ISSN 2321-2926

EXPERIMENTAL STUDY ON PERFORMANCE OF R.C.C BEAMS WITH VARIOUS ORIENTATIONS OF SHEARREINFORCEMENT

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Abstract: *The performance of shear reinforcement is determined by the ultimate shear strength, deflection, crack patterns and mode of failure. The shear reinforcement is provided in different forms. Each form has its own advantages in the performance of the R.C beams. In this work an investigation has been performed to compare the shear resisting capacities between beams with vertical, spiral stirrups. A total of two shear reinforced concrete beams are fabricated and casted with concrete and tested under two-point bending after 28 days. To evaluate the shear performance of different type of shear reinforcement, the beams must be designed for the same shear strength and a comparative study is made between these two types of shear reinforcement related to the performance of the beams pertaining to the ultimate strength, deflection and crack widths. The local carrying capacity of beam with spiral stirrups (SS1) was 9% more than that of beam with vertical stirrups (SV1). The crack widths were significantly reduced in beams with vertical stirrups (SV1) from 2.5 mm to 1.3 mm in beams with spiral stirrups (SS1). At service load the performance of the beam with spiral reinforcement (SS1) was more effective than that of beam with vertical stirrups (SV1). The deflection is reduced by 59% and crack widths are reduced by 25%.*

Key words: Shear reinforcement, Performance, R.C.C. Beams

1. BACKGROUND OF THE STUDY

Shear reinforcement is designed to resist shear forces in excess of the shear strength of concrete. They are provided in forms of vertical or spiral stirrups or longitudinal reinforcement bent up at 45 degrees at locations where they are no longer needed to resist bending.

Concrete beams are reinforced with steel rods (reinforcing bars) in order to resist internal tension forces within the cross section. Steel provides the substantial tension stress; concrete may be safely stressed only in compression. Reinforced concrete beams are most common structural member in civil construction.

Generally, beams may fail in flexure or shear. The combined bending and shear failure take place when the beam reached its ultimate load. The inclined shear cracks may develop before or after the flexural crack formation in the beam. Shear reinforcements are necessary to improve the shear resisting capacity of the beams if the permissible shear stress is lesser than the actual shear stress. Shear reinforcement is designed to resist shear forces in excess of the shear strength of concrete. Two types of shear reinforcement of RC beam were investigated, conventional stirrups, spiral stirrups. Various kinds of shear reinforcements include bent up bars, spirals are reviewed in the literature extensively to comprehend the merits and demerits of spiral stirrups. The RC beams with different types of shear reinforcement were tested for shear under two-point loading system. Comparisons were made between both types of RC beam on load-deflection, load-steel strain, load-concrete strain behavior and mode of failure.

PURPOSE OF STIRRUPS:

Stirrups are necessary to prevent buckling of columns and beams as well as to aid in lateral resistance.This is designed to mitigate shear failure, which is generally diagonal in the case of beam fractures.The presence of stirrups contributes to the strength of shear mechanisms in the following ways.In addition to their own shear carrying capacity, shear reinforcement, stirrups facilitate concrete contribution to shear resistance in the following ways.They improve the contribution of dowel action. The stirrups an effectively support a longitudinal bar that is being crossed by a flexural shear crack, close to the stirrup.They limit the opening of diagonal cracks within the elastic range; this enhancing and aiding the shear transfer by aggregate inter lock.When stirrups are closely placed, they provide confinement to the core concrete, thus increasing the compression strength and failure strain of concrete.They prevent break down of bond, when splitting cracks develop in anchorage zones, because of dowel and anchorage forces.

bituminous concrete, providing a systematic approach to optimizing mixture proportions, ensuring performance and durability, facilitating quality control, and contributing to cost efficiency in roadway construction and maintenance. Its application enables engineers to create asphalt pavements that meet specific project requirements while delivering long-lasting, high-performance infrastructure.One of the most significant production issues that businesses have focused on during the last decades is quality that includes not only the quality of products but also the quality of services and processes. As markets become more and more competitive, quality becomes a key ingredient for business success, as customers get more and more aware of its significance and ask from every company to assure the fulfillment of their needs.

These are the steel bars vertically placed around the tensile reinforcement at suitable spacing along the length of the beam. Their diameter varies from 6 mm to 8 mm. The free ends of the stirrups are anchored in the compression zone of the beam to the anchor bars (hanger bar) or the compressive reinforcement. Depending upon the magnitude of the shear force to be resisted the vertical stirrups. It is desirable to use closely spaced stirrups for better prevention of the diagonal cracks. The spacing of stirrups near the supports is less as compared to spacing near the mid-span since shear force is maximum at the supports.

