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Research Paper

EXPERIMENTAL EVALUATION OF REINFORCED CONCRETE BEAM RETROFITTED WITH FERROCEMENT

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In present RC beams initially stressed to a prefixed percentage of the ultimate load are retrofitted with ferrocement to improve the performance of RC beam in both shear and flexure, the welded wire mesh is wrapped around the beam in U shape. An experimental work is conducted to evaluate the performance of RC beam retrofitted with ferrocement. In experimental work total 25 beams are casted, from that three beams are control beams. Six beams are shear deficient beam and retrofitted with single and double layer of wire mesh at 00 and 450 orientation. Remaining sixteen beams are distressed at 60%, 80% of ultimate load and retrofitted with ferrocement in number of layers at various orientation. Such distressed beams are divided in four groups. In one group distressed beams are retrofitted with single layer of wire mesh at 00.In another three group retrofitting are worked out with single layer of wire mesh at 450, double layers of wire mesh at 00, double layers of wire mesh at 450, respectively. The load deflection characteristics and mode of failure are studied. The test results indicate that, when beam retrofitted with wire mesh in layers at orientations, it significantly increases the load carrying capacity, first crack load, stiffness but deflection is decreases in both flexural and shear strengthening.

Keywords: Ferrocement, Retrofitting, Jacketing, Wire mesh, Beams, Ultimate load

INTRODUCTION

Civil engineering structures are an important element of infrastructure and provide good service to the user they experience distresses on account of reason and need of strengthening and retrofitting to bring them into functional use again. Deterioration of concrete structures is one of the major problems in construction industry today. Today various retrofitting techniques are available in field like plate bonding. In plate bonding ferrocement one of the retrofitting technique to improve the structural performance of deteriorated structure. Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely

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spaced layers of continuous and relatively small size wire mesh. In its role as a thin reinforced concrete product and as laminated cement based composite, ferrocement has found itself in numerous applications both in new structures, repairs and rehabilitation of existing structures. Compared with the conventional reinforced concrete, reinforcement in ferrocement in two directions. Due to this two direction reinforcement it has homogeneous-isotopic properties in two directions. Benefiting from its usually high reinforcement ratio, ferrocement generally has a tensile strength and modulus of rupture.

CONSTITUENT MATERIALS OF FERROCEMENT

a) Cement: The cement should comply with Indian Standards. The cement should be fresh, of uniform consistency and free of lumps.

b) Fine aggregate: Normal weight fine aggregate passing IS 2.36 mm sieve used in jacketing. Grading of the sand is to be such that a mortar of specified proportions is produced with a uniform distribution of the aggregate.

c) Water: Water used in the mixing is to be fresh and free from any organic and harmful solution. Portable water is fit for use as mixing water as well as curing for ferrocement structures.

d) Reinforcing Mesh: One of the essential components of the ferrocement is wire mesh. The function of the wire mesh and reinforcing rod in the first instant is to act as lath providing the form and to support the mortar in its green state.

Paramasivam *et al.* (1998) has been carried out to strengthening of reinforced concrete beam with ferrocement laminates. Investigation into the transfer of forces across the concrete/ferrocement interface, the effect of the level of damage sustained by the original beams prior to repair, and the results of repeated loading on the performance of the strengthened beams are discussed. The results show that ferrocement is a viable alternative for strengthening and rehabilitations of reinforced concrete structures.

An experimental investigation has been carried out to study the effect of ferrocement jacketing on the strength and behavior of distressed reinforced concrete flexural elements by Ganeshan *et al.* (2005) The reinforced concrete specimens are subjected to different stages of loading, viz., 0.7, 0.8 and 0.9 times their ultimate load carrying capacity. Such distressed specimens are retrofitted by ferrocement having different values of volume fraction of mesh reinforcement viz, 0.26, 0.52 and 0.78%. The results indicate that retrofitted beam improves the load carrying capacity, stiffness and energy absorption capacity of the beam.

Sheela *et al.* (2009) made an attempt has been made to determine the effect of number of layers of wire mesh on the performance of the beams retrofitted using ferrocement. Also, the effects of number of layers of GFRP on the performance of retrofitted beams are studied. From the experimental investigation it was found that the ultimate load carrying capacity of beams retrofitted with ferrocement having one, two and three layers of wire mesh increased by 6.25%, 50% and 81.25% and that of GFRP retrofitted beams with 1, 2 and 3 layers increased by 50%, 68.75% and 81.25%, respectively.

