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Experimental Investigation of Wired Mesh - RC Beam

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Abstract: Wire mesh is a form of reinforcement that differs from conventional reinforcement primarily by the manner in which the reinforcing elements are dispersed and arranged. The well distributed and aligned reinforcement has made wire mesh to behave like steel plates. As concrete is weak in tension the tensile stresses in flexural member is resisted by steel reinforcement. Hence in this project presents about an experimental investigation done on beam prototype made of reinforced concrete overlaid by a thin section of wire mesh over the main reinforcement. The major parameter studied in this project were type of wire mesh varied in spacing of interlocks. The entire beams prototypes were tested using two point loading system. Test results clearly indicate that the use of wire mesh layers as an additional reinforcement significantly enhances the flexural strength, cracking behaviour and energy absorption capability. Obtained results are compared with the control specimen. The test results show that the use of wire meshwith closely spacing provides the higher energy absorption capacity and flexural strength and decreases the crack width among those concrete beam specimens. The results obtained from this work is expected to be useful in determining the strength, energy absorption capacity and crack width.
Key words: Wire mesh, Flexural strength, Energy absorption capacity.

Introduction

Reinforced concrete is a composite material being much stronger in compression as well, reinforcing steel can also supplement concrete in bearing compressive forces as in column. The first invention of reinforced concrete is ferrocement. The main difference between the conventional reinforcement and ferrocement is in scaling of elements. Ferrocement consist of closely spaced steel rods (wire mesh) embedded in cement motor. Due to the closely spacing interlocks the reinforced concrete member provides good ductility and bearing capacity. In this paper an approach is made to provide an additional reinforcement with wire mesh.The beam, or flexural member, is frequently encountered in structures andmachines. A beam is a member subjected to loads applied transverse tothe long dimension, causing the member to bend.

Increased number of wiremesh sustain greater loading when compared to plain ferrocement specimens because of greater strain carrying capacity. It has good moment of resistant under both monotonic & repeated loading and also found to be more effective in increasing the margin between first crack and ultimate flexural strengths[1].

Composite beam action between layers of wire mesh cannot be attained without shear studs. Minimum of five number is used as a shear stud to attain full composite action. This provide full bond until failure[2].

In this paper ferrocement cover has been successfully introduced for reinforced concrete slabs. Crack width of the slab was considerably narrowed by the use of ferrocement layer and showed more stiffness and cracking moment when compared with control specimen. And also a slight improvement in bending capacity[3].Ferrocement box beam gives ultimate shear strength and cracking as the mesh reinforcement is increased. As the increase in mesh number the cracks are higher in number and finer in size[4].

Composite constitute wire mesh with epoxy significantly enhance the performance of concrete in flexure. The specimen bonded with wire mesh performed better and delayed the first crack and this associated with increase in number of layer. Increase in number of layer of wire mesh also increased the energy absorption capacity. Wire mesh used in four layer was found to be optimum[5].

Wire mesh used in slab increased the punching strength of the slab with volume fraction. Combination of wire mesh and steel reinforcement increases significantly the punching resistant at column stud[6].

Wire mesh was encased in light weight aerated concrete which perform better in compressive strength and flexural strength. Water absorption was reduced to fraction when compared to control specimen. The composite element falls under light weight structural elements. Due to the addition of wire mesh the composite element transformed to a ductile material from brittle element[7].When wire mesh interlock is less than 20 times of wire mesh diameter, the crack spacing is independent on the type of reinforcements and bond performance. Tension stiffening of welded mesh with small spacing is higher than RC elements with normal reinforcement[8].When wiremesh aligned at 45° orientation made the weakest configuration because of the lowest volume fraction of wire mesh in the direction of loading at this orientation[9].When the ferrocement laminate is used in the soffit of the beam it delayed the first crack load, restrain the crack width and increases the flexural stiffness. It also increases the load capacities of the strengthened beams. Mid-span deflection were lower compared to the control beam when ferrocement is used as cover in soffit of the beam[10].

Experimental Program

The experiment includes testing of 4 prototype beams under a static loading. The beams were tested under the two point loading system. The strength of M25 concrete mix which showed the better result of strength was used for casting of beam. The major parameters used were type of mesh reinforcement, namely spacing and diameter of wire mesh used as an additional reinforcement. These beams are compared with a control beam and with one another. All the beams were rectangular cross section: width, depth and length of the beam were 100mm, 120mm, 200mm and 1000mm respectively. All the beams were cast and cured for 28 days.

