Behaviour of Reinforced Concrete Beams with Wire Mesh As Shear Reinforcement

Elavarasi D, Sumathi A

Abstract**:** ***This paper presents a study of shear behaviour of reinforced concrete beams. The major parameters used were type of shear reinforcement, namely stirrups alone, wire mesh alone and combination of both wire mesh and stirrups as shear reinforcement. The replacement of wire mesh was done on the basis of weight with stirrups. The experimental program includes four beams. All the beams were tested using two point loading system. It is evident from the result that the use of wire mesh enhanced improved shear performance and bearing capacity in the examined beams. Beams with wire mesh as shear reinforcement and combination of both wire mesh and stirrups exhibited some amount of increase in shear capacity with respect to the beams with stirrups alone as shear reinforcement. Furthermore beams with wire mesh and combination of wire mesh and stirrups as reinforcement exhibited less number of crack patterns compared beams with stirrups*****.**

Key words: Wire mesh, Shear behavior, load-deflection, crack pattern

I. INTRODUCTION

Ferrocement (FC) is defined as welded wire mesh reinforcement impregnated with mortar [1]. The main difference between the conventional reinforcement and ferrocement is in scaling of elements. Ferrocement (FC) consist of closely spaced steel rods embedded in cement motor. Due to the closely spacing interlocks the reinforced concrete member provides good ductility and bearing capacity. The use of FC improves properties such as lightness, durability, water-tightness, toughness, strength and environmental stability.

Welded wire mesh is used in shear strengthening techniques to improve the shear capacity of the beam. Increase in diameter of the mesh shows a significant increase in the ultimate strength of reinforced beam. It delay the first crack load and tends to narrow the crack width and causing in large deflection at ultimate load [1]. Wire mesh is used as reinforcement in flanged ferrocement member, such as channel section, box section and sandwich ribbed plates. The ultimate shear strength of thin walled section increases as shear span to depth ratio decreases [2]. FC box beam gives ultimate shear strength as the mesh reinforcement is increased. As the increase in mesh number the cracks are more in number and small in size [3]. Spiral reinforcement in rectangular beam improves the post-peak deformation capacity and exhibits higher shear capacity when compared with the control beam [4]. Wire mesh used for strengthening techniques with higher cracking capacity, ultimate load with minimum deflection when compared with control beam specimen [5].

Two types of shear failure were noticed in ferrocement panel, namely flexure shear and web shear. These failure increases with decrease in span to depth ratio and the volume fraction of mesh is increased. Web shear failure mode occurs higher than the flexure-shear failure [6]. Wire mesh along with epoxy coating, a new composite constituent perform an increase in flexural strength rather than with plain mortar. This type of strengthening also provides a greater first crack load and energy absorption capacity. The optimum layer of wire mesh was found to be four [7].

II. 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 was found with and without HRWRA, the better result of strength was used for casting of beam. The major parameters used were type of shear reinforcement, namely steel stirrups, wire mesh and combination of both wire mesh and steel stirrups as shear reinforcement. These beam are compared with a control beam.

Material properties:

a) Cement: 43 grade Ordinary Portland cement [9] was used. The properties of the cement are presented in Table 1.
b) Fine aggregate: Locally obtained natural river sand of 2.36 mm size with a fineness modulus of 3.35 and specific gravity of 2.65 as per IS 2386 [10]was used.
c) Coarse aggregate (CA): The aggregates used ranges between 12.5 mm to 20 mm of specific gravity 2.74 using IS 2386[10]. The properties such as impact, crushing, water absorption and abrasion value were 17.18, 21.46, 1.56 and 24.4 respectively.
d) Super-plasticizer: CONPLAST SP430 (G) complies with IS: 9103 [11] type 'F' having a specific gravity of 1.2 was used. Air entrainment contains approx. 1% additional (As per Manufacturers manual).
e) Water: Tap water was used for mixing and curing of concrete.
f) Reinforcement: Steel bars of Fe 500 grade was used. The welded wire mesh has used as the shear reinforcement. The wire mesh was used as stirrups replacement on the basis of weight with stirrups

Revised Manuscript Received on September 05, 2019.

