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Title: Manual Design And Analysis of Multi-Storied Office Building.

Volume 06, Issue 05, Page No: 2241 – 2250.

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MANUAL DESIGN AND ANALYSIS OF MULTI-STORIED OFFICE BUILDING

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ABSTRACT:-

Due to advancement of technology humans are creating software to make things easier and time saving. As a result in the civil engineering point of view the manual design of buildings has lost its importance. It is true that design using a software is easy and time saving and mostly results are accurate. On the other hand manual design is a cumbersome job and a time consuming process, but for a beginner manual design helps to understand the basic fundamentals that are involved in designing a building. Once a person gains knowledge in manual design he will be knowing the elements involved in designing and can easily understand the usage of software. The main objective of the project is to use the knowledge that we have learnt during our graduation and learn to deal with practical cases. We wish this project will fulfill our purpose.

Keywords: Composite beam, Column, RCC column, RCC beam, Shear Connector, SAP 2000 Software

INTRODUCTION

The use of Steel in construction industry is very low in India compared to many developing countries. Experiences of other countries indicate that this is not due to the lack of economy of Steel as a construction material. There is a great potential for increasing the volume of Steel in construction, especially the current development needs in India. Composite construction essentially different materials are completely compatible and complementary to each other; they have almost the same thermal expansion; they have an ideal combination of strengths with the concrete efficient in compression and the steel in tension; concrete also gives corrosion protection and thermal insulation to the steel at elevated temperatures and additionally can restrain slender steel sections from local or lateral-tensional buckling. This paper includes comparative study of RCC with Composite Story building Comparative study includes Storey Stiffness , Displacement, Drifts, Axial Force in column , Shear force in column, Twisting Moment, Bending Moments in composite with respect to RCC Sections. Steel-concrete composite frame system can provide an effective and economic solution tomost of these problems in medium to high-rise buildings.

OBJECTIVE

The composite sections using Steel encased with Concrete are economic, cost and time effective solution in major civil structures such as bridges and high rise buildings. This project has been envisaged which consists of analysis and design of a high rise building us in Steel-Concrete composites. The project also involves analysis and design of an equivalent RCC structure so that a cost comparison can be made between a Steel –Concrete composite structure and an equivalent RCC structure.

ELEMENTS OF COMPOSITE STRUCTURE

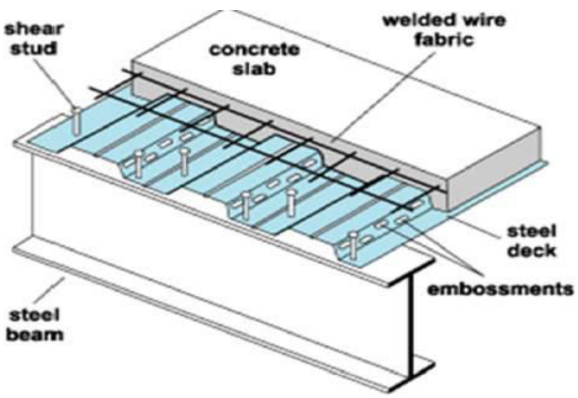
In the past, for the design of a building, the choice was normally between a concrete structure and a masonry structure. But the failure of many multi-storied and low-rise RCC and masonry buildings due to earthquake has forced the structural engineers to look for the alternative method of construction. Use of composite or hybrid material is of particular interest, due to its significant potential in improving the overall performance through rather modest changes in manufacturing and constructional technologies. Literature says that if properly configured, then composite steel-concrete system can provide extremely economical structural systems with high durability, rapid erection and superior seismic performance characteristics. Formally the multi-story buildings in India were constructed with RCC framed structure or Steel frame structure, but recently the trend of going towards composite structure has started and growing. In composite construction the two different materials are tied together by the use of shear studs at their interface having lesser depth which saves the material cost considerably. Thermal expansion (coefficient of thermal expansion) of both, concrete and steel being nearly the same. Therefore, there is no induction of different thermal stresses in the section under variation of temperature.

Shear Connectors: 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 1: Shear Connectors

Composite Slab: The loads are applied in such a way that the load combination is most unfavorable. Load factors of 1.5 for both dead load and imposed load are employed in design calculations.

