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# "Cost, Analysis and Design of Steel-Concrete Composite Structure Rcc Structure"

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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..Steel-concrete composite with R.C.C. options are considered for comparative study of G+5 storey office building with 3.658 m height, which is situated in earthquake zone III(indore)& wind speed 50 m/s. The overall plan dimension of the building is 56.3 m x 31.94 m.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 more economical.*
***Keywords:*** *Composite column**,** steel beam, shears connectors & staad-pro.*

## I. 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.

### 1.1 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 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.

## II. 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 R.C.C structure so that a cost comparison can be made between a Steel-Concrete composite structure and an equivalent R.C.C. structure.

## III. Elements Of Composite Structure

### 3.1 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.

### 3.2 Profiled Deck

Composite floors using profiled sheet decking have become very popular in the West for high-rise buildings. Composite deck slabs are generally competitive where the concrete floor has to be completed quickly and where medium level of fire protection to steel work is sufficient.

### 3.3 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. Verification is required for the floor slab after composite behavior has commenced and any props have been removed.

**3.4 Composite Beams**

Composite beams, subjected mainly to bending, consist of steel section acting compositely with flange of reinforced concrete. To act together, mechanical shear connectors are provided to transmit the horizontal shear between the steel beam and the concrete slab, ignoring the effect of any bond between the two materials. These also resist uplift force acting at the steel concrete interface.

**3.5 Encased Columns**

A composite member subjected mainly to compression and bending is called as composite column.

$\mathbf{P_p = A_aP_y + A_c P_{CK} + A_S P_{sk}}$ Where, $\mathbf{P_y = 0.8 f_y}$; $\mathbf{P_{ck} = 0.4(f_{ck})_{cu}}$ **and** $\mathbf{P_{sk} = 0.67 f_y}$

## IV. Modeling And Analysis

**4.1DEAD LOAD :** IS 875 (Part I)-1987
**4.2LIVE LOAD:** 4.00 KN/m2
**4.3WIND LOAD** : IS : 875 (Part III) - 1987
Location : Indore
Basic wind speed = 50m/s

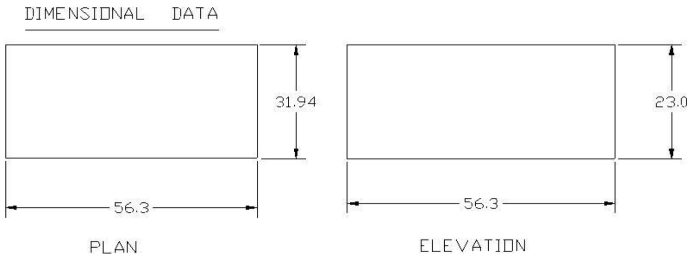


**Fig. 1 Plan and Elevation of Regular Building**

**4.3.1 Wind Loads-Parallel To Shorter Direction**

| Floor | GF | 1ST | 2ND | 3RD | 4TH | 5TH |
|---|---|---|---|---|---|---|
| H | 4.51 | 8.17 | 11.83 | 15.55 | 19.15 | 22.81 |
| Ac | 10.12 | 16.47 | 16.47 | 16.47 | 16.47 | 8.23 |
| Cf | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Pz | 0.61 | 1.11 | 1.40 | 1.51 | 1.60 | 1.84 |
| F | 6.17 | 18.28 | 23.05 | 24.86 | 26.35 | 15.14 |

**4.3.2wind Loads-Parallel To Longer Direction**

| Floor | GF | 1ST | 2ND | 3RD | 4TH | 5TH |
|---|---|---|---|---|---|---|
| H | 4.51 | 8.17 | 11.83 | 15.55 | 19.15 | 22.81 |
| $A_c$ | 20.52 | 40.95 | 40.95 | 40.95 | 40.95 | 16.65 |
| $C_f$ | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| $P_z$ | 0.61 | 1.11 | 1.40 | 1.51 | 1.60 | 1.84 |
| F | 12.52 | 45.45 | 57.33 | 61.83 | 65.52 | 30.636 |