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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

Methods of Concrete Mixing and Casting

a) Mix proportions: Concrete mix was done in accordance with IS 10262:2009 [13] and IS 456:2000 [14] was done for M25 grade. The proportions arrived as 1:1.58:2. The w/c ratio was maintained as 0.4. The specimens such as cubes and cylinders were for with and without chemical admixtures (SP) to achieve the better strength.

b) Casting: Three numbers of 150 mm cube specimens and three numbers of cylinder specimens of 150 mm diameter and 300 mm height were cast as per IS 516:1959 [15] to obtain the strength of concrete. The strengths was found out at 7 and 28 days of curing. The average compressive strength and split tensile strength of concrete is shown in Table 2.

c) Beam specimens were cast with size of 100mm × 150mm × 1200 mm to study the behavior of beams. All beams were reinforced with 2- 12 mm diameter on tension zone, 2- 8mm diameter as hanger bars 6 mm diameter stirrups were also provided. The wire were of 2 mm diameter and the spacing of interlocking links were of 34 mm × 34mm were used for shear reinforcement. The weight of the wire mesh was 2.385kg/m2. Concrete were placed in the well lubricated mould and compacted well and the specimens were left at room temperature for 24 hrs and the specimens were placed in curing tank for 28 days. The beams were classified based on the details given in the Table 3. Fig. 1-3 gives the reinforcement details.

Table 2. Strength Results

Description	Compressive strength(MPa)		Split tensile strength (MPa)	
	7days	28days	7days	28days
Without admixture	19.6	28.4	2.13	3.13
With admixture	19.87	32.7	2.15	3.21

Table 3. Beam details

Specimen ID	Details
B-1	Control beam
B-2	RC beam with stirrups as shear reinforcement
B-3	RC beam with wire mesh and stirrups as shear reinforcement
B-4	RC beam with wire mesh as shear reinforcement

Fig. 1 Reinforcement setup of B-2

Fig. 2 Reinforcement setup of B-3

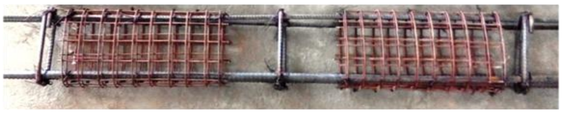

Fig. 3 Reinforcement setup of B-4

Test setup: All the beam specimens were tested under two point loading in the Universal testing machine of 1000 kN capacity. The effective span of the beam was 900 mm with end bearings of 150 mm. Dial gauge of 0.01 mm accuracy was used exactly at the mid- span point to measure the deflections at different loading points. Demecs are placed on the surface of the beam to find the surface strains which are placed at a distance of 100 mm from one another. The strains at these points are found using a mechanical strain gauge. During testing, formations of cracks were marked on the surface of the beams. To perform the test in the beam specimens, the rate of loading considered during the test was 10 kN/min until the beam reached the peak load. The Fig.4 gives the test set-up of the beam.

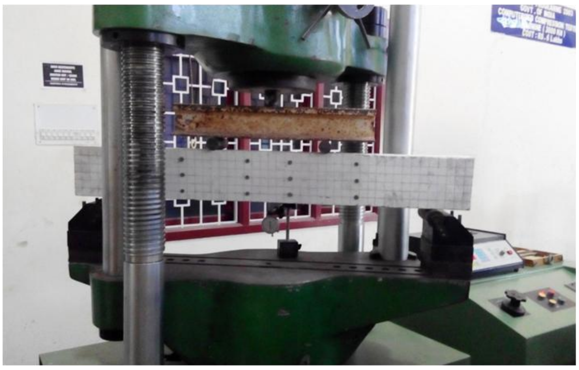

Fig. Beam test set-up

III. RESULTS AND DISCUSSIONS

First crack and Ultimate load

The beam specimen B-1 the peak load is observed at 25 kN and failed at the ultimate load of 53.35 kN in shear. The peak load of the specimen B-1 can be taken as maximum permissible shear load. The specimen B-2, B-3 and B-4 have shown similar load behaviour.

The specimen B-2 with normal steel stirrup, have shown maximum load capacity of 108.42 kN and failed in flexure. The specimen also have cracked at a load of 30 kN. Whereas the specimen B-3 with combination of stirrups and welded wire mesh had a cracking load of 37 kN and a maximum peak load of 110.35 kN. The specimen B-4 with wire mesh as shear reinforcement had failed at the maximum load of 114.3kN and the first cracks were observed at a load of 28 kN. The cracking load and peak load of various specimens is given in the Fig.5.