Figure 2: Composite Slab



Composite Beam: 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.

ii) Collapse prevention under the largest earthquake demanded that may occur at the site. Such earthquake occurs with a return period of approximately 2500 years. The inelastic deformation demands are smaller than their deformation capacities taking approximate account of gravity loads, second order effects and deterioration of stiffness and strength due to cyclic loading. Also the story deformations are sufficiently small so as to prevent catastrophic damage to non structural elements. Deformations are the key parameter for performance based earthquake design rather than force or strength. Deformation can be classified in to three categories.

a) Overall building movements and Story drifts and other internal deformations.

b) Story drifts and other internal deformations.

c) Inelastic deformations for structural components and elements.

BUILDING DESCRIPTION

The building considered here is an office building having G+9 stories located in seismic zone III and for earthquake loading, the provisions of IS: 1893 (Part1)-2002 is considered. The wind velocity 39 m/s. The plan of building is shown in Figure 5 of columns and plan dimensions. The building is planned to facilitate the basic requirements of an office building. The building plan is kept symmetric about both axes. Separate provisions are made for car parking, lift, staircase, security room, pump house and other utilities. The plan

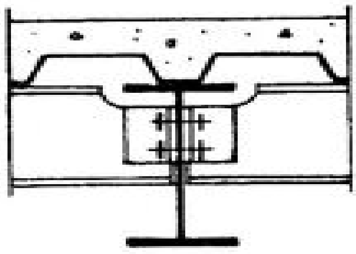


Figure 3: Composite Beam

Composite Column: Column is conventionally a compression member in which the steel element is a structural steel section. There are three types of composite columns used in practice, which are Concrete Encased, Concrete filled, Battered Section.

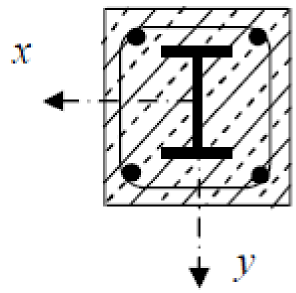


Figure 4: Composite Column

EARTHQUAKE ANALYSIS AND DESIGN PROCEDURE

The traditional codes gives us procedure attempts to satisfy implicitly objectives.

i) Negligible damage in once in a lifetime earthquake shaking demands having a return period of about 50 years. This can be achieved by elastic structural response and limiting the storey drifts to minimize damage to non-structural components such as cladding and internal walls. dimension of the building is 24.00 m by 36.00m, which is on land area of about 1800 m_2. Height of each storey is kept same as 3.50 m and the total height of building is kept as 38.5m. Columns are placed at 6 m center to center and are taken to be square, as the square columns are more suitable for earthquake resistant structures. The study is carried on the same building plan for RCC and composite constructions with some basic assumptions made for deciding preliminary sections of both the structures. The basic loading on both type of structures are kept same. Other relevant data is tabulated in Table 1.

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Figure 5: Position of Columns and Building Plan

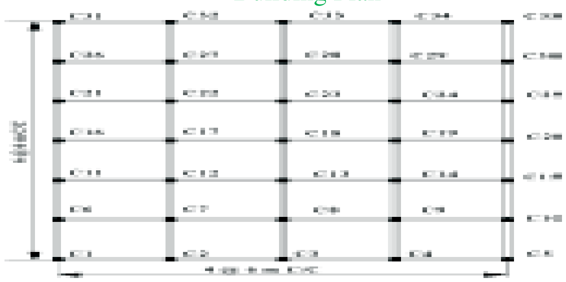


Table 1: Comparison Between RCC Structure and Composite Structure

Particulars	RCC Structure	Composite Structure
Plan dimensions	24 m X 36 m	24 m X 36 m
Total height of building	38.5 m	38.5 m
Height of each storey	3.5 m	3.5 m
Height of parapet	0.90 m	0.90 m
Depth of foundation	2.50 m	2.50 m
Plinth height	1.00 m	1.00 m
Size of beams	300 mm X 600 mm	ISMB400@61.6 kg/m
Size of columns	700 mm X 700 mm	500 X 500 mm (SC250@85.6 kg/m + 125mm concrete cover)
Thickness of slab	125 mm	125 mm
Thickness of external walls	230 mm	230 mm
Thickness of internal walls	115 mm	115mm
Seismic zone	III rd	III rd
Soil condition	Hard soil	Hard soil
Response reduction factor	5	5

Table 1 (Cont.)

