Comparision Of R.C.C. And Comosite Multistoried Buildings

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ABSTRACT

Steel-concrete composite construction means steel section encased in concrete for columns & the concrete slab or profiled deck slab is connected to the steel beam with the help of mechanical shear connectors so that they act as a single unit. In this present paper, steel-concrete composite with R.C.C. options are considered for comparative study of G+15 storey office building which is situated in earthquake zone IV & wind speed 39m/s. Equivalent Static Method of Analysis is used. For modeling of Composite & R.C.C. structures, staad-pro software is used and the results are compared; and it is found that composite structure are more economical.

Keywords— Composite column, steel beam, shear connectors & staad-pro Software

1. INTRODUCTION & OBJECTIVE

steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction combines the better properties of the both i.e. concrete in compression and steel in tension, they have almost the same thermal expansion and results in speedy construction. This paper include Comparative study of R.C.C. with Composite (G+15) Storey building. Comparative study includes deflections, bending moments in x & y direction, axial force & shear force in columns & beams, size and material consumption of members in composite with respect to R.C.C.sections, also the comparison of cost of R.C.C. and composite construction is carried out, saving in saleable area, benefit of extra floor & benefit in terms of rent in composite construction is carried out.

2. COMPOSITE CONSTRUCTION

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 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. In India, many consulting engineers are reluctant to accept the use of composite steel-concrete structure because of its unfamiliarity and complexity in its analysis and design. But 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. A need to study the composite design of the multi-story buildings keeping in view of the rapid development in this field. In India, it is comparatively new and no updated design codes are available for the same.

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.

1) Composite beam, slab & shear connectors

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. Rolled steel sections themselves are found adequate frequently for buildings and built up girders are generally unnecessary.
The composite beam can also be constructed with profiled sheeting with concrete topping or with cast in place or precast reinforced concrete slab.

2) Composite Column

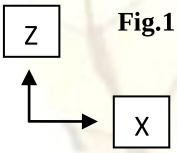
A steel – concrete composite column is conventionally a compression member in which the steel element is a structural steel section. There are three types of composite columns used in practice which are Concrete Encased,
Concrete filled, Battered Section.

3. BUILDING DETAILS

The building considered here is an office building having G+15 storied located in seismic zone 4 & wind velocity 39 m/s. the plan of building is shown in fig. 1 the building is planned to facilitate the basic requirements of an office building. The plan of building is kept symmetric about both the axes. Separate provisions are made for car parking, lift, staircase, security room, pump house and other utilities; however they are excluded from scope of work.

The plan dimension of the building is 25.61mx15.92m. height of each storey is kept same as 3.35m and the total height of the building is 56.5m. The study is carried out on the same building plan for R.C.C. and composite construction with some basic assumption made for deciding preliminary sections of both the structures. The basic loading on both types of structures are kept same, other relevant data is tabulated in table 1 & 2.

