COMPARATIVE STUDY OF R.C.C AND STEEL-CONCRETE COMPOSITE (G+10) RESIDENTIAL BUILDING

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ABSTRACT :
Steel-concrete composite construction has gained large acceptance all over the world as an substitute for pure steel and pure concrete construction. However this approach is a new concept for construction industry. R.C.C is no longer economical because of their increased dead load, hazardous formwork. The present study deals with comparison of reinforced concrete, steel and composite structures under the effect of static and dynamic loads. The results of this work show that composite structures are best suited for high rise buildings compared to that of steel and reinforced concrete structures. Response spectrum method is used for comparison of three structures with the help of ETABS software.

KEY WORDS: *Composite beam, Composite column, Composite slab,* Bare frame, Base shear, Displacement and Inter-storey drift.

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1. INTRODUCTION

In today's modern period and faster growing economy with simultaneously increasing human population the need of shelter with higher land cost in major cities where further horizontal expansion is not much possible due to space shortage, we are left with the solution of vertical expansion. Steel-concrete composite construction is a faster technology which saves lot of time in construction which will help the planners to meet the demand with minimum time in real estate market. This technology provides more carpet area than any other type of construction. Composite construction also enhances the life expectancy of the structure.

Composite construction has gain wide acceptance because of their many advantages i.e. faster to erect, lighter in weight, better quality control, reduced time of construction, has better ductility and hence superior lateral load resisting behavior.

The present research is an attempt to study the behavior of reinforced concrete, steel and composite structures under the effect of seismic loading. The parameters considered are base shear, displacement and inter-storey drift.

2. COPOSITE MULTISTORIED BUILDINGS

The primary structural components use in composite construction consists of the following elements.

1. Composite deck slab
2. Composite beam
3. Composite column
4. Shear connector

2.1. COMPOSITE DECK SLAB

Composite floor system consists of steel beams metal decking and concrete. They are combined in a 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 built-up steel beam connected to a formed steel deck and concrete slab. The metal deck typically spans unsupported between steel members, while also providing a working platform for concreting work. The composite floor system produces a rigid horizontal diaphragm, providing stability to the overall building system, while distributing wind and seismic shears to the lateral load-resisting systems.

Composite action increases the load carrying capacity and stiffness by factors of around 2 and 3.5 respectively. The concrete forms the compression flange – the steel provides the tension component and shear connectors ensure that the section behaves compositely. Beam spans of 6 to 12 m can be created giving maximum flexibility and division of the internal space. Composite slabs use steel decking of 46 to 80 mm depth that can span 3 to 4.5 m without temporary propping. Slab thicknesses are normally in the range 100 mm to 250 mm for shallow decking, and in the range 280 mm to 320 mm for deep decking. Composite slabs are usually designed as simply supported members in the normal condition, with no account taken of the continuity offered by any reinforcement at the supports.

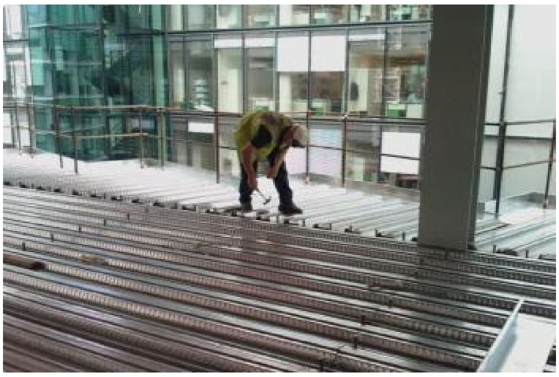

Fig. 1 Composite deck slab

2.2. COMPOSITE BEAM

In conventional composite construction, concrete slabs rest over steel beams and are supported by them. Under load these two 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 their 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 in compression than in tension, and steel is susceptible to buckling in compression. By the composite action between the two, we can utilize their respective advantage to the fullest extent. Generally in steel concrete composite beams, steel beams are integrally connected to prefabricated or cast in situ reinforced concrete slabs.

