REVIEW OF RESEARCH
ISSN: 2249-894X
IMPACT FACTOR : 5.2331(UIF)
VOLUME - 7 | ISSUE - 6 | MARCH - 2018

REHABILITATION OF RCC BEAMS-A COMPARISON OF STRENGTHENING METHODS

Ranganath T. V. L.[1] and Dr. Shrishail B. Anadnni[2]
[1]Ph.D. Research scholar, civil engineering department, Himalayan University, Arunachala Pradesh
[2]Principal, Vijay Vittal Institute of Technology, Hennur, Bagalur Road, Bangalore.

ABSTRACT

The Reinforced structures may become unfit to use due to several reasons like overloading, uneven settlement of soil, seismic loads, environmental effects and etc,. Such structures can be strengthened and rehabilitated using several FRP materials. FRP is a composite and consists of fibers, matrix and the interface. Micro concrete can also be used for repairing of structures. In the present investigation about 8 RCC beams were casted with M20 concrete and Fe415grade steel. Two beams were considered as control beams and two each were strengthened with E Glass, carbon fiber FRP and micro concrete respectively. A comparative study has been made to study the flexural behavior like ultimate load carrying capacity, deflections at mid point and one-third points and cracking pattern.

KEY WORDS: *RCC beams, FRP, carbon FRP, E glass FRP, Micro concrete, and Ultimate load carrying capacity.*

1. INTRODUCTION

Many failures have taken place in the civil engineering structures due to several reasons. The several reasons for the deterioration of these elements may be due to ageing, poor maintenance, corrosion of reinforcement and constructional defects. The strengthening and retrofitting of these structures will increase the service life of these structures. Rehabilitation of civil engineering structures like buildings, beams, columns, piers and deck slab of bridges etc., has become a major issue in recent days.FRP(Fiber Reinforced Polymer) is one of the construction material that can be used for retrofitting of civil engineering structures.

In the above context research was carried out to study to know the improvement of strength of plain concrete members by wrapping with FRP. The plain concrete cubes, cylinders and prisms were casted and wrapped with FRP and were tested for the improvement in their strength.

2. CHARACTERISTICS OF FRP COMPOSITES AND MICRO CONCRETE

2.1 FRP materials

FRP composites are widely used for several applications. The two major components of FRP are resin and reinforcement. A few main characteristics of the Fiber Reinforced Polymer are:

* There is an improvement in tensile strength of concrete by the use of FRP composites. Tensile strength of the composites is normally about four to six times greater than that of steel or aluminum. (E_{steel} = 200 x 10^3 MPa & $E_{carbon\ FRP}$ = 120 to 580 x 10^3 MPa)
* Application of fiber to the concrete members is easy and less labour involved.
* FRP composites are light in weight and offers great strength to the concrete members. Composite materials are about 30- 45% lighter than aluminum and caters the same functional requirements.
* FRP is high moisture resistant and hence makes the structure as corrosion resistant.
* Composites are also temperature resistant.

2.2 Micro concrete

Micro concrete also known as micro cement or interior concrete is cement based coating which can be applied thinly over the surface of tile, wood or concrete. Micro concrete is basically formed by a cement bound mortar and a resin. Micro concrete is suitable for all kinds of repairs of concrete structures. Some of the advantages of micro concrete are high early strength, low shrinkage, fast drying and excellent bond to concrete structures. The compressive strength and flexural strength of micro concrete at 28 days is about 80 N/mm^2 and 8 N/mm^2 respectively.

3. OBJECTIVES OF THE PRESENT STUDY

In the present investigation 8 beam specimens of cross section 230mm x 150mm and of length 2430mm were casted and cured for 28 days.

Out of 8 specimens, two specimens were kept as control specimens and two each were wrapped with single layer of carbon and glass FRP respectively. Two more were treated with micro concrete.