Particulars	RCC Structure	Composite Structure
Importance factor as per Is-1893-2002 Part -1 for different. zone as per clause 6.4.2.	1.5	1.5
Zone factor	0.16	0.16
Floor finishes	1.875 kN/m^2	1.875 kN/m^2
Live load at roof level	2.0 kN/m^2	2.0 kN/m^2
Live load at all floors	5.0 kN/m^2	5.0 kN/m^2
Grade of Concrete	M20	M20
Grade of concrete in composite column	–	M30
Grade of reinforcing Steel	Fe415	Fe415
Grade of Structural Steel	–	Fe250
Density of Concrete	25 kN/m^3	25 kN/m^3
Density of brick masonry	20 kN/m^3	20 kN/m^3
Damping ratio	5%	3%

Modeling of Building

The building are modeled using the finite element software SAP 2000. The analytical models of the building include all components that influence the mass, strength, stiffness and deformability of structure. The building structural system consists of beams, columns, slab, walls, and foundation. The non-structural elements that do not significantly influence the building behavior are not modeled. Beams and columns are modeled as two noded beam elements with six DOF at each node. The floor slabs are assumed to act as diaphragms, which insure integral action of all the vertical load-resisting elements and are modeled as four noded shell elements with six DOF at each node. Walls are modeled by equivalent strut approach and wall load is uniformly distributed over beams. The diagonal length of the strut is same as the brick wall diagonal length with the same thickness of strut as brick wall, only width of strut is derived. Walls are considered to be rigidly connected to the columns and beams. The 3D building model generated in SAP2000 are shown in Figure 6.

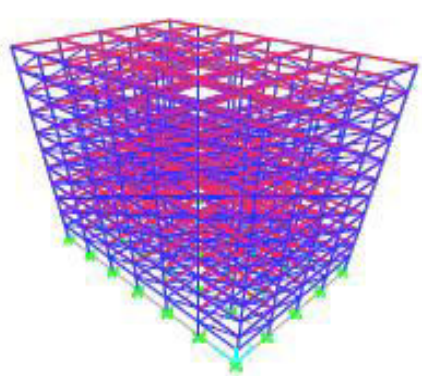
Analysis of Building

In India, Indian Standard Cri teria for Earthquake Resistant Design of Structures IS 1893 (Part-I): 2002 is the main code that provides outline for calculating seismic design force.

1) Equivalent static analysis and Dynamic analysis:

a) The weight of all the floors and the roof is calculated and total seismic weight of the building is found out.

Figure 6: 3D Model of Commercial Building



b) The approximate fundamental natural period of vibration (T_a), in seconds, of all buildings, including moment-resisting frame buildings with brick infill panels, is estimated by the empirical expression

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C)The design horizontal seismic coefficient *h A* for a structure is determined by the following expression:

d) The total design lateral force or design seismic base shear is determined by the following expression.

e) The design base shear computed as above is distributed along the height of building as per the following expression.

RESULTS AND DISCUSSION

A) Equivalent Static Analysis: Equivalent static analysis is performed on both types of structures. Loads are calculated anddistributed as per the code IS1893: 2002 and the results obtained are compared with respect to the following parameters.

i) Storey stiffness: It can be observed that the transverse and longitudinal storey stiffness for composite structure is large as compared to RCC structure. The storey stiffness for composite structure is about 12% to 15% more in transverse direction and about 6% to 10% more in longitudinal direction than the RCC structure are shown
in Figures 7 and 8.