2.2.1 **COMPOSITE ACTION IN BEAMS**

Composite beams, subjected mainly to bending, consist of section action composite with flange of reinforced concrete. To act together, mechanical shear connectors are provided to transmit the horizontal shear between the steel beam and concrete slab, ignoring the effect of any bond between the two materials. These also resist uplift forces acting at the steel concrete interface. If there is no connection between steel beam and concrete slab interface, a relative slip occurs between them when the beam is loaded. Thus, each component will act independently. With the help of deliberate and appropriate connection between concrete slab and steel beam the slip can be minimized or even eliminated altogether. If slip at the interface is eliminated or drastically reduced, the slab and steel member will act together as a composite unit. Slip is zero at mid-span and maximum at the support of the simply supported beam subjected to uniformly distributed load. Hence, shear is less in connectors located near the centre and maximum in connectors located near the support. Composite beams are often designed under the assumption that the steel beam supports the weight of the structural steel or wet concrete plus construction loads. This approach results in considerably less number of connectors than they are required to enable the maximum bending resistance of the composite beam to be reached. However the use of such partial shear connection results in reduced resistance and stiffness.

2.2.2 ADVANTAGES OF COMPOSITE BEAMS

1. Keeping the span and loading unaltered, more economical steel section in terms of depth and weight) is adequate in composite construction compared with conventional non-composite construction.
2. Encased steel beam sections have improved fire resistance and corrosion.
3. It satisfied requirement of long span construction a modern trend in architectural design.
4. Composite construction is amenable to fast track construction because of use of rolled steel sections.
5. Composite sections have higher stiffness than the corresponding steel sections and thus the deflection is lesser.
6. Permits easy structural repairs/ modification.
7. Provides considerable flexibility in design and ease of fabrication.
8. Enables easy construction scheduling in congested sites.
9. Reduction in overall weight of the structure and there by reduction in foundation cost.
10. Suitable to resist repeated earthquake loading which requires high amount of resistance and ductility.

2.3. COMPOSITE COLUMN

A steel concrete composite column is a compression member, comprising either of a concrete encased hot rolled steel section or a concrete filled hollow 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 the design of composite column. The method of design in this report largely follows EC4, which incorporates latest research on composite construction. Indian standard for composite construction IS 11384-1985 does not make any specific reference to composite columns. This method also adopts the European bucking curves for steel columns as a basic of column design.

2.3.1 THE ADVANTAGES OF COMPOSITE COLUMNS ARE

1) Increased strength for a given cross sectional dimension.

2) Increased stiffness, leading to reduced slenderness and increased bulking resistance.
3) Good fire resistance in the case of concrete encased columns.
4) Corrosion protection in encased columns.
5) Significant economic advantages over either pure structural steel or reinforced concrete alternatives.
6) 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.
7) Erection of high rise building in an extremely efficient manner.
8) Formwork is not required for concrete filled tubular sections.

2.4. SHEAR CONNECTOR

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

2.4.1 TYPES OF SHEAR CONNECTORS

1. RIGID TYPE

As the name implies, these connectors are very stiff and they sustain only a small deformation while resisting the shear force. They derive their resistance from bearing pressure on the concrete, and fail due to crushing of concrete. Short bars, angles, T sections are common examples of this type of connectors. Also anchorage devices like hoped bars are attached with these connectors to prevent vertical separation.

2. FLEXIBLE TYPE

Headed studs, channels come under this category. These connectors are welded to the flange of the steel beam. They derive their stress resistance through bending and undergo large deformation before failure. The stud connectors are the types used extensively. The shank and the weld collar adjacent to steel beam resist the shear loads whereas the head resists the uplift

3. BOND OR ANCHORAGE TYPE

It is used to resist horizontal shear and to prevent separation of girder from the concrete slab at the interface through bond. These connectors derived from the resistance through bond and anchorage action.

3. MATHEMATICAL FORMULATION

A (G+10) storied structure for R.C, Steel and composite structure is considered and Response spectrum method of analysis is used.

