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Research Paper

COST ANALYSIS OF STEEL-CONCRETE COMPOSITE STRUCTURE

Mahesh Suresh Kumawat[1]* and L G Kalurkar[1]

*Corresponding author: **Mahesh Suresh Kumawat** ✉ kumawat.sir@gmail.com

Steel concrete composite construction means the concrete slab is connected to the steel beam with the help of shear connectors, so that they act as a single unit. In the present work steel concrete composite with RCC options are considered for comparative study of G+9 storey commercial building which is situated in earthquake zone-III and for earthquake loading, the provisions of IS: 1893 (Part1)-2002 is considered. A three dimensional modeling and analysis of the structure are carried out with the help of SAP 2000 software. Equivalent Static Method of Analysis and Response spectrum analysis method are used for the analysis of both Composite and RCC structures. The results are compared and found that composite structure more economical).

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. Exploring Steel as an alternative construction material and not using it, where it is economical is a heavy loss for the country. Also, it is evident that now-a-days, 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.

COMPOSITE STRUCTURES

Composite Steel-Concrete Structures are used widely in modern bridge and building construction. A composite member is formed when a steel component, such as an I beam, is attached to a concrete component, such as a floor slab or bridge deck. In such a composite T-beam the comparatively high strength of the concrete in compression complements the high strength of the steel in tension. The fact

[1] Department of Civil Engineering, Jawaharlal Nehru Engineering College N-6, CIDC, Aurangabad, Maharashtra, India.

that each material is used to the fullest advantage makes composite Steel-Concrete construction very efficient and economical. However, the real attraction of such construction is based on having an efficient connection of the Steel to the Concrete, and it is this connection that allows a transfer of forces and gives composite members their unique behavior.

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. In due consideration of the above fact, this project has been envisaged which consists of analysis and design of a high rise building using 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. 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. Formally the multi-story buildings in India were constructed with RCC framed structure or Steel framed 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.

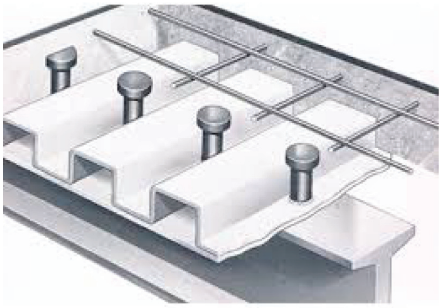
Shear Connectors: Shear connections are essential for steel concrete construction as they integrate the compression capacity of supported concrete slab with supporting steel beams/girders to improve the load carrying capacity as well as overall rigidity (Figure 1).

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).

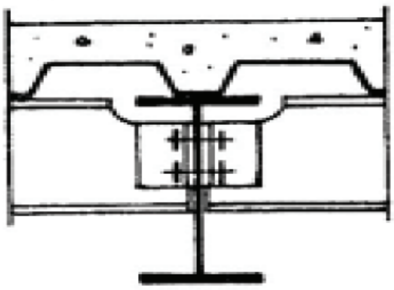
Composite Beam: A steel concrete composite beam consists of a steel beam, over which a reinforced concrete slab is cast

Figure 2: Composite Slab



with shear connectors. The composite action reduces the beam depth shown in Figure 3.

Figure 3: Composite Beam



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.

Encased Columns: A composite member subjected mainly to compression and bending is called as composite column (Figure 4).

Pp = AaPy + Ac P_{CK} + AS Psk Where, Py = 0.8 fy; Pck = 0.4(fck)cu and Psk = 0.67 fy

MODELING AND ANALYSIS

Dead load : 875 (part i)-1987

Live load: 4.00 kn/m2

Wind load : is : 875 (part iii) -1987

location: Aurangabad

Basic wind speed = 39 m/s

Seismic load: IS: 1893(Part I): 2002

Position of columns and Building plan shown in Figure 5.