Rafeeqi (2011) focused on short investigation of theoretical prediction models for plain concrete confined with ferrocement. The proposed model posses the capability of predicting strength of plain concrete, confined with ferrocement for all the possible and practical method of confinement by way of, integrally cast mesh layer, mesh layers in precast shell and wrapped mesh layer on precast core.

Reddy (2011) investigate, the experimental program consists of casting and preloading of 24 deficient reinforced concrete beams. The preloading levels adopted in this investigation are 70%, 90% and ultimate. Ferrocement jacketing is done with 2, 4, 6 and 8 layers of woven wire mesh. After investigation test results indicate that the shear failure was transferred to flexural failure in retrofitted beams.

Patil *et al.* (2012) studied RC beams initially stressed to a prefixed percentage of the safe load are retrofitted using ferrocement to increase the strength of beam in both shear and flexure, beams are distressed 60% ,80% of ultimate load. The chicken mesh is placed along the longitudinal axis of the beam. After experimental work researcher concluded that chicken mesh stressed with 60% after retrofitting the stressed beam has the highest load carrying capacity with chicken mesh and also a significant increase in the ductility ratio.

OBJECTIVES OF STUDY

1. To find out an effect on strength of the RC beam retrofitted with ferrocement in single and double layer at 0^0,45^0 orientations, wrapping on three sides by comparing the load carrying capacity of the retrofitted beam and control beam.
2. To determine the flexural rigidity of the RC beam retrofitted with ferrocement in single and double layer at 0^0,45^0 orientations, wrapping on three sides by measuring deflection of the retrofitted beam and compare with control beam.
3. To observe behavior of the RC beam retrofitted with ferrocement in single and double layer at 0^0,45^0 orientations, wrapping on three sides and control beam with respect to first crack load, crack pattern and crack width.

EXPERIMENTAL PROGRAM

Materials

The experimental work consists of casting and testing of 25 simply supported RC beams of 100 mm x 150 mm cross section and 1000 mm length. The materials used in the investigation are given below:

Cement

Ordinary portland cement of 43 grade used. The specific gravity of cement is 3.15.

Fine Aggregate

Locally available natural river sand was used as fine aggregate. The specific gravity of sand was found to be 2.66 and fineness Modulus was 2.55 confirming to zone II.

Coarse Aggregate

Machine crushed angular shaped, maximum 20 mm size aggregate was used. The specific gravity was found to be 2.96 and fineness modulus of coarse aggregate was 7.49.

Steel

The longitudinal steel used was 8 mm diameter HYSD TMT bars. Mild steel bars of 6 mm diameter was used as lateral stirrups spaced at 150 mm c/c. Details of reinforcement as shown in Figures 1 and 2.

Figure 1: Beam Reinforcement Details with Shear Stirrups

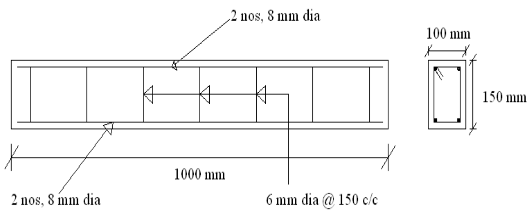
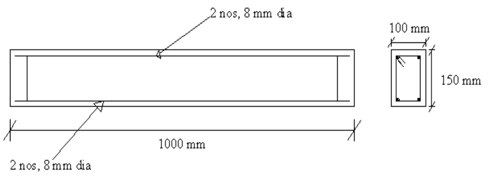


Figure 2: Beam reinforcement details without shear stirrups



Wire Mesh

MS welded wire mesh of square grid was used. The size of opening was 16 mm x 16 mm. The diameter of wire mesh was 0.8 mm.

Mix Selection

Indian standard code 10262 – 2009 was used to arrive final mix proportion. The final mix proportions adopted in the investigation are 1:2.16:3.75 with w/c ratio 0.55 for M 20 grade of concrete.

Water

Clean potable water was used for mixing and curing.