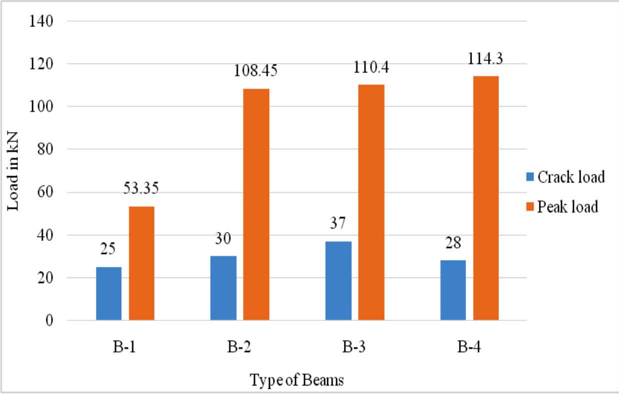

Fig.5 First Crack and Peak load

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 0.3 mm. For the beam specimen B-2, the beam failed in flexure with number shear cracks than flexural cracks. Specimen B-3 performed similar to that of specimen B-2. The specimen B-4 performed better than other specimens with the cracks distributed all over the surface with the crack width less than 0.1 mm. The crack formation of the specimens were shown in Fig. 6-9. The numbers of cracks are presented in Table 4.

Table 4. Number of cracks

Specimen	Shear zone	Flexure zone
B-1	8	8
B-2	13	11
B-3	13	11
B-4	19	11

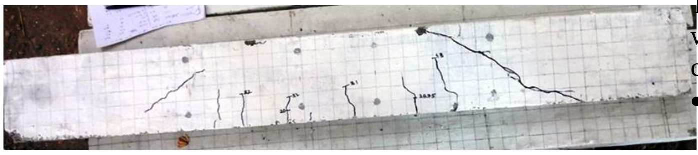

Fig.6 Crack formation in B-1

Fig.6 Crack formation in B-2

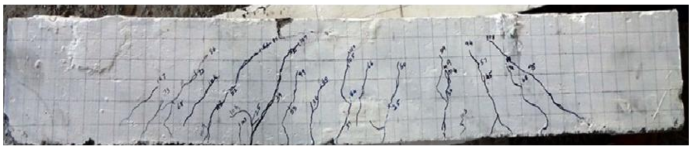

Fig.6 Crack formation in B-3

Fig.6 Crack formation in B-4

Load Deflection Behaviour

The load vs displacement graph was drawn from the readings obtained from the testing of specimens. The beam specimen B-1 failed at the peak load of 53.35 kN in shear with deflection of 7.2mm. The peak load of the specimen B-1 can be taken as maximum permissible shear load. The specimen B-2, B-3 and B-4 have shown similar load-deflection behaviour. The specimen B-2 with normal steel stirrup have shown maximum load capacity of 108.42 kN and failed in flexure with deflection of 8.2mm. Whereas the specimen B-3 with combination of stirrups and welded wire mesh underwent more load-deflection behaviour with deflection of 9.80mm at 110.35 kN. The specimen B-4 with wire mesh as shear reinforcement had failed at the maximum load of 114.3kN with far less deflection of 7.6mm. The load-deflection behaviour is shown in the Fig.4.

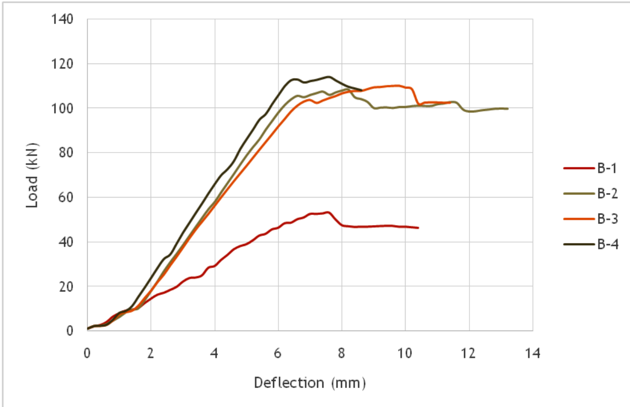

Fig.10 Load- Displacement for beams

IV CONCLUSION

The study on the shear behaviour of the beam specimens, with wire mesh as shear reinforcement have led to the following conclusions.

- Wire mesh when used as shear reinforcement in beam, enhanced the shear behaviour of the beam by distributing the shear forces along the section.
- Beam using only wire mesh as shear reinforcement have performed better than any other specimen by having low deflection at peak load.
- The use of wire mesh have made a significant effect on delaying the crack, increasing the number of crack and reducing the crack width.

- The ultimate moment capacity for the beam specimens have considerably improved if wire mesh alone is used as shear reinforcement.
- The beam specimens with mesh as shear reinforcement and specimen with a combination of wire-mesh and steel stirrup as shear reinforcement have performed similarly and both have failed in flexure. They had more number of cracks all distributed along the direction.

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Retrieval Number: L31951081219/2019©BEIESP
*DOI: 10.35940/ijitee.*L3195.*1081219*

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