Material properties:

a) Cement: Ordinary Portland cement of 43 grade confirming to IS 8112:1989[9]of locally available RAMCO cement which comprises good quality. The chemical configuration of cement was found using X-ray fluorescence analysis and has the following properties are given in table1.

Table 1: Physical and chemical composition of ordinary Portland cement (OPC)

Description	**Composition**
Physical Properties	
Color	Grey
Specific gravity	3.15
Specific surface area (cm^2/g)	3540
Chemical Composition	
CaO (%)	62.8
SiO_2 (%)	20.3
Al_2O_3 (%)	5.4
Fe_2O_3 (%)	3.9
MgO (%)	2.7
Na_2O (%)	0.14
K_2O (%)	62.8

b) Fine aggregate: For fine aggregates, uncrushed locally available natural river sand of maximum size 2.36 mm with a fineness modulus of 3.35 and specific gravity of 2.65 using IS 2386(Part III):1963[10] was used.

c) Coarse aggregate: The size of the coarse aggregates used ranges between 10 mm to 12 mm of specific gravity 2.74 using IS 2386(Part III):1963. The properties of coarse aggregate are given in Table 2.

Table 2. Properties of coarse aggregate

Aggregate properties	Values
Impact value	17.18
Crushing value	21.46
Water absorption	1.56
Abrasion value	24.40

d) Admixtures (Super-plasticizer): CONPLAST SP430 (G) complies with IS: 9103:1999[11] and BS: 5075 (Part 3) and ASTM-C-494[12] type 'F' having a specific gravity of 1.2 was used as a high range water reducing agent. Air entrainment of Approx. 1% additional (As per Manufacturers manual)

e) Water: Ordinary potable tap water was used for mixing and curing.

f) Reinforcement: Steel bars of Fe 500 grade was used for main reinforcement and stirrups.

g) Wire mesh:The welded wire mesh has been used as the flexural reinforcement. In this project presents about an experimental investigation done on beam prototype made of reinforced concrete overlaid by a thin section of wire mesh over the main reinforcement. The major parameter studied in this project were type of wire mesh varied in spacing of interlocks. Three different kind of wiremesh used and shown in table 4.

Table 4. Wired mesh properties

Description	Diameter	Spacing	Weight
Type 1	1.5 mm	30 x 30 mm	2.465 kg/m^2
Type 2	1.5 mm	25 x 38 mm	2.485 kg/m^2
Type 3	2 mm	25 x 38 mm	2.665 kg/m^2

Concrete:

a) Mix proportions: Design of Concrete mix was in accordance with IS 10262:2009[13] and IS 456:2000 [14] and was done for M25 grade. The proportions of the material by weight was 1: 1.78: 2.9 for M25 mix design. The w/c ratio was maintained as 0.45. The specimens such as cubes and cylinders were cast early with and without chemical admixtures to get the better strength.

b) Casting: Before casting of beam prototype three number of 150 mm cube specimens and three numbers of 150 mm diameter and 300 mm height cylinder specimens were cast as per IS 516:1959[15] for finding the compressive strength and tensile strength of concrete. The compressive strength and the split tensile strength was found out at 7 and 28 days of curing with and without the use admixture. The average compressive strength and tensile strength of M25 grade concrete is shown in Table 5.

Table 5. Average Compressive strength and Split tensile strength

Description	Compressive strength(MPa)		Split tensile strength (MPa)	
	7days	28days	7days	28days
With admixture	19.87	32.7	2.15	3.21

Totally 4 prototype beams were designed for the optimum compressive strength obtained from the mix. The longitudinal bars were of 8 mm diameter and the stirrups were of 6 mm diameter with spacing of 150 mm throughout. The specimen ID for beams are given in Table 6 along with the type of reinforcements used and fig1 shown beam prototypes.

Table 6. Beam specimen ID

Specimen ID	Details
Control beam	RC beam without shear reinforcement
W-1	RC beam with Type 1 wire mesh
W-2	RC beam with Type 2 wire mesh
W-3	RC beam with Type 3 wire mesh

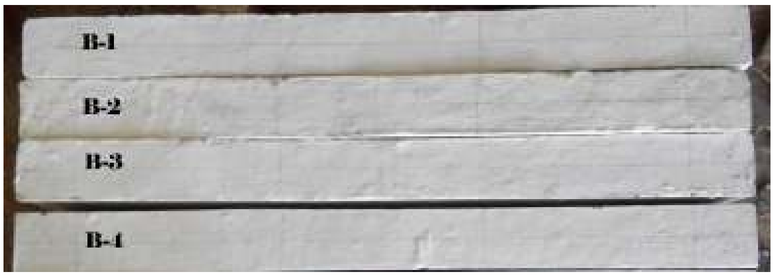

Fig.1 Beam Prototypes

Test setup:

