Structural Monitoring and Analysis of RCC Beams with Different Type of Stirrups

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Abstract- *Most frequently used web reinforcement in RC beams is transverse stirrups. Utilization of closed stirrups in very large beams occurring in several structures including strip beams and pile cap is inconvenient labour intensive, time consuming and expensive. To minimize the difficulties involved with closed stirrups reinforcement, the conventional stirrup was modified to two-piece "C"shaped stirrups. Stirrup units joined together on the top and bottom faces of beam to consecutive stirrup. The test satisfied the prime aim of investigation and the results demonstrates that C-shaped stirrups specimens exhibited equal strength and serviceability criteria.*

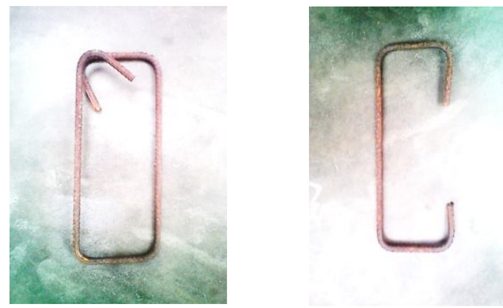
I. INTRODUCTION

A reinforced concrete beam might be subjected to one way shear, axial force tension or compression, two way shear, torsion, in addition to flexure. Generally bending moment and shear force coexist in a typical flexural member. But proportioning a beam for flexure and shear is done separately .In many decades of investigational done research and use of highly complicated tools of analysis, shear failure is not fully understood and it is far from solution, though design is possible by experimental research and empirical rules. Bending failure of member is gradual and ductile, while diagonal tension or shear failure is sudden brittle and catastrophic. Therefore the shear failure is inhibited and flexural failure is allowed in a design. In a typical beam, flexural failure precedes shear failure. In additional words shear strength is equal to or exceeds the flexural strength. Shear strength accrues to RC-beam from the sources, from transverse reinforcement. We are providing shear reinforcement to avoid the shear failure of beams. Different form of shear reinforcement is used.

Reinforcement Shear Employed in Different Forms are

a) Two legged or multi legged vertical stirrups or links, perpendicular to the longitudinal axis of the beam.
b) Inclined stirrups making an inclination of about 45^0 with the longitudinal flexural reinforcement of the member.
c) Part of bent up longitudinal flexural tension reinforcement with angle of 30^0 or more degrees with longitudinal tension reinforcement.

In this research we were used c-stirrups. Hook Bend angle is 180^o and the hook length is four time of dia of the bar ($4d_b$). The following figures are the closed and c-stirrups.



Closed and C-stirrups

II. LITERATURE RIEVIEW

Moayyad and Asha[10][11](2013) conducted an experiment on "The Use of Swimmer bars as Shear Reinforcement in RC Beams", in this study they were used swimmer bars as web reinforcement in RC beams. Swimmer bars means small inclined bars, with both ends bendflat for a small distance of, welded at the top and bottom of the main bar. They said that the shear failure is unsafe failure mode. The effectiveness of swimmer bar system is discussed in this study. The shear strength is improved in swimmer bar beams compare with the traditional system. The deflection of beams is also reduced and crack width is less. Finally they concluded that swimmer bar system is a greate advantage than the traditional stirrups, where we have congested reinforcement in beams

Rafeeqi, Lodi, Wadalawala[16]conducted an experiment on "Behaviour of RC Beams Strengthened in Shear". In this investigation they said about shear modes of failure in beams IS undesired mainly being a brittle failure. In this study they use Ferro cement .this is transforming brittle failure to ductile failure modes. Only in the shear spans they provided Ferro cement wraps and equally spaced strips. They said that the increased stiffness because of the Ferro cement strips and wraps and deflections are decreased compare with control specimens. Cracks are more but crack widths are decreased in strengthened beams. Failure of beam is delay because of using this Ferro cement wraps and these are more effective than the Ferro cement strips.

