International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 02 | Feb 2022 www.irjet.net p-ISSN: 2395-0072

Experimental Investigation on Effect of Curtailed reinforcement in R.C beams

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Abstract - *A study on the effect of curtailed reinforcement in RC beams is presented in this project. In this study, it is discussed how curtailed reinforcement may affect crack width and failure mechanisms, as well as deformation in RC beams. We compare beams with and without curtailed reinforcement here. For this study, The beam's cross section is 1200mm*150mm*150mm, with 3 numbers of 12mm diameter rods on top, 3 numbers of 8mm diameter rods on the bottom, and 9 numbers of 8mm diameter stirrups on the shear reinforcement. The grade of concrete and steel are M 25 and Fe 415.*

Key Words: Curtailed reinforcement, Shear reinforcement, Crack width, Deformation.

1. INTRODUCTION

In reinforced concrete structures, curtailed reinforcement is commonly used. Especially in continuous beams, where reinforcement is frequently reduced to match the length of the hogging moment for an optimised design. Curtailed reinforcement is also commonly used in structures that require additional reinforcement for practical reasons. It is considered safe to add additional reinforcement here.

1.1 Reinforced concrete beam

Reinforced cement concrete is a composite material in which the relatively low tensile strength and ductility of concrete are offset by the addition of reinforcement with higher tensile strength and ductility. Reinforcing structures are typically designed to withstand tensile stresses in specific areas of the concrete that could result in unacceptable cracking and structural failure. IS 456: 2000 guidelines were used to design the beam.

1.2 Steel reinforcement

Construction is one of the most important steel-using industries, accounting for more than half of total global steel production. High-quality steel is 96.5 percent iron with about 2% carbon added. It also contains 1.5 percent manganese, which contributes to its tensile strength. Chromium is also added to stainless steel. There is a fear of scarcity of these naturally occurring components, as well as rising prices, which is challenging human societies around the world to find solutions. As a civil engineer, one method for reducing steel usage in the construction industry without sacrificing structural quality is to reduce the steel used in reinforced concrete beams.

1.3 Curtailed reinforcement

Flexural reinforcement must be extended beyond the point where it is no longer required to resist flexure for a distance equal to the effective depth of the member or 12 times the bar diameter, whichever is greater, except at a simple support or at the end of a cantilever.

When the resistance moment of the section, considering only the continuing bar, equals the bending moment, reinforcement is no longer required to resist flexure. Despite the fact that reinforcement curtailment is so widely used, the amount of analytical work conducted to study the influence of curtailment appears to be rather low.

Curtailment is a theoretical point where some of the reinforcement is removed along the span of the beam where the bending moment decreases, assuming that the remaining reinforcement can support the reduced bending moment. The steel is adjusted to account for changes in bending moment across a section. Congestion of bars can also be avoided, improving concrete compaction. It is done primarily to save money on the design of a flexural member by shortening the tensile bars at the section beyond which flexure resistance is no longer required.

Curtailment can be used on simply supported beams, but it is usually not cost effective, and the real benefits come from repetitive multi-span beams (continuous beams) and slabs. It can also be used to make construction easier by shortening bars to more manageable lengths.

1.4 Advantages of Curtailed reinforcement

- By reducing the reinforcement, the amount of steel used can be reduced.
- Reinforcement curtailment can result in a 15% to 25% reduction in the amount of steel used.
- Construction costs are low.

- The structure's weight can be reduced.

2. EXPERIMENTAL INVESTIGATIONS

2.1 Materials used

- **Cement**

All of the specimens were cast with ordinary Portland cement (OPC) of grade 53 and specific gravity 3.15.

- **Fine aggregate**

Manufactured sand (M-Sand) is a concrete construction material that can be used in place of river sand. Crushing hard granite stone yields manufactured sand.

As a construction material, the crushed sand is cubical in shape with grounded edges, washed, and graded. Manufactured sand (M- Sand) has a particle size of less than 4.75mm.

- **Coarse aggregate**

The specimens were cast using crushed granite aggregate with a specific gravity of 2.6, passing through 20mm and remaining on 12.5mm.

- **Water**

The portable water was used for casting and curing the specimens.

2.2 Specimen details

Six series of specimens were cast based on the results of slump cone, compressive, and split tensile testing.

Six specimens were cast, three of which were beams with curtailed reinforcement and three of which were beams without curtailed reinforcement.