The test setup includes two point loading using a single point loading system by which the loads are transferred equally to the two points using a spreader beam and two rollers. Dial gauges are placed in the bottom of the beam at the mid-point to find the deflection. Demecs are placed on the surface of the beam to find the surface strains which are placed at a distance of 100mm from one another. The clear setup of the test is shown in the fig.2.The strains at these points are found using a mechanical strain gauge. The crack patterns are noted on both sides of the beams at particular intervals. The gauge length between the load points is 300 mm and 150 mm are left on both sides of the beam at the supports. All the specimens were capped for uniform loading prior testing. The control of load over the test was 10 kN/min. Automatic data acquisition system was used to record the load, strain and axial displacement which in turn connected to the computer.

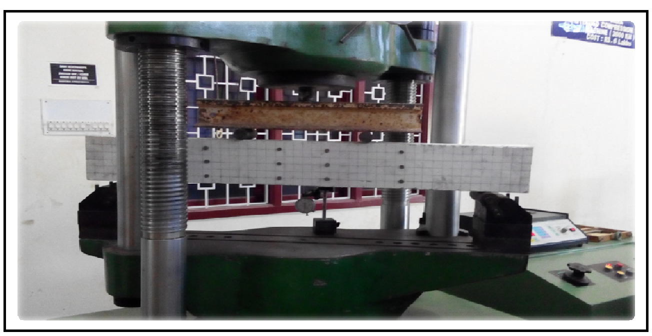

Fig.2 Test setup

Experimental Results and Discussions

First crack and peak load

The beam specimen B-1 the peak load is observed at 30 kN and failed at the peak load of 80.75 kN in shear. The peak load of the control specimen can be taken as maximum permissible shear load. The specimen W-1, W-2 and W-3 have shown similar load behaviour. The specimen W-1 have shown maximum load capacity of 94.34 kN and failed in flexure. The specimen starts cracking at a load of 30 kN. Whereas the specimen W-2 with combination of stirrups and welded wire mesh had a cracking load of 40 kN and a maximum/ peak load of 110.35 kN. The specimen W-3 had failed at the maximum load of 101.3kN and the first cracks were observed at a load of 35 kN. The cracking load and peak load of various specimens is given in the Fig.3 below.

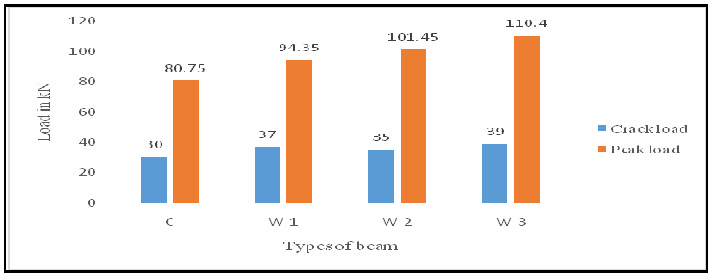

Fig.3 First Crack and Peak load

Crack Pattern and Spacing

All the beam specimens performed well in both shear and flexure. The control specimen provided with only flexure reinforcement failed with a large shear crack having width more than 1mm. For the beam specimen W-1, the beam failed in flexure with equal number of flexure cracks and shear cracks. Specimen W-2 performed similar to that of specimen W-1 having lesser number of shear crack than flexural crack. The specimen W-3 performed better than other specimens with the cracks distributed all over the surface with the crack width less than 0.1 mm. The crack number shown in table7 and crack pattern of the specimens were given in the Fig.4, to Fig.7 and the Fig.4 for the beam prototype of C, W-1, W-2 and W-3 respectively.