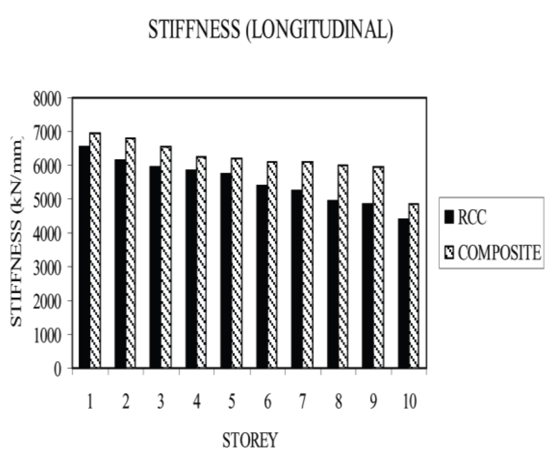


Figure 7: Comparison of Storey Stiffness

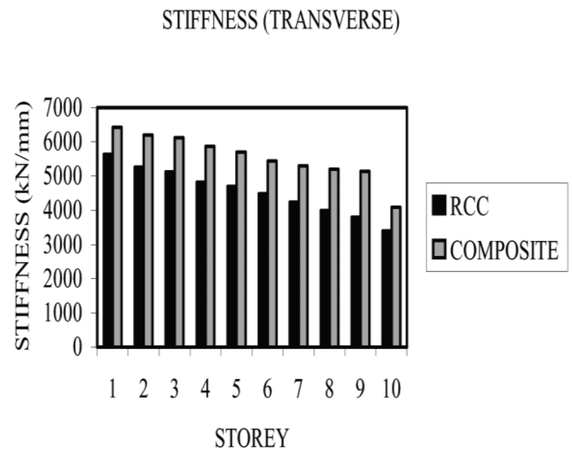


Figure 8: Comparison of Storey Stiffness

ii) Lateral displacement: Displacement in composite structure is reduced by 41% to 58% in transverse direction and about 37% to 57% in longitudinal direction than that in RCC structure.

iii) Storey drift: The result shows that the inter storey drift for composite structure is comparatively less than RCC structure inboth transverse and longitudinal direction. The storey drift is reduced by 35% to 50% and 27% to 38% in transverse and longitudinal directions respectively.

iv) Axial force, shear force, twisting moment and bending moment in columns: The result shows that axial force in composite columns is reduced by 20% to 30% than RCC columns shown in Figure 9. From Figures 10 and 11 Shear force in composite column is reduced by 28% to 44% and 24% to 40% in transverse and longitudinal direction respectively. The Figures 12 and 13 shows that the twisting moments are found to be negligible and for composite structure these are reduced by 48% to 63% and 49% to 65% in transverse and longitudinal directions respectively as compared to RCC structure. The Figures 14 and 15 that