Casting

In the casting process, all the ingredients were first mixed in dry condition, to the dry mix; calculated quantity of water was added and thoroughly mixed to get a uniform mix. Shuttering oil was applied on the inner face of plywood mould and the reinforcement cage was placed in the position. Concrete was poured in three layers was compacted by tamping rod as shown in Figure 3. The specimens were cured in curing tank for 28 days.

Figure 3: Casting of Beam Specimen

TESTING PROCEDURE

Nineteen beams were designed and casted to fail in flexure only. Six beams were casted as a shear deficient means without shear stirrups. After completion of curing time, beams were tested using universal testing machine of 600 KN capacity with two point loading. The deflections at three points were recorded by using dial gauge having least count 0.01 mm at every 2.5 KN increment of load. Out of twenty five beams three beams were tested as a control beam to find out ultimate load of the beam. Eight beams were distressed by 60% of ultimate load. Balance eight beams were distressed by 80% of ultimate load. Cracking pattern in control beam and experimental set up is shown in Figure 4.

Figure 4: Test set up for two point loading

PROCESS OF RETROFITTING

After first stage of loading, the distressed beams were retrofitted by using ferrocement jacketing. Ferrocement is another form of reinforced concrete in which cement sand mortar is reinforced with closely spaced MS welded wire mesh. In this study, square grid MS welded wire mesh (wire mesh of 16 mm x 16 mm x 0.8 mm diameter) was used for all specimens in single, double layer at 0^0 and 45^0 orientations. The surfaces of the distressed beam were roughened by using hacker and wire mesh was wound over it. The mesh was tightened using binding wires. A thick cement paste was applied as bonding agent before application of mortar in order to get a good bond. Plastering was done with cement mortar having the ratio of 1:3 by weight and water cement ratio was kept as 0.5. The 20 mm thickness of mortar was applied on the beam surface. The retrofitted beams were cured for 28 days in curing tank. Following Figure 5 shows process of retrofitting.

Figure 5: Process of Retrofitting

FERROCEMENT CONFIGURATION FOR RETROFITTING

60% and 80% distressed beams were retrofitted in single, double layers of wire mesh at 0^0 and 45^0 orientations. Following Table 1 shows ferrocement configuration for retrofitting.

RESULTS AND DISCUSSION

Experimental Results and Behavior of Beams

All beams were tested under two point loading by using universal testing machine of 600 KN capacity. All the beams were failed in flexural failure, the first crack were appeared in flexural span in vertical direction after that diagonal shear cracks were developed in shear span. In control beams, first hair crack were initiated at bottom sides in the mid span of the beam and shows propagation towards upward direction at a load of about 19.0 KN. The first crack was seen in flexural span at 70 mm to 100 mm from centre of the beam towards point load. As the load increases additional flexural cracks and shear cracks were developed.

Finally beam failed by the conventional ductile failure with yielding of the steel followed by crushing of concrete in the compressive zone. Control beams were failed in flexure at a load of 50.70 KN. Table 2 summarized maximum load experienced by the all type of retrofitted beams with first crack load, deflection, moment of resistance.

Table 1: Ferrocement Configuration for Retrofitting

Particulars	% of Distress	Designation
Control Beam	-	CB1, CB2, CB3
Single layer	60 %	R1 = 60% Single Layer 0^0
Single layer	80 %	R2 = 80% Single Layer 0^0
Double Layer	60 %	R3 = 60% Double Layer 0^0
Double Layer	80 %	R4 = 80% Double Layer 0^0
Single layer	60 %	R5 = 60% Single Layer 45^0
Single layer	80 %	R6 = 80% Single Layer 45^0
Double Layer	60 %	R7 = 60% Double Layer 45^0
Double Layer	80 %	R8 = 80% Double Layer 45^0
Double Layer	Shear deficient	S1= Shear Double Layer 0^0
Double Layer	Shear deficient	S2= Shear Double Layer 45^0
Single layer	Shear deficient	S3 = Shear Single Layer 45^0

Table 2: Experimental results of all type of retrofitted beams with mode of failure