Fig.1: Plan showing typical floor



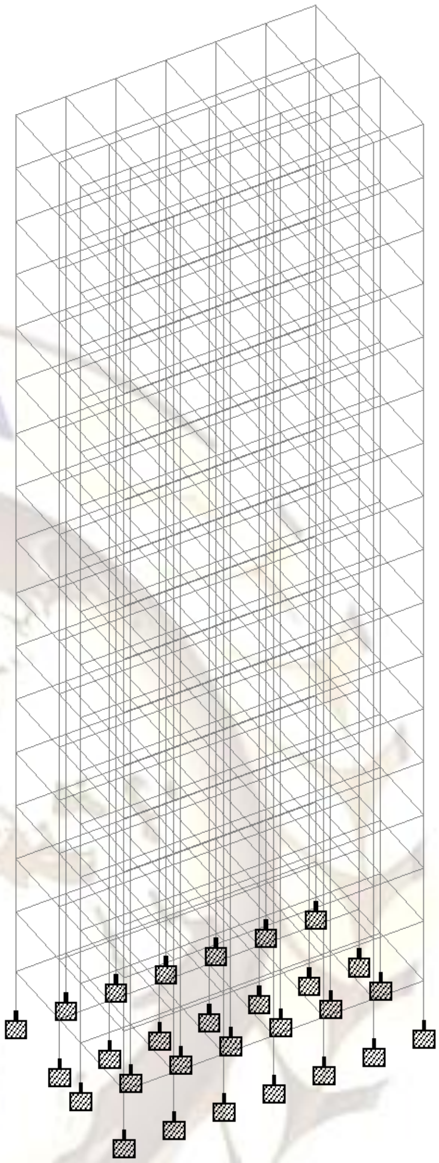


Fig.2-3D Model of Building

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

Plan dimension	25.61mx15.92m
Total height of building.	56.5m.
Height of each storey	3.35m
Height of parapet	1.0m
Depth of foundation	2.9m
Size of beams 6.0m span	300x650
Size of beams 3.0m span	300x450
Size of beams 4.0m span	230x500
Size of outer columns	450x850
Size of internal columns	450x1100
Thickness of slab	140mm
Thickness of l walls	230mm
Seismic zone	IV

Wind speed	39 m/s
Soil condition	hard soil
Importance factor	1.0
Zone factor	0.24
Floor 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%

Table 2 : Data for Analysis of Composite Structure

Plan dimension	25.61mx15.92m
Total height of building.	56.5m.
Height of each storey	3.35m
Height of parapet	1.0m
Depth of foundation	2.9m
Size of beams 6.0m span	ISMB 450
Size of beams 4.0m span	ISMB 300
Size of beams 3.0m span	ISMB 200
Size of outer columns (ISMB 400)	320X580
Size of internal columns (ISMB 450)	330X630
Thickness of slab	140mm
Thickness ofl walls	230mm
Seismic zone	IV
Wind speed	39 m/s
Soil condition	hard soil
Importance factor	1.0
Zone factor	0.24
Floor 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%

4. ANALYSIS

The explained 3D building model is analysed using Equivalent Static Method. The building models are then analysed by the software Staad Pro. Different parameters such as deflection, story drift, shear force & bending moment are studied for the models. Seismic codes are unique to a particular region of country. In India, Indian standard criteria for earthquake resistant design of structures IS 1893 (PART-1): 2002 is the main code that provides outline for calculating seismic design force. Wind forces are calculated using code IS-875 (PART-3) & SP64.

5. RESULTS AND DISCUSSION

5.1 COMPARISONS OF COMPOSITE AND R.C.C. BUILDINGS

Factor	Composite building	R.C.C. building
Time period	5.79 (sec)	3.48 (sec)
Max nodal displacement	0.123 (X-dir)m 0.123 (Z-dir)m	0.059 (X-dir)m 0.048 (Z-dir)m
Max support reactions	7670.71 kN	7726.02 kN
Story drift	X-dir =0.0116 m Z-dir =0.0105 m	X-dir =0.0045m Z-dir =0.0037m
Actual weight of column & beam	11018 kN	27873.627 kN

5.2 Comparisons of composite and R.C.C. column :-

Comparison property	Composite column	R.C.C. column
MAX. Axial force	7670.71kN	7726.02 kN
MAX. Shear force	120.37 kN	128.68 kN
MAX. Bending moments(x axis)	420.53 kNm	434.46 kNm
MAX. Bending moments(z axis)	145.4 kNm	124.03 kNm