These treated beams were tested and their deflections at right, left and centre was noted. The crack patterns of these strengthened beams were also studied. The variation in ultimate load carrying capacity was estimated.

The studies were made to know the deflection, crack width and flexural strength of retrofitted concrete members.

3.1. Properties of materials used in the study

Zuari cement of 43 grade confirming to the standards of IS-4031(Part 1)-1996 was used. The river sand was used as a fine aggregate which was confirming to IS-2386-1963 - part III. Crushed coarse aggregates of 20 mm size used were confirming to IS 2386- 1963-part III. Indian Standard method was used for the concrete mix design and the mix proportion for M20 concrete was obtained as **1: 1.645:3.20** with a water cement ratio of 0.50. Weigh batched materials were mixed in a concrete mixer. HYSD bars of 10 mm diameter were used as reinforcement.

3.2. Nomenclature of Test specimens

The following table gives the details regarding the test specimens

Table-1 Details of Test specimens

Sl.no.	Specimen Designatio	Specifications	No.of specimens tested
1.	Control -1 Control -2	For comparison	2
2.	B.SR – 1C B.SR – 2C	Beam single wrapped	2

		with carbon FRP	
3.	B.SR – 1G B.SR – 2G	Beam single wrapped with E-Glass FRP	2
4.	B.SR – 1MC B.SR – 2MC	Beams with single coating of micro concrete	2

4. SPECIMENS AND TESTING EQUIPMENTS

4.1 Details of beam specimens

The structural design details are as follows:
Width of the beam = 150 mm
Overall depth of the beam = 230 mm
Clear cover to the reinforcement = 25mm
Area of tensile steel = 3 bars of 10 mm dia
Anchor bars = 2 bars of 10 mm dia
Shear reinforcement=2-Legged 6mm dia at 150 mm C/C
Grade of concrete = M20
Grade of steel = Fe 415
The details of dimensions and the reinforcement is shown in Fig. 1 below.

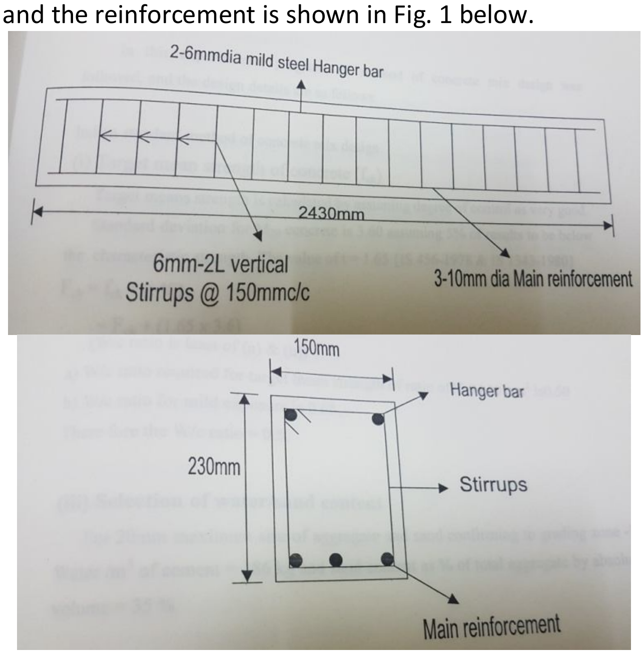

Fig 1 Details of dimensions and reinforcement

4.2 Surface preparation

Surface preparation of cured specimens was done. The blow holes and imperfections were filled with epoxy putty to get a smooth surface. In order to mark the stud points, load points and support points and also for the easy identification of cracks the beams were painted with primer.

4.3 Application of FRP

The fiber was wrapped to the beams at flexure zones using epoxy resin. At the beginning the epoxy primer in the ratio of 9: 1 was applied with a brush until the substrata is locally saturated. The epoxy resin was mixed in the proportion of 2:3 and prepared mix was applied on the specimens within 20 minutes of mixing. The neatly cut fibers to the required size has to be glued on the beam surface. Finally epoxy saturate for aesthetic blending and for protecting fibers from environmental attacks is applied.