Beam type	Beam mark	First crack load (KN)	Ultimate load (KN)	Deflection (mm)	Moment of resistance (KN-m)	Mode of failure
Control beam	CB	19.00	50.70	5.61	7.605	Flexural failure
Flexural retrofitted	R 1	29.5	80.25	6.89	12.0375	Flexural failure
Flexural retrofitted	R2	29.0	77.75	5.25	11.66	Flexural failure
Flexural retrofitted	R3	33.75	84.5	5.97	12.675	Flexural failure
Flexural retrofitted	R4	32.0	80.50	5.12	12.075	Flexural failure
Flexural retrofitted	R5	32.15	83.75	7.0	12.56	Flexural failure
Flexural retrofitted	R6	30.75	81.00	5.935	12.15	Flexural failure
Flexural retrofitted	R7	35.05	86.5	5.775	12.975	Flexural failure
Flexural retrofitted	R8	34.75	82.75	5.14	12.4125	Flexural failure
Shear retrofitted	S1	20.0	66.0	5.33	9.90	Flexural failure
Shear retrofitted	S2	32.5	81.4	5.05	12.21	Flexural failure
Shear retrofitted	S3	21.0	61.0	5.5	9.15	Flexural failure

COMPARISON OF RESULTS

To evaluate experimental results, it is required to compare results of retrofitted beam with control beam. The comparison of control beam and retrofitted beam is divided into four groups. These groups are classified on the basis of number of layers used at orientation. The comparative discussion is carried out on "which layer at what orientation" showing greater performance.

1. Group I: Single layer of wire mesh at 0^0 orientations.

a) Comparison between 0% distressed control beam and 60%, 80% distressed beam retrofitted with single layer of wire mesh at 0^0 orientation.

R1, R2 beams were 60%, 80% distressed respectively and retrofitted with single layer of wire mesh at 0^0 orientation. Control beams were loaded under two point loading, the first crack was observed at a load of 19.0 KN. Control beam was failed at a load of 50.70 KN and deflection at middle was 5.61 mm. Table 2 and Figure 6 shows linear elastic behavior up to yielding of steel at a load 80.25 KN, 77.75 KN in R1, R2 beams respectively. Deflection in retrofitted beam at load of 50.70 KN was 4.02 mm, 2.61 mm in R1, R2 beams, respectively. First crack was observed in retrofitted beam 29.5 KN, 29.0 KN, respectively. The failure of control and retrofitted beam was purely due to flexural cracks. From this curve it was observed that

Figure 6: Load v/s Deflection Curve For Control Beam And Single Layer of Wire Mesh At 0^0 Orientation

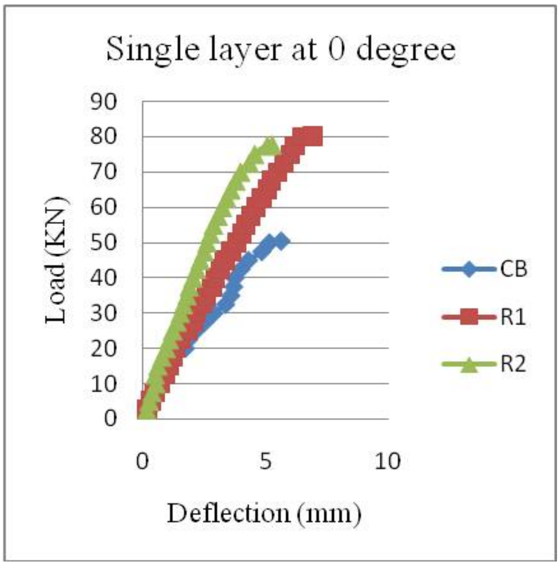
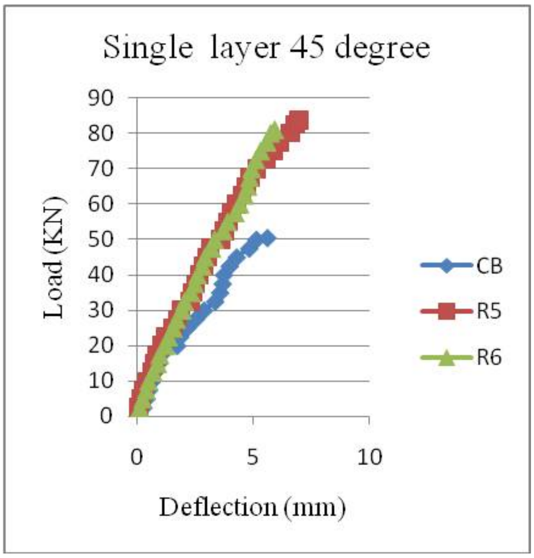


