

Effect of Relative Dimensions of Beam and Column Members of RC Portal Frames on the Cost of the Frames

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ABSTRACT: The effect of the ratio of moment of inertia of beam members (I_1) and that of column members (I_2) on the total cost of portal frames has been studied by designing five hundred and sixty RC portal frames. The effect of ratio of I_1/I_2 on the quantities of steel and concrete has been investigated. The variation of cost with the increase in the ratio of height to span has also been investigated.

Notations:

b- Breadth of cross section.

d- Effective depth cross section.

f_{ck} - Characteristic compressive strength of concrete.

f_y - Characteristic yield strength of steel.

I_1 - Moment of inertia of cross section of beam member.

I_2 - Moment of inertia of cross section of column member.

L- Span of portal frames.

s- Spacing of portal frames.

M_u - Ultimate moment of resistance of beam sections.

w_u - Total ultimate load acting per unit length on the beam member.

KEY WORD: Portal frames, Spacing, Span, Moment of inertia, Cost per unit area

1. INTRODUCTION

Reinforced concrete portal frames are widely used in industrial buildings, community halls and bridges to support RC slabs over them. At present no literature is available on the economical aspects related to the relative dimensions of beam and column members of portal frames and the spacing of the frames.

Scope

In this investigation the following parameters have been considered.

Span, L = 5m, 10m, 15m and 20m

Spacing of frames = 4m, 4.5m, 5m, 5.5m and 6m

I_1/I_2 = 0.5, 1, 1.5, 2, 3, 4 and 5

h/l = 0.2, 0.3, 0.4 and 0.5

Live load on RC slab = 2kN/m²

Grade of concrete = M20

Grade of steel = Fe 415

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

Cost of concrete = Rs 4850/m³

Cost of steel = Rs 4600/kN

Cost of formwork = Rs 450/m²

Bearing capacity of soil = 180kN/m²

The method of analysis and design are based on the reference No 1 and the Indian Standard Code of practice No 456-2000. The special publication, SP-16 Design Aids of Reinforced Concrete has been made use of wherever necessary.

The MS excel program has been made use of to design all the five hundred and sixty RC slab- portal frame systems and to estimate their costs.

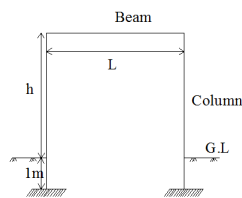


Fig 1

II. STEPS FOLLOWED FOR THE ANALYSIS AND DESIGN

Step: 1 Length, L, height, h and spacing of frames is selected.

Step: 2 The RC continuous slab is designed using the bending moment coefficients given in IS 456: 2000.

Step: 3 Initially the breadth, b of the beam member is assumed. By taking depth $d = 2b$ and taking $M_u = 0.138 \cdot f_{ck} \cdot b \cdot d^2$, the value of d is obtained where $M_u = w_u \cdot l^2 / 12$. Breadth of column is taken equal to the width of beam.

Step: 4 The value of I_1/I_2 is assumed and then, the depth D of the column is determined. The load transmitted by the slab on the beam member of the portal frame and the self weight of the beam member are then calculated.

Step: 5 The depth of the isolated footing foundation is assumed as 1m. The end conditions of columns are assumed as fixed. Relative stiffness value is calculated as $k = I/L$ for beam members and

$k = I/L$ for column members

Analysis of portal frames is carried out by the moment distribution method.

Step: 6 The mid span section of beam member is designed as a Tee beam section and the end section as a rectangular section as the end section is subjected to hogging moment. Limit state method of design is adopted.

Step: 7 The column section is also designed by the limit state method of design. Then the isolated footing foundation is designed.

Step: 8 The quantities of steel, concrete and formwork are calculated per spacing of portal frames.

Step: 9 The total cost of slab, portal frame and foundation per spacing of portal frames is estimated.

Step: 10 The cost per unit area covered, equal to total cost divided by $L \cdot s$, is calculated.

