



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 9, September 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Experimental Investigation on Behaviour of Reinforced Concrete Beams Retrofitted with Ferrocement

Hari Akshaya E K R¹, Dr.D.Shoba Rajkumar²

P.G. Student, Department of Civil Engineering, Government College of Engineering, Salem, Tamilnadu,India¹

Professor and Head, Department of Civil Engineering, Government College of Engineering, Salem, Tamilnadu,India²

ABSTRACT: The present investigation on behaviour of reinforced concrete beams retrofitted by using ferrocement to increase the performance of beams in both shear and flexure. The reinforced concrete beam specimens were casted of size 150mmx150mmx1500mm with M25 concrete grade with high strength deformed bars as longitudinal and shear reinforcement. The control beam was tested for ultimate load, and the remaining beams were preloaded to 60% of ultimate load, then wrapped with single and double layer mesh arrangement at 0 degree orientation and retrofitted with 20mm thick layer of ferrocement. The load deflection characteristics, first crack load, crack pattern, mode of failure are studied. The test results indicate an increase in load carrying capacity of 27.66% in single layer and 48.99% in double layer retrofit beams than control beams, enhancement in flexural strength of about 28.59% in single layer and 49.69% in double layer retrofit beams than control beams, also an improvement in crack control, stiffness, ductility and deflection parameters. of strengthened beams.

KEYWORDS: Ferrocement, Jacketing ,Retrofitting, RC beams, Weld mesh

I. INTRODUCTION

Reinforced concrete structural components exhibit distress and damage even before their service period due to deterioration of concrete and reinforcements caused by aggressive environment. The awareness on strengthening of structures came into being in the minds of engineers and scientists during the 1960s. Strengthening technique was essentially originated as concrete structures are normally designed to last long. Some of them do last a great length of time, but some of them became unusable and are in need of restoration or repair. Old and ancient structures needing extensive amount of rehabilitation is not a matter of grave concern, however the fact is that some of the newly constructed structures are also showing signs of decay in their early life spans, sometimes even within a decade or two of their construction is quite disturbing. The result is that the number of structures needing rehabilitation has gone up sharply in recent times. Further, it is always desirable to strengthen the structures rather rebuild them.

Ferrocement Jacketing is one of the most popular and economical method for strengthening of existing structures. Ferrocement is a special form of reinforced concrete which exhibits uniform dispersion of reinforcement in matrix offers improved tensile and flexural strength, fracture, toughness, crack control and impact resistance. Ferro cement technique is commonly used for retrofitting due to its lightness. due to their light weight, ease of construction, durability, less skilled labour ,their property of being cast to any shape without any significant formwork and development of finer cracks for the same steel-stress under loading.

II. LITERATURE REVIEW

Y V Ladi, P M Mohite [1]Evaluated the performance of RC beams retrofitted with ferrocement. in which the specimens were preloaded to 60% and 80% of the ultimate load and retrofitted. The results indicates a significant increase in load carrying capacity, first crack load, stiffness but deflection decreases in both flexural and shear strengthening.Dr.RagheedFatehiMakki [2]Investigated the behaviour of reinforced concrete beams retrofitted by ferrocement to increase the strength of beams in both shear and flexure. The experimental results indicated that the rehabilitation technique (strengthening and repairing) of R.C beams by using ferrocement system is applicable and can increase the ultimate load from 69.8 - 175%(strengthening) and from 50.94 – 125%(repairing).Gurbir Singh Benipal, Kamaldeep Singh [3]This work has focused mainly on the effect of wire mesh orientation on the strength of stressed beams retrofitted with ferrocement jackets. The results show that there is an increase in load carrying capacity to about

