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EFFECT OF VARIATION OF SHEAR REINFORCEMENT IN REINFORCED CONCRETE BEAM

Richa Para[1], Prof.Archana Tiwari[2]

[1]*PG Student, Department of Civil Engg.,MITS Gwalior*
[2] *Professor,Department of Civil Engg., MITS Gwalior*

Abstract:Reinforced concrete is one of the most important building materials and is widely used in many types of engineering structures. To predict exact behavior of element detailed properties and behavior of RC elements under different Reinforcement conditions is needed. In present study investigated Crack identification of beam using various shear reinforcement such as stirrups in vertical, inclined and combinations form. So in this study three type of beam, total nine beam casted. Laboratory tests are carried out on a beam dimension 750mm x 150mm x 150mm of M25 grade of concrete for reinforced cement concrete beam. The variable of the investigation ratio of shear span to effectivedepth (a,/d) is constant in all beams. The specimen was water cured for 28 days and tested with three-pointload. Beam are loaded under three-point loading by usinguniversal testingmachine. The diagonal crack width was measure by micrometer crack measure instruments.Crack width of beam compared with the maximum load found during crack formation on RCC beam.

Keywords: Concrete, RCC beam, Deflection, stirrups, Reinforcement, shear span to depth ratio ($\frac{a_v}{d}$).

I. Introduction

Reinforced concrete beams and columns are most common structural members in civil engineering structures. The main objective of the structural design is that the structure must satisfy the serviceability limit states. A concrete structure is said to be durable when it performs satisfactorily in the working environment during its anticipated exposure conditions throughout its working life. Structures designed by limit state of collapse must be checked for deflection and width of cracks. The cracks in the concrete occur when the tensile strength of the concrete is lesser than the nominal tensile stress in concrete. Excessive cracking of concrete and deflection seriously affects the appearance and durability of the structure. Generally, beams may fail in flexure or shear. The combined bending and shear failure takes place when the beam reached its ultimate load. The inclined shear cracks may develop before or after the flexural crack formation in the beam. Analysis of rectangular beams of reinforced concrete is based on nonlinear and/or discontinuous stress-strain relationships and such analyses are difficult to perform. Provided the nature of loading, the beam dimensions, the materials used and the quantity of reinforcement are known, the theory of reinforced concrete permits the analysis of stresses, strains, deflections, crack width and also the collapse load. Cracks is generally wider than the flexural cracks and occurred in the shear zone which is nearer to the supports. The width of the shear crack was greater in vertical shear reinforced beams than in inclined shear reinforced beam.

Biao Hu et. al. (2017) performed an experimental work and analysis of test results on diagonal cracking behavior of reinforced concrete (RC) beams that failed in shear. The value of Vs calculated in this way is generally larger than that obtained from the strains measured at mid-height of stirrups in the case of strong bond, while the difference is insignificant in the case of weak bond.**Ammash et. al. (2017)** conducted an experimental and theoretical study on reinforced concrete beams using steel strip plates. Five specimens with same dimensions and properties were used in this study. Four thicknesses of plates were used, 1mm 2mm, 3mm, and 4mm. The experimental results showed a good agreement in term of the ultimate load within the range of 99.86 – 113.33 % of the ultimate load of the reference beam. The steel strips work as a regular tie to control the cracks. The analytical result showed that there is a good agreement between the numerical results and the experimental results in the term.**Mohamed Zakaria (2009)** Conducted experimental investigation to clarify shear cracking behavior of reinforced concrete beams. the effects of the various influential parameters on the spacing between shear cracks and the relationship between shear crack width and stirrup strain at the intersection with shear cracks were shear cracks were carefully investigated.

II. Objectives of Study

The objective of this research is to obtain the suitable combinations of beam reinforcement by using stirrups as vertical, inclined and combination of inclined and vertical in RCC beam. The study performed to find shear crack and beam strength of RCC beam in which stirrups placed at various modes to minimize shear crack and find suitable maximum strength.

This study based on the performance on reinforced concrete beams. This objective was planned to be achieved by an experimental study on reinforced concrete beam elements. Accordingly, the scope and objective of this work have been set as follows:

- To study the crack propagation, and maximum crack spacing on beams.
- To find best combinations of stirrups for RCC beam for minimum shear.
- To identify the most effective shape of shear reinforcement bar to carry of shear force.

III. Materials Used

The following raw materials are used in the manufacturing of RCC beam.

- **Cement**

The Ordinary Portland Cement (OPC 43 grade) was used, Properties of cement were investigated in lab are shown in Table 1.

