

Economical Design of R.C Elements

S.L.Sivasubramanian¹, S.Kearthi², M.Gobinath³, R.Deepan⁴

P.G. Scholar, Department of Civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, India¹

P.G. Scholar, Department of Civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, India² P.G.

Scholar, Department of Civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, India³

P.G. Scholar, Department of Civil Engineering, Bannari Amman Institute of technology, Sathyamangalam, India³

ABSTRACT: The following types of reinforced concrete beams are analyzed, designed and the total cost of each of these has been estimated.

1. Singly reinforced beam.
2. Doubly reinforced beam.
3. T-beam with slab

The singly reinforced beams are designed for flexure by varying the span, Live Load, L/d ratio, B/D ratio, Grade of concrete and Grade of steel. Similarly doubly reinforced beams are designed for flexure for the same variables indicated in singly reinforced beams, by reducing the depth of singly reinforced beams and considering do/d ratio. The T-beam with slabs are designed for flexure by varying the spacing of T-beams, Live load, Grade of concrete and Grade of steel.

Based on the design of ten thousand singly reinforced beams, ten thousand doubly reinforced beams and four hundred and twenty three T-beam with slabs, the most economical section for each of these structural members have been found out. The results of this investigation are very useful to all Structural design Engineers.

KEYWORDS: Live load, Grade of concrete, Grade of steel, L/d ratio, B/D ratio, do/d ratio and Spacing of T-beams

I. INTRODUCTION

Reinforced concrete structural members could be designed using different grades of concrete and steel. To identify that combination of the grade of concrete and the grade of steel which would result in the lowest cost to resist a given load is a problem of structural design.

SCOPE OF THE INVESTIGATION

The singly reinforced beams are designed for flexure by varying

- Span (4m, 6m, 8m, 10m)
- Live Load (2 kN/m, 4 kN/m, 6 kN/m, 8 kN/m, 10 kN/m)
- L/d ratio (12, 14, 16, 18, 20)
- b/d ratio (0.2, 0.4, 0.6, 0.8, 1)
- Grade of concrete (20 N/mm², 25 N/mm², 30 N/mm², 35 N/mm², 40 N/mm²)
- Grade of steel (250 N/mm², 415 N/mm², 500 N/mm², 550 N/mm²)

The Doubly reinforced beams are designed for flexure by varying

- Span (4m, 6m, 8m, 10m)
- Live Load (2 kN/m, 4 kN/m, 6 kN/m, 8 kN/m, 10 kN/m)
- do/d (0.9, 0.8, 0.7, 0.6, 0.5)
- b/d ratio (0.2, 0.4, 0.6, 0.8, 1)
- Grade of concrete (20 N/mm², 25 N/mm², 30 N/mm², 35 N/mm², 40 N/mm²)
- Grade of steel (250 N/mm², 415 N/mm², 500 N/mm², 550 N/mm²)

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- L/d (20)

The T-beam with slabs are designed for flexure by varying

- Spacing of T-beam (2m, 2.2m, 2.4m, 2.6m, 2.8m, 3m, 3.2m)
- Live load (2 kN/m², 2.5 kN/m², 3 kN/m²)
- Grade of concrete (20 N/mm², 25 N/mm², 30 N/mm², 35 N/mm², 40 N/mm²)
- Grade of steel (250 N/mm², 415 N/mm², 500 N/mm², 550 N/mm²)

MS –Excel has been used for the design of all the above mentioned structural components. The estimation of cost of each of the designed structural element has been done. Based on the design and the estimated cost of all these type of R.C structural elements, the most economical section in each case has been arrived.

R.C.SINGLY REINFORCED BEAMS

A reinforced concrete flexure member should be able to resist tensile, compressive and shear stresses induced in it by the loads acting on the member. Concrete is fairly strong in compression but very weak in tension. Plain concrete members are thus limited in carrying capacity by the low tensile strength. Steel is very strong in tension. Thus, the tensile weakness of concrete is overcome by the provision of reinforcing steel in the tension zone round the concrete to make a reinforced concrete member. A reinforced concrete flexure members may be a beam, slab, wall or component of a foundation. The basic approach of design of a flexural members is the same whereas the details may differ. The designs are done as per IS 456 codal provision.

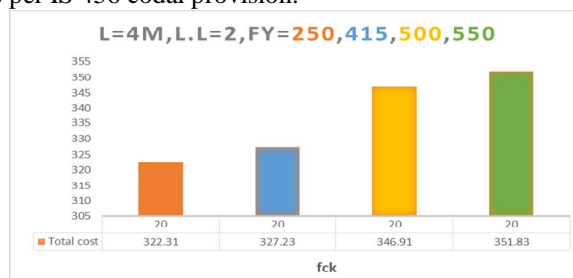


Fig.1 Result of singly reinforced beams for Span = 4m, L.L = 2 kN/m.