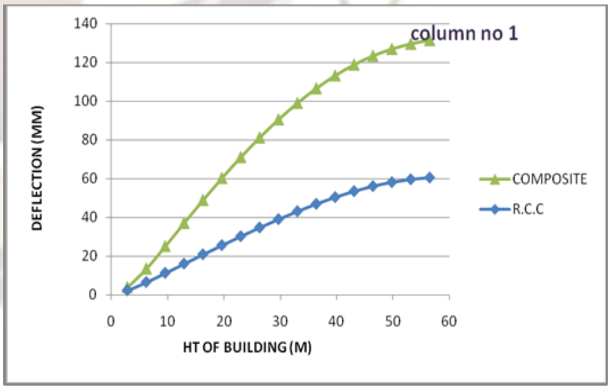


Fig. 3: comparison of deflection

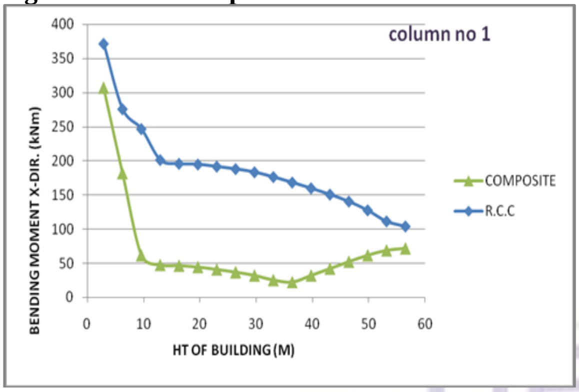


Fig. 4: comparison of bending moment X-direction

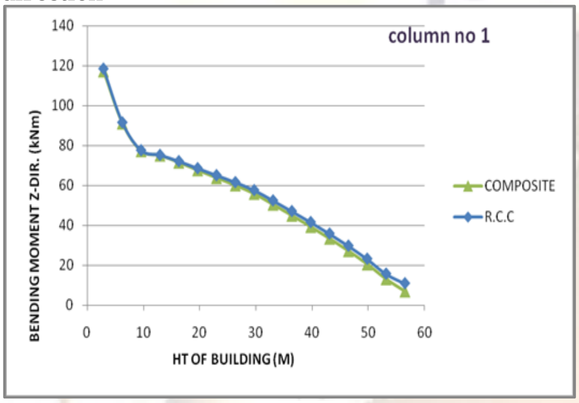


Fig. 5: comparison of bending moment Z-direction

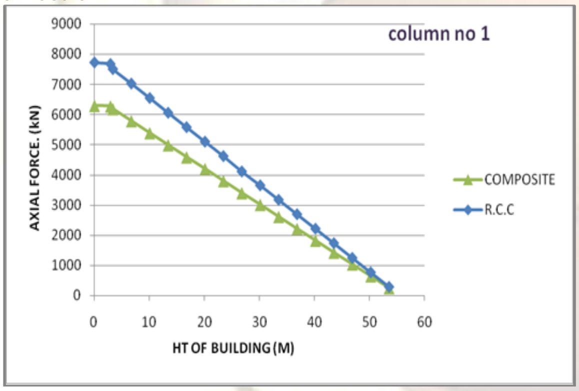


Fig. 6: Comparison of Axial force

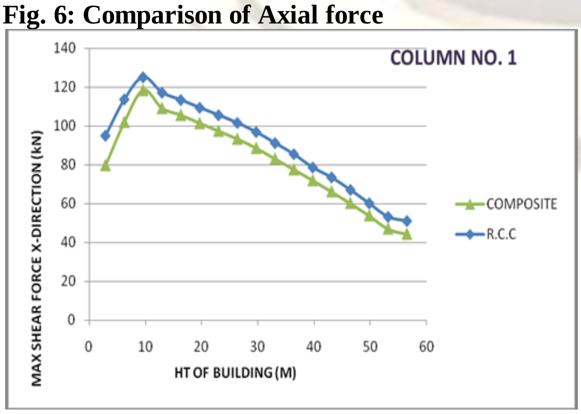


Fig. 7: Comparison of Shear force X-direction

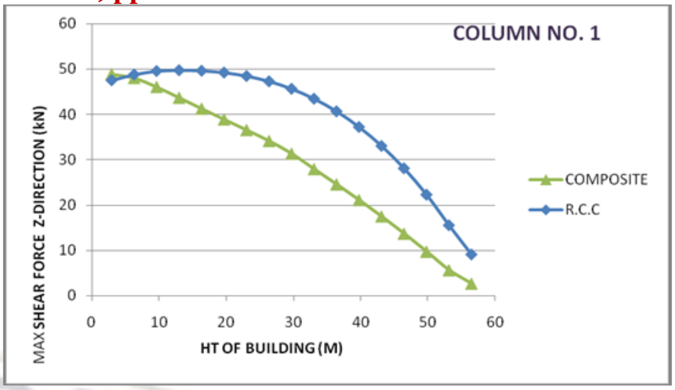


Fig. 8: Comparison of Shear force Z-direction

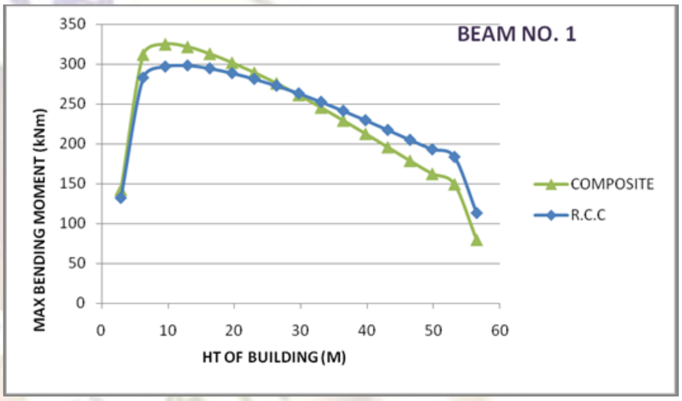


Fig. 9: Comparison of Bending moment

6 COMPARISON OF COST FOR COMPOSITE & R.C.C. STRUCTURE

6.1 R.C.C. Structure:-

Volume of concrete of columns & beams (from staad take off results)=1183.03 cu.mt.
Quantity of slab (140mm thk.) = 15.92x25.61x0.14x16 = 913.27 cu.mt
Assuming the rate of M30 concrete = Rs. 6000/cu.mt.
Cost of concrete = (1183.03 + 913.27)x6000 = Rs.12577800/-
Reinforcing steel of columns & beams (from staad t Off results)=825.4kN (82.54 T.)
