

Analysis and Design of Multi Storied Building Subjected to Seismic Loading Using Composite and RCC Structures

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ABSTRACT: Reinforced concrete and steel construction is extensively preferred over the whole world. But use of composite construction is of particular interest, due to its significant potential in improving the seismic performance of structure without much more changes in manufacturing and construction techniques. Steel concrete composite construction is built in place of RCC structures to get maximum benefit of steel and concrete and to produce efficient and economic structure. Composite construction combines the better properties of both steel and concrete along with lesser cost, speedy construction, fire resistance, high durability and superior seismic performance characteristics. Thus it has gained wide acceptance world wide as an alternative to pure steel and concrete construction. Now, not only stimulating the Indian structural designer to take keen interest in it, but also enhance the composite construction in India. In this study an attempt has been made to analyze, design, and compare seismic performance of **six story (G+5) RCC and Composite Institutional building** situated in seismic **zone IV. Equivalent static method** is preferred for seismic analysis and **ETABS** is used for modelling, analyzing and designing the structures. Analytical results are compared to achieve the most suitable resisting system and economic structure against the seismic forces. On the basis of analysis, design and comparison it is proved that steel concrete composite building is better option.

KEYWORDS: Composite construction, Seismic loading, Equivalent static method, ETABS.

I. INTRODUCTION

The performance of building during an earthquake depends upon several factors, such as stiffness, ductility, lateral strength and Simple and regular configuration. 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 R.C.C. and masonry buildings due to earthquake. This problem forced the structural engineers to look for the alternative method of construction. Concrete structures are bulky and impart more seismic weight and less deflection whereas Steel structures instruct more deflections and ductility to the structure, which is beneficial in resisting seismic forces. In such circumstances, use of composite construction is of particular interest, due to its significant potential in improving the seismic performance of structure without much more changes in manufacturing and construction techniques.

II. RELATED WORK

Rahul Pandey¹ compared the performance of a (G+7) storey RCC, Steel and Composite building frame situated in earthquake zone 5 using SAP2000 software. He concluded that the storey drift in X-direction was more for steel frame as compared to RCC and composite frame. And RCC frame has the lowest value of story drift because of its high stiffness, which indicates as the value of stiffness increases, story drift values decreases.

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Prof. Swapnil B. Cholekar and Basavalingappa S.M² described the effect of Mass on story drift, base shear, dead weight, shear force and joint displacement during earthquake, also compared RCC and composite structures and found that with increase in the difference of mass between two stories, mass irregularity increases.

Thierry Chicoine³, investigated the behaviour and strength of a new type of partially encased composite column made with thin-walled, welded I-section, stiffened with transverse links. Concrete was poured between the flanges of the steel section. He described and presented the results of the testing of five large size short column specimens. Failure of specimens was due to local buckling of the plates along with concrete crushing.

III. COMPOSITE STRUCTURE

Composite structures 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. Numbers of the studies are carried out on composite construction techniques by different researchers in different parts of the world and found it to be better earthquake resistant and more economical as compared to RCC construction. In composite construction different types of composite sections are used such as composite beams (RCC slab rest over steel beam), encased composite beams (steel sections encased in concrete), pure steel column sections, composite column sections (encased composite column sections and concrete filled in steel tubes column sections). Sometimes composite deck slabs (concrete slab on steel profiled sheets) are also used in the construction of high rise buildings.

Elements of Composite Construction:

The primary structural components used in composite construction consist of the following elements.

- 3.1 Composite slab
- 3.2 Composite beam
- 3.3 Composite column
- 3.4 Shear connector

IV. BUILDING DESCRIPTION

The building selected for the study is an Institutional building having G+5 storied which is located in seismic zone IV. The plan and elevation of building is shown in Fig.1(a) and 1(b). The dimension of the building is 24m x 15m, and total height of the building is 20.5 m. The study is carried out for R.C.C and Composite building. Other relevant data is tabulated in Table 1 and 2.