52.29% and a considerable increase in energy absorption for 45 degree orientation as compared to 0 degree and 60 degree orientations. C. Neeladharan, A. Muralidharan, P. Satish, K. Mohan [4] In this investigation, the performance of R.C beams is strengthened by epoxy injection and ferrocement retrofitting. The retrofitted beams were tested which indicates that upto 85% of the preloaded beams can be strengthened using epoxy and ferrocement and the load carrying capacity is higher for 70% preloaded beams. Awadhesh Kumar, Nitin Modi [5] This investigation has been carried out mainly to find a feasible and most efficient strengthening alternative and thus reinforced concrete beams are strengthened with carbon fibre reinforced polymer (CFRP), glass fibre reinforced polymer (GFRP) and ferrocement laminates. The CFRP and GFRP strengthened beams along with ferrocement strengthened beams have enhanced first crack load by 17.3%, 33.1% and 9.4% respectively while ultimate load carrying capacity was enhanced by 19%, 31% and 10.4% respectively for CFRP strengthened, GFRP strengthened and ferrocement strengthened beams.

III. OBJECTIVE

The main objective of the present thesis is to evaluate the behaviour of the RC beams retrofitted with ferrocement in single and double mesh layer at 0 degree orientation with wrapping on four sides in comparison with control beam with respect to load carrying capacity, flexural strength, first crack load, crack pattern, ductility and stiffness criteria.

IV. CONSTITUENT MATERIALS AND PROPERTIES

1. Ordinary Portland Cement: Ordinary Portland Cement of 43 grade was tested and used for the mortar mix. The physical properties test of the cement, such as Consistency (33%), Initial Setting Time (30 minutes), Final Setting Time (270 minutes), Fineness (4%), Soundness (3mm) and Specific Gravity (3.12), were done in accordance to the procedure laid in IS 8112:1989.

2. Fine Aggregate: The locally available M - sand was used as fine aggregate in cement mortar conforming to grading zone II as per IS: 383-2016. The sand was sieved in 4.75 mm sieve to remove deleterious material and then used. The physical properties which the M-sand was tested for are Specific Gravity (2.62), Loose Bulk Density (1510.288 kg/m³), Dense Bulk Density (1788.075 kg/m³), Fineness Modulus (3.61) and Water Absorption (2.4%).

3. Coarse Aggregate: The locally available coarse aggregate was used, as per IS 383-1970, coarse aggregate in sieve size 20mm passing and 4.75mm retaining in saturated surface dry (SSD) condition with Specific Gravity (2.68), Bulk Density (1684 kg/m³), and water absorption (0.5%).

4. Steel reinforcement: The HYSD steel bars of two 10mm dia bars and two 8mm diameter bars were used as longitudinal reinforcement in tension and compression zone respectively, and 6 mm diameter ties at 150 mm spacing were provided as lateral reinforcement.

5. Mesh: The woven galvanised steel chicken mesh with a hexagonal opening of size 12mm, wire thickness of 0.7mm (20 gauge) is used and steel wire mesh woven in square pattern with grid size of mesh is 12.7mm * 12.7mm having the thickness of wire 1mm and 25.4mm * 25.4mm having the thickness of 1.5mm are used for single and double layer mesh reinforcement.

6. Epoxy resin: Bondtite epoxy resin is used for the purpose of gluing the cracks on the surface of distressed beam, mesh reinforcement and the ferrocement jacketing which requires a hardening time of 6-8 hours to attain higher strength characteristics.

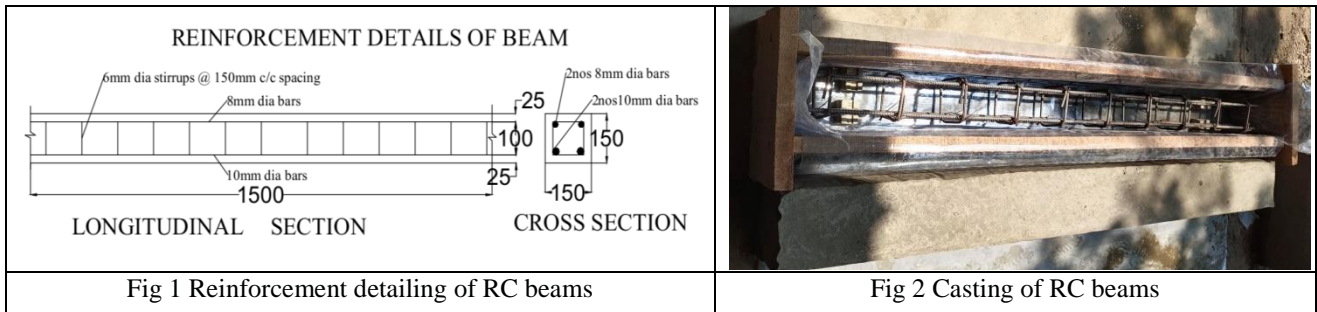
7. Water: Water is a crucial and important ingredient of the concrete as it actively participates in the chemical reaction with cement and results in hardening of the concrete. Potable water was used for mixing the alkaline activators. Water used in this study confirmed to the requirements of IS 456:2000.