Fig.2 Result of singly reinforced beams for Span = 6m, L.L = 6 kN/m.

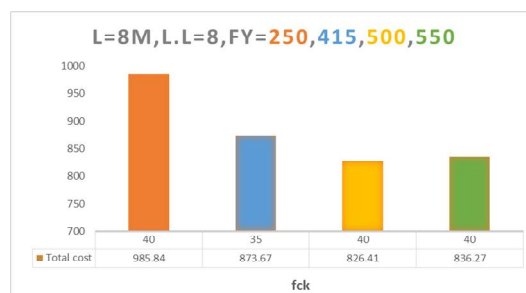


Fig.3 Result of singly reinforced beams for Span = 8m, L.L = 8 kN/m.

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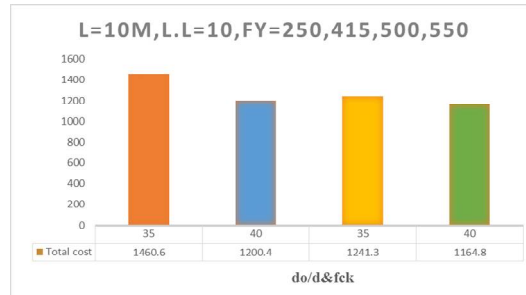


Fig.4 Result of singly reinforced beams for Span = 10m, L.L =10 kN/m.

R.C.DOUBLY REINFORCED BEAMS

Concrete has very good compressive strength and almost negligible tensile strength. Hence, steel reinforcement is used on the tensile side of concrete. Thus, singly reinforced beams reinforced on the tensile face are good both in compression and tension. However, these beams have their respective limiting moments of resistance with specified width, depth and grades of concrete and steel. The amount of steel reinforcement needed is known as $A_{st,lim}$. Problem will arise, therefore, if such a section is subjected to bending moment greater than its limiting moment of resistance as a singly reinforced section. The reinforced concrete beams having steel reinforcement both on tensile and compressive faces are known as doubly reinforced beams. Doubly reinforced beams, therefore, have moment of resistance more than the singly reinforced beams of the same depth for particular grades of steel and concrete. In many practical situations, architectural or functional requirements may restrict the overall depth of the beams. The designs are done as per IS 456 codal provision.

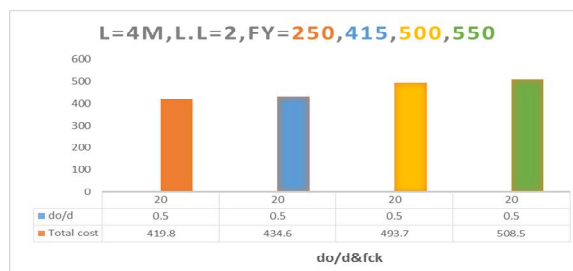


Fig.5 Result of doubly reinforced beams for Span = 4m, L.L = 2 kN/m.

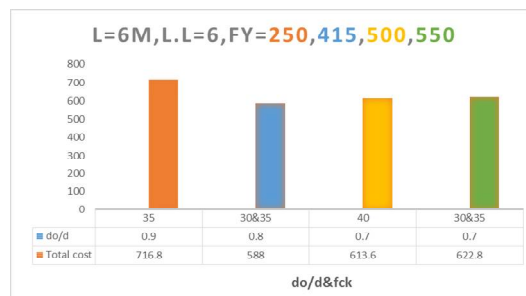


Fig.6 Result of doubly reinforced beams for Span = 6m, L.L = 6 kN/m.

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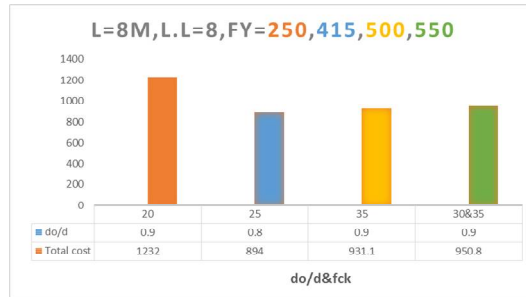


Fig.7 Result of doubly reinforced beams for Span = 8m, L.L = 8 kN/m.

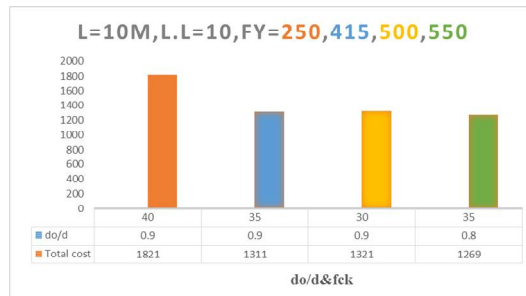


Fig.8 Result of doubly reinforced beams for Span = 10m, L.L = 10 kN/m.