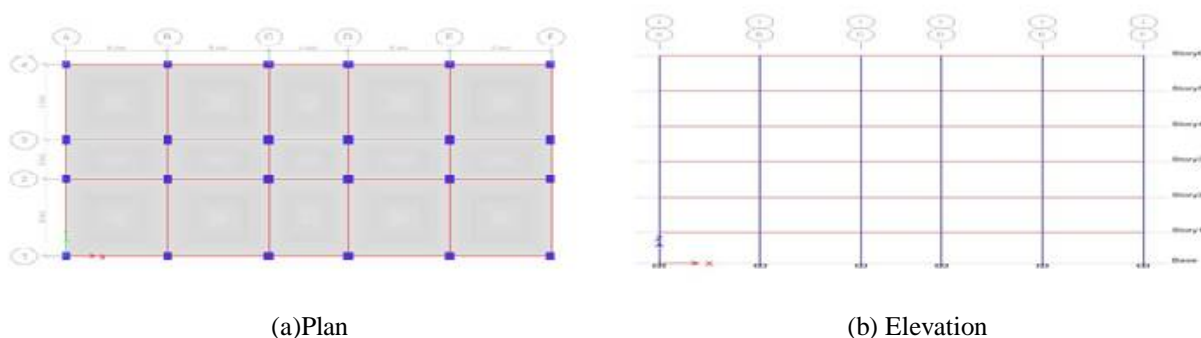


Fig.1 Plan and Elevation

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Vol. 6, Issue 2, February 2017

Table: 1 Data for Analysis of R.C Structure.

Plan dimension	24m x 15m
Total height of building.	20.5m.
Height of story	3.5m
Height of parapet	1.0m
Depth of foundation	3.0m
Size of beams 6.0 m span	230mm x 600mm
Size of beams 5.0 m span	230mm x 520mm
Size of beams 4.0 m span	230mm x 450mm
Size of beams 3.0 m span	230mm x 380mm
Size of outer columns	450mm x 650mm
Size of internal columns	450mm x 680mm
Thickness of slab	150mm
Thickness of internal & external walls	230mm
Seismic zone	IV
Soil condition	medium soil
Live load at roof	2.0 KN/m ²
Floor finishes	1.0 KN/m ²
Live load at all floors	4.0 KN/m ²
Grade of concrete	M30
Grade of reinforcing steel	Fe415
Density of concrete	25 KN/m ³
Density of brick	20 KN/m ³
Damping ratio	5%

Table: 2 Data for Analysis of Composite Structure.

Plan dimension	24m x 15m
Size of Main beams	ISMB 200
Size of secondary beams	ISLB 200
Size of outer columns	300mm X 350mm (ISMB 200)
Size of internal columns	300mm X 350mm (ISMB 200)
Thickness of slab	150mm
Thickness of internal & external walls	230mm
Seismic zone	IV
Soil condition	Medium soil
Importance factor	1.0
Zone factor	0.24
Live load at roof	2.0 KN/m ²
Floors finish	1.0 KN/m ²
Live load at all floors	4.0 KN/m ²
Grade of concrete	M30
Grade of reinforcing steel	Fe415
Density of concrete	25 KN/m ³
Density of brick	20 KN/m ³
Damping ratio	5%
Total height of building.	20.5m.
Height of story	3.5m
Height of parapet	1.0m
Depth of foundation	3.0m

V. ANALYSIS AND DESIGN

The Three Dimensional (3D) building model is analysed using Equivalent Static Method, with the software E TABS. Different parameters such as Story drift, displacement, story shear are found for both the models of RCC and composite structures. IS 1893 (PART-1): 2002 is used for calculating seismic design forces.

A. R.C BUILDING DESIGN

The Seismic analysis of RCC structure is carried out using IS 1893-2002 code and the design is carried out using limit state method and strictly follows the recommendations of IS 456-2000 Code for RCC structure & IS 13920 for ductile detailing. Fig.2(a) and Fig.2(b) shows the reinforcement details of typical beam and column.