8. Mix selection: The mix proportions of M25 concrete grade with 1:1.42:2.46 with water cement ratio of 0.45 was adopted for the casting of RC beams as per IS 10262-2009 and the cement – sand mortar mix of 1:2 with water cement ratio of 0.4 has been adopted for retrofitting.

V. EXPERIMENTAL PROGRAMME

The experimental work was carried out on a total of three RC beams that were designed using limit state method considering it to be an under-reinforced section and as per IS 456-2000 recommendations which are grouped as control beam, Retrofit RB1 and Retrofit RB2. The control beam was tested to find their ultimate load carrying capacity, whereas the RB1 beam and RB2 beam were designated for 60% preloading of ultimate load of control beam and wrapped with single and double mesh layer at 0 degree orientation respectively, retrofitted with ferrocement

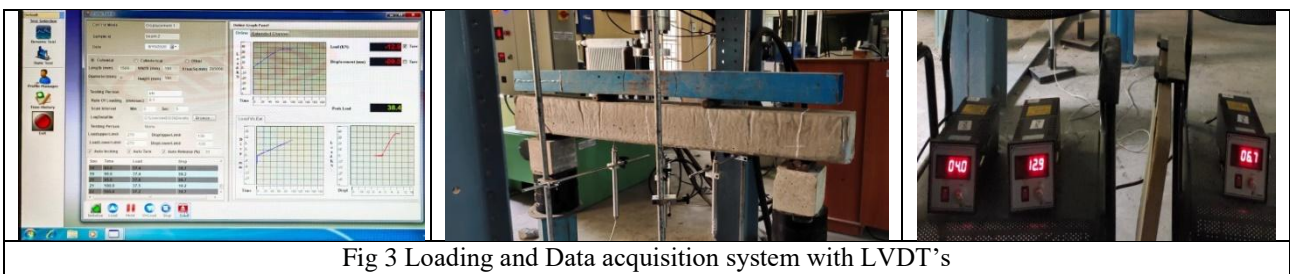
1. Casting of specimens: The reinforced concrete beam specimens were cast in mould size of 150x 150 x 1500mm having two 10mm dia bars and two 8mm diameter bars were used as longitudinal reinforcement in tension and compression zone respectively, and 6 mm diameter ties at 150 mm spacing were provided as lateral reinforcement with concrete mix of cube compressive strength 25 N/mm² provided clear cover of 25mm After 24 hours, the specimens were removed from the moulds and burlap sacks were placed over the specimens and subjected to curing for about 28 days.



2. Testing and preloading of specimens: The load is applied to the beam with the help of hydraulic jack of capacity 250KN and the data is recorded from the data acquisition system for the increment of 5KN, which is attached with the load cell (Actuator). The beam designated as control beam was tested under two point loading system upto ultimate load whereas, the RB1 and RB2 beams were loaded upto 60% of the ultimate load of control beam. The three LVDT's were placed at bottom of the beams, one is placed at the mid span and other two LVDT's were placed at a distance of span/3 from each end and the deflection values are obtained from these LVDT's

