

Composite Column- Importance and Design Methodology as per Indian Code

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ABSTRACT: Composite steel-concrete construction uses steel and concrete together to obtain a system with better performance. Composite steel-concrete columns are generally described as being superior to traditional I-shaped, tube steel columns because the concrete can carry the compression and the steel carries the tension. A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load-bearing member in a composite framed structure. This paper evaluates the advantages and design methodology of composite column which have been proposed/used in India in terms of performance. The object of this paper is to introduce steel-concrete composite members and construction; to explain the composite action of the two different materials and to show how the structural members are used, particularly in building construction.

KEYWORDS: Composite, Column, Design Methodologies, Load-Bearing Member, Compression Member

I. INTRODUCTION

A steel concrete composite column is conventionally a compression member in which the steel element is a structural steel section. A steel-concrete composite structural member contains both structural steel and concrete elements which work together. A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load-bearing member in a framed structure. Note that there is no requirement to provide additional reinforcing steel for composite concrete filled tubular sections, except for requirements of fire resistance where appropriate. Here, the steel element contributes tensile capacity, provides confinement to concrete elements, and reduces concrete shrinkage while concrete element prevents steel from premature local buckling and fatigue.

This paper illustrates design of steel-concrete composite columns subjected to axial load as per IS 456:2000. The object of this paper is to introduce steel-concrete composite members and construction; to explain the composite action of the two different materials and to show how the structural members are used, particularly in building construction.

II. INPUT DATA FOR DESIGN EXAMPLE

Ultimate load (P_u) = 76666 kN,

Working load (P) = $76666/1.5 = 51111$ kN.

R. C. C. Column Size = 1500 mm X 1500 mm

Grade of Concrete = M 60

Grade of reinforcing steel = Fe 500

Grade of structural steel = 340 N/mm²

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III. CLAUSE FOR DESIGN OF COMPOSITE COLUMN AS PER IS 456:2000 (CLAUSE NO. B-3.4)

The allowable axial load P on a composite column consisting of structural steel or cast-iron column thoroughly encased in concrete reinforced with both longitudinal and spiral reinforcement, shall not exceed that given by the following formula.

$$P = \sigma_{cc}A_c + \sigma_{sc}A_{sc} + \sigma_{mc}A_m$$

Where,

σ_{cc} = Permissible stress in concrete in direct compression,

A_c = Net area of concrete section; which is equal to the gross area of the concrete section- A_{sc} - A_m ,

σ_{sc} = Permissible compressive stress for column bars

A_{sc} = Cross-sectional area of longitudinal bar reinforcement,

σ_{mc} = Allowable unit stress in metal core, not to exceed 125 N/mm² for a steel core, or 70 N/mm² for a cast iron core

A_m = the cross-sectional area of the steel or cast iron core.

IV. DESIGN OF COMPOSITE COLUMN AS PER IS 456:2000 (CLAUSE NO. B-3.4)

The total axial load on the column is to be distributed in three components

1. Load taken by concrete column ($\sigma_{cc}A_c$)
2. Load taken by reinforcing steel ($\sigma_{sc}A_{sc}$)
3. Load taken by structural steel core. ($\sigma_{mc}A_m$)

$$\sigma_{cc} = 0.25 f_{ck} = 0.25 \times 60 = 15 \text{ N/mm}^2 \text{ (for M 60 Grade Concrete)}$$

$$\sigma_{sc} = 190 \text{ N/mm}^2 \text{ (For Fe 500 grade steel)}$$

$$\sigma_{mc} = 0.5f_y = 0.5 \times 340 = 170 \text{ N/mm}^2$$

Assuming 2% reinforcing steel (Fe500)

$$A_{sc} = 0.02 \times 1500^2 = 45000 \text{ mm}^2$$

$$A_c = (1500 \times 1500) - A_{sc} - A_m = (1500 \times 1500) - 45000 - 85000 = 2120000 \text{ mm}^2$$

Assuming 25% of the axial load is taken by structural steel core.