Table-1 Data for analysis

Plan dimension	12.5mx12.5m
Height of each storey	3.2m
Slab thickness	150mm
Wall thickness	150mm
Seismic zone	III
Importance factor	1
Dead load	3KN/m^2
Live load	1KN/m^2
Density	25KN/m^3
Grade of concrete	M20
Damping ratio R.C.C STEEL COMPOSITE	5% 2% 2%

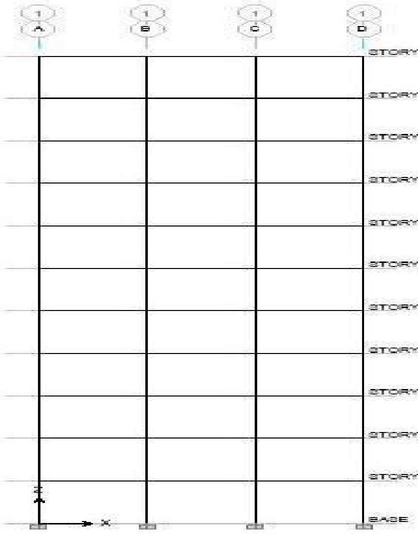

Fig. 2 Elevation of structure

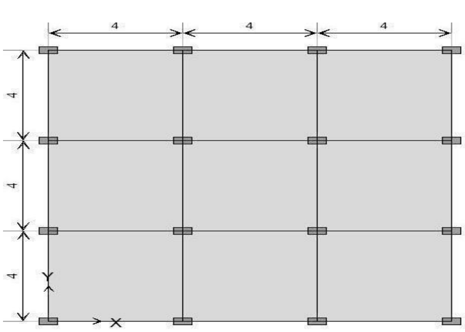

Fig. 3 Plan of structure

Table-2 Variation of base shear

BASE SHEAR (KN)			
STRUCTURE	R.C.C	Steel	Composite
EQX	184.03	129.27	127.61

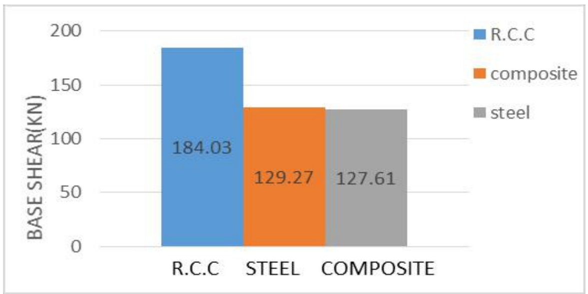

Fig. 4 Graph for base shear

Table-3 Variation of displacement

BARE FRAME			
DISPLACEMENT (mm)			
STOREY NO.	R.C.C	STEEL	COMPOSITE
11	10.2106	20.2977	19.8489
10	9.8655	19.6733	19.2432
9	9.3113	18.6247	18.2193
8	8.5583	17.1028	16.726
7	7.711	15.1258	14.7764
6	6.7384	12.8979	12.6862
5	5.6383	10.5184	10.3636
4	4.4083	7.9711	7.86
3	3.1417	5.3604	5.2879
2	1.8564	2.9405	2.9014
1	0.6627	0.9423	0.9299

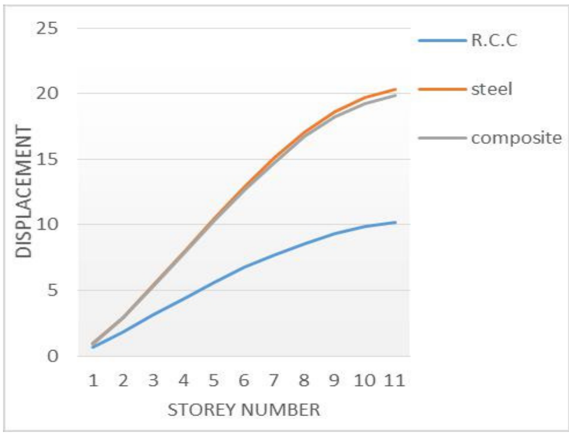

Fig.5 Graph for Displacement v/s storey number

Table-4 Variation of Drift

BARE FRAME

DRIFT (mm)