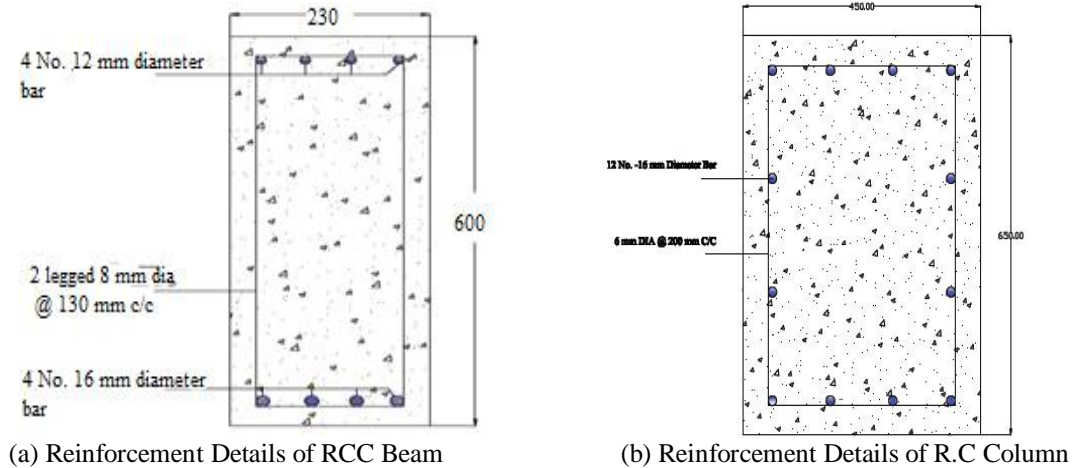


Fig.2 Reinforcement Details of RCC Building

5.2 Composite Building Design

The seismic analysis of Composite structure is carried out using IS 1893-2002 code and the design is carried out using limit state method and strictly follows the recommendations of IS 456-2000, AISC360-10 Code for Composite structure. Fig.3(a) and Fig.3(b) shows the reinforcement details of typical beam and column.