Papa Rao and Murty[14](2011) said about their investigation on "New stirrups detailing schemes for shear demands in pile cap beams". Reinforced and pre-stressed members with concrete requires an effective interaction among concrete and reinforcing steel. Not only is an sufficient quantity of reinforcement required but it must also be properly detailed to insure super satisfactory member behaviour under all loading conditions. Pile cap is an intermediate structure to transfer super structure vertical load, through a column to deep foundation, a grouping of piles. Pile caps resemble beams or slabs depending on their plan geometry and are subjected mainly to flexure or direct tension. One-way shear and two way shear. Conventional stirrups closed stirrups present troubles in the placing of stirrups reinforcing in complex steel cages, in place of inconvenience, highly involved and expensive closed stirrups, an alternative easy and more convenient stirrup detailing, comprising two piece "C" shaped open stirrups. Two series of beams, having six specimens, were designed and tested, to compare the strength and performance of the beam with single piece closed stirrups and two piece stirrups. The test undertaken satisfy the prime aim of the investigation, demonstrating that two-piece stirruped specimens exhibited marginally higher ultimate strength and equal serviceability .And smaller crack widths and deflections at service load, compared to the companion single piece closed stirruped specimens..

Lesley and Julio[9](2008) discussed that the experimental research to test that "the depth doesn't influence the shear strength of RC beams do not have shear reinforcement", in this study they tested eight beams which don't have shear reinforcement and skin reinforcement. In this research the effective depth was variable while the standards of further constraints proven to influence of shear strength were said constant. The values selected for the constraints said constant were chosen an attempt to reduce the concrete shear strength.

III. METHODOLOGY

In this study of investigation three beam specimens were designed and tested. First beam is designed stirrups at the ends of beam , and 2^{nd}&3^{rd} beams are designed with shear reinforcement. The beams closed stirrup and open stirrup beam (CSB & OSB) are identical in shear reinforcement. But we used different forms of stirrups. They are closed stirrup beam (CSB), and open stirrup beam (OSB).

Material Properties:

The material properties and specifications of various materials used in the preparation of cubes, cylinders, prisms and beams are as follows.

Cement

The cement used for the investigation was MAHAGOLD (OPC) 53 grade "conforming to IS 12269:1987". It was fresh, was of uniform colour, consistency, and free from lumps and foreign matter. Mortar cube strengths corresponding to 3, 7 and 28 days were 28 N/mm^2, 36.75 N/mm^2 and 54.5 N/mm^2 respectively.

Fine Aggregate

The fine aggregate used in the present experimental programme is river sand conforming to Zone-II as per IS 383:1970. It is clean, free from organic matter, silt and clay.

Coarse Aggregate

The coarse aggregate used in from well-established quarry, satisfying the code IS 383:1970. The mixture of coarse aggregate is used; mix proportion used is 60% of 20mm and 40% of 10mm. The material is of uniform colour and has good angularity. The physical properties of coarse aggregate are tabulated in Table

Water

"The water used is potable water collected from laboratory taps and satisfies the code IS 3025:1984. Water cement ratio of 0.48 for M25 grade of cement is adapted in the experimental programme"

Description of work

Formwork

The formwork was made ready with brickwork on flat floor made of lean concrete, free from undulations, and surface was made smooth for casting beams specimens of size (1000mm x 300mm x 150mm).

Preparation of Specimen

The two beam specimens were cast in a single day by mixer. The sides and base of moulds were coated with oil to allow easy removal from the formwork. The cover blocks of size 25mm were placed below the reinforcement firmly to maintain the clear covers of 25mm. The reinforcement cage was placed in position above cover blocks.

Concreting was weigh batched, machine mixed and placed in the mould in six layers. Each layer was compacted with tampering rod and with 20mm needle immersion vibrator. The top surface of the specimen is smoothened with a trowel. Simultaneously for each beam, six cubes of each size 150mm x 150mm x 150mm and three cylinders of each size 150mm (dia) x 300mm were casted. After 24 hours, erected the specimens from the moulds and the specimens were made ready for the curing.

Casting of Test Specimens

The experimental study includes casting and testing of specimens for compressive strength, split – tensile and flexural strength of the cubes, cylinders, prisms.
Specimens are prepared using concrete design mixesM25

Compaction of Concrete

This is the process to removing the entrapped air from the concrete. Mixing and placing of concrete process, air is entrapped in the concrete. If this air is not fully removed, the concrete strength is loses. To remove these voids with compacting efforts are available for the compaction. In the current study, the needle vibrator is used for compaction of the concrete. It is consisting steel tube, this needle is inserted in the fresh concrete. Tube is connected to an electric motor through. The size of poker is 40 mm

Demoulding

After 28days three cubes were allowed to dry and then were tested for compression

Curing of Specimen

It is the process of maintaining acceptable moisture content and a favorable temperature in concrete during the period, so that hydration of cement. After casting, the moulded specimens are stored in the laboratory free from vibration, in moist air (at 90% relative humidity) and at a room temperature for 24 hours from the time at addition of water to the dry ingredients. After this period, the specimens are removed from the moulds, immediately submerged in clean fresh water tank. The water in which specimens are submerged, are renewed every seven days and maintain at temperature of $27^{o}C \pm 2^{o}C$. The specimens are cured for 7 and 28 days in the present work.