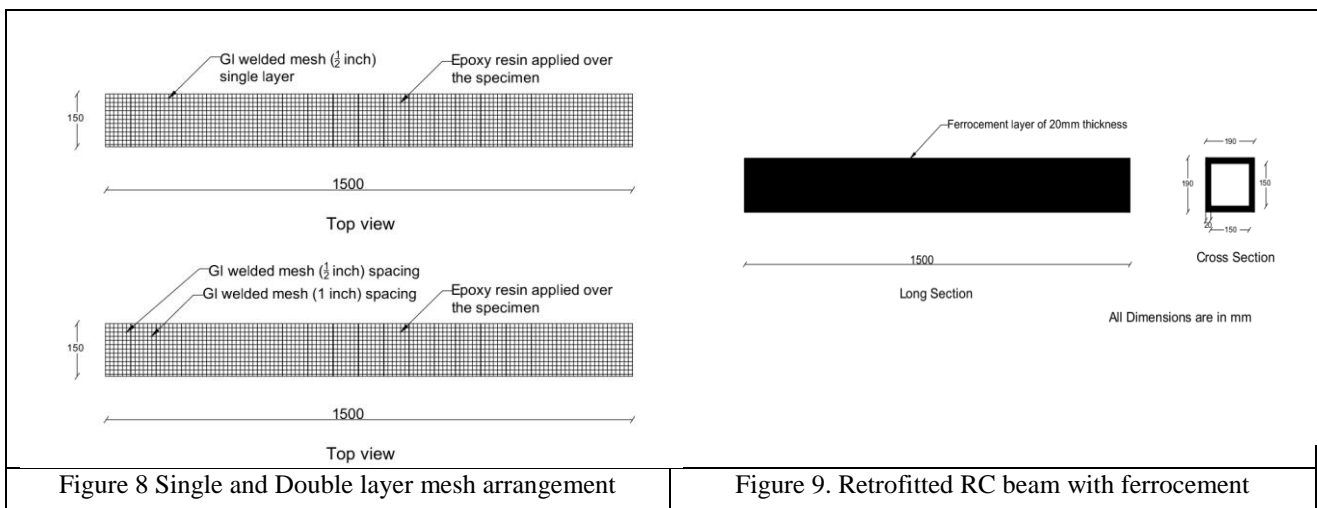
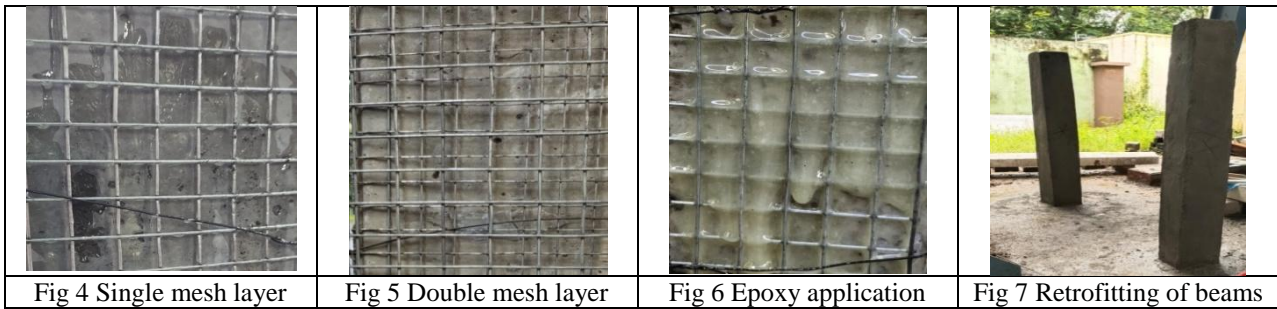
Table. 1 Designation of specimens

| GROUP ID | AMOUNT OF PRELOADING | NO OF MESH LAYER |
|--------------|----------------------|------------------|
| Control beam | - | - |
| Retrofit RB1 | 60% | 1 |
| Retrofit RB2 | 60% | 2 |



3. Retrofitting of specimens: The preloaded specimens surfaces has been cleaned properly and filling of surface cracks was done by epoxy injection. The beams are left undisturbed for half an hour to one hour for the purpose of healing of minute cracks in the beams which are developed during testing of beams. Then the surfaces of beams are roughened for the effective application of epoxy coating over the beam's surface to enhance the bonding between the surface of RC beam and the mesh layer and allowed to hardening for about 6-8 hours.