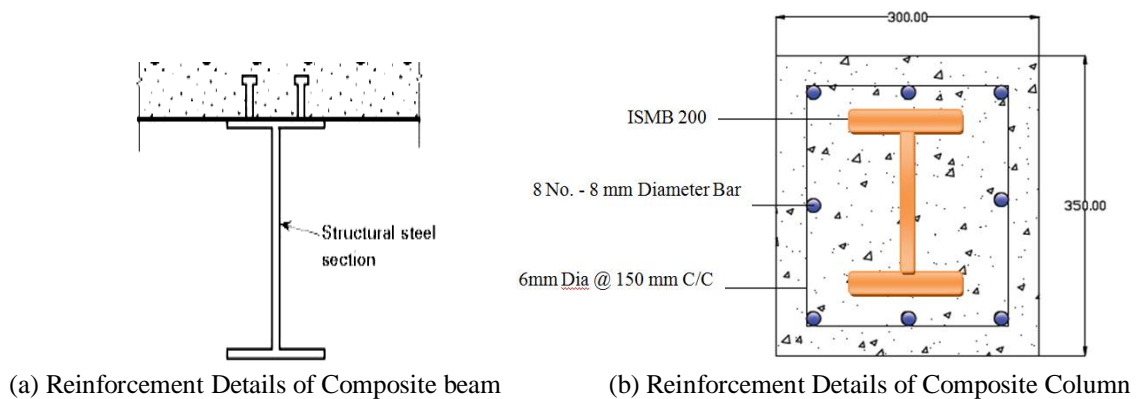


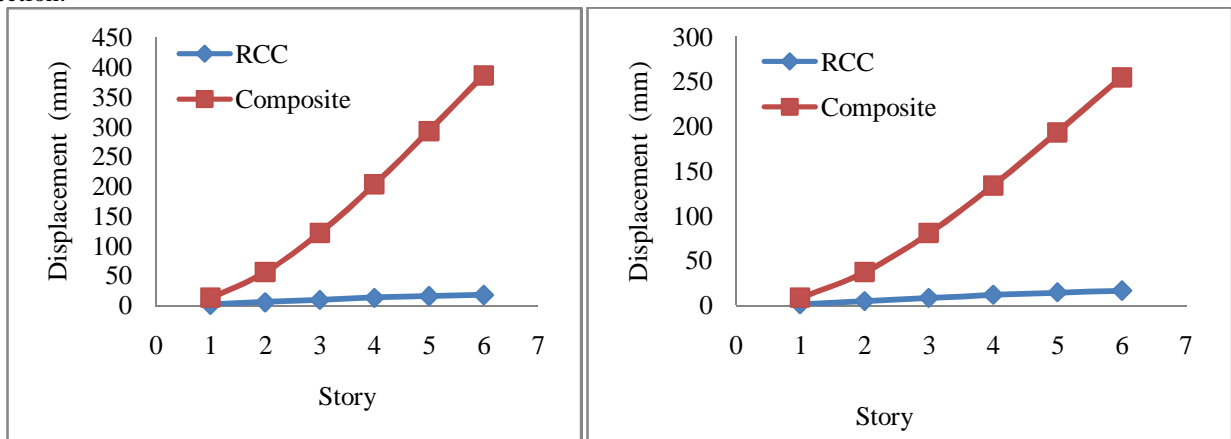
Fig.3 Reinforcement Details of Composite Building

VI. RESULTS AND DISCUSSION

In the present study, analysis of RCC and composite building using ETABS has been carried out. And the maximum displacement, story drift, story shear of both RCC and composite building is obtained.

A. MAXIMUM DISPLACEMENT

Fig.4(a) and Fig.4(b) shows the maximum displacement results along X and Y direction of RCC building and composite building. From the graphs it was observed that maximum displacement along X direction is more than Y direction.



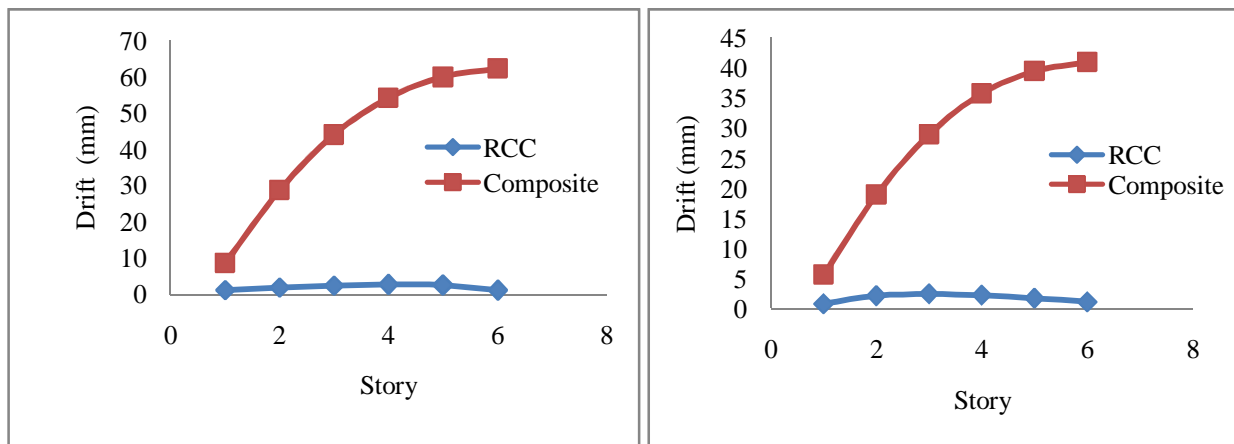
(a) Story vs. Displacement in X Direction.

(b) Story vs. Displacement in Y Direction.

Fig.4 Story vs. Displacement

B. STORY DRIFT

Fig.5(a) and Fig.5(b).Presents the story vs. Story drift graph of RCC and composite building. From the graphs it was observed that, the maximum story drift along X and Y- direction for RCC building is more for composite building. RCC building has the lowest values of story drift because of its high stiffness.



(a) Story vs. Story Drift in X Direction

(b) Story vs. Story Drift in Y Direction.

Fig.5 Story Drift vs. Displacement

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C. MAXIMUM STORY SHEAR

Fig.6(a) and Fig.6(b) shows the story shear results along X and Y direction of RCC building and composite building. It was observed that Story shear for RCC building is maximum because the weight of the RCC building is more than the composite building.