While stirrups are typically used in columns to resist shear forces, incorporating spirals in beams can also provide similar benefits, especially in seismic regions or in structures subjected to heavy loads. The helical shape of the stirrups distributes the shear forces more evenly along the length of the beam, improving its overall performance and resilience.

2. OBJECTIVES OF THE STUDY:

The main objective of this study is to study on performance of R.C.C beams with various orientations of shear reinforcement

Specific objectives

- To study the shear resistance with variation of detailing in shear reinforcements.
- To study the benefits of spiral stirrups over the vertical stirrups.
- To make a comparative study on deflections and crack widths for these two cases.
- To study the properties like ductility, flexural strength and crack width of RC beams with spiral reinforcement

3. METHODOLOGY OF THE STUDY

Selection of materials and properties of materials:

Ordinary Portland cement of 43 grade was used throughout this study and found conforming to the specifications as per IS 8112:2013. The specific gravity of cement was found as 3.15.

20 mm nominal size crushed granite coarse aggregate and locally available river sand free from impurities as fine aggregate were used for concrete casting. The properties of the coarse and fine aggregate were tested accordance with IS 2386:1963

Table 1. Properties of specimen

Specimen label	Width mm	Overall depth mm	Effective depth mm	Length mm	Flexural reinforcement		Shear reinforcement	Cub com o stre days
					At top	At bottom		
SV1	230	300	250	1500	3-12 mm diameter	4-16 mm diameter	2L vertical stirrups 8@mm 160mm c/c	38
SS1	230	300	250	1500	3-12 mm diame	4-16 mm diamet	Spiral stirrups 8mm@ 160mm	38

ISSN 2321-2926

Fig. Vertical Stirrups

Fig. Spiral stirrups

Experimental Study:

The capabilities of inclined stirrups in shear resistance of reinforced concrete beams, in comparison with vertical stirrups. A total of 2 beams in one pair were fabricated and tested. The beams are named as SV1 and SS1.

In that pair, the beams were identical in all respects except that the first beam had vertical stirrups and the second one had spiral stirrups.

The inclination of stirrups was 45 degrees to the longitudinal axis of the beam. The beams V1, S1 were 230mm wide 300mm high, 1500mm long and were tested on a span of 1200mm, with a pure moment zone 300mm; the shear span to effective depth ratio of these beams was 1.69.

This value 1.69 being less than 2.5. IS 456:2000 permits placement limit of inclined stirrups, upto effective depth, through the limit is only 0.75 times effective depth, in case of vertical stirrups.

The grade of concrete of beams was M30. Portland slage cement is used. 10 and 20 mm nominal size crushed granite coarse aggregate and locally available river sand free from impurities as fine aggregate were used for concrete casting.

The beam moulds for casting, were made of Plywood masonry on the laboratory floor and plastered smooth. The concrete was poured in the moulds in three layers and each layer was compacted with a tamping rod with 25 blows.

The control specimens, cubes and cylinders were compacted in a standard way. Curing of specimens started after 24 hours of casting.

The beams were taken from the moulds after 24 hours and curing was done with wet gunny bags in the laboratory. Curing was done till testing at 28 days after casting.

The reinforced concrete beams were tested on a loading frame under two- point transverse loading at one-third point of span with simple support condition as indicated in Figure.

The point loads were applied on the beam with shear span less than 2.5d. Where, d is the effective depth of a beam. In this testing, av = 350 mm (1/3rd of effective span).

Before testing, the beam specimens were white washed to identify the cracks during testing at various stages of loading.

The beam deflections under the mid span and load points were monitored. At each load stage, the deflection readings were recorded and the cracks were marked on the surface of the beam.

Fig. Specimen tested with spiral stirrups

Fig. Specimen tested with vertical stirrups

4. LITERATURE REVIEW

PATHAN in reinforced cement concrete the replacement of main reinforcement into spiral form leads to increase the bending moment, torsional moment, shear, ductility with reduced deflection. This also leads to better earthquake performance. The main objective is to carry out the experiments and mathematical modelling on RCC beams and columns having main spiral reinforcement. Compressive yield strength of conventional RCC beams with minimum shear reinforcement is 30MP Compressive yield strength of RCC beams with spiral shear reinforcement is 38MPa. Compressive yield strength of RCC columns with main spiral reinforcement is 60MPa.

Research objectives: The study aimed to investigate the influence of different types of shear reinforcement, including vertical reinforcement and inclined reinforcement, on the shear cracking behaviour of reinforced concrete beams. The objectives were achieved through experimental investigation and numerical analysis.