Table 1: Properties of Cement

S. No.	Properties	Result values
1.	Standard consistency %	33%
2.	Initial setting time	45 min
3.	Final setting time	300 min
4.	Specific gravity	3.15

- **Fine Aggregates**

The river sand was mixed in this investigation as fine aggregates it was free from natural contamination. The zone of fine aggregate was zone II as per IS specifications. The Properties of fine aggregate are given in table 2.

Table 2: Properties of Fine aggregates

S. No.	Test	Result
1.	Zone	II
2.	Specific gravity	2.6
3.	Fineness Modulus	3.76
4.	Water Absorption	0.6%

- **Coarse Aggregate:** Crushed stone of under 20mm size used as coarse aggregates.

Table 3: Properties of Coarse aggregate

S. No.	Properties	Values
1.	Specific Gravity	2.884
2.	Maximum Size	20mm
3.	Fineness	7.00
4.	Water absorption	0.40%

- **Water:** Potable water available in the laboratory was used. The water was free from organic impurities and its PH value was 6.5.

IV. Experimental Setup

In this study three types of RCC beam designed by using stirrups as inclined, vertical and combinations of both stirrups. Total nine simply supported beam casted using stirrups variations.The study performed to find out crack width and beam strength of RCC beam in which stirrups placed at various modes to minimize shear crack and optimize suitable maximum strength. All the beam were rectangular cross section 750mm*150mm*150mm.the ratio of shear span to effective depth is 2.6 same for all beam.

Ordinary Portland cement of 43 grade was used throughout this study and found conforming to the specification as per is code 8112:2013. This specific gravity of cement was found as 3.15. 20mm nominal size coarse aggregate and locally available river sand free from impurities as fine aggregate were used for concrete casting. this properties of the coarse and fine aggregate were tested accordance with is code 2386:1963. The concrete mix design was done as per is 10262-2009.the mix proportion was 1:1.71.:2.86 and the water cement ratio is 0.5 the mix design was also checked by concrete cubes after 28 days curing and the compressive strength was found 25N/mm^2

- Test specimen

Cube of size 150mm×150mm×150mm were cast IS 516-1959 to test the compressive strength of the concrete used for RC beam casting.

Table 4: Description of Specimen

Specifications	Reinforced concrete beams
Grade of Concrete	M25
Grade of steel	Fe415
Dimensions of Beam	750 mm × 150 mm × 150 mm
Reinforcement Steel bar	12 mm Ø bars(4)
Stirrups bar	8 mm Ø
Spacing of stirrups	125 mm

Figure 2: Beam Reinforcement with vertical Stirrups

Figure 3: Beam Reinforcement with Inclined Stirrups

Figure 4: Beam Reinforcement with combination of Stirrups

Figure 5: Casting of Reinforced concrete beam

V. Results and Discussion

In this investigation nineRCC beam are prepared by using proportions of cement, Sand, Coarse aggregate and water. Conventional method is used for making Beams. Beammoulds of size (750x150x150) mm were kept ready. First all the ingredients cement, sand and coarse aggregate were mixed thoroughly in dry state to make a homogeneous mixture. Then to the mixture of cement, sand and coarse aggregate, water is added gradually to achieve proper consistency.Mixing was done within 4-5 minutes.The moulds was filled with the wet mix and is vibrated by using vibrating table for 30 seconds. After finishing the brick samples were demoulded after 24 hours.After curing, the RCC beam loaded under three point by using compressive testing machine the load are gradually applied till the crack developed at bottom of the beam. tests were performed to optimize strength with minimum crack formation on the RCC beam. Table 5 shows the crack formations with respect to load in RCC beam using inclined stirrups.Table 6 shows the crack formations with respect to load in RCC beam using Vertical stirrups.Table 7 shows the crack formations with respect to load in RCC beam using combination stirrups.

And the cracks width measure is a high quality microscope. Themicroscope used for measuring crack widths in concrete members, masonry walls and other structures. The apparatus operates by an adjustable lamp unit and the image is focused by turning a knob. The eyepiece scale can be turned through 360° to align with the direction of the crack or pitch under examination. Which is designed specifically for measuring cracks in concrete This high-definition microscope is further enhanced by having its own adjustable light source for dark condition.