The RB1 beam was wrapped with single layer of welded wire mesh of size 12.7mm*2.7mm with 1.1mm diameter wires at 0 degree orientation, whereas the RB2 beam was retrofitted with one layer of welded wire mesh of size 12.7mm*12.7mm with 1.1mm diameter and another layer of welded wire mesh of size 25.4mm*25.4mm with 1.5mm diameter held at 0 degree orientations. Before the application of mortar over the beams, these are surrounded with the chicken mesh of 0.7mm diameter. The purpose of using chicken mesh is to hold the mortar of thickness 20mm with 1:2 cement mortar ratio and water cement ratio 0.40, which is applied over the mesh layer and the specimens were subjected to curing.



4. Testing of retrofitted specimens: The two retrofitted beams of RB1 and RB2 were loaded under the actuator, in two point loading system and the obtained results are compared with the control specimens (values obtained before retrofitting). The retrofitted beams have been loaded until reaching its ultimate load carrying capacity and the bending & deflection behaviours were studied

In the control beam, the deflection increases almost linearly with the increase in load upto the ultimate load of 53.5 KN with final deflection recoded at 14.9mm. The first crack in the beam was observed at a load of 34.5 KN thereafter number of cracks increased and spread over the entire length of the beam. The RB1 and RB2 beams which were initially stressed to a safe load of 36 KN shows maximum improvement after retrofitting in which the ultimate load of RB1 beam increased from 53.5 KN (control Beam) to 68.3 KN with deflection of 7.6 mm, whereas the ultimate load of RB2 beam shows an increase from 53.5 KN (control Beam) to 79.5 KN with deflection of 12.5mm.

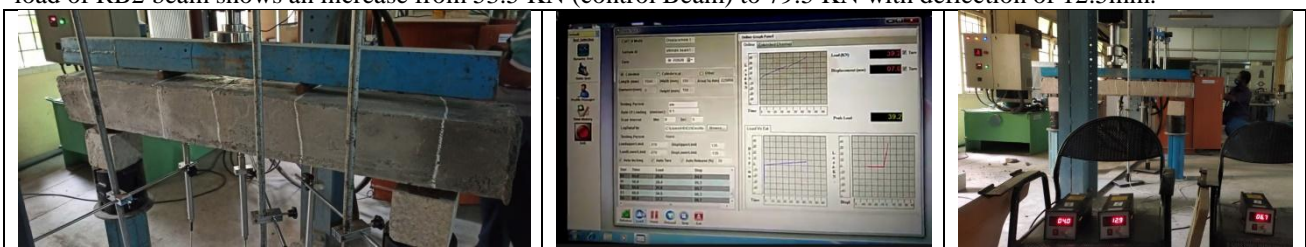


Fig 10 Testing of Retrofitted specimens

VI.RESULTS AND DISCUSSION

The results of the study in terms of ultimate load carrying capacity, flexural behaviour,deflection,stiffness, ductility, failure patterns and its detailed discussions are given in the following section.

Ultimate load carrying capacity: The RC beams jacketed with single layers of weld mesh subjected to 60% preloading gained 27.66% increase in ultimate load carrying capacity whereas, RC beams subjected to 60% preloading with two layers of meshing improved its load carrying capacity by 48.99% respectively. Hence, the confinement action increases with number of weld mesh layers during jacketing. Thus, theincrease in no of weld mesh layers, ultimate load carrying capacity of the beams are improved considerably.