Figure 7: Load V/S Deflection Curve For Control Beam And Single Layer Of Wire Mesh At 45^0 Orientation



the ultimate load increased by 58.28% in R1 beam and in R2 beam it increased about 53.63%. However, it is seen that deflection of the retrofitted was decreased as compared to control beam. The performance of the R1 beam was increased as compared to R2 beam. Also it was observed an increase in stiffness, first crack load, ultimate load with single layer wire mesh at 0^0 orientation.

2. Group II: Single layer of wire mesh at 45^0 orientations

a) Comparison between 0 % distressed control beam and 60%, 80% distressed beam retrofitted with single layer of wire mesh at 45^0 orientation.

R5, R6 beams were 60%, 80% distressed respectively and retrofitted with single layer of wire mesh at 45^0 degree orientation. Table 2 and Figure 7 shows linear elastic behavior up to yielding of steel at a load 83.75 KN, 81.0 KN, respectively. Also the deflection in retrofitted beam as compared to control beam was 3.77 mm, 3.715 mm in R5, R6 beams respectively. First crack was observed in retrofitted beam at a load of 32.15 KN and 30.75 KN, respectively.

From this curve it was observed that the ultimate load increased by 65.18% in R5 beam and 59.76% increased in R6 beam. However, it is seen that deflection R6 beam was decreased as compared to control beam and R5. The ultimate load of R5 beam was increased as compared to R6 beam. But deflection in R6 beam was decreased as compare to others.

b) Comparison between 0% distressed control beam and shear deficient beam retrofitted with single layer wire mesh at 45^0 orientation.

S3 beam was shear deficient beam and retrofitted with single layer of wire mesh at 45^0 orientation. From Table 2 and Figure 8, it was

Figure 8: Load v/s Deflection Curve For Control Beam And Shear Deficient Beam Retrofitted With Single Layer Of Wire Mesh At 45⁰ Orientation

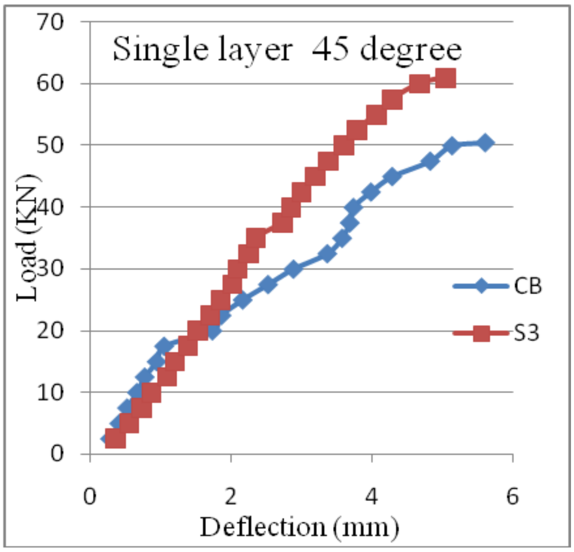
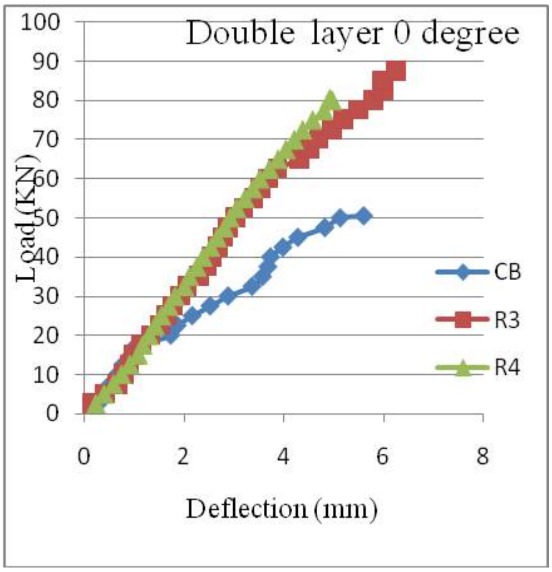