**4.4 SEISMIC LOAD:** IS: 1893(Part I): 2002

**4.5 Calculation Of Lateral Forces**

| Floor level | $h_i$ (m) | $W_i$(kN) | Wihi$^2$ | Qi=$V_B$Wihi$^2$/W $_ih_i$ | $V_j = \sum Q_i$ |
|---|---|---|---|---|---|
| G f | 3.66 | 13977. | 0.187 x $10^6$ | 73.77 | 8770.38 |
| 1st | 7.32 | 13977. | 0.749 x $10^6$ | 295.48 | 8696.6 |
| 2nd | 10.98 | 13977. | 1.685 x $10^6$ | 664.72 | 8401.13 |
| 3rd | 14.64 | 13977. | 2.99 x $10^6$ | 1179.53 | 7736.4 |
| 4th | 18.3 | 13977. | 4.681 x $10^6$ | 1846.62 | 6556.88 |
| 5th | 21.96 | 13977. | 6.74 x $10^6$ | 2658.9 | 4716.26 |
| Roof | 23.0 | 9856 | 5.2 x $10^6$ | 2051.4 | 2051.4 |
| | | | 22.23 $10^6$ | | |

**4.6 Modeling Of Rcc Frame Structure**

For the analysis of multi storied building following dimensions are considered which are elaborated below. In the current study main goal is to compare the Static and Dynamic Analysis of symmetrical (Rectangular) building.

**Static Parameters:-**

Design Parameters- Here the Analysis is being done for G+5 (rigid joint regular frame) building by computer software using STAAD-Pro.

Design Characteristics: - The following design characteristics are considered for **Multistory rigid jointed plane frames**

**Table 1 Design Data of Frame Structures**

| S.No | Particulars | Dimension/Size/Value |
|---|---|---|
| 1. | Model | G+5 |
| 2. | Seismic Zone | III |
| 3. | Floor height | 3.6M |
| 4. | Depth of foundation | 2.4M |
| 5. | Building height | 23M |
| 6. | Plan size | 56.30Mx31.94M |
| 7. | Total area | 1798 Sq.m |
| 8. | Size of columns | 0.9Mx0.5M |
| 9. | Size of beams | 0.3Mx0.90M |
| 10 | Walls | (a)External-0.20M (b)Internal-0.10M |
| 11. | Thickness of slab | 125mm |
| 12. | Earthquake load | As per IS-1893-2002 |
| 13. | Type of soil | Type -II, Medium soil as per IS-1893 |
| 14. | Ec | $5000\sqrt{fck}$ N/ mm2(Ec is short term static modulus of elasticity in N/ mm2) |
| 15. | Fck | $0.7\sqrt{fc}$ k N/ mm2(Fck is characteristic cube strength of concrete in N/ mm2 |
| 16. | Live load | 4 kN/ m2 |
| 17. | Floor finish | 1.00kN/ m2 |
| 18. | Water proofing | 2.500kN/ m2 |
| 19 | Specific wt. of RCC | 25.00 kN/ m2 |
| 20. | Specific wt of infill | 20.00 kN/ m2 |
| 21. | Material used | Concrete M-30and Reinforcement Fe-415(HYSD Confirming to IS-1786) |
| 22. | Reinforcement used | High strength deformed steel Confirming to IS-786. It is having modulus of Elasticity as 2 00 kN/ mm2 |
| 23. | Static analysis | Equivalent static lateral force method. |
| 24. | Software used | STAAD-Pro for static analysis |
| 25. | Specified characteristic | compressive strength of 150mm cube at 28 days for M-30grade concrete- 30N/ mm2 |
| 27. | Fundamental natural period of building | Ta = 0.075 h0.75 for moment resisting RC frame building without infill's Ta = 0 .09 h /$\sqrt{d}$ for all other building i/c moment resisting RC frame building with brick infill walls Where h = height of building d = base dimension of building at plinth level in m along the considered direction of lateral forces. |
| 28. | Zone factor Z | as per Is-1893-2002 Part -1 for different. zone as per clause 6.4.2. |

### 4.6.1 Analysis

Analysis was done assuming that the building is a concrete building. 2D analysis was done for two cases:-

1. Frame along shorter direction 2. Frame along longer direction

Footing was idealized as fixed support. The load cases adopted are dead load and live load, wind load and the seismic load .