Figure 6: Micrometer used for measuring width of crack

Figure 7: Analyzing Beam Strength on Universal Testing Machine

Figure 8: Crack found on RCC beam using inclined stirrups

Figure 9: Crack found on RCC beam using Vertical stirrups

Figure 10: Crack found on RCC beam using Combination of both stirrups

Table 5: Crack width of Beam using Inclined stirrups

Beams	Crack width (mm)	Crack found at load (KN)
I1	0.2	58.55
I2	0.1	60.35
I3	1	84.35

Table 6: Crack width of Beam using Vertical stirrups

Beams	Crack width (mm)	Crack found at load (KN)
V1	0.4	38.55
V2	0.8	38
V3	0.9	48

Table 7: Crack width of Beam using combination stirrups

Beams	Crack width (mm)	Crack found at load (KN)
C1	1	45
C2	0.5	53.85
C3	0.5	74

- Load vs Crack width of beam using stirrups vertical, inclined and combinations

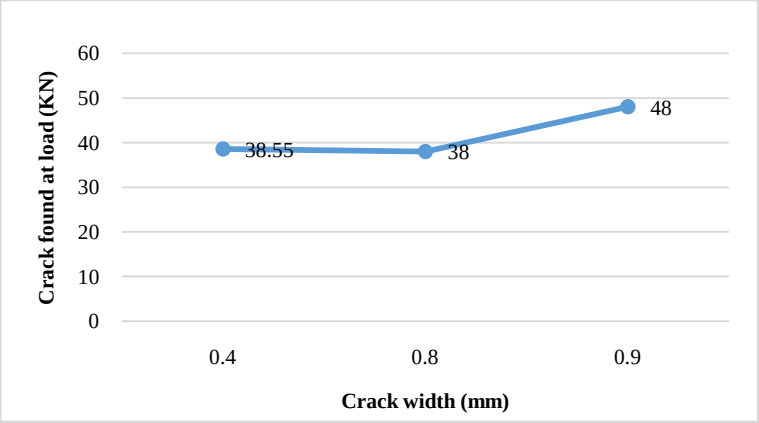

Figure 11: Load vs Crack in RCC beam using Vertical stirrups

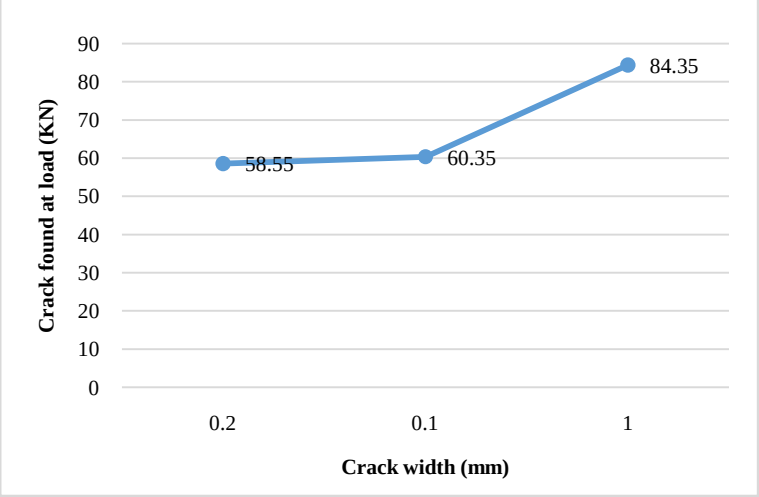

Figure 12: Load vs Crack in RCC beam using Inclined stirrups

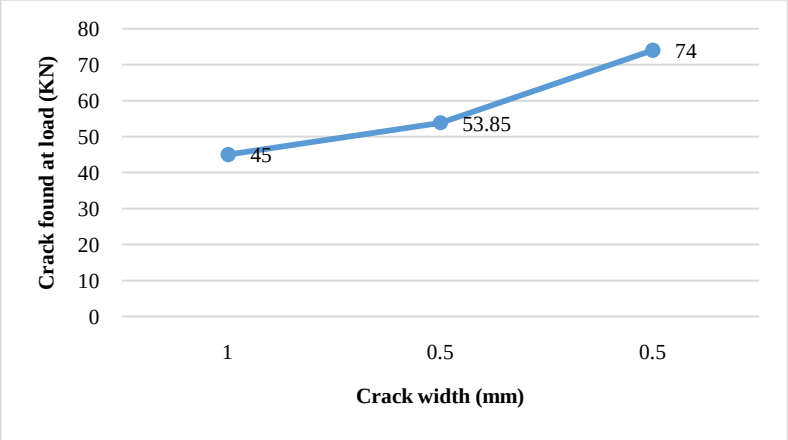

Figure 13: Load vs Crack in RCC beam using Combination of stirrups

Conclusion

The study deals with the flexural behavior of plain and RC beam under flexural loading. The following Conclusions can be drawn from the study.

- The shear strength and load carrying capacity was higher in beams with inclined stirrups than vertical stirrups shear reinforced beam.
- As per above study it is found that beam with inclined stirrups having maximum strength of 84.35 KN with crack width of 1mm.
- Minimum strength found on vertical stirrups using beam of 38 KN with 0.8 mm crack width.
- the above results, it is to conclude that beams with inclined stirrups reinforcements can show stable and good performance than the other shear reinforced beams.

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