Table. 2 Consolidated test results

| Description | Control Beam | Retrofit RB1 | Retrofit RB2 |
|--|--------------|--------------|--------------|
| Ultimate load(KN) | 53.5 | 68.3 | 79.5 |
| Mid span deflection | 14.9 | 7.6 | 12.5 |
| 1 st crack load(KN) | 34.5 | 39 | 45 |
| Deflection @ 1 st crack load | 5.6 | 2.9 | 7.4 |
| Ductility ratio | 1.68 | 2.62 | 2.66 |
| % of load increment | - | 27.66 | 48.99 |
| Compressive strength(N/mm ²) | 1.58 | 1.26 | 1.46 |
| Flexural strength(N/mm ²) | 11.61 | 14.93 | 17.38 |
| Stiffness(KN/mm) | 3.59 | 8.9 | 6.36 |

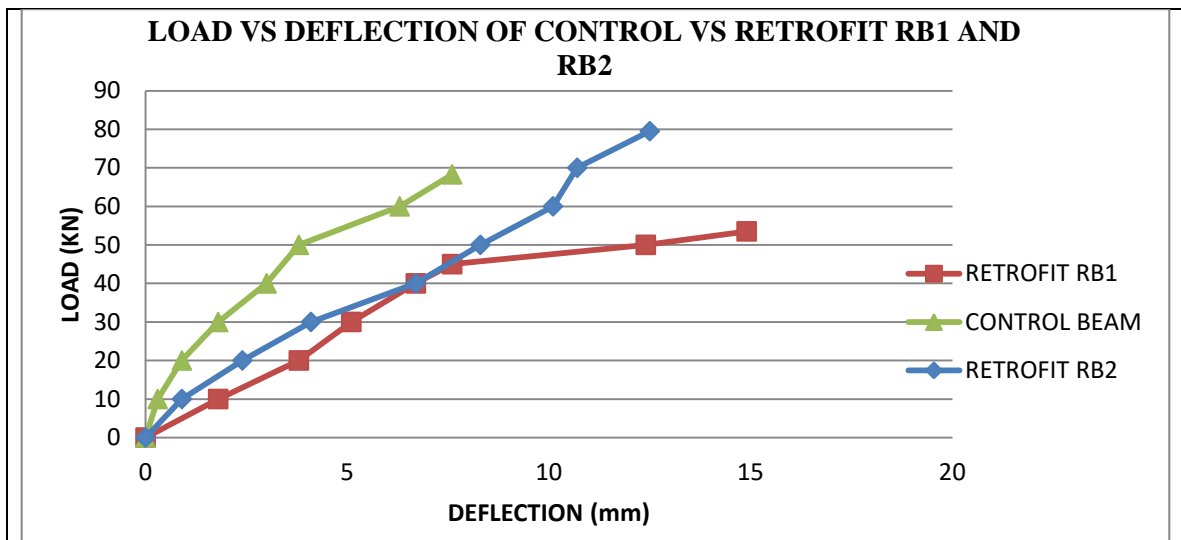


Fig 11 Comparison of ultimate load of control vs retrofitted beams

Failure pattern of specimens:The bond strength between the ferrocement jacketing and the original beams were enhanced due to epoxy resin, thus no bond failure occurred due to debonding in case of double mesh layer retrofittedRB2 beam (Fig 14) whereas, debonding of retrofitted layer was observed in single mesh layer retrofitted RB1 beam(Fig 13).

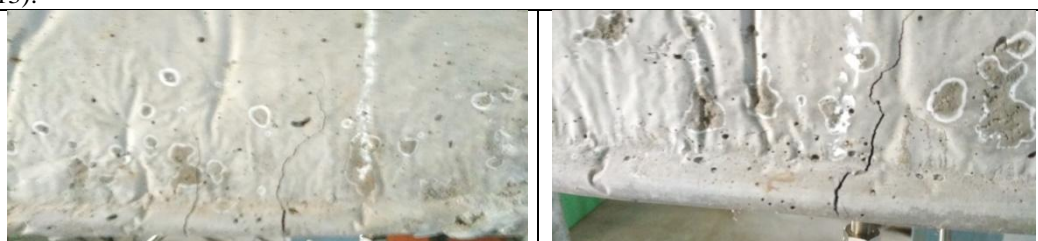


Fig 12 Failure and crack pattern of control beam



Fig 13 Failure and crack pattern of retrofitted RB1 beam



Fig 14 Failure and crack pattern of retrofitted RB2 beam

VII. CONCLUSION

Based on the results and observation of the experimental investigations presented in this thesis regarding the behaviour of Reinforced Concrete beams retrofitted with ferrocement, the following conclusions are drawn