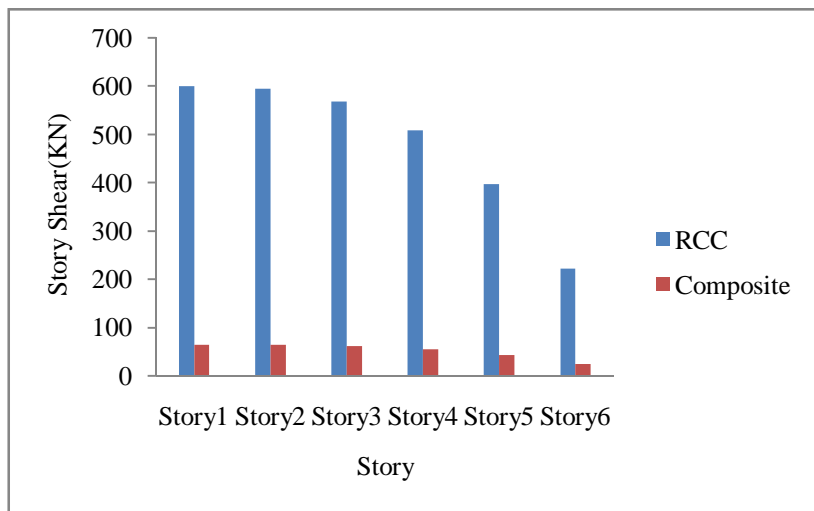


Fig.6(a) Story vs. Story shear Along X Direction.

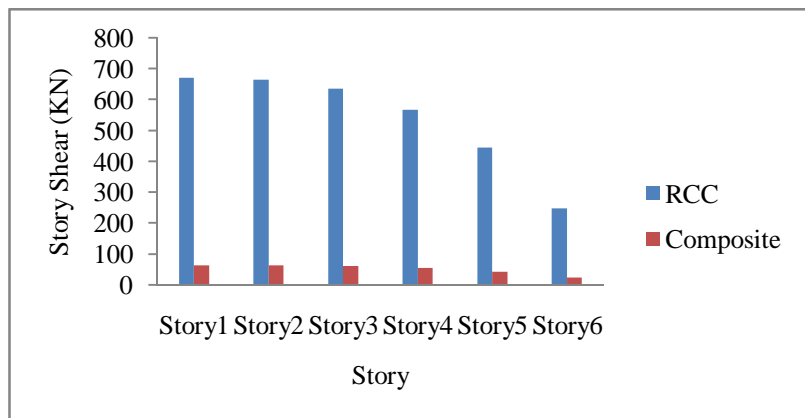


Fig.6(b) Story vs. Story shear along Y Direction

D. COST COMPARISON ANALYSIS

Table 2 and 3 shows the cost of composite and RCC building. It is observed that cost of composite building is less than RC building because composite building required lesser sizes of members as compare to RCC building. And the difference between the cost of RCC and composite building is found as Rs.1, 80,252/-

International Journal of Innovative Research in Science, Engineering and Technology

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Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

Table 2: Composite Frame Structure

Material	Quantity Used	Rate of material	Amount
Structural Steel (kg)	29125.4	Rs-50/kg	Rs-14,56,270
Reinforcing bar (kg)	3463.7	Rs-40/kg	Rs-1,38,548
Concrete used (m3)	51	Rs-5000/m3	Rs-2,25,000
Total Sum			Rs-18,19,818/-

Table3: RCC Frame Structure

Material	Quantity Used	Rate of material	Amount
Reinforcing bar (kg)	10207.74	Rs-40/kg	Rs-4,70,889.6
Concrete used (m3)	305.84	Rs-5000/m3	Rs-15,29,180
Total Sum			Rs-20,00,070/-

$$\begin{aligned} \text{Reduction Factor for Composite} &= \text{Cost of Composite/Cost of RCC} \\ &= 18,19,818/20,00,070 \\ &= 0.91 \end{aligned}$$

Hence, reduction in cost of composite frame is 9% compared with cost of RCC frame. This involves material cost only and doesn't include fabrication cost, transportation cost, labour cost etc.