Analysis was done for the load combinations givenbelow:

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)xdirection

5Dead load + live load +earthquake load(- ve)xdirection.

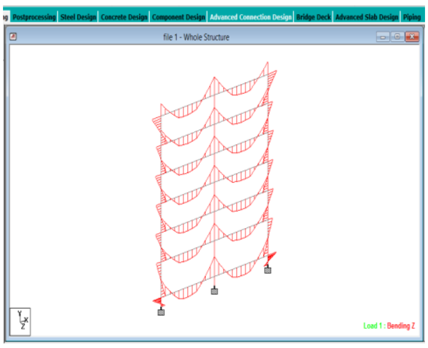

**Fig.2 Bending moment diagram of intermediate frame in Shorter direction**

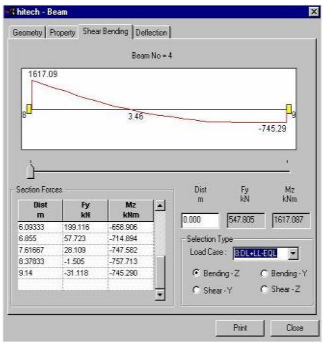


**Fig.3 B M D for Beam**

## V. Design Of Elements (Composite)

**5.1 DESIGN OF SLAB:** BS:5950 :Part 4
Effective Span = 3.0m Total Depth of the slab = 125 mm
Live load = 4kN/$m^2$ Grade of concrete = M25
Density of concrete (dry) = 24 kN/ $m^2$
Density of concrete (wet) = 25 kN/ $m^2$ $t_s$ = 125 mm $f_{yp}$ = 345 N/$mm^2$

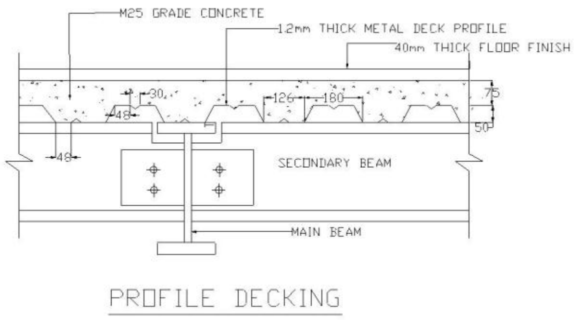


**Fig 5. C/S Profile Decking**

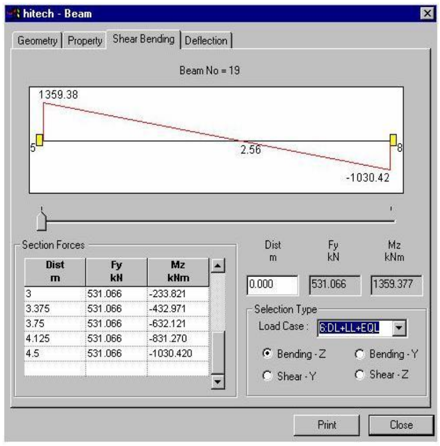


**Fig.4 B M D for Column**

**5.2 Design Of Beams** BS: 5950 Part III Secondary beams : ISMB 350 Spacing :-3.00m
SHORTER DIRECTION : STAAD PRO Analysis 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
LONGER DIRECTION
Beam 3This beam is used for the first and the second floor. ISMB 400@ 0.442 KN/m
Maximum Bending Moment(Mu(+ve)) = 426.541 KN m Maximum Bending Moment (Mu(-ve) ) = 418.718 KN m Maximum Shear Force = 192.198 KN
Beam 4This beam is used for the third, fourth and fifth floor.ISMB 250 @ 0.373 KN/m
Maximum B M (Mu(+ve) ) = 255.141 KN m Maximum BM(Mu(-ve) ) = 248.131KN m
Maximum Shear Force = 111.594 KN

**5.3design of Column**
Design Axial Load, $F_x$ = 6201.959 kN.m.
Design BM about x-x axis, $M_{ux}$ = 1359.377 kN.m. Design BM about y-y axis, $M_{uy}$ = 416.74 kN.m.
Column dimension=600x600x3600 Concrete grade=M25
Steel Section = ISHB 450 with plates of thickness 25mm on both the flanges Reinforcement 4 - 25mm dia.Bars.
OTHER COLUMNS
Column 2: The third ,fourth and fifth floor.ISHB 300@0.63kN/m with 25mm plates both the flanges.Both the plates are of 320mm width Mux = 787.405 KN m Muy = 292.717 KN m Fx = 2618.69KN