Figure 9: Load v/s Deflection Curve For Control Beam And Double Layer Of Wire Mesh At 0⁰ Orientation



observed that ultimate load of S3 beam was 61.00 KN which is 20.31% of load increment as compared to control beam. The first crack load was observed that at a load of 21.0 KN which is 10.52 % of load increment as compared to control beam. In S3 beam first crack load was observed in the middle portion of the beam, it means that beam was failed in flexure. Also the deflection in retrofitted beam (S3) is minimum as compared to control beam which is 3.78 mm.

3. Group III: Double layer of wire mesh at 0^0 orientations.

a) Comparison between 0% distressed control beam and 60%, 80% distressed beam retrofitted with double layer wire mesh at 0^0 orientation.

R3, R4 beams were 60% and 80% distressed beams retrofitted with double layer of wire mesh at 0^0 orientation. From Table 2 and Figure 9, ultimate load in beam R3 and R4 were 84.50 KN, 80.50 KN, respectively. Also the deflection in retrofitted beam at a 50.70 KN load of 3.185 mm, 3.06 mm in R3, R4 beams, respectively. First crack was observed R3, R4 beams at a load of 33.75 KN, 32.0 KN, respectively.

Load deflection behavior of the beams evaluated by double layers of wire mesh at 0^0 plotted in Figure 9. From this curve it was observed that the ultimate load increased by 66.66 % in R3 beam and 58.77% increased in R4 beam. However, it is seen that deflection of the retrofitted beam was decreased as compared to control beam. The performance of the 60% distressed beam in ultimate load was increased as compared to 80% distressed beam. Also it was observed an increase in stiffness, first crack load, ultimate load with double layer wire mesh at 0^0 orientation.

b) Comparison between 0 % distressed

Figure 10: Load v/s Deflection Curve For Control Beam And Shear Deficient Beam Retrofitted With Double Layer Of Wire Mesh at 0^0 Orientation

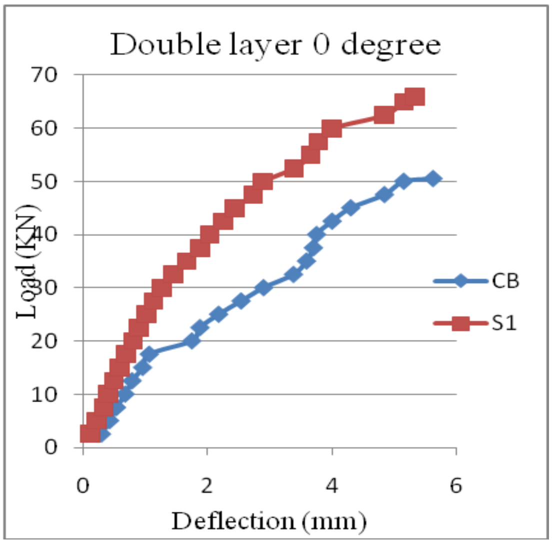
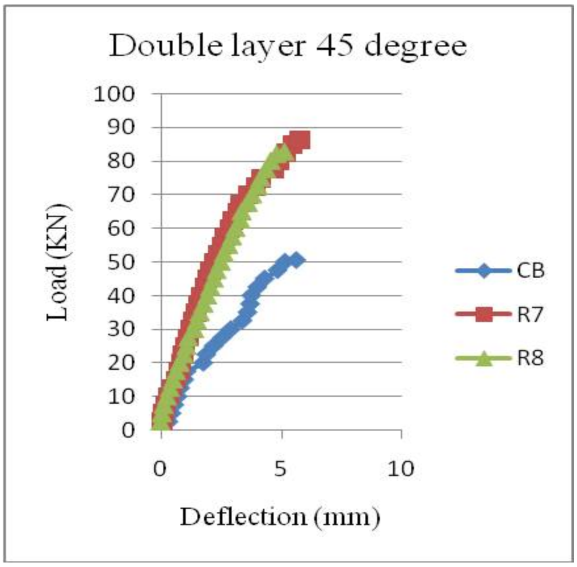


Figure 11: Load v/s Deflection Curve For Control Beam And Double Layer Of Wire Mesh At 45^0 Orientation



control beam and shear deficient beam retrofitted with double layer of wire mesh at 0^0 orientation.