Reinforcing steel in slab (assuming 60kg/m^3) = 913.27x60
= 54796 kg (54.796 T.)
Rates of Reinforcing steel = Rs. 51500/M.T.
Cost of reinforcing steel = (82.54+54.796)x51500
= Rs. 7072804/-
Total cost in R.C.C. structure = Rs. 12577800+Rs. 7072804 = **Rs. 19650604/-**

6.2 Composite Structure:-

Quantity of column =
10X0.33X0.63X56.5 = 117.46
18X0.32X0.58X56.5 = 188.75
Total = 306.21 cu.mt.

Assuming the rate of M30 concrete for columns = Rs. 6000/cu.mt.
Cost of concrete = 306.21x6000 = Rs.1837260/-
Quantity of slab (125mm thk.) = 15.92x25.61x0.125x16
= 815.42 cu.mt.
Assuming the rate of M30 concrete for slab (as no form work is required)= Rs. 4000/cu.mt.
Cost of concrete = 815.42x4000 = Rs.3261680/-
Reinforcing steel of column:- (4-25□ □
4x3.86x28x56.5 = 24426 kg
Stirrups = 8000 kg
Total = 32426 kg (32.426 T.)
Reinforcing steel of slab:- (assuming 30kg/m^3 as profile sheet will act as tension steel)
Quantity = 815.42x30 = 24462.6kg. (24.46 T.)
Cost of reinforcing steel = (32.426+24.46)x51500 = Rs. 2929629/-