MODELING OF RCC FRAME STRUCTURE

The building considered here is an office building having G+15 stories located in seismic zone III and for earthquake loading, the provisions of IS: 1893(Part1)-2002 is

Figure 4: Composite Column

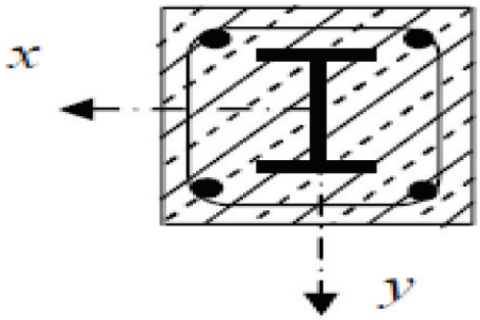
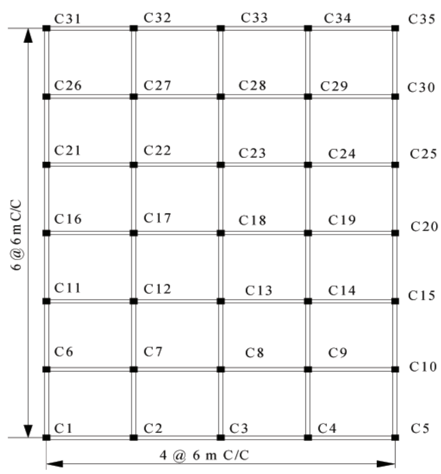


Figure 5: Position of columns and Building plan (24.00 m x 36.00 m)



Plan (24.00 m x 36.00 m)

Table 1: Sample Calculation of Lateral Forces

Floor Level	hi (m)	Wi(kN)	Wihi2
Ground Floor	3.65	13976.00	0.186×10^6
Qi= VBWihi2/Wihi **73.760**		Vj = Σ Qi **8770.420**	

considered. The wind velocity is 39 m/s. The plan of building is shown in figure showing position figure 1.0 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 dimension of the building is 24.00m by 36.00m, which is on land area of about 1800m^2. Height of each storey is kept same as 3.50m and the total height of building is kept as 38.50 m. Columns are placed at 6m centre to centre 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 2.

Table 2: Comparison Between RCC Structure and Composite Structure

Particulars	RCC Structure	Composite Structure
Plan dimensions	*24m X 36m*	*24m X 36m*
Total height of building	*38.5m*	*38.5m*
Height of each storey	*3.5m*	*3.5m*
Height of parapet	*0.90m*	*0.90m*
Depth of foundation	*2.50m*	*2.50m*
Plinth height	*1.00m*	*1.00m*
Size of beams	300mm X 600mm	ISMB400@61.6kg/m
Size of columns	700mm X 700mm	500X500mm (SC250@85.6kg/m + 125mm concrete cover)
Thickness of slab	125mm	125mm
Thickness of external walls	230mm	230mm
Thickness of internal walls	115mm	115mm
Seismic zone	III rd	III rd
Soil condition	Hard soil	Hard soil
Response reduction factor	5	5

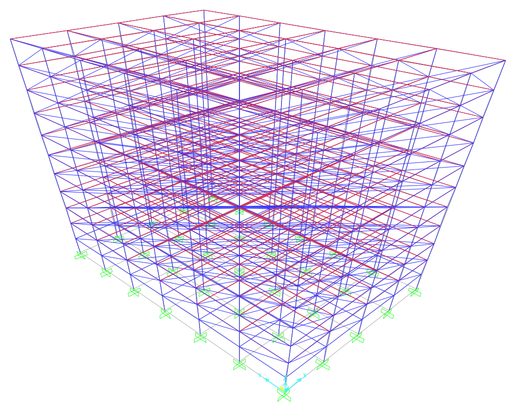
Table 2 (Cont.)

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 RCC and Composite building are modeled using the finite element software SAP 2000 shown in Figure 6. 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 element 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

Figure 6: 3D Model Of Commercial Building



of strut is derived. Walls are considered to be rigidly connected to the columns and beams. The 3D building model generated in SAP2000.