IV. RESULTS AND DISCUSSION

Specimen Details

Three reinforced concrete beam specimens were constructed and tested in the Swarnandhra College of Engineering & technology Laboratory. The specimen dimensions were 1000mm in length, 300mm in depth, and150mm in width. One beam specimen contained stirrups at the end of beam, second beam specimen contained closed shear stirrups (CSB) and 3^{rd} beam contains open type stirrups (OSB).And 25MPa concrete is used.

Test setup

The specimens were tested on UTM (universal testing machine). The beam specimen of length 1000mmwas placed on rollers supported horizontally leaving 75mm on either side of beam, so that the effective span of this specimen is 850mm. A hydraulic jack was placed on the top of the beam at the Center of the beam. A dial gauge was placed exactly under the center mark of this span for measuring deflections

Stirrups at the end of the Beam:

Reinforcement of stirrups at the end of beam

Crack pattern of stirrups at the end of the beam:

In the beam the first crack is developed at the stage of 80kN and this crack is observed in the flexure zone. Load increases, cracks are propagates from bottom to top. The maximum crack width of the beam is 1mm. The ultimate load of the NSB is 160kN. The NSB fails in shear.

Appearance of beamafter testing

Closed stirrup beam(CSB):

Reinforcement of CSB

Crack pattern for CSB:

In CSB the first crack was developed at the stage of 100kN.This crack is observed in the flexural zone. Load increases, cracks are propagates from bottom to top.The maximum crack width of the CSB is 2mm.The ultimate load of the CSB is 180kN.The CSB is failed in flexure.

Appearance of CSB after testing

Open Stirrup Beam(OSB):

Reinforcement of OSB

Crack pattern of OSB:

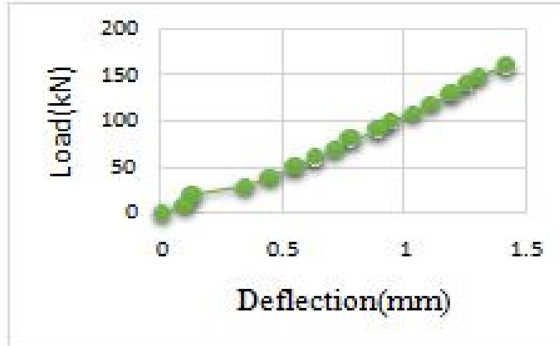
In the OSB the first crack is developed at the stage of 90kN and this crack is observed in the flexure zone of the beam. Increasing Load shows that cracks are propagates from bottom to top(where the load appiled).The maximum crack width of the OSB is 1mm.The ultimate load of the OSB is 170kN.The OSB is failed in flexure.

Appearance of OSB after testing

Graphs for beams

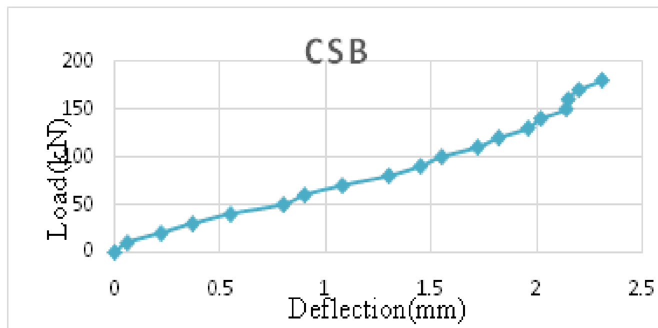
Graph for stirrus at the end of the beam:

The graph has been plotted for the load versus deflection for the beam. The first crack of 80kN.As the load increased corresponding deflections also got increased and finally the maximum deflection of 1.41mm is obtained for an ultimate load of 160kN.