S1 beam was shear deficient beam and retrofitted with double layer of wire mesh at 0^0 orientation. From Table 2 and load deflection response shown in Figure 10, it was observed that ultimate load of S1 beam was 66.00 KN which is 30.17 % increment as compared control beam. The first crack load was observed that at a load of 20.0 KN which is 5.26 % load increment as compared to control beam. In comparison with control beam deflection in retrofitted was 2.98 mm which is minimum.

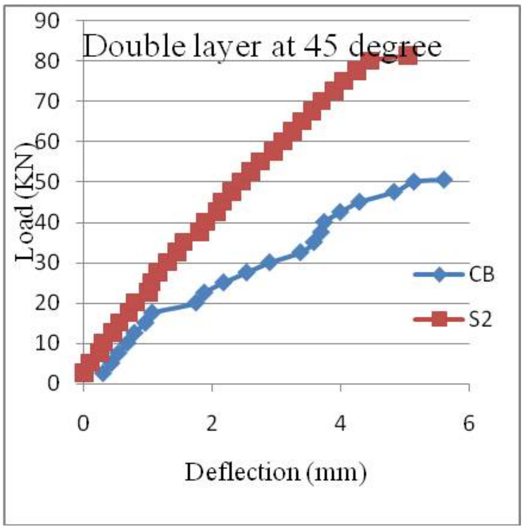
4. Group IV: Double layer of wire mesh at 45^0 orientations.

a) Comparison between 0 % distressed control beam and 60%, 80% distressed beam retrofitted with double layer wire mesh at 45^0 orientation.

R7, R8 beams were 60%,80% distressed beam retrofitted with double layer wire mesh at 45^0 orientation. R7, R8 beam shows linear elastic behavior up to yielding of steel at a load 86.5 KN, 82.75 KN, respectively. Also the deflection in R7, R8 beam was 2.365 mm, 2.63 mm, respectively. First crack was observed in R7 and R8 beam were 35.05 KN, 34.75 KN, respectively. As per curve, the behavior of both retrofitted beam was similar. From this curve it was observed that the ultimate load increased by 70.61% in R7 beam and 63.21% in R8 beam. However, it is seen that deflection was decreased in distressed retrofitted beam as compared to control beam and 80% retrofitted beam. The ultimate load of the R7 beam was increased as compared to R8 beam. But deflection in R7 beam, it was decreased as compare to others.

b) Comparison between 0 % distressed

Figure 12: Load v/s Deflection Curve For Control Beam And Shear Deficient Beam Retrofitted With Double Layer Of Wire Mesh At 45⁰ Orientation



control beam and shear deficient beam retrofitted with double layer wire mesh at 45^0 orientation.

To evaluate the performance of shear deficient beam retrofitted with ferrocement, S2 beam were retrofitted with double layer of wire mesh at 45^0 orientation. From Table 2 and load deflection response shown in Figure 12, it was observed that ultimate load of S2 beam was 81.4 KN which is 60.55% load increment as compared to control beam. The first crack load was observed that at a load of 32.5 KN which is 71.05% load increment as compared to control beam. First crack load was observed in the middle portion of the beam, it means that beam was failed in flexure. Also the deflection in retrofitted beam was 2.6 mm