Figure 9: Comparison of Displacements

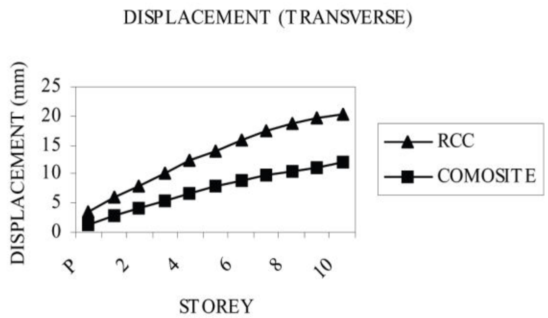


Figure 10: Comparison of Displacements

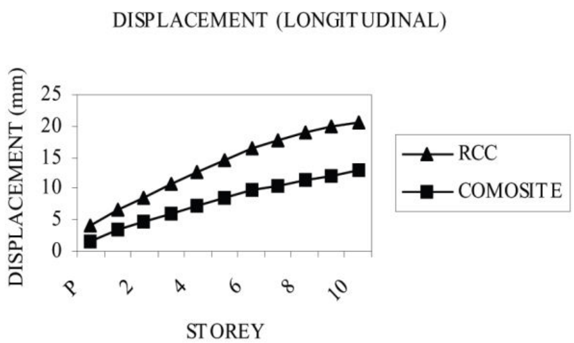


Figure 11: Comparison of Storey Drifts

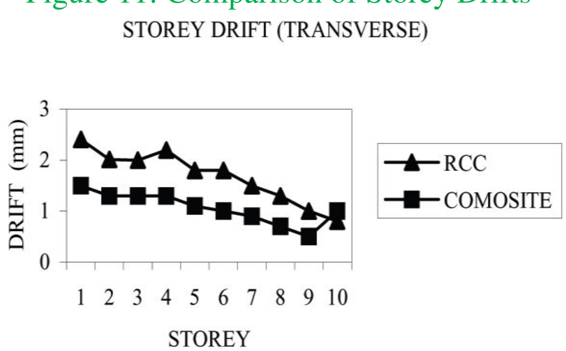


Figure 12: Comparison of Storey Drifts

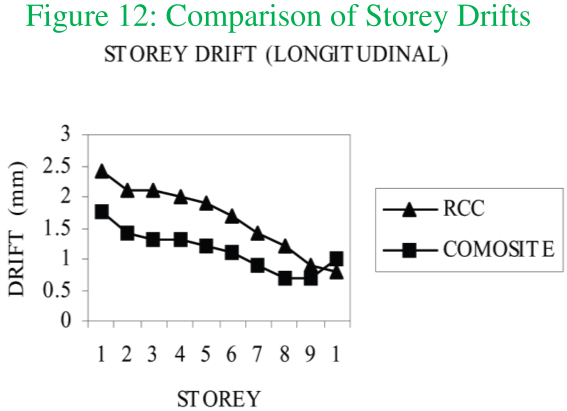


Figure 13: Comparison of Axial Force in Columns

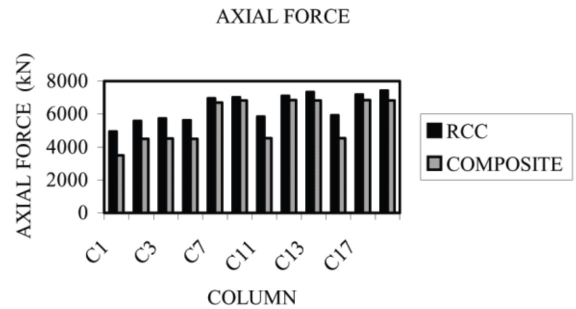


Figure 14: Comparison of Shear Force in Columns

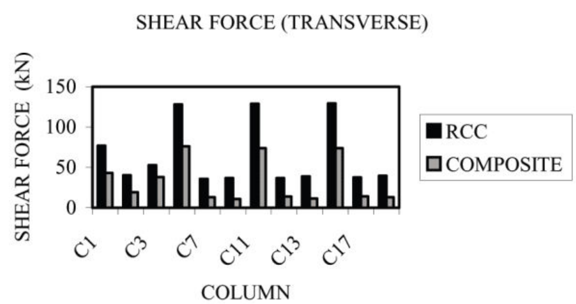
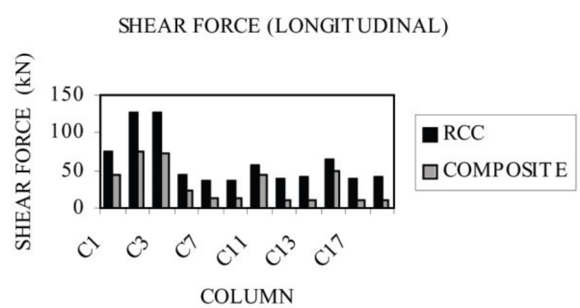


Figure 15: Comparison of Shear Force in Columns



the bending moment in composite columns is reduced up to 22% to 45% in transverse direction and 23% to 47% in longitudinal direction as compared to RCC columns.

B) Response spectrums Analysis: Response Spectrum analysis allow the users to analyze the structure for seismic loading.

i) Time period and frequency: The increased stiffness of the composite structure results in increased frequency and reduction in time period than the RCC structure. The frequency of composite structure is increased by 10% to 17% whereas time period is reduced by 14% to 29% from Figures 16 and 17.

ii) Lateral displacement: The lateral displacement in composite structure is reduced up to 46% to 58% and 45% to 56% in transverse and longitudinal directions respectively. This reduction is observed due to higher stiffness and reduction in seismic forces from Figures 18 and 19.

iii) Axial force, shear force, twisting moment and bending moment in columns: The maximum axial force, shear force, twisting moment and bending moment in columns in transverse and longitudinal direction are as shown in Figures 22 to 28. The axial

