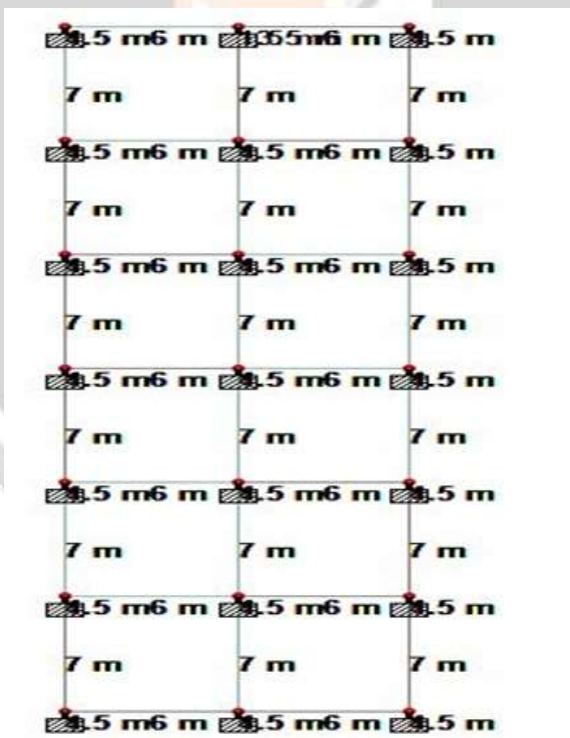

Fig -1: Typical Plan of RCC Building

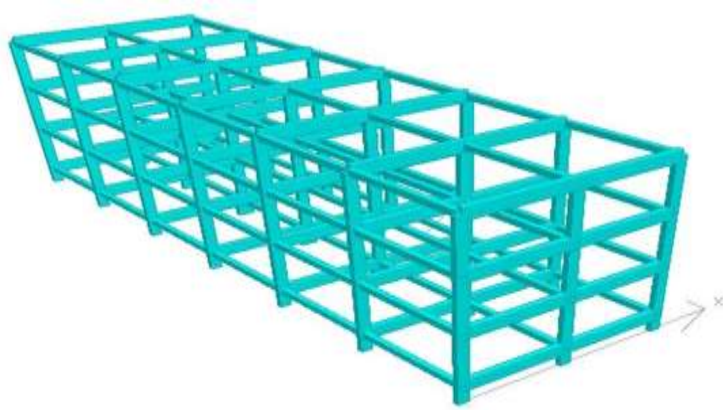

Fig-2: 3D Model of Building

Table no-1: Data for the analysis of RCC structure

Plan Dimensions	12x42 m
Total height of the structure	15 m
Height of each storey	4.5 m
Height of parapet	1 m
Size of beams at plinth level	1x0.3 m
Size of beam at floor level	1x0.3 m
Size of column	0.6x0.3m
Thickness of the slab	0.150 m
Thickness of wall	0.230 m
Seismic Zone	III
Wind speed	33 m/s
Importance factor	1
Zone factor	0.16
Floor Finish	1.5 KN/m^2
Live load	7 KN/m^2
Grade of concrete for slabs	M 30
Grade of concrete for beams and columns	M 30
Grade of reinforcement steel	Fe415
Density of concrete	25 KN/m^3
Density of brick	20 KN/m^3
Damping Ratio	5%
Grade of structural steel	Fe250
Concrete cover to reinforcement for slab	0.025 m
Concrete cover to reinforcement for beam	0.025 m
Concrete cover to reinforcement for column	0.040 m

Table no-2: Data for the analysis of Steel structure

Plan Dimensions	12x42 m
Total height of the structure	15 m
Height of each storey	4.5 m
Height of parapet	1 m
Size of beams at plinth level	ISMB-450
Size of beam at floor level	ISMB-450
Size of column	ISMB-500
Thickness of the slab	0.150 mm
Thickness of wall	0.230 m
Seismic Zone	III