Therefore

$$P_{ss} = \text{Working Load} \times 25/100 = 51111 \times 25/100 = 12777.75 \text{ kN}$$

$$A_{mreq} = 12777.75 \times 103 / \sigma_{mc} = 12777.75 \times 103 / 170 = 75163.23 \text{ mm}^2$$

Therefore,

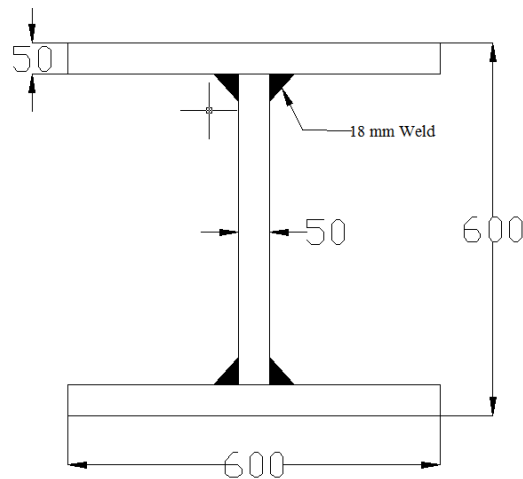
Let us provide following section

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Area of fabricated section $A_m = 85000 \text{ mm}^2$

Let us check capacity of the section with metal core

$$P = \sigma_{cc}A_c + \sigma_{sc}A_{sc} + \sigma_{mc}A_m$$

$$P = (15 \times 2120000) + (190 \times 45000) + (170 \times 85000)$$

$$P = 54800000 \text{ N} = 54,800 \text{ kN} > P (51111 \text{ kN})$$

Hence OK.

V. DESIGN OF BASE PLATE FOR COMPOSITE COLUMN

Assuming 25% of the axial load is taken by structural steel core.

Area of fabricated section provided $A_m = 85000 \text{ mm}^2$

Therefore actual load taken by metal core = $85000 \times 170 = 14450000 \text{ N} = 14450 \text{ kN}$

Allowable bearing pressure on concrete = 12 N/mm^2 (For M50 grade concrete)

Therefore area of slab base = $14450000 / 12 = 1204166.67 \text{ mm}^2$

Let us provide square base plate

Therefore side of base plate $\sqrt{1204166.67} = 1097 \text{ mm}$.

Let us provide base plate of size $1150 \text{ mm} \times 1150 \text{ mm}$

Under side pressure on base plate $w = 14450000 / 1150^2 = 10.93 \text{ N/mm}^2$

Thickness of base plate
$$t = \sqrt{\frac{3w}{\sigma_{bc}} \left(a^2 - \frac{b^2}{4} \right)}$$

Where,

a = Greater projection = $(1500-600)/2 = 275 \text{ mm}$

b = Shorter side projection = 275 mm

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σ_{mc} = Permissible bearing stress in slab base = 185 N/mm²

$$t = \sqrt{\frac{3 \times 10.93}{185} \left(275^2 - \frac{275^2}{4} \right)}$$

$$t = 100.26 \text{ mm}$$

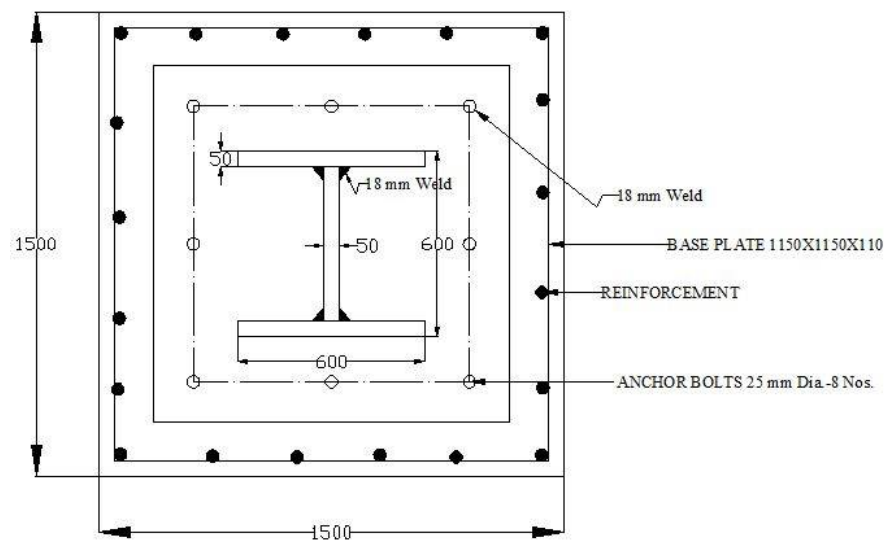
Let us provide 110 mm thick plate.

Thus plate size = 1150 mm x 1150 mm x 110 mm

VI. DESIGN OF FABRICATION BOLTS

As there is no uplift on column and also no moment is shared by structural steel member
Thus provide nominal bolts.

Provide 25 mm dia. 8 no. of bolts.



VII. CONCLUSION

From the above analyses and design of composite column as per IS 456:2000

Conclusions can be gained as follows:

When there is restriction imposed by architects on size of column, then composite column is the best suited. Steel option is better than R.C.C. if we consider time as a constraint but option of composite is best among all three options (RCC, Steel, and Composite) for high rise building

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