STOREY NO.	R.C.C	STEEL	COMPO
11	0.3451	0.6244	0.6057
10	0.5542	1.0486	1.0239
9	0.753	1.5219	1.4933
8	0.8473	1.977	1.9496
7	0.9726	2.2279	2.0902
6	1.1001	2.3795	2.3226
5	1.23	2.5473	2.5036
4	1.2666	2.6107	2.5721
3	1.2853	2.4199	2.3865
2	1.1937	1.9982	1.9715
1	0.6627	0.9423	0.9299

Table-5 Variation of column forces

Column forces			
Column	R.C.C	Steel	Composite
corner column	1555.12	707.29	679.33
Side column	2134.44	1123.58	1086.44
Inner column	2758.19	1563.15	1491.54

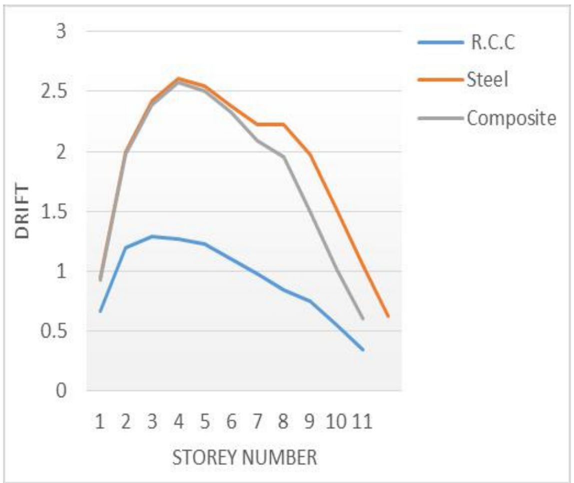

Fig. 6 Graph for Drift v/s storey number

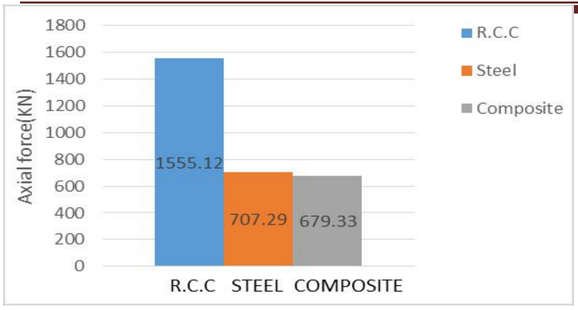

Fig. 7 Graph for Column forces

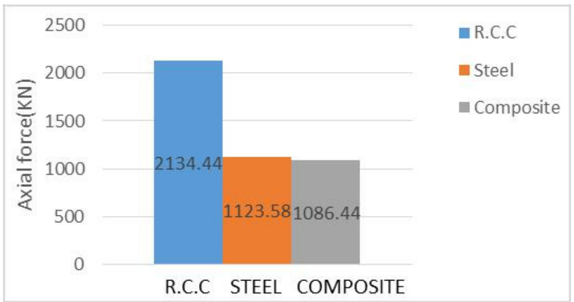

Fig. 8 Graph for Column forces

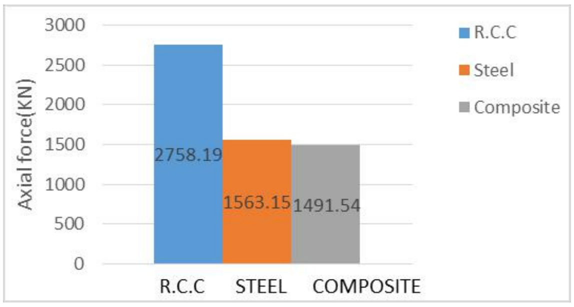

Fig. 9 Graph for Column forces

Table-6 Variation of Beam Moments

Beam moments (KN-m)