- Retrofitting of the beams by ferrocement technique with single layer and double layer of welded wire mesh shows that considerable increase in the load carrying capacity of about 48.99% in double layer retrofitted beam RB2as compared to the capacity of 27.66% in single mesh layer retrofitted beam RB1 compared to the control beam.
- The flexural strength of retrofitted beams has been increased upto 28.59% in single mesh layer retrofitted beam RB1 and 49.69% in double mesh layer retrofitted beams RB2as compared to the control beam.
- Due to retrofitting, there is a slight decrease in deflection, which indicates an increase in the stiffness of retrofitted beams than control beam which is due to the mesh reinforcement
- The beams retrofitted using ferrocement exhibit increased load carrying capacity, increase in flexural strength, and significant increase in ductility ratio, and delay in the first crack load compared to the control beam.
- The bond strength between the ferrocement jacketing and the original beams were enhanced due to epoxy resin, thus no bond failure occurred due to debonding in case of double mesh layer retrofitted beam whereas, debonding of retrofitted layer was observed in single mesh layer retrofitted beam.
- The retrofitted beams also show a considerable reduction in crack width, spacing of cracks and the failure of specimens characterized by development of shear and flexural cracks over the tension zone which is due to the better distribution of stress in RB2 beam(double mesh layer) than the RB1 beam (single mesh layer)

Thus it is concluded, that the double mesh layer retrofitted beam are strengthened in terms of shear and flexure as compared to the single mesh layer retrofitting which indicates that double layer retrofitting is much suitable for strengthening of existing damaged structures in all aspects.

REFERENCES

1. IS 456 – 2000,
2. IS 10262 – 2009
3. ACI Committee Report No.549 “State of Art Report on Ferrocement” ACI- 549-97 American Concrete Institute, Detroit, Part 5, pp. 549R2.
4. ACI Committee 549-IR-93. Guide for the Design, Construction and Repair of Ferrocement.



5. Handbook on repair and rehabilitation of RCC buildings, CPWD, Government of India,
6. Ferro cement Jacketing for Strengthening of Reinforced Concrete Beam under Flexural Load - doi: 10.1016/j.proeng.2013.03.066 , Elsevier
7. Gurbir Singh Benipal, Kamaldeep Singh, “Reinforced concrete beams retrofitted Ferrocement” International journal of engineering development and research, Vol. 3, No. 4.
8. Ladi Y V and Mohite P M, “Experimental evaluation of reinforced concrete beam retrofitted with ferrocement”, International journal of research in engineering and technology, Vol. 2, No. 3. August 2013
9. Gurpreet Singh Dhanoa, Jagmeet Singh and Rajindervir Singh, “Retrofitting of reinforced concrete beam by ferrocement technique” Indian journal of science and technology, Vol 9, No 15.
10. Prem Pal Bansal ,Kumar Maneek , KausikS.K, “Effect of Wire Mesh Orientation On Strength Of Beams Retrofitted Using Ferrocement jackets” “International Journal of Engineering” Vol.(2);Issue (1)
11. Nassif. H.H., Chirravuri. G., Sanders. M.C., “Flexural Behaviour of Ferrocement/Concrete Composite Beams”, Proceedings of the Sixth International Symposium on Ferrocement, Naaman, A.E. (Eds.), University of Michigan. Ann Arbor, June 1998, 7 - 10, pp. 251 - 258.
12. Paramasivam.P, Ong, K.C.G, Ong .Lim.C.T.E. ‘Flexural Strengthening of R.C Beams with Ferrocement Laminates’, “Cement & Concrete Composites” Vol.20 1998 pp 53-65
13. Ganeshan N and Thatathil S P (2005), “Rehabilitation of Reinforced Concrete Flexural Elements using Ferrocement Jacketing”, Journal of Structural Engineering, Vol. 31, No. 4.
14. 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.
15. 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.
16. Andrews, G.; and Sharma, A.K., “Repaired Reinforced Concrete Beams” ACI, Concrete International, Detroit, April 1998, pp. 47-50.



INNO SPACE
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details