VII. CONCLUSIONS

From the analysis and design of RCC and composite building, it is concluded that,

- The floor displacement is maximum for composite building as compared to RCC building. RCC building has the lowest values of displacement because of its high stiffness.
- Story drift in Equivalent Static Analysis along X and Y direction is more for Composite building as compare to RCC building.
- RCC frame has the lowest values of story drift because of its high stiffness.
- The differences in story drift for different stories along X and Y direction are owing to orientation of column sections. Moment of inertia of column section is different in both directions.
- Story shear for RCC building is maximum because the weight of the RCC building is more than the composite building. Story shear gets reduced by 89.15 % in X- direction and 90.3 % in Y-direction for Composite building in comparison with the RCC building.
- Reduction in cost of Composite frame is 9% compared with cost of RCC frame. This involves material cost only and doesn't include fabrication cost, transportation cost, labour cost etc.

REFERENCES

- [1] Rahul Pandey, "Comparative seismic analysis of RCC, steel & steel-concrete composite frame", Department of Civil engineering National Institute of technology Rourkela, 2014
- [2] 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

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

- [3] Thierry Chicoine, "behavior and strength of partially encased composite columns with built up shapes", journal of structural engineering, vol. 128 no. 3, march 2002, pp 279-288.
- [4] Tao Li, Junichi Sakai, And Chiaki Matsui, "seismic behavior of steel concrete composite column bases". IN 12WCEE 2000
- [5] Riyad S Aboutaha, "cyclic response of a new steel-concrete composite frame system ", IN 12 WCEE2000.
- [6] Oreste S. Bursi, Stefano Caramelli, "pseudo-dynamic testing of a 3D full-scale high ductile steel concrete composite MR frame structure at elsa. IN 13 WCEE.
- [7] Prabuddha Dasgupta, Subhash C. Goel, "performance-based seismic design and behavior of composite buckling restrained braced frame". IN 13 WCEE.
- [8] AISC, 2010a. ANSI/AISC 360-10: An American National Standard – Specification for Structural Steel Building, American Institute of Steel Construction. One East Wacker Drive, Suite 700, Chicago, Illinois, 60601, June 22.
- [9] AISC, 2010b. Commentary on the Specification for Structural Steel Buildings, American Institute of Steel Construction. One East Wacker Drive, Suite 700, Chicago, Illinois, 60601. June 22.
- [10] AISC, 2010c. ANSI/AISC 341-10: Seismic Provisions for Structural Steel Buildings. American Institute of Steel Construction. One East Wacker Drive, Suite 700, Chicago, Illinois, 60601. June 22.
- [11] IS: 456(2000), "Indian Standard Code of Practice for Plain and Reinforcement concrete (Fourth Revisions)", Bureau of Indian Standards (BIS), New Delhi.
- [12] IS: 13920-1993 "ductile detailing of reinforced concrete structure subjected to seismic forces code of practice."
- [13] IS 800(1984), IS 800(2007), "Indian Standards Code of Practice for General Construction in Steel", Bureau of Indian Standards (BIS), New Delhi.
IS 808(1989), "Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections," Bureau of Indian Standards (BIS), New Delhi.
- [14] IS 875(1987-Part 1), "code of practice for design loads (other than earthquake) for buildings and structures, Dead loads," Bureau of Indian standards (BIS), New Delhi.
- [15] IS 875(1987-Part 2), "code of practice for live loads," Bureau of Indian Standards (BIS), New Delhi.
- [16] SP 64, "Explanatory Handbook code of practice for design loads (other than earthquake) building and structure, Part-3 wind load".
- [17] IS 11384 (1985), "Code of Practice for Design of Composite Structure," Bureau of Indian Standards (BIS), New Delhi.
- [18] Pankaj Agrawal, Manish Shrikhande. "Earthquake Resistant Design of Structures". 2006 PHI Learning Private Limited, New Delhi.
- [19] S. K. Duggal "Earthquake Resistant Design of Structures", Oxford University Press. 2007
- [20] R.P. Johnson, MA, MICE, "Composite Structure of Steel and Concrete," (Vol- I;," Blackwell, scientific publication, UK 1987.
- [21] R.P. Johnson, MA, MICE, "Composite Structure of Steel and Concrete" (Vol- II" Blackwell, scientific publication, UK, 1987