4.4 Arrangements of test set up

The beams were tested under two point loading to create pure bending and cause flexural failure. The loading system consists of supports, loading frame, loading Jack and load transfer system. The loading frame of 250 KN capacity was used to test the specimens. The loading system is as shown below.

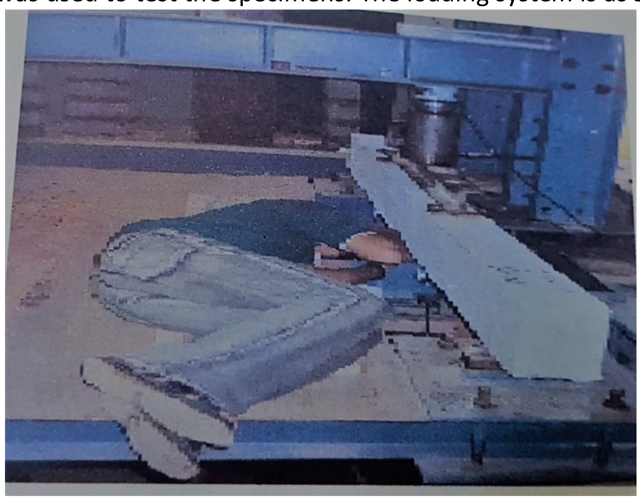

Fig. 2 Loading arrangement and test set up

All the 8 beams were tested by loading at an increment of 1 T. At evey increment of load the demec gauge readings,dial gauge readings, crack numbers, crack width and crack spacing were noted down in the tabular column. The beams were loaded till failure.

4.1. Presentation and discussion of Test Results

The beams were tested under the two points loading till the failure. During testing the following points were followed:

1. The minimum load increment was 1 tone.
2. The strains were measured using Demec gauge.
3. The crack widths were measured using a traveling telescope.
4. The deflections were measured with dial gauges.

The following table gives the test results:

Table-2 Behavior of cubes and prisms

Sl.No.	Beam Type	Characteristick compressive strength F_{ck} N/mm^2	Modulus of repture F_{cr} N/mm^2	Schmidt hammer reading on cubes S_{hr} N/mm^2
1	Control -1	36.00	6.57	27.703
2	Control- 2	35.80	6.57	27.52
3	B.SR- 1C	34.00	6.57	24.83
4	B.SR-2C	33.65	6.57	24.35
5	B.SR -1 G	30.84	6.08	24.00
6	B.SR -2 G	31.30	6.08	24.10
7	B.SR-1 MC	35.60	6.76	22.75
8	B. SR-2MC	34.87	6.76	23.15

Fig 3 Beams after testing

Table 3 Test results of cracking load and experimental ultimate load on RCC beams

Sl. No.	Beam Type	Cracking load P_{cr} in kN	Experimental Ultimate load $P_{U\ Exp}$ in kN
1	Control -1	60	82.5
2	Control- 2	60	82.5
3	B.SR- 1C	54	78
4	B.SR-2C	54	78
5	B.SR -1 G	45	75
6	B.SR -2 G	45	75
7	B.SR-1 MC	59	82
8	B. SR-2MC	59	82

Table-4 Central deflection of RCC beams at various loads

Sl. No.	Beam Type	Central deflection in mm at				
		80 KN	90 kN	100 kN	110 kN	115 kN
1	Control -1	12.45	-	-	-	-
2	Control- 2	12.33	-	-	-	-
3	B.SR- 1C	8.51	9.55	10.51	12.94	17.36
4	B.SR-2C	8.35	9.42	10.79	13.03	16.42
5	B.SR -1 G	9.03	10.23	12.52	19.01	-
6	B.SR -2 G	8.70	9.75	11.02	15.70	-
7	B.SR-1 MC	11.00	17.05	-	-	-
8	B. SR-2MC	12.29	-	-	-	-