The specimen properties, loading method, and bond strengths obtained are summarised in the table below.

No.	Specimen details	
1	Size of specimen	150mm x 150mm
2	Length of specimen	1200mm
3	Diameter of the rods used	8mm & 12mm
4	Grade of concrete	M25
5	Grade of steel	Fe415
6	Mix Ratio	1:1:2

Table -1: Specimen details

2.3 Loading details

Table -2: Loading details

S.No.	Type of loading	Load value
1	Static compressive loading	500KN

2.4 Mix proportioning

M25 concrete with 20mm coarse aggregate was used. The material quantities used per cubic metre of concrete were as follows:

Table -3: Mix proportioning

S.No	Material	Quantity
1	Cement	448.6 kg/m^3
2	Water	197.4kg/m^3
3	Fine aggregate	752.71kg/m^3
4	Coarse aggregate	1064.65 kg/m^3
5	Water/Cement ratio	0.45

2.5 Casting of specimens

Six series of static compressive loading on reinforced concrete beams were performed with the assistance of a loading frame. Three of them were carried out to investigate the effect of reinforcing the beams, while the other three were used to compare the beams with and without reinforcing the beams.

Four specimens were cast with HYSD bars of 8mm and 12mm diameter and varying lengths.

2.6 Reinforcement details:

Table - 4: Reinforcement details

S.No.	Reinforcement details
1	8mm - 5 No.s of 1200mm & 1 No. of 378mm
2	12mm - 5 No.s of 1200mm & 1 No. of 563mm

2.7 Curing of the specimens:

The maximum strength of the concrete is obtained by curing for a period of 28 days. For curing, Jute sacks were used. During the curing process, Wet and damp environment was maintained.

2.8 Casting of the specimens:

The specimens were cast at the laboratory

Figure -1: Reinforcement without curtailment

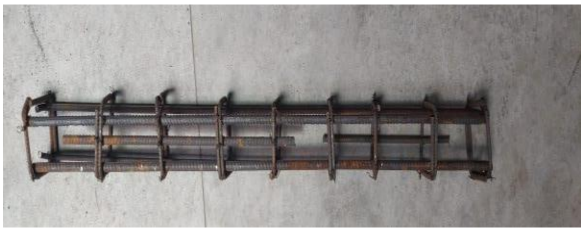


Figure -2: Reinforcement with curtailment

Figure -3: Casting of beam specimens

3. Experimental setup

Figure - 4: Experimental setup

The testing of beams is done in the loading frame which is available in the Structural Engineering Laboratory, Sri Krishna Collage of Technology. The testing procedure is same for all the six specimens. With static load, until failure under two point loading, the beams were tested. The rails were used to transfer the load to the test specimen through two loading using rollers. The dial gauge is noted for the deflection of the beam. The propagation and crack development were marked and the mode of failure was recorded.

4. Testing of beams:

Testing is done for six beams one after the other. Three beams are with curtailed reinforcements and three beams of conventional reinforcement. The dial gauge readings are noted for the gradual increase in load and deformation of the beams. The deformation readings are shown in the dial gauge. The load is applied till the ultimate failure of the beam and at which the first crack is developed is recorded as cracking load of the beam.

The deflection with respect to load for the beams with conventional and curtailed reinforcement are recorded and furnished in the table. The data furnished in this chapter has been interpreted and discussed to obtain the conclusion.

5. Crack developments

i) Beam without curtailed reinforcement:

Figure -5: Crack development in Beam without curtailed reinforcement

ii) Beam with curtailed reinforcement:

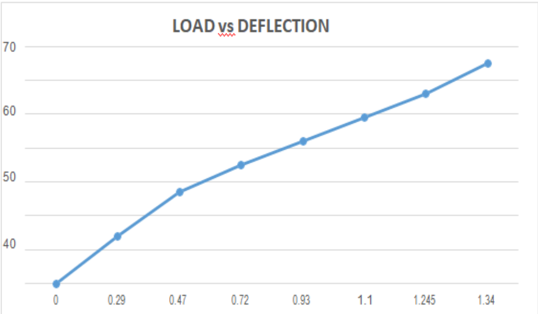
Figure - 6: Crack development in Beam with curtailed reinforcement

6. Graphs

6.1 Graphs without curtailment

Specimen 1

Load (kN)