Wind speed	33 m/s
Importance factor	1
Zone factor	0.16
Floor Finish	1.5 KN/m2
Live load	7 KN/m2
Grade of concrete for slabs	M 30
Density of concrete	25 KN/m3
Density of brick	20 KN/m3
Damping Ratio	5%
Grade of structural steel	Fe250
Concrete cover to reinforcement for slab	0.025 m

Table no-3: Data for the analysis of Steel structure

Plan Dimensions	12x42 m
Total height of the structure	15 m
Height of each storey	4.5 m
Height of parapet	1 m
Size of beams at plinth level	ISMB-300
Size of beam at floor level	ISMB-300
Size of column	ISMB-400
Thickness of the slab	0.150 m
Thickness of wall	0.230 m
Seismic Zone	III
Wind speed	33 m/s
Importance factor	1
Zone factor	0.16
Floor Finish	1.5 KN/m^2
Live load	7 KN/m^2
Grade of concrete for slabs	M 30
Grade of concrete for beams and columns	M 30
Grade of reinforcement steel	Fe415
Density of concrete	25 KN/m^3
Density of brick	20 KN/m^3
Damping Ratio	5%
Grade of structural steel	Fe250
Concrete cover to reinforcement for slab	0.025 m
Concrete cover to reinforcement for beam	0.025 m
Concrete cover to reinforcement for column	0.040 m

3.2 Analysis

The explained 3D building model is analyzed using Equivalent Static Method. The buildings models are analyzed by using Staad-Pro V8i software. In composite structure the beam is modeled as composite beam element and column is modeled as encased steel composite element. In RCC structure the beam and column is modeled as RCC beam element. In Steel structure the beam and column is modeled as Steel beam element. The different parameters such as node displacement, maximum shear force, axial force and maximum bending moment, Cost are studied for the models. The dead load and live load are considered as per IS-875(part 1 &2) and wind load is considered as per IS-875(part 3).For earthquake loading IS:1893(Part1)-2002 is used.

4. RESULTS AND DISCUSSION

In the present study the G+2 composite, steel and RCC multistory Industrial building is considered. An effort has been made to calculate the cost effectiveness of composite, steel and RCC structure elements. The parameter considered is nodal displacement, maximum shear force, axial force and maximum bending moment is considered and their variation in the form of graph is shown.

4.2 Cost of Beam

The quantity of composite, steel and RCC Beams is taken from design and calculated total quantity as shown below. The rate of Reinforcement steel, Structural Steel and concrete is obtained from the present market. The Cost of RCC beams, Steel beams and Composite beams as given in table-4 and graph variation of the cost of beam is shown in graph

Table no-4: Cost of beams in different structures.

Material	Composite Structure			Steel Structure			RCC Structure		
	Quantity of beam	Rate	Amount	Quantity of beam	Rate	Amount	Quantity of beam	Rate	Amount
Structural Steel	60.81	60000	3648600	60.81	60000	3648600	-	60000	
Reinforcement Steel	10.58	56000	592480	13.6	56000	761600	43.76	62000 (include bar bending)	2713120
Concrete	302.4	4000 (form work is not)	1209600	226.8	5000	1134000	410.4	8500	3488400
Total Amount			5450680			5544200			6201520