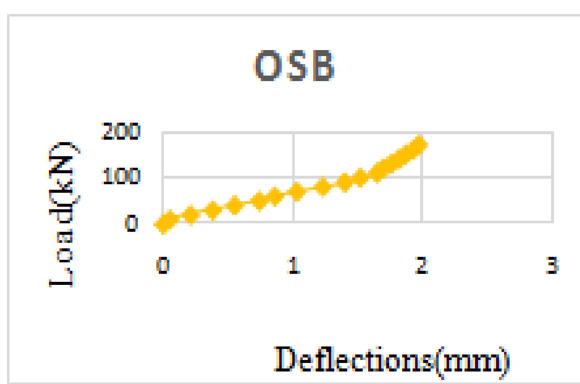
Graph for CSB

The graph has been plotted for the load versus deflection obtained for the CSB. The first crack was developed at the stage of 100kN.As the load increased corresponding deflections also got increased and finally the maximum deflection of 2.25mm is obtained for an ultimate load of 180kN



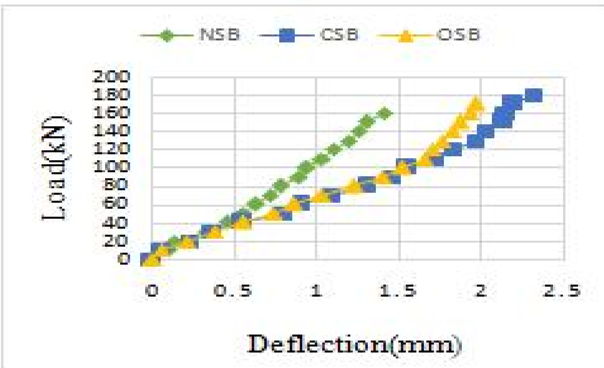
Graph for OSB

The graph has been plotted for the load versus deflection obtained for the. This graph shows that the curve is linear for first crack of 90kN .As the load increased corresponding deflections also got increased and finally the maximum deflection of 1.97 is obtained for an ultimate load of 170kN.



Graphs for Comparison of Beam Deflections

The comparison of load versus deflection of all the three beams of NSB, CSB and OSB has been plotted in the graph. On comparing of the three beams for a constant load of 180 kN the maximum deflection of 2.25mm is obtained for CSB



IV. DISCUSSIONS OF TEST RESULTS

Stirrups at the end of Beam (NSB)

The Beam 0.99% longitudinal reinforcement developed initial flexural crack at 50% of ultimate load. As the load increased further, cracks extended to top layer and a maximum deflection of 1.41mm is recorded at an ultimate load of 160kN.NSB without web reinforcement failed at an ultimate moment of 34.1kN-m.The beam failed in shear at 80.47kN.

Closed Stirrup Beam (CSB)

The Beam CSB with 0.99% longitudinal reinforcement and conventional stirrups developed initial crack that was flexural at 55% of ultimate load. As the load increased further cracks extended upwards and a maximum deflection of 2.2mm is recorded at an ultimate load of 180kN.CSB With shear reinforcement failed at an ultimate moment of 38.35kN-m, the corresponding shear stress is 2.24N/mm^2. Maximum crack width of 2mm observed at ultimate failure load. The beam fails in flexure. The ratio of experimental to theoretical moment is 1.02.

Open stirrup Beam (OSB)

The Beam OSB with 0.99% longitudinal reinforcement and open stirrups developed initial crack that was flexural at 53% of ultimate load. As the load increased further cracks extended upwards and a maximum deflection of 1.9mm is recorded at an ultimate load of 170kN.OSB with shear reinforcement failed at an ultimate moment of 36.2kNm, the corresponding shear stress is 2.13N/mm^2.The beam fails in flexure. The ratio of experimental to theoretical moment is 0.96.

V. CONCLUSION

1. In large beams, the fabrication of conventional closed stirrups find difficult and cage construction problems, they may be replaced by C-stirrups joining in the top & bottom faces of the beam.
2. The beams OSB and CSB are failed at the around same ultimate load and the failure observed was flexure.
3. The deformation behaviour of OSB (C or open stirrup beam) is slightly better than the CSB due to less crack width and deflection at its ultimate load.
4. C- Stirrup detailing can be used in all kinds of beams in place of closed stirrups, resulting in reduction in time.

Scope of further study

In some cases where the compression reinforcement is more and for pouring of concrete is difficult. The study may be extended to provide the stirrups with combination of cross ties and ‘U’ type stirrups. The comparisons can be made with ‘C’ type stirrups and ‘U’ type stirrups

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