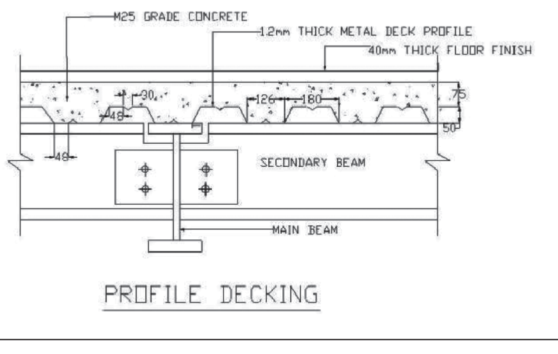
ANALYSIS OF BUILDING

Seismic codes are unique to a particular region or country. In India, Indian Standard Criteria for Earthquake Resistant Design of Structures IS 1893 (Part-I): 2002 is the main code that provides outline for calculating seismic design force. This force depends on the mass and seismic coefficient of the structure and the latter in turn depends on properties like seismic zone in which structure lies, importance of the structure, its stiffness, the soil on which it rests, and its ductility.

1. Dead load + live load
2. Dead load + live load + wind load (+ve) x – direction
3. Dead load + live load + wind load (- ve) x – direction
4. Dead load + live load +earthquake load (+ve) x direction
5. Dead load + live load +earthquake load(- ve) x direction.

DESIGN OF SLAB: BS:5950 : Part 4 shown if Figure 7.

Figure 7: Detailing of Slab



Effective Span = 3.0 m Total Depth of the slab = 125 mm

Live load = 4 kN/m^2 Grade of concrete = M25

Density of concrete (dry) = 24 kN/ m^2

Density of concrete (wet) = 25 kN/ m^2 ts = 125 mm

fyp = 345 N/mm^2

DESIGN OF BEAMS

BS: 5950 Part III Secondary beams: ISMB 350

Spacing:-3.00m

Shorter direction: Maximum positive B.M

Mu(+ve)= 1617.087 KNm Maximum

Negative B.M Mu(-ve)= 980.359 kN.m

Maximum S.F Vu= 547.085 kN

Beam 2: This beam is for the third, fourth and fifth floor. ISMB 450 @ 0.724 KN/m

Maximum BM (Mu(+ve)) =1449.789 KN m

Maximum B M (Mu(-ve)) = 821.236 KN m

Maximum S F = 507.435 KN

Design of Foundation: square footing. The safe BC of the soil is assumed 250 kN / m^2 Side of The footing L = 4.2 m provide 6-20 mm dia. both direction bars.

Design of Beams : SP – 16

Beam 1: longer span

Maximum positive B.M Mu(+ve)= 1617.087 kN.m Maximum negative B.M Mu(-ve)= 980.359 kN.m

Maximum S.F Vu= 547.085 kN.

Beam : 300 x 900 Considering 60% of steel, Providing reinforcement of 8mm dia. @200mmc/c.

Beam 2: shorter span

Maximum positive B.M Mu(+ve)= 426.541 kN.m Maximum negative B.M Mu(-ve)= 418.718 kN.m

Maximum S.F ,Vu= 192.198 kN

Beam : 250 x 600 Considering 60% of steel, Providing reinforcement of 8mm dia. @200mmc/c

RESULTS AND DISCUSSION

As per the table shown the above cost comparison of steel-concrete composite structure and concrete building. We found that the cost of the composite structure is more costly than the concrete building.

1. The slab material quantity run per meter Than amount of the both composite and concrete slab
2. Consist the beam of the shorter span and amount of the composite and concrete building.
3. Consists the beam of the longer span and the amount of the composite and concrete building.
4. The column quantity and the amount of the composite and concrete building.

CONCLUSION

The cost comparison reveals hat Steel-Concrete composite design structure is more costly, reduction in direct costs of steel-composite structure resulting from speedy erection will make Steel-concrete Composite structure economically viable. Further, under earthquake considerations because of the inherent ductility characteristics, Steel-Concrete structure will perform better than a conventional RCC structure.

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