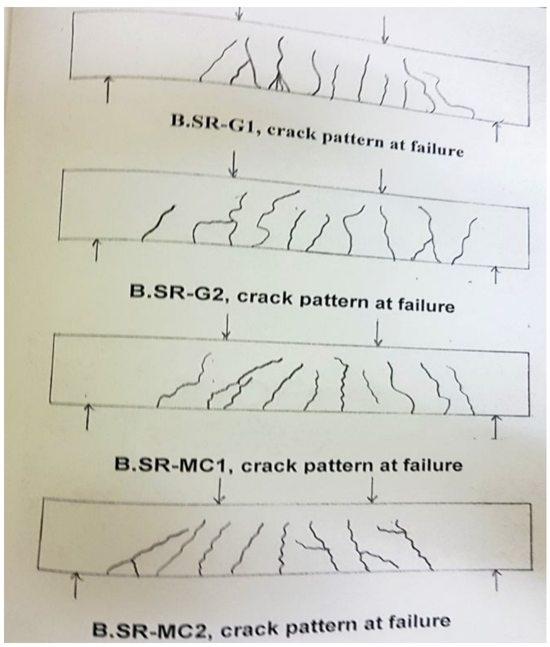

Fig 4 Crack patterns at failure for various beams

Table-5 Effect of wrapping on maximum crack width (w_{max})

l. No.	Beam Type	Average maximum crack widths at different loads in mm (w_{max})				
		80 kN	90 kN	100 kN	110 kN	115 kN
1	Control	0.49	-	-	-	-
2	B.SR- C	0.30	0.35	0.37	0.42	0.58
3	B.SR G	0.20	0.21	0.50	0.65	-
4	B. SR- MC	0.55	1.15	1.6	-	-

5. DISCUSSION ON RESULTS AND CONCLUSIONS

Based on the above test results the following conclusions have been drawn.

1. There is an increase in ultimate load carrying capacity of 43.75% for carbon fiber wrapped, 37.5% for E-Glass fiber wrapped and 12.5% for micro concrete treated beams when compared to control beams.
2. The load carrying capacity of carbon fiber wrapped beams was more than that of E glass fiber wrapped and micro concrete treated beams.
3. There was a significant decrease in deflection of wrapped specimens at any particular loading even up to the failure.
4. The beams strengthened with micro concrete are more flexible as they deflect more for the same amount of load.
5. It was observed that the use of composite fibers and micro concrete is not only a simple technique but it also improves the ultimate load carrying capacity of the beams and enhances their flexural behavior.

6. REFERENCES

[1]Rajiv Nehru and Arpit Patni, "**Strengthening Reinforced Concrete Beams"**, Construction World, January 2003, pp.35-36.

[2] M. S. Shetty," Concrete Technology",S Chand & Company publishers.

[3] www.aleicta.com ALEICTA guide- Strengthening of Reinforced concrete structures with externally bonded composite materials.

[4] M.Sarafraz; F. Danesh, **"Flexural Enhancement of RC columns with FRP"**, proceedings of the 14th World conference on Earthquake Engineering, October 12-17, 2008, Beijing, China.

[5] P.N. Balaguru, N.Permalsamy and C.Chang"**High strength composites for repair, rehabilitation and strengthening of concrete structures"** ICI Journal Jan-Mar 2003.

[6] https://materia.nl/material/micro-concrete/

[7] http://livingconcrete.co.uk/micro-concrete/

[8] http://chemisol.com/index.php/micro-concrete-mc-500-free-flowing-micro-concrete/

Ranganath T. V. L.
Ph.D. Research scholar, civil engineering department, Himalayan University, Arunachala Pradesh

Dr. Shrishail B. Anadnni
Principal, Vijay Vittal Institute of Technology, Hennur, Bagalur Road, Bangalore.