Table 7. Crack numbers along the length of the member

Specimen	Shear zone	Flexure zone
Control beam	6	4
W-1	6	6
W-2	5	6
W-3	5	7

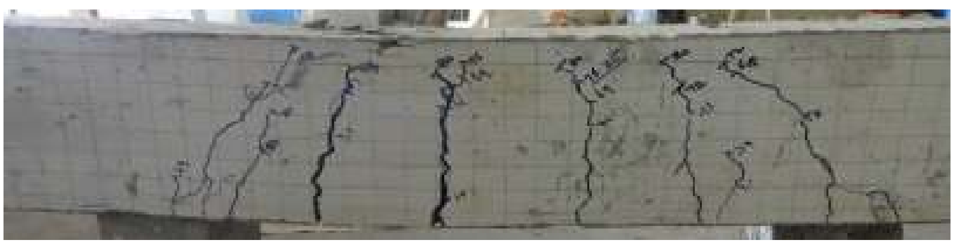

Fig.4 Crack pattern of control beam

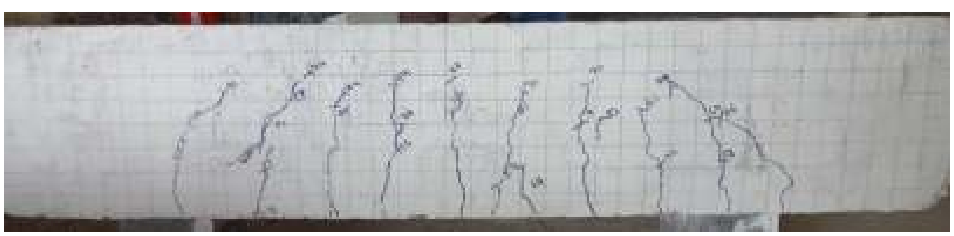

Fig.5 Crack pattern of W-1

Fig.6 Crack pattern of W-2

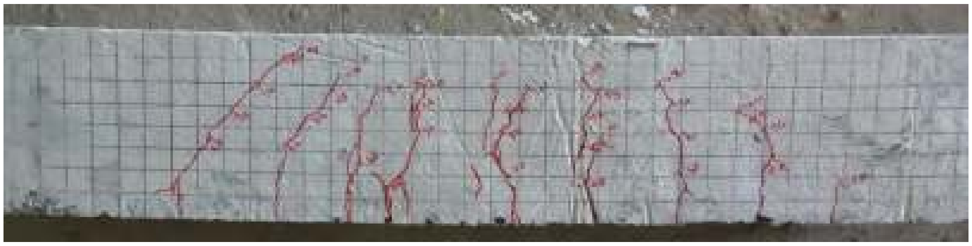

Fig.7 Crack pattern of W-3

Load Deflection Behaviour

Fig.8 shows the load-deflection curves for beams tested. In general, beams with wire mesh layer exhibited greater stiffness than the control specimens. The ratio of the average total deflection near ultimate load for specimens with wire mesh to the corresponding average value of the control specimens was 0.87, 0.74 and 0.73 specimen W-1, specimen W-2 and specimen W-3, respectively. The reduction in the deflection was higher for specimens W-1. The control beam failed at the peak load of 80.75 kN in shear with deflection of 9.4mm. The specimen W-1, W-2 and W-3 have shown similar load-deflection behaviour. The specimen W-1 with have shown maximum load capacity of 94.85 kN and failed in flexure with deflection of 6.8mm. Whereas the specimen W-2 with combination of stirrups and welded wire mesh underwent more load-deflection behaviour with deflection of 9.40mm at 110.4 kN. The specimen W-3 had failed at the maximum load of 101.45kN with far less deflection of 8.8mm.

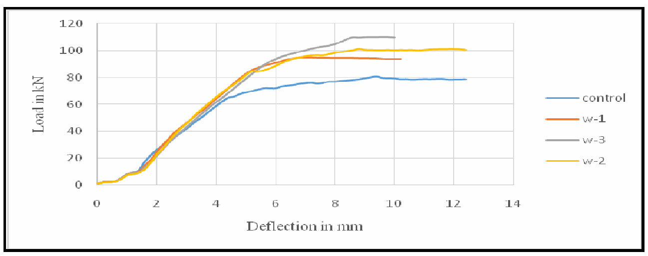

Fig.8 Load vs Displacement for beams

Conclusion

The study on the flexural behaviour of the beam specimens, with wire mesh encased the steel reinforcement have led to the following conclusions.

- Wire mesh when used as an additional reinforcement in beam, enhanced the flexural behaviour of the beam by distributing the forces along the section.
- It can be observed that, the first crack and ultimate strength increases up to 30% and 37% respectively with the use of wiremesh.
- Compared to the control beam, the peak load increased by 17%, 26% and 37% for beam W-1, W-2 and W-3 respectively. This shows that the beam has significant effect on spacing and diameter of the rod. Rectangular wiremesh performed better than square type wire mesh.
- The use of wire mesh have made a significant effect on crack pattern of the reinforced concrete beams by delaying the crack appearance, increasing the number of crack and reducing the crack width.
- The ultimate moment capacity for the beam specimens have considerably improved with the use of wiremesh.
- Compared to the control beam specimen, the energy absorption capacity improved significantly for wired mesh RC-beam. Energy absorption capacity is more for wiremesh having greater diameter rod about 30% greater than control beam.

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