Figure 16: Comparison of Twisting Moment in Columns

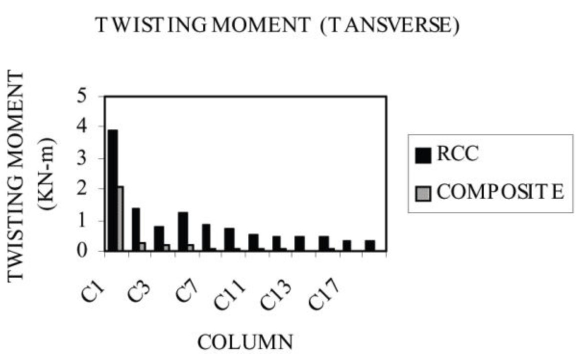


Figure 17: Comparison of Twisting Moment in Columns

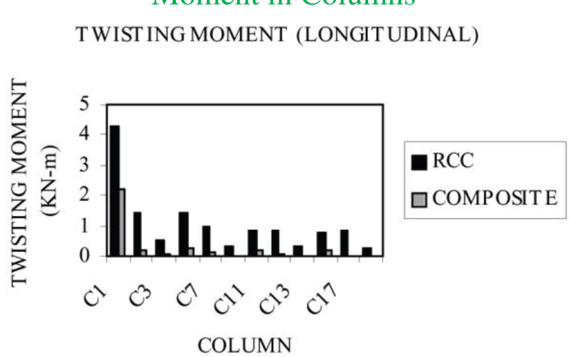


Figure 18: Comparison of Bending Moment in Columns

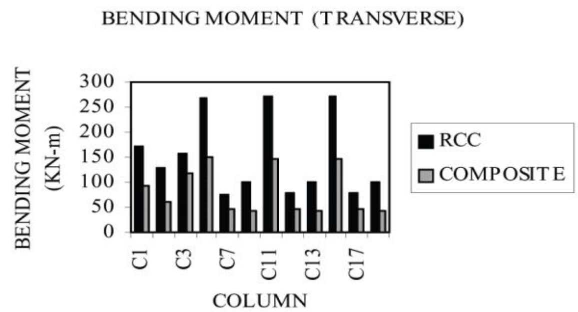


Figure 19: Comparison of Bending Moment in Columns

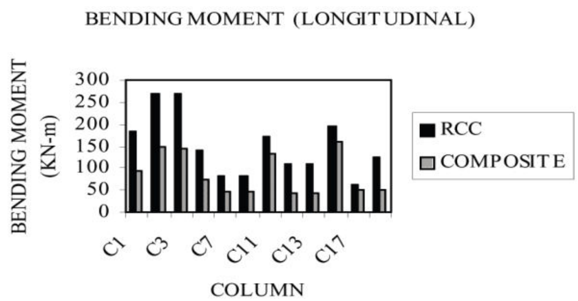


Figure 20: Time Period

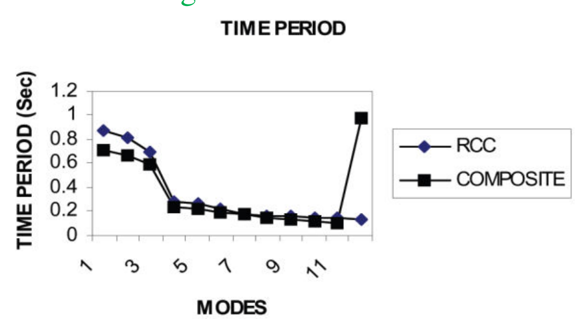


Figure 21: Comparison of Frequency

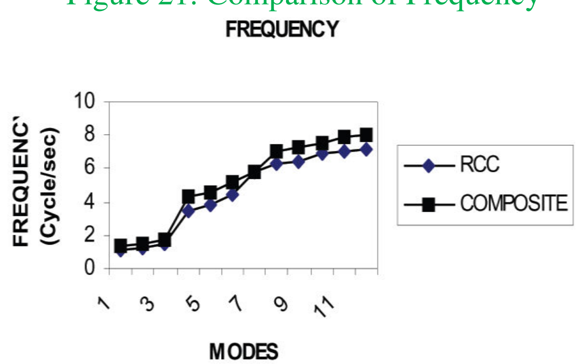


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Figure 22: Comparison of Story Drifts