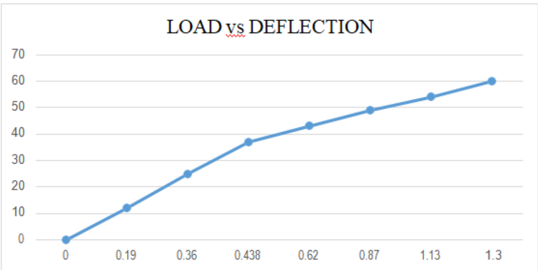


Deflection (mm)

Figure -7: Load v/s deflection for beam without curtailed reinforcement specimen 1

Specimen 2

Load (kN)

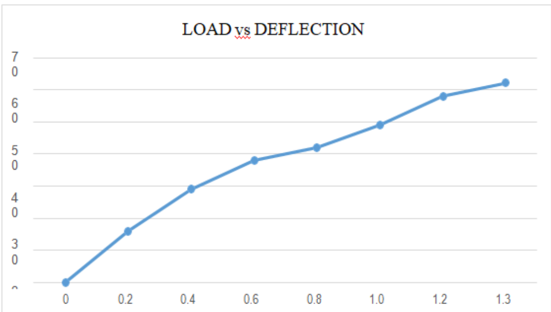


Deflection (mm)

Figure -8: Load v/s deflection for beam without curtailed reinforcement specimen 2

Specimen 3

Load (kN)



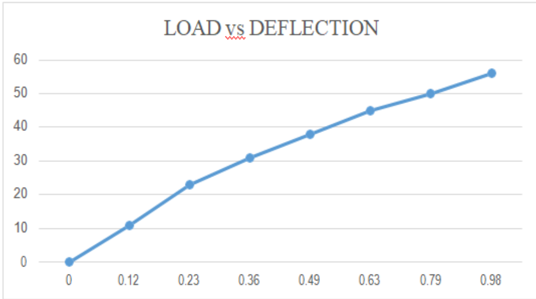
Deflection (mm)

Figure -9: Load v/s deflection for beam without curtailed reinforcement specimen 3

6.2 Graphs with curtailment

Specimen 1

Load (kN)

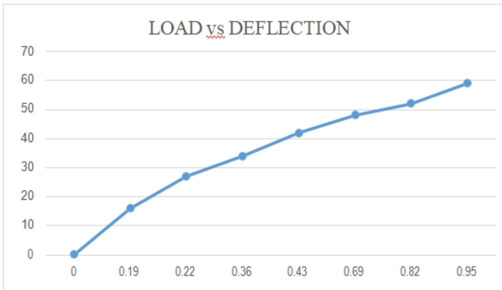


Deflection (mm)

Figure -10: Load v/s deflection for beam with curtailed reinforcement specimen 1

Specimen 2

Load (kN)

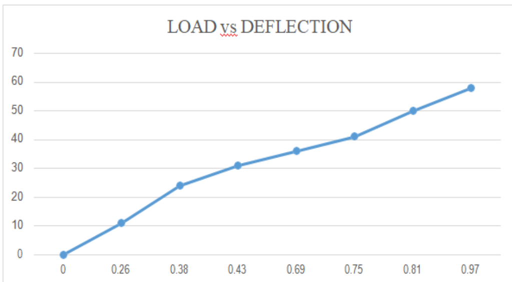


Deflection (mm)

Figure -11: Load v/s deflection for beam with curtailed reinforcement specimen 2

Specimen 3

Load (kN)



Deflection (mm)

Figure -12: Load v/s deflection for beam with curtailed reinforcement specimen 3

7. Discussions

7.1 Comparison of R.C beam with and without curtailment

When comparing the results, the amount of deflection for RC beam with curtailed reinforcement is same when compared with RC beam without curtailed reinforcement, as well as beam with curtailed reinforcement consume low amount of steel than RC beam without curtailment.

7.2 Comparison of Analytical results

Table - 5: Comparison of Analytical results

S.No	Type of beam	Load (KN)	Deformation (mm)
1	RC Beam without curtailment	50	1.080
2	RC Beam with curtailment	50	0.988

8. Conclusions

- The deformation for the curtailed reinforced beam is same ascompared with conventional RC beam.
- 10.65% of steel reduction is obtained in Beam with curtailed reinforcement.
- Due to reduction in steel, the excess steel can be used for other purposes.
- From the above test results, it can be concluded that self weight of the beam can be reduced.
- Cost and labour for the curtailed reinforcement is reduced as it is an advantage for the cost efficient projects.

9. References

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