Table 3: Comparative Results Of Control Beam And Retrofitted Beam

Beam	Area of wire mesh (mm2)	% of steel increment	First crack load (kN)	% of load increment	Ultimate load (kN)	% of load increment	Flexural rigidity kN.m^2	% of increment	Moment of resistance (kN. m)	% of increment
CB	0	0	19.0	0	50.70	0	116.92	0	7.605	0
R1	13.052	12.98 %	29.50	55.26 %	80.25	58.28 %	150.68	28.87 %	12.0375	58.28 %
R2	13.052	12.98 %	29.0	52.63 %	77.75	53.35 %	191.59	63.86 %	11.66	53.32 %
R3	26.104	25.96 %	33.75	77.63 %	84.50	66.66 %	183.11	56.61 %	12.675	66.66 %
R4	26.104	25.96 %	32.0	68.42 %	80.50	58.77 %	203.41	73.97 %	12.075	58.77 %
R5	17.068	16.97 %	32.15	69.21 %	83.75	65.18 %	154.78	32.38 %	12.56	65.15 %
R6	17.068	16.97 %	30.05	61.84 %	81.00	59.76 %	176.56	51.00 %	12.15	59.76 %
R7	34.136	33.95 %	35.05	84.47 %	86.50	70.61 %	193.782	65.73 %	12.975	70.61 %
R8	34.136	33.95 %	34.75	82.89 %	82.75	63.21 %	208.28	78.52 %	12.41	63.18 %
S1	26.104	25.96 %	20.0	5.76 %	66.00	30.17 %	160.201	37.01 %	9.90	30.17 %
S2	34.136	33.95 %	32.5	71.05 %	81.40	60.55 %	208.53	78.35 %	12.21	60.55 %
S3	17.068	16.97 %	21.0	10.52 %	61.00	20.31 %	156.27	33.65 %	9.15	20.31 %

which is minimum as compared to control beam Following Table 3 shows the percentage increment of ultimate load, first crack load, moment of resistance, flexural rigidity.

$$Deflection = \frac{23PL^3}{648EI} \text{ where } P = W/2$$

CONCLUSION

The conclusions drawn from the results obtained in this study are as follows:

1. All the beams retrofitted with ferrocement in single layer and two layers of wire mesh at various orientations experience flexural failures. None of the beams exhibit premature brittle failure or shear failure.
2. Ferrocement properly bonded to three sides of RC beams can enhance the flexural strength substantially. The flexural retrofitted beams exhibit an increase in flexural strength of 60 to 66% for single layer at 45^0 orientation and 64 to 71% for two layers at 45^0 orientations.
3. In shear retrofitting, it exhibit an increase in shear strength of 66.55% for double layer of wire mesh at 45^0 orientation and 30.17 to 20.31% increase in shear strength for two layers of wire mesh at 0^0 and single layer of wire mesh at 45^0, respectively.
4. The flexural retrofitted beams enhance first crack load is about 83 to 85%. In shear retrofitting it increases about 71%.
5. At any given load level, the stiffness are increased significantly because of decreasing deflection of the retrofitted beams because of an increasing percentage of steel. At ultimate load level of the control specimens, the retrofitted beams exhibit a decrease of deflection up to 60%.
6. After retrofitting, all the test specimens observed reduced crack widths, deflection and spacing of cracks at the ultimate load.
7. In flexural retrofitted beam 80% distressed beam exhibits about 70% increment in flexural rigidity. In shear strengthening it increases in between 31 to 70%
8. The beams retrofitted with ferrocement at different orientations do not de-bond when loaded to failure.

REFERENCES

1. Ganeshan N and Thatathil S P (2005), “Rehabilitation of Reinforced Concrete Flexural Elements using Ferrocement Jacketing”, *Journal of Structural Engineering*, Vol. 31, No. 4.
2. Paramasivam P, Lim C T E and Ong K C G (1998), ”Strengthening of RC Beams with Ferrocement Laminates”, *Cement and Concrete Composites, Vol*. 20, pp. 53-65.
3. Patil S S, Ogale R A and Dwivedi A K (2012), “Performances of Chicken Mesh on Strength of Beams Retrofitted Using Ferrocement Jackets”, *Journal of Engineering,* Vol. 2, pp. 1-10.
4. Rafeeqi S F A and Ayub T (2011), “Investigation of Versatility of the Theoretical Prediction Models for Plain Concrete Confined with Ferrocement”, *Asian Journal of Civil Engineering,* Vol. 12, No. 3, pp. 337-352.
5. Reddy M V (2011), “Retrofitting of Shear Deficient RC Beams using Ferrocement

Jacketing", *Journal of Institute of Engineers* (India), Vol. 92, pp. 42-48.

6. Sheela S and Anugeetha B (2009), "Study on the Performance of Reinforced Concrete Beam Retrofitted using Ferrocement and GFRP", 10th National Conference on Technological Trends, pp. 6-7.