Figure 23: Comparison of Story DriftsFigure 24: Comparison of Shear Force in Columns

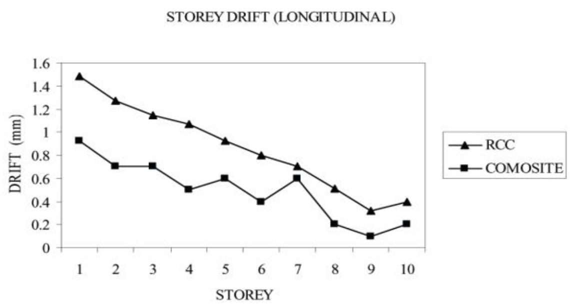

Figure 24: Comparison of Shear Force in Columns

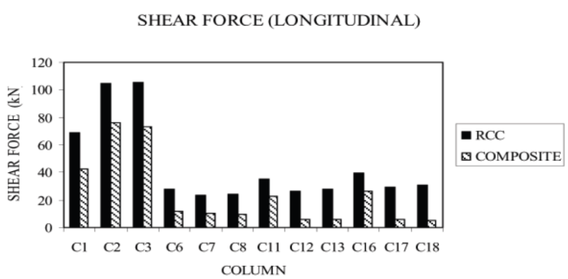

Figure 25: Comparison of Shear Force in Columns

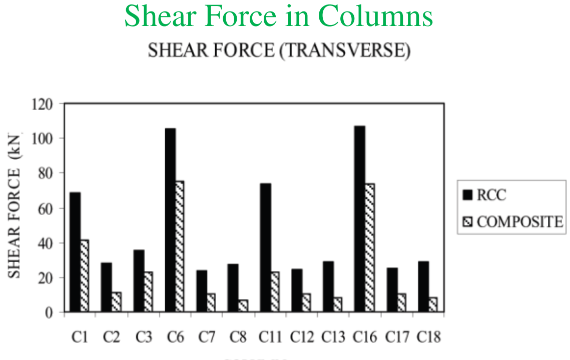

Figure 26: Comparison of Twisting Moment in Columns

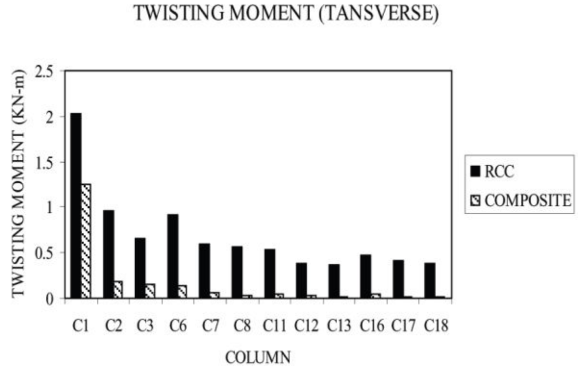

Figure 27: Comparison of Twisting Moment in Columns

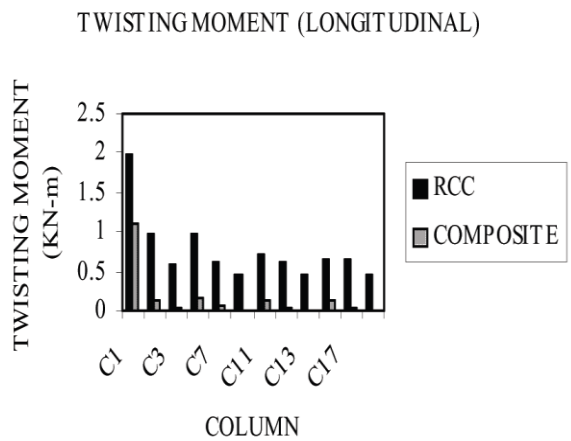

Figure 28: Comparison of Bending Moment in Columns

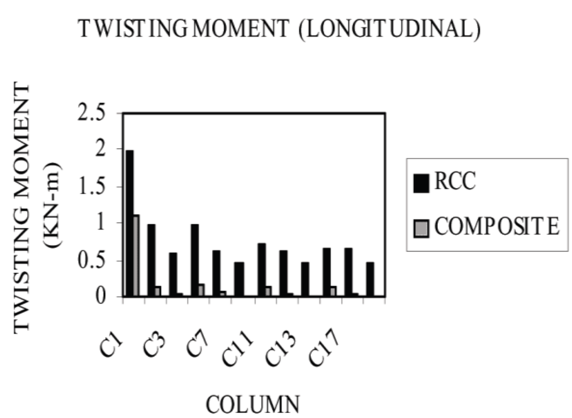

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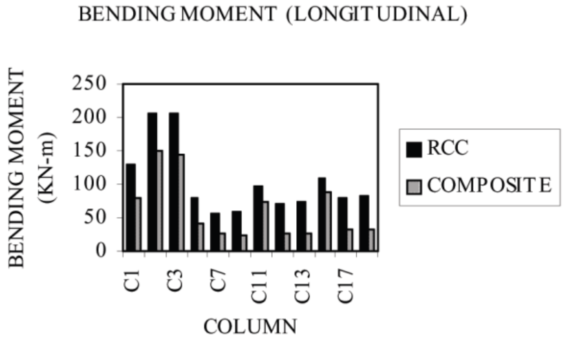
Figure 29: Comparison of Bending Moment in Columns



force in all composite columns is reduced by 18% to 30% than RCC columns. The shear force in exterior columns is observed to be more than interior columns in transverse direction and for composite columns it is reduced by 31% to 47%. Shear force in longitudinal direction is also more for exterior columns than interior columns and for composite columns it is reduced by 30% to 45%. Twisting moment in columns of composite structure is reduced from 40% to 66% and about 39% to 65% in transverse and longitudinal directions respectively as compared to RCC structure. It can be seen that the bending moment in composite columns in transverse direction is reduced by 24% to 41% whereas in longitudinal direction it is reduced only by 25% to 42%

CONCLUSION

Based on the analysis results following conclusions are drawn

1) The dead weight of composite structure is found to be 15% to 20% less than RCC structure and hence the seismic forces are reduced by 15% to 20%

2) It is observed that stiffness in composite structure is increased by 12% to 15% in transverse direction and about 6% to 10% in longitudinal direction as compared to reinforced concrete structure.