R.C.T-BEAMS WITH SLABS

When a concrete is cast monolithically it is connected to rectangular beams, a portion of the slab above the beam behaves structurally as a part of the beam in compression. The slab portions is called flange and the beam portion is called the web. The flange portion of the beam gets projected on either sides of the rectangular web or rib. The resulting cross section resembles the T-shape and hence it is called a T-beam section. The designs are done as per IS 456 codal provision.

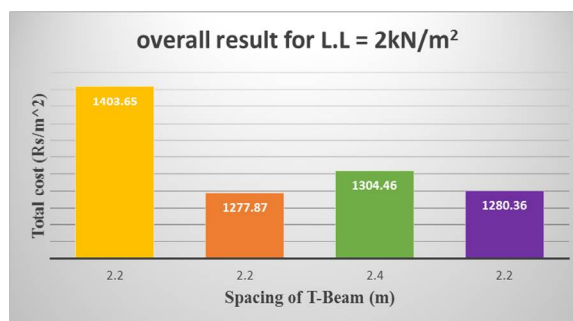


Fig.9 Result of T-beam with slabs for L.L= 2 kN/m².

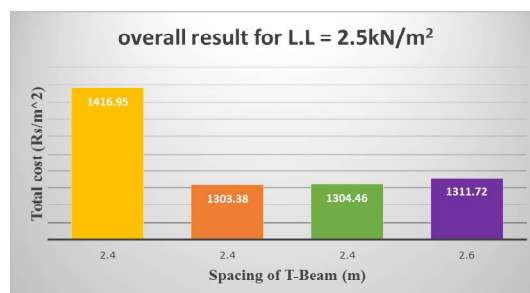


Fig.10 Result of T-beam with slabs for L.L= 2.5 kN/m².



Fig.11 Result of T-beam with slabs for L.L= 3 kN/m².

II. RESULT AND DISCUSSION

CONCLUSIONS ON R.C.SINGLY REINFORCED BEAMS

In this study, ten thousand singly reinforced beams have been designed for flexure by varying the span from 4m to 10m, live load from 2kN/m to 10kN/m, L/d ratio from 12 to 20, b/d ratio 0.2 to 1, grade of concrete from 20N/mm² to 40N/mm² and adopting four grades of steel namely Fe-250, Fe-415, Fe-500 and Fe-550.

It is found

- That the combination of M20 grade of concrete and Fe-250 grade of steel results in the most economical section for the span 4m and live load 2kN/m.(Fig 1)
- That the combination of M30 or M35 grade of concrete and Fe-250 grade of steel results in the most economical section for the span 4m and live load 4kN/m.
- That the combination of M35 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 4m and live load 6kN/m.
- That the combination of M35 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 4m and live load 8kN/m.
- That the combination of M40 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 4m and live load 10kN/m.
- That the combination of M20 grade of concrete and Fe-250 grade of steel results in the most economical section for the span 6m and live load 2kN/m.
- That the combination of M25 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 6m and live load 4kN/m.
- That the combination of M35 grade of concrete and Fe-550 grade of steel results in the most economical section for the span 6m and live load 6kN/m. (Fig 2)
- That the combination of M40 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 6m and live load 8kN/m.
- That the combination of M35 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 6m and live load 10kN/m.
- That the combination of M20 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 8m and live load 2kN/m.
- That the combination of M25 grade of concrete and Fe-550 grade of steel results in the most economical section for the span 8m and live load 4kN/m.
- That the combination of M40 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 8m and live load 6kN/m.
- That the combination of M40 grade of concrete and Fe-500 grade of steel results in the most economical section for the span 8m and live load 8kN/m. (Fig 3)
- That the combination of M40 grade of concrete and Fe-550 grade of steel results in the most economical section for the span 8m and live load 10kN/m.
- That the combination of M20 grade of concrete and Fe-550 grade of steel results in the most economical section for the span 10m and live load 2kN/m.

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- That the combination of M30 or M35 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 10m and live load 4kN/m.
- That the combination of M35 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 10m and live load 6kN/m.
- That the combination of M40 grade of concrete and Fe-415 grade of steel results in the most economical section for the span 10m and live load 8kN/m.
- That the combination of M40 grade of concrete and Fe-550 grade of steel results in the most economical section for the span 10m and live load 10kN/m. (Fig 4)

III. CONCLUSIONS ON R.C.DOUBLY REINFORCED BEAMS

In this study, ten thousand doubly reinforced beams have been designed for flexure by varying the span from 4m to 10m, live load from 2kN/m to 10kN/m, L/d ratio from 12 to 20, b/d ratio from 0.2 to 1, do/d ratio from 0.5 to 0.9, grade of concrete from 20N/mm² to 40N/mm² and adopting four grades of steel namely Fe-250, Fe-415, Fe-500 and Fe-550.