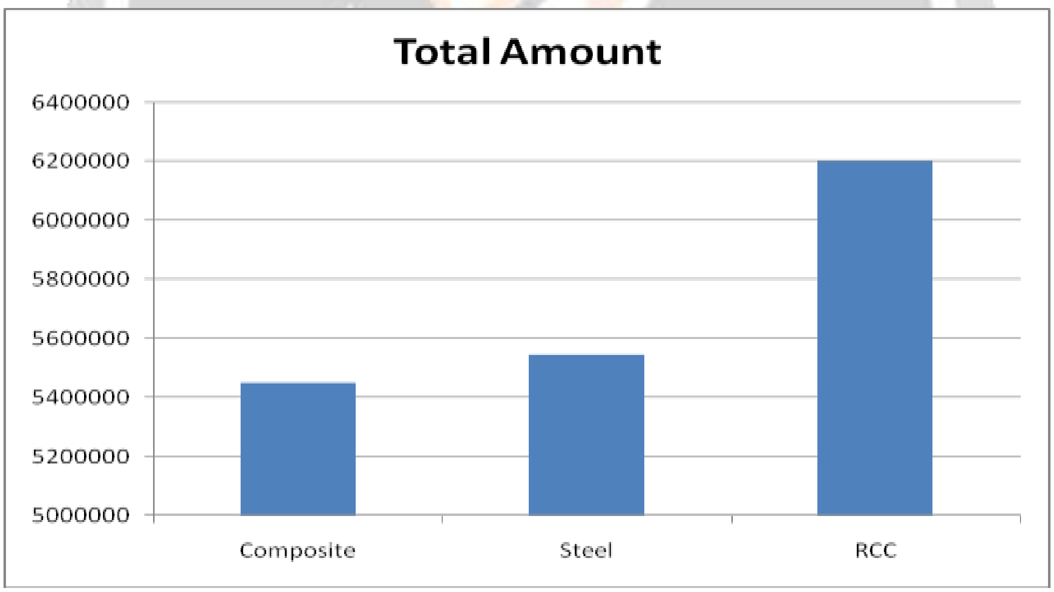

Fig-6: Cost Variation Graph of Beams for Composite, Steel and RCC Related

4.3 Cost of Column

The quantity of column for Composite, Steel and RCC structure are taken from the design and total quantity is shown below. The rate of reinforcing steel ,Structural steel and concrete are taken from market. The table 5 show the total cost of columns for RCC, Steel and composite structure.

Table no-5: Cost of Columns in different structures.

Material	Composite Structure			Steel Structure			RCC Structure		
	Quantity of column	Rate	Amount	Quantity of column	Rate	Amount	Quantity of column	Rate	Amount
Structural Steel	16.5	60000	960000	24.97	60000	1498200	-	60000	0
Reinforcement Steel	-	56000	0	-	56000	0	17.25	62000	1069500
Concrete	36.3	4000	145200	-	5000	0	5.7	8500	48450
Total Amount			1105200			1498200			1117950

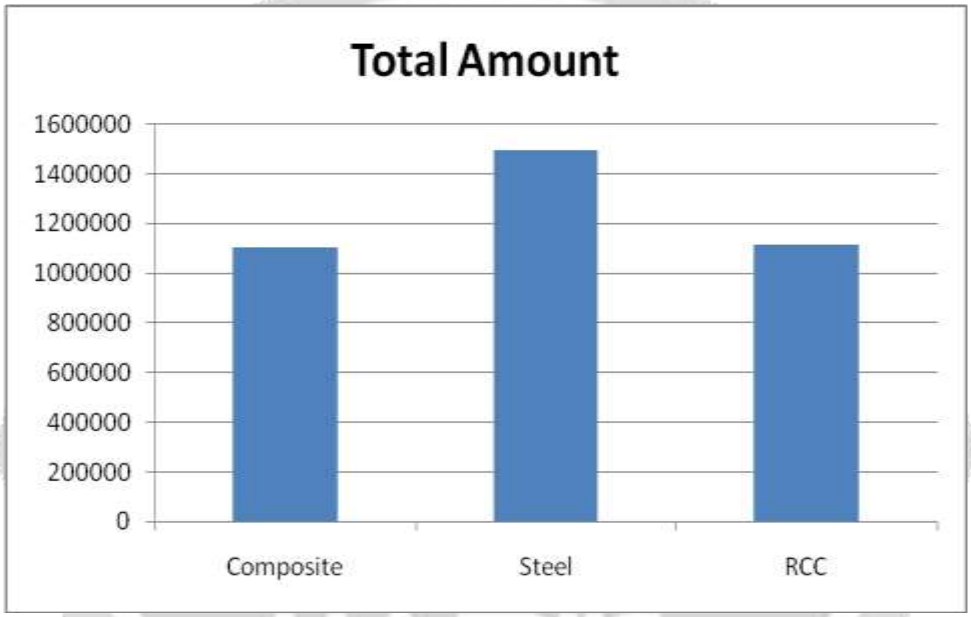

Fig-7: Cost Variation Graph of Columns for Composite, Steel and RCC Related

4.4 Axial Force

From the analysis results axial forces are taken for composite, Steel and RCC structure at different floor. The table 6 shows the maximum axial forces in Composite and RCC structure.