3) It is also observed that for composite structure the lateral displacements are reduced from 41% to 58% in transverse direction and about 37% to 57% in longitudinal direction than the RCC structure in linear static analysis and for linear dynamic analysis it is reduced by 46% to 58% and 45% to 56% in transverse and longitudinal directions, respectively.

4) It is found that the lateral drift for composite structure is reduced by 35% to 50% and 27% to 38% in transverse and longitudinal directions respectively in linear static analysis. In linear dynamic analysis the lateral drift is reduced by 42% to 50% and by 37% to 48% in transverse and longitudinal directions respectively than that of RCC structure.

5) The axial force in composite columns is found to be 20% to 30% less than RCC columns in linear static analysis and in linear dynamic analysis it is found to be 18% to 30% less than RCC columns.

6) The shear force in composite column is reduced by 28% to 44% and 24% to 40% in transverse and longitudinal directions respectively than the RCC structure in linear static analysis.

7) The shear force in response spectrum analysis is also found to be less by 31% to 47% in transverse direction and about 30% to 45% in longitudinal direction in composite column than the RCC column.

8) The twisting moment in composite columns is found to be 48% to 63% less and 49% to 65% less in transverse and longitudinal directions respectively than reinforced concrete columns in linear static analysis and in case of linear dynamic analysis the twisting moment is reduced by 40% to 66% and about 39% to 65% in transverse and longitudinal directions respectively than the RCC structure.

9) The frequency of composite structure is increased by 10% to 17% and time period decreased by 14% to 29% than the RCC structure.

10) The maximum negative bending moment in composite beam is found to be reduced by 16% to 32% in equivalent static analysis and is also reduced by 11% to 18% in composite beams in response spectrum analysis than pure RCC beams.

11) In composite structure due to high ductile nature of steel it leads to increased 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.

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