III. EFFECT OF I_1/I_2 ON THE COST OF PORTAL FRAMES

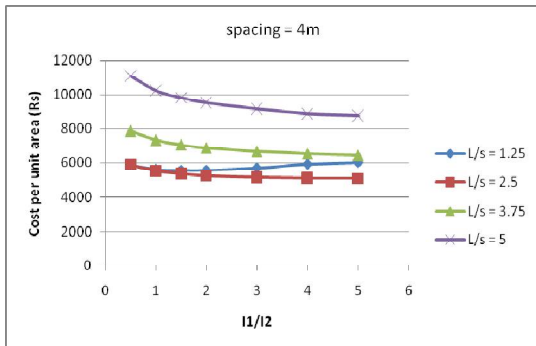


Fig. 2

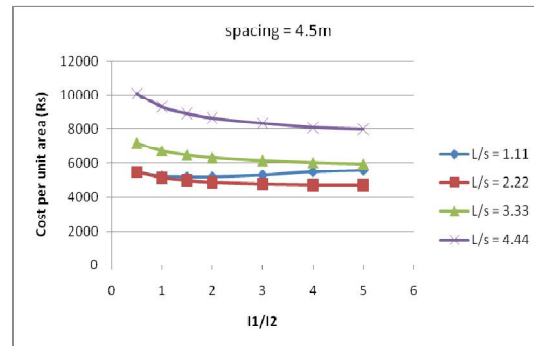


Fig. 3

Fig. 2 shows the effect of I_1/I_2 ratio on the cost of portal frames of spacing 4m for various L/s values and Fig. 3 shows the effect of I_1/I_2 ratio on the cost of portal frames of spacing 4.5m for various L/s values.

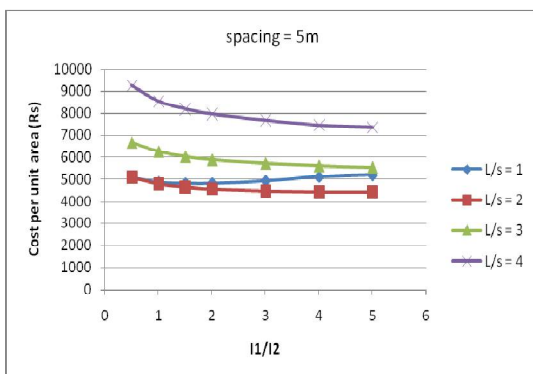


Fig. 4

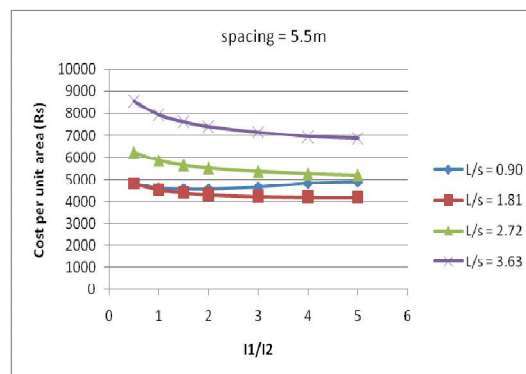


Fig. 5

Fig. 4 shows the effect of I_1/I_2 ratio on the cost of portal frames of spacing 5m for various L/s values and Fig. 5 shows the effect of I_1/I_2 ratio on the cost of portal frames of spacing 5.5m for various L/s values.

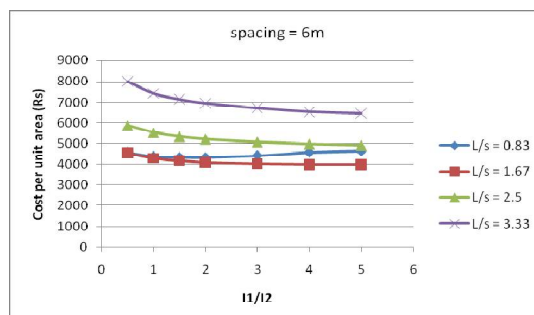


Fig. 6

Fig. 6 shows the effect of I_1/I_2 ratio on the cost of portal frames of spacing 6m for various L/s values.