Moment	R.C.C	Steel	Composite
support	44.01	25.31	15.02
Center	27.61	15.94	6.97

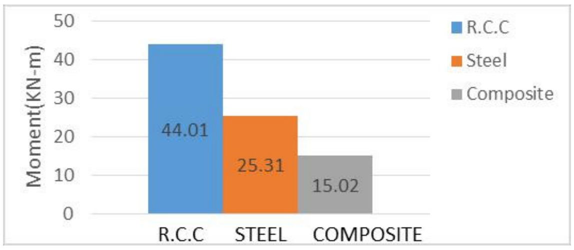

Fig. 10 Graph for Beam Moments

4. CONCLUSION

1. Base shear for composite structure has reduced by 34% and for steel structure by 26% compared to that of Reinforced concrete structure.
2. Displacement for composite structure has increased by 49% and for steel structure by 46% compared to that of Reinforced concrete structure.
3. Storey drift for steel structure is more compared to R.C.C and composite structure.
4. Drift of all structures is within permissible limit.
5. Column forces in steel structure have reduced by 44% and in composite structure by 54% compared to that of R.C.C structure
6. Beam moments in composite structures have reduced considerably compared to that of R.C and steel structures.
7. As column forces have reduced sizes of footings also reduces compared to that of R.C structure.
8. Composite structures are more economical compared to that of R.C structures.
9. Also time required for construction of composite structures is less compared to that of R.C structures as no formwork is required.

REFERENCES

[1] Panchal D.R., and Marathe P.M., "*Comparative study of R.C.C, Steel and Composite (G+30) Building*" Institute Of Technology, Nirma University, Ahmadabad, 2011.

[2] Prof. Charantimath, S.S., Prof. Cholekar, Swapnil B, and Birje, Manjunath M. (2014) "*Comparative Study on Structural Parameter of R.C.C and Composite Building" IISTE*, ISSN 2224-5790 (Paper) ISSN 2225-0514, *6(6)* 98-109.

[3] Koppad Shashikala, and Dr. Itti S.V., (2013) "*Comparative Study of RCC and Composite Multistoried Buildings*" *International Journal of Engineering and Innovative Technology (IJEIT) 3(5)* 341-345.

[4] Sairaj P., and Padmanabham K., (2014) "*Performance Based Seismic Design of Braced Composite MultiStoried Building*" *International Journal of Innovative Research in Science Engineering and Technology (IJIRSET) 3(2)* 9545-9553.

[5] M. S. Kumawat, and L. G. Kalurkar (2014) "*Cost Analysis of Steel-Concrete Composite Structure*" *International journal of Structural and Civil Research, 3(2)*, 159-167.

[6] G.S.Hiremath, and Kushappa M Kabade, (2014) "*Comparative Study Of Performance Based Plastic Design Of R.C And Composite (cfrst) Moment Resisting Frames Based On Inelastic Response Analysis*" *International Journal of Advance Research In Science And Engineering ,(IJARSE), 3(8)*, 37-49.

[7] Baldev D. Prajapati & D. R. Panchal(2013) „*'Study Of Seismic And Wind Effect On Multi Storey R.C.C., Steel And Composite Building"" International Journal of Advances in Engineering & Technology, 6(4)*,1836-1847.

[8] Syed Rehan and Mahure, S.H., (2014) "*Study of Seismic and Wind Effect on Multi Storey R.C.C. Steel and Composite Building*" *International Journal of Engineering and Innovative Technology (IJEIT), 3(12),* 78-83.

[9] Zafar Mujawar and Prakarsh Sangave., (2014) "*Comparative Evaluation Of Reinforced Concrete, Steel And Composite Structures Under The Effect Of Static And Dynamic Loads. ISSN 2248-9622 VOL 5*

[10] IS 456:2000, "*Indian Standard code of practice for Plain and Reinforced concrete*", Bureau of Indian Standards,
New Delhi, India.

[11] IS 11384:1985, "*Code of Practice for Design of Composite Structure*", Bureau of Indian Standards, New Delhi, India.

[12] IS 800:1998, " *Indian Standard code of practice for General Construction in steel*", Bureau of Indian Standards, New Delhi, India

[13] IS 875(part1 to 5):1987, "*Code of Practice for design loads for buildings and structures*", Bureau of Indian Standards,
New Delhi, India.

[14] "*Handbook of composite construction Multi-storey Buildings*" INSDAG publications No. INS/PUB/022.