Table no-6: Maximum Axial force in different structures.

Type of floor	Maximum Axial Force in Composite	Maximum Axial Force in Steel	Maximum Axial Force in RCC
Plinth	1800	1600	2500
Gr. Floor	1450	1450	1850
1st Floor	1260	900	1200
2nd Floor	900	520	426

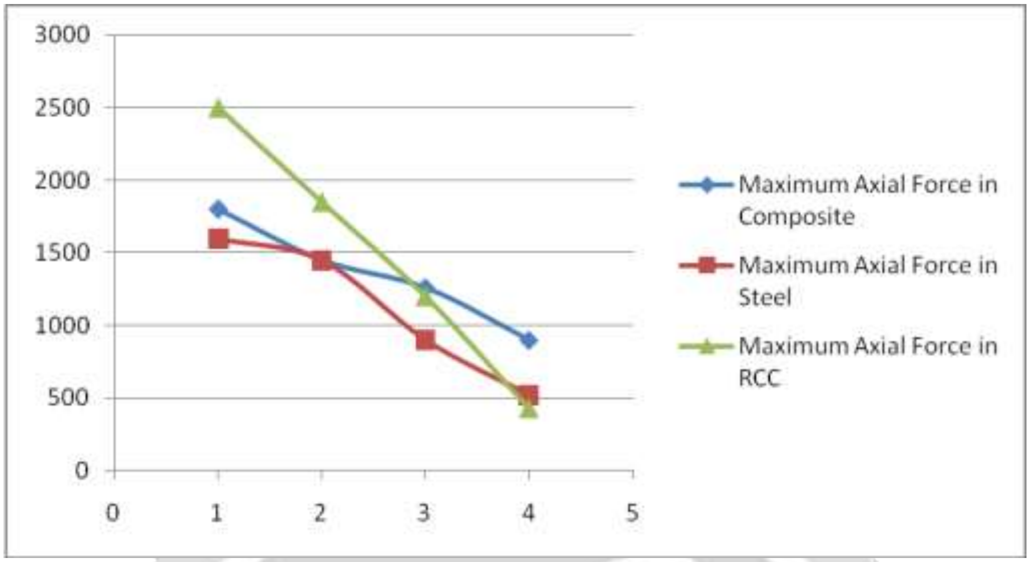

Fig-8: Axial forces variation graph for RCC, Steel and composite structure

4.5 Node Displacement

From the analysis results of node displacement are taken for composite, Steel and RCC structure. The node displacement for composite and RCC structure are given in table-7

Table no-7: Node Displacement in different structures.

Type of floor	Composite Structure	Steel Structure	RCC Structure
Plinth	1.5	2.3	1.1
Gr. Floor	15	24	12
1st Floor	27	31	21
2nd Floor	41	49	37