**5.4design 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.

## VI. Design Of Elements (R.C..C.)

**6.1 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

**6.2 Design of Column** SP-16
Design Axial Load, Fx = 6201.959 kN.m.
Design BM about x-x axis, Mux = 1359.377 kN.m. Design BM about y-y axis Muy = 416.74 kN.m.
Considering a section of 500 x 900 mmUsing 4% of reinforcement, Therefore p = 5.5%
Weight of steel □ $_{100}{}^{5.5}$ □900□ 500□ 3.66□1000□ 7800□$10^{-9}$ =173.74$kg$ ≈ 200kg Volume of concrete = 0.9□ 0.5□ 3.66 =1.647m3

**6.3design Of Formwork**
**Short beam** Consider 1m length, Formwork required□□0.3 □ 0.9 □ 0.9□□1□ 2.1$m^2$ / $m$ □ 19.194$sq.m$
**Long beam** Formwork required□□0.25 □ 0.6 □ 0.6□□1□ 1.45$m^2$ / $m$ =6.525$sq.m$
**Column** Formwork required□□0.5 □ 0.5 □ 0.9 □ 0.9□□1 □ 2.8$m^2$ / $m$

## VII. Comparision Of Composite Steel-Cocrete Structure And Rcc Structure:-

**Table1. Slabs**

| Material | Rate | Composite design | Amount | R.C.C design | Amount |
|---|---|---|---|---|---|
| Steel | Rs.35/kg | 9.36 kg/sq.m | Rs.328 | 3.9kg/m | Rs.136 |
| Concrete | Rs.2050/ $m^3$ | 0.075 $m^3$/m | Rs.153. | 0.15 $m^3$/m | Rs.307 |
| Form work | Rs.80 /sq.m | - | - | 0.075 sq.m/m | Rs.6 |
| | | Total | Rs.481. | Total | Rs.447 |

**Table2.Beams** a) Considering shorter span beams,

| Material | Rate | Composite design | Amount | R.C.C design | Amount |
|---|---|---|---|---|---|
| Steel | Rs.35/kg | 1839kg | Rs.64365 | 650kg | Rs.22750 |
| Concrete | Rs.2050/$m^3$ | - | - | 2.46 $m^3$ | Rs.5060 |
| Formwork | Rs.80/sq.m | - | - | 19.19 sqm | Rs.1535.5 |
| | | Total | Rs.64365 | Total | Rs.24792 |

**Table3. Beams** a) considering longer span beams

| Material | Rate | Composite design | Amount | R.C.C design | Amount |
|---|---|---|---|---|---|
| Steel | Rs.35/kg | 277.2kg | Rs.9702 | 131.5kg | Rs.4602 |
| Concrete | Rs.2050/ $m^3$ | - | - | 0.675 $m^3$ | Rs.1383 |
| Formwork | Rs.80/sq. m | - | - | 6.52sq.m | Rs.522 |
| | | Total | Rs.9702 | Total | Rs.6508 |

**Table4. Column**

| Material | Rate | Composite design | Amount | RCC design | Amount |
|---|---|---|---|---|---|
| Steel | Rs.35/kg | 798.3.9kg | Rs.27939 | 200kg | Rs.7000 |
| Concrete | Rs.2050/$m^3$ | 1.21 $m^3$ | Rs.2480 | 1.647$m^3$ | Rs.3376 |
| Formwork | Rs.80/sq.m | 2.4 sq.m | Rs.192 | 10.248 sq.m | Rs.820 |
| | | Total | Rs.30611 | Total | Rs.111 |

## VIII. Result 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.
Table 1 shown the slab material quantity run per meterThan amount of the both composite and concrete slab
Table 2 consist the beam of the shorter span and amount of the composite and concrete building.
Table 3consists the beam of the longer span and the amount of the composite and concrete building.
Table 4 shown the column quantity and the amount of The composite and concrete building.

## IX. 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 R.C.C. structure.

## Acknowledgement

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