Structural Steel:-
ISMB 450 (Encased Column)– 10X56.5X0.724 = 409.06 kN
ISMB 400 (Encased Column) – 18X56.5X0.615 = 625.45 kN
ISMB 450 (Main Beam) – 1428X0.724 = 1033.87 kN
ISMB 300 (Main Beam) – 1632X0.46 = 750.72 kN
ISMB 200 (Main Beam) – 357X0.242 = 86.39 kN
ISMB 200 (Secondary Beams @ 2.0m. spacing) – 24X0.242X4X16 = 371.71 kN
Total = 3277.2 kN
327.72 T
Cost of structural steel = 327.72x58325 = Rs. 19114269/-
Cost of profiled sheets –
Weight of profiled sheet from table 1 = 0.082kN/m^2
Total weight of profiled sheet = 15.92x25.6x16x0.082 = 535 kN.(53500kg)
Assuming the rates of sheet & it's Labour as Rs. 75 + Rs. 10 = Rs. 85/kg
Cost of sheet = 53500x85 = 4547500/-
Total cost in Composite Structure = **Rs. 31690338/-**
Total cost difference in construction of R.C.C. & Composite Structure= 31690338-19650604 = **12039734/-**

LET'S HAVE COMPARISION OF SALEABLE AREA SAVING IN COMPOSITE STRUCTURE & IT'S COST EFFECTIVENESS:-

Carpet area covered by R.C.C. column:-
10x0.45x1.1 = 4.95 sq.mt.
18x.45x.85 = 6.885 sq.mt.
Total area = 11.835 x 16 floors = 189.36sq.mt.
Carpet area covered by Composite column:-
10x0.33x0.63 = 2.08sq.mt.
18x0.32x0.58 = 3.34sq.mt.
Total area = 5.42x16 floors = 86.72sq.mt.
Total area difference = 189.36- 86.72 = 102.64sq.mt.
If assuming the minimum market area rates as Rs.5000/sq.ft.
The cost of carpet area saving = 102.64x10.764x5000 = 5524085/-
Maximum depth of beam in R.C.C. structure is 650mm
While Maximum depth of beam in R.C.C. structure is 450mm
If we reduce the storey height by 200mm
The total reduction in height of building is = 16x0.2 = 3.2mt. (almost one floor height)
So we can increase one floor keeping same height as R.C.C. building.
Increase in saleable area of extra floor = 12x4x6x1.2
= 345.6sq.mt. (built up area of 12 offices)
Saleable cost of extra floor = 345.6x10.764x5000
= Rs.18600192/-
Total cost saving = 5524085+18600192 = Rs.24124277/-
Saving in terms of carpet area & extra floor
= Rs.24124277/-
Difference of cost for composite construction
= Rs.12039734/-
Net saving in composite construction = Rs. 12084543/-
The above results shows that the composite construction is economical.

FURTHER DISCUSSION-

Assuming that construction of R.C.C. building will take nearly 24 months to complete.
The composite construction is speedy, no form work is required for slab so no wastage of stripping time, at the same time work can be carried out at different levels simultaneously i.e. erection & concreting work may go on simultaneously at different levels, assuming the saving in time nearly 9 months.
The earning in terms of rent of offices (assuming Rs. 323/sq.mt. i.e. Rs.30/sq. ft.)
Rent = 12x4x6x10.764x30x15x9 = **Rs. 12555130/-**
Which is a considerable amount.

9. CONCLUSION

Analysis and design results of G+15 storied building with composite columns and R.C.C. columns is given in chapter 6. The comparison of results of composite column building and R.C.C. column building shows that:-

1) The deflection & storey drift in composite structure is nearly double than that of R.C.C. Structure but the deflection is within the permissible limit.

2) The graph shows that there is significant reduction in bending moments of columns in X Direction.
3) The graph shows that there is no significant difference in bending moments of columns in Z Direction.
4) Axial Force & Shear force in R.C.C. structure is on higher side than that of composite structure.
5) Max. bending moment in beams of composite structure is slightly on higher side in some storey's than R.C.C. Structure.
6) Composite structures are more economical than that of R.C.C. structure as shown in earlier chapter.
7) Speedy construction facilitates quicker return on the invested capital & benefit in terms of rent.
8) Weight of composite structure is quite low as compared to R.C.C. structure which helps in reducing the foundation cost.
9) Composite structures are the best solution for high rise structure.

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