Experimental investigation: The authors conducted an experimental study on reinforced concrete beams with different types of shear reinforcement. The specimens were tested under four-point bending to determine the shear cracking behaviour. The results showed that

the inclined reinforcement was more effective in reducing the crack width compared to vertical reinforcement.

Sri rama Chandra Murthy and P. Dinakar conducted a study in 2017 title is "The Impact of Inclination of Stirrups on Shear Strength and Deformation of Reinforced Concrete Beam." The study aimed to investigate the effect of the inclination angle of stirrups on the shear strength and deformation behaviour of reinforced concrete beams. Here is a brief literature review on their study:

Research objectives: The study aimed to investigate the effect of the inclination angle of stirrups on the shear strength and deformation behaviour of reinforced concrete beams. The objectives were achieved through experimental investigation and numerical analysis.

Experimental investigation: The authors conducted an experimental study on reinforced concrete beams with different inclination angles of stirrups. The specimens were tested under four-point bending to determine the shear strength and deformation behaviour. The results showed that the inclination angle of stirrups had a significant effect on the shear strength and deformation behaviour of the beam.

Bello and Dela Cruz the shear performance of reinforced concrete beams with spiral reinforcement likely discusses the investigation of how incorporating spiral reinforcement affects the shear behaviour of concrete beams. This study likely examines factors such as shear capacity, ductility, and overall performance of the beams under various loading conditions. The abstract might provide insights into the methodology, findings, and implications of the research for the design and construction of reinforced concrete structures.

Research objectives: The study aimed to investigate the effect of the inclination angle of stirrups on the shear strength and deformation behaviour of reinforced concrete beams. The objectives were achieved through experimental investigation and numerical analysis.

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stirrups. The specimens were tested under four-point bending to determine the shear strength and deformation behaviour. The results showed that the inclination angle of stirrups had a significant effect on the shear strength and deformation behaviour of the beam.

Srinivas Rao, B.S. Sharma, and Lakshmana conducted a study titled "Seismic Behaviour of Laced Reinforced Concrete Beam." The study aimed to investigate the behaviour of laced reinforced concrete beams under seismic loads. Here is a brief literature review on their study. Research objectives: The study aimed to investigate the effect of the inclination angle of stirrups on the shear strength and deformation behaviour of reinforced concrete beams. The objectives were achieved through experimental investigation and numerical analysis.

Experimental investigation: The authors conducted an experimental study on reinforced concrete beams with different inclination angles of stirrups. The specimens were tested under four-point bending to determine the shear strength and deformation behaviour. The results showed that the inclination angle of stirrups had a significant effect on the shear strength and deformation behaviour of the beam.

5. RESULTS AND DISCUSSIONS

The following test results are as follows:

1. In SV1 the initial crack was recorded at 143.10 KN, where as in SS1 the initial crack was marked at 241.50 KN.

2. The ultimate load for SV1 was recorded at 385.40 KN with a deflection 11.5 mm and crack width of 2.5 mm, whereas for SS1 the ultimate load was marked at 420.75 KN with a deflection 9.5 mm and crack width of 1.3 mm.

3. If the service load is at 256.93 KN. The deflection marked in SV1 and SS1 are 4.10 mm and 2.7 mm respectively and the corresponding crack widths were 0.4 mm and 0.1 mm respectively.

Table 2

Specimen label	At initial crack		At Service load				At Ultir	
	Central load KN	MomentKN-M	Central load KN	Moment KN-M	Deflectionunder load mm	Crack width mm	Central load KN	MomentKN-M
SV1	143.1	32.20	256.93	57.81	4.10	0.4	385.40	86.72

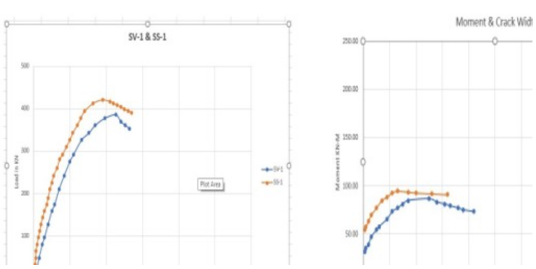

Fig. Deflection Vs Load

6. CONCLUSIONS

- The local carrying capacity of beam with spiral stirrups (SS1) was 9% more than that of beam with vertical stirrups (SV1).
- The crack widths were significantly reduced in beams with vertical stirrups (SV1) from 2.5 mm to 1.3 mm in beams with spiral stirrups (SS1).
- At service load the performance of the beam with spiral reinforcement (SS1) was more effective than that of beam with vertical stirrups (SV1). The deflection is reduced by 59% and crack widths are reduced by 25%.
- In compression it was found that the performance of beam with spiral stirrups is more effective than that of beams with vertical stirrups.

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