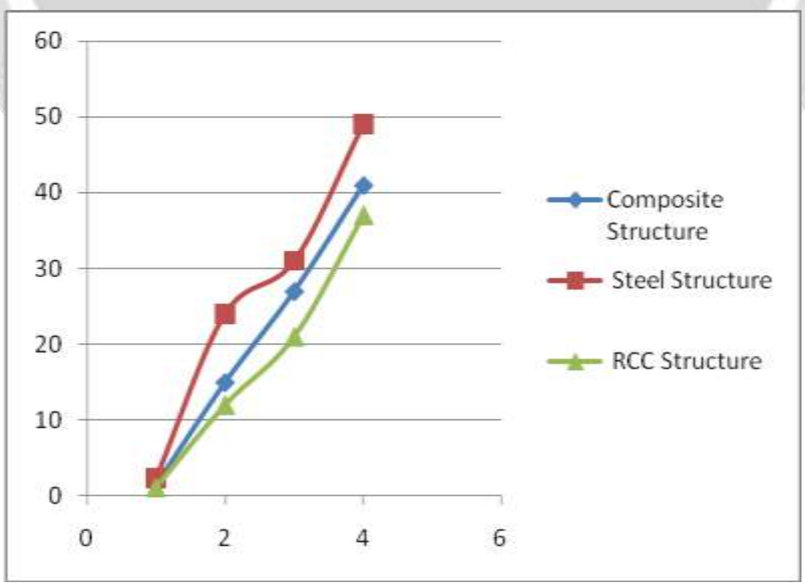

Fig-9: Node Displacement for RCC, Steel and composite structure

4.6 Maximum Bending Moment And Shear Force

From the analysis results maximum bending moment and shear force are taken for composite, Steel and RCC structure. The table 8 shows the maximum bending moment and shear force in composite and RCC structure.

Table-8: Max BM and SF in RCC, steel and composite structure

Comparison property	Composite beam	Steel beam	RCC beam
Max Shear force (KN)	370	280	460
Max Bending moment in Z-direction (KN-m)	410	321	510

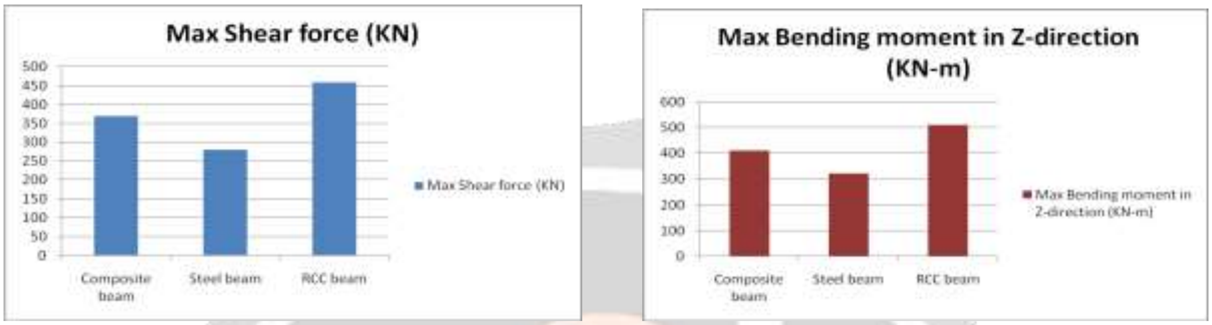

Fig-10: Max shear force and Max Bending Moment for RCC Steel and composite structure

4.7 Discussion

1. From the beam cost comparison chart and table it is clear that the cost of the Composite beam is 1.7% less than Steel Structure beam and 13.7% less than the RCC beam. This is because, the Composite beam does not required bar bending and form work.
2. From the Column cost comparison chart and table it is clear that the cost of the Composite beam is 35% less than Steel Structure Column and 1.7% less than the RCC Column. This is because, the Composite beam does not require bar bending and steel binding of column.
3. Fr0m the Axial force chart and table it is clear that axial f0rce is less than the RCC structure but quite more than the Steel Structure.
4. From node displacement table and chart, it is clear that C0mposite Structure has less displace of node compare to Steel Structure but More than the RCC structure.
5. From the maximum bending moment and shear force chart and table it is clear that the max bending moment and shear force in composite beam is less compared to RCC and quite more than the Steel structure

5. CONCLUSION

In this work. The comparative study of R.C.C, Steel and Composite Structure for industrial building (G+2) is presented. The parameter considered are cost of beam, cost of column, node displacement, member deflection, maximum bending moment, maximum shear force is considered. Thus based on the analysis results discussed in previous chapter fallowing conclusions drawn.