IV. EFFECT OF h/L ON THE COST OF PORTAL FRAMES

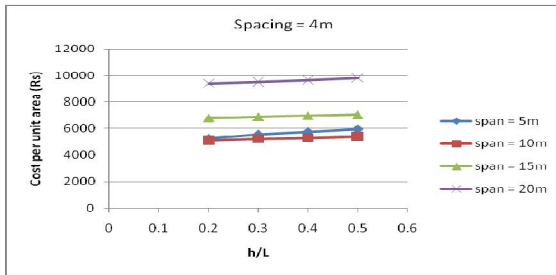


Fig. 7

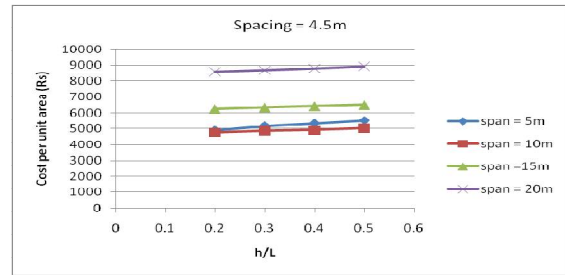


Fig. 8

Fig. 7 shows the effect of h/L ratio on the cost of portal frames of spacing 4m for various span values and Fig. 8 shows the effect of h/L ratio on the cost of portal frames of spacing 4.5m for various span values.

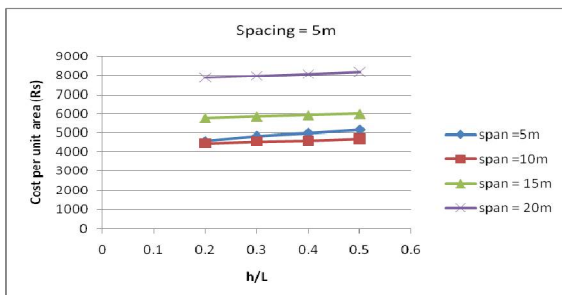


Fig 9

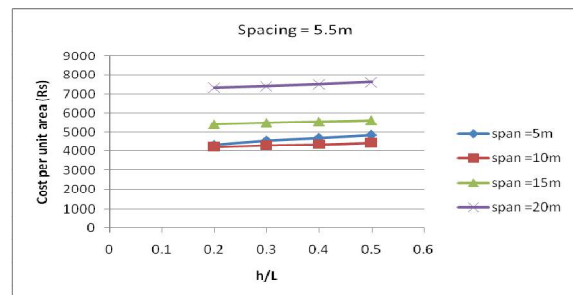


Fig. 10

Fig. 9 shows the effect of h/L ratio on the cost of portal frames of spacing 5m for various span values and Fig. 10 shows the effect of h/L ratio on the cost of portal frames of spacing 5.5m for various span values.

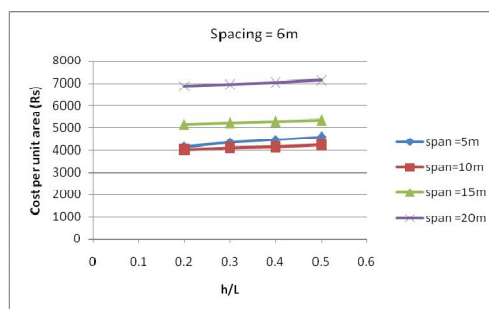


Fig 11

Fig. 11 shows the effect of h/L ratio on the cost of portal frames of spacing 6m for various span values.

V. CONCLUSIONS

From figures 2 to 6 the following could be concluded.

- i. For span to spacing ratio (L/s) of portal frames less than 1.25, $I_1/I_2 = 2$ gives economical design.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

- ii. For L/s greater than 1.25, the ratio $I_1/I_2 = 3$ to 4 results in the most economical design.
- iii. From figure 7 to 11 it could be concluded that the variation of cost per unit area covered with h/L ratio is linear.

VI. ACKNOWLEDGEMENT

The authors thank the management of Bannari Amman Institute of Technology for providing all the necessarfacilities for carrying out this investigation.

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