It is found

- That the combination of M20 grade of concrete, Fe-250 grade of steel and 0.5 do/d ratio results in the most economical section for the span 4m and live load 2kN/m. (Fig 5)
- That the combination of M20 grade of concrete, Fe-415 grade of steel and 0.6 do/d ratio results in the most economical section for the span 4m and live load 4kN/m.
- That the combination of M20 grade of concrete, Fe-415 grade of steel and 0.7 do/d ratio results in the most economical section for the span 4m and live load 6kN/m.
- That the combination of M30 or M35 grade of concrete, Fe-415 grade of steel and 0.8 do/d ratio results in the most economical section for the span 4m and live load 8kN/m.
- That the combination of M30 or M35 grade of concrete, Fe-415 grade of steel and 0.5 do/d ratio results in the most economical section for the span 4m and live load 10kN/m.
- That the combination of M40 grade of concrete, Fe-250 grade of steel and 0.5 do/d ratio results in the most economical section for the span 6m and live load 2kN/m.
- That the combination of M35 grade of concrete, Fe-415 grade of steel and 0.6 do/d ratio results in the most economical section for the span 6m and live load 4kN/m.
- That the combination of M30 or M35 grade of concrete, Fe-415 grade of steel and 0.8 do/d ratio results in the most economical section for the span 6m and live load 6kN/m. (Fig 6)
- That the combination of M35 grade of concrete, Fe-550 grade of steel and 0.8 do/d ratio results in the most economical section for the span 6m and live load 8kN/m.
- That the combination of M35 grade of concrete, Fe-550 grade of steel and 0.9 do/d ratio results in the most economical section for the span 6m and live load 10kN/m.
- That the combination of M20 grade of concrete, Fe-415 grade of steel and 0.5 do/d ratio results in the most economical section for the span 8m and live load 2kN/m.
- That the combination of M30 grade of concrete, Fe-415 grade of steel and 0.7 do/d ratio results in the most economical section for the span 8m and live load 4kN/m.
- That the combination of M40 grade of concrete, Fe-550 grade of steel and 0.7 do/d ratio results in the most economical section for the span 8m and live load 6kN/m.
- That the combination of M25 grade of concrete, Fe-415 grade of steel and 0.8 do/d ratio results in the most economical section for the span 8m and live load 8kN/m.(Fig 7)
- That the combination of M40 grade of concrete, Fe-550 grade of steel and 0.9 do/d ratio results in the most economical section for the span 8m and live load 10kN/m.
- That the combination of M35 grade of concrete, Fe-415 grade of steel and 0.5 do/d ratio results in the most economical section for the span 10m and live load 2kN/m.
- That the combination of M35 grade of concrete, Fe-500 grade of steel and 0.7 do/d ratio results in the most economical section for the span 10m and live load 4kN/m.

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- That the combination of M35 grade of concrete, Fe-500 grade of steel and 0.8 do/d ratio results in the most economical section for the span 10m and live load 6kN/m.
- That the combination of M30 or M35 grade of concrete, Fe-550 grade of steel and 0.9 do/d ratio results in the most economical section for the span 10m and live load 8kN/m.
- That the combination of M35 grade of concrete, Fe-550 grade of steel and 0.8 do/d ratio results in the most economical section for the span 10m and live load 10kN/m.(Fig 8)

IV. CONCLUSIONS ON R.C.T-BEAMS WITH SLABS

In this study, four hundred and twenty three T-beams with slabs are designed for flexure by varying the spacing of T-beam from 2m to 3.2m, live load from 2kN/m² to 3kN/m², grade of concrete from 20 N/mm² to 40N/mm², and adopting four grades of steel namely Fe-250, Fe-415, Fe-500 and Fe-550.

It is found

- That the combination of M20 grade of concrete, Fe-415 grade of steel and 2.2m Spacing of T-beam results in the most economical section for the Live Load = 2 kN/m². (Fig 9)
- That the combination of M20 grade of concrete, Fe-415 grade of steel and 2.4m Spacing of T-beam results in the most economical section for the Live Load = 2.5 kN/m². (Fig 10)
- That the combination of M20 grade of concrete, Fe-550 grade of steel and 2.4m Spacing of T-beam results in the most economical section for the Live Load = 3 kN/m². (Fig 11)

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