1. The axial force in R.C.C structure is higher than the Composite Structure.
2. Composite Structures are more economical than the RCC and steel Structure.
3. mass of composite structure is less than RCC structure but more than the Steel structure
4. Speed of work and speedy erection facilitates quicker return on the invested capital and benefit in terms of rent.
5. For the erection work labor requirement is very less in composite structure compare to RCC structure
6. Deflection in composite structure is more compared to RCC structure and less compared to steel structure.
7. The maximum bending moment and shear force is more than the RCC structure and less than the steel structure.

6. REFERENCES

[1] D.R. Panchal, P. M. Marathe, "*Comparative Study of R.C.C, Steel and Composite (G+30 Storey) Building"*, Institite of Technology, Nirma University, Ahmedavada-ISSN:382481,vol-4, Jully, 2011, pp. 08-10.

[2] Shashikala.Koppad, Dr. S.V.Itti, "*Comparative Study of RCC and Composite Multistoried Building(B+G+15)",* International journal of Engineering and Innovative Technology(IJEIT)- Volume 3, Issue 5, November 2013

[3] Sandeep Chaudhary, Umesh Pendakar and A.K nagpal, "*hybrid procedure for cracking and time dependant effects in composite frames at service load"* American Society of Civil Engineers 10.1061(ASCE) 0733-9445(2007) 133:2(166)

[4] 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, VOl-5 Issue 10,p--.1-6 October 2015

[5] Rahul Pandey, " *Comparative Seismic Analysis of RCC, Steel &Steel Concrete Composite Frame*", Department of Civil Engineering National Institute of Technology Rourkela,2014

[6] 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-2, Issue-12, pp. 41-50, December,2013

[7] Bhavin H. Et al., "*Comparative Study of Steel, RCC and Composite Building*" International journal of Innovative Research in Science, Engineering and Technology, IJIRSET, ISSN, Vol-5, Issue-1,pp.354365, January,2016

[8] Enric Spacone et al., *" Non Linear Analysis of Composite Structures"* American Society of Civil Engineers, 10.1061/(ASCE)0733-9445(2004)

[9] IS456-2000- "*Indian slandered Code of Practice for Reinforcement Concrete"* (4^{th} revision) Bureau of Indian Standard (BIS) New Delhi

[10] SP16:1980 "*Design Aids for Reinforced Concrete to IS-456-1978*" Bureau of Indian Slandered, New Delhi

[11] IS-800-2007 –"*Indian standard code practice for general construction in steel",* bureau of Indian standard (BIS) new Delhi

[12] IS-875 (1987 part-1) "*Code of Practice for Design Loads(other than Earth quake) for Building and Structures, Dead Loads*", Bureau of Indian Standard (BIS) New Delhi

[13] IS-875 (987 part-II) "*Code Practice for Live Load*", Bureau of Indian Standard (BIS) New Delhi.

[14] IS-1893(P-I, P-II) -2002 *"Creiteria for Earthquake Resistant Design of Structure"* General Provisions and Buildings, Bureau of Indian Standards, New Delhi

[15] IS11384:1985 *" code practice or design of composite structures*" bureau of Indian standard (BIS) New Delhi.

[16] Euro code 3 "*design of steel structure"* European committee for standardization committee European denormalization europaisches committee fur normung.

[17] Euro code 4 "*design of Composite structure*" European committee for standardization committee European denormalization europaisches committee fur normung.

[18] S. Ramamurutham "*Design of Reinforced Concrete Structures*", Text Book, Fourth Edition, Dhanapat rai Publications.

[19] R.P. Johnson, "*Composite structures of steel and concrete elements"* (beams, Slabs, Column and Frames for building) , Text Book, Blackwell publications UK-1994

[20] G.W Owens, P R knowels and P J dowling, *"Steel design manual of 5th addition-the steel construction institute",* Text Book, Published -blackwell science.

[21] "*Handbook of composite construction multi-storey building*" INSDAG publications N0.INS/PUB/022

[22] S K Duggal "*design of steel structure*" the McGraw-hill companies publications, new York-2010

[23] R.Narayanan "*Composite steel Structures*" Advances design and construction, Elsevier, Applied Science, UK-1987

[24] S.ramamrutham, "*Steel table*" Dhanpat Rai Publications.