Utilization of laminates for strengthening of RCCbeam

Siddharth[1]
Research Scholar
Department of Civil Engineering
National Institute of Technology, Patna, Bihar, India

Sagar Sarangi[2]*
Assistant Professor
Department of Civil Engineering,
Sarala Birla University, Ranchi, Jharkhand, India
sagarsarangicit@gmail.com

ABSTRACT

Present investigation paper summarized the utilization of retrofitting techniques for strengthening the beam by using low cost fibrous material and resin. For this study thirty reinforced concrete beam specimen as per BIS standard were casted by using local available construction materials. Here, we strengthen the specimen externally by the help of hardener, resign and fibrous material. Here, U wraps and bottom wrap technique was adopted for retrofitting. The sample after wrap was tested in UTM by using two-point loading system and results were observed. From the result it was shown on improving ultimate load bearing capacity and flexural strength of the proposed specimen as compared to control specimen. In case of single synthetic u-wrap and single cotton u-wrap specimen improved flexural strength 8.66% & 11.22% respectively of control specimen at the age of 28 days. Which is lesser as compared to any other material fiber collected from previous research mentioned in literature? But it gives impressive result along with economic so, it can be applicable in rehabilitation of defected RC structures due to age, defective design and corrosion of steel reinforcement in adverse environmental condition.

Keywords— Retrofitting, Flexural strength, Rehabilitation, Fiber, Fiber Reinforced Polymer (FRP)

Highlights

- Economic retrofitting technique
- Strengthen of RC beam by using fibrous material
- Useful techniques for rehabilitation of defected RC structures

1. Introduction

Now days beautiful and important structure built from ancient period going to be affected its structural integrity due to adverse environmental condition. Durability of that structure is only possible by using various protecting technology. Now days, lamination technology is one of the leading interest by the researchers for improving existing old structure for rehabilitating purpose. It is very much essential due to flaws in structural design, deterioration of reinforcement due to corrosion, aging of concrete and many more. Till date lot of techniques developed by the researchers and young scientist for strengthening a RC beam and apart from that external strengthening using FRP technique is quite interesting, also it is acceptable by worldwide due its easy on site possibility. FRP is a composite matrix of material fiber and resin, where carbon fiber, glass fiber are treated as reinforcing agent and resin as binder. By using this technique material fiber can be utilised for enhancement the tensile strength of beam. But, due to economic consideration glass, carbon, aramid fibres are not suitable for financially challenged beneficiary living in rural area. To overcome that obstacle young scientist utilised natural fiber such as jute, hemp, flax etc. fiber as reinforcing agent for making FRP composite. In this investigation we used polyester came from ester functional group polymer fiber along with cotton fiber sheet as a reinforcing agent for making FRP composite. This is economic as compared to other types of fiber. [1]Campione investigated on retrofitting of the beam by using CFRP. From his observation derived a relationship between strength and length of the composite wrap. Using GFRC in RC beam was investigated by Pannirselvem and observed impressive growth in flexural strength of beam after wrapping [2][3]. Adi A S carried out the similar investigation as Pannirselyem and observed the relationship between crack growth of concrete and GFRP wrap area is vice versa [4]. Retrofitting of RC beam by pre-stressed GFRC composite able to reduce the spalling of concrete was observed by Lin H Y [5]. Use of carbon fiber reinforced polymer in strengthening technique able to enhanced stiffness and first cracking load significantly were observed by researcher Ramana V [6]. In case of fatigue behaviour of carbon fiber reinforced plastic laminated RC beam technique was not acceptable recommended by Erki M A [7]. From the previous studied in this research work we are utilizing synthetic fiber and cotton fiber as a raw material as reinforcing agent for making FRP with resin.

2. Experimental Investigation

For carried out experimental work in laboratory 150mm x 150mm x 700mm RCC beam specimens were cast. Where 8mm Ø# 5 numbers and 6mm Ø@ 125mm spacing (Centre-Centre) TMT bar used as tension and shear reinforcement respectively. The reinforcement details on the beam shown in "Figure 1".

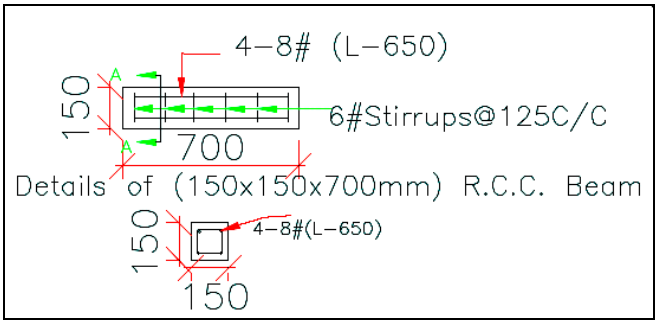

Figure 1:Detailing of Reinforcement in RC Beam Specimen

a. Material

For this work Portland Slag Cement manufactured by "Ultra Tech Cement Ltd" conforming to IS 455:1989 utilized as binding material and the properties are shown in "Table-1"[8]. Locally available river sand and crushed granite stone MSA of 20mm size conforming to IS 383:1970 used as fine aggregate and coarse aggregate respectively[9]. The properties of the aggregate are shown in "Table-2". HYSD Fe- 500 8mm Ø #5 number and Fe-250 6mm Ø TMT bar @ 125mm spacing (Centre- Centre) used as tension and shear reinforcement respectively; properties of the bar shown in "Table-3" and detailing of reinforcement shown in "Figure 1". Polyester and cotton textile fiber sheet collected from local textile shop were utilised for wrapping purpose over precast concrete beam specimen. Araldite epoxy resin and hardener used as matrix for composite material.

Table 1: Properties of Cement

Chemical Properties	**Obtained**	**As per Indian Standard 455:1989**
Mg O	5.28	<10% Max
SO_3	1.08	<3% Max
MgO	5.27	<10%
S	0.66	<1.5%
SO_3	1.08	<3%
Insoluble residue	1.10	<4%
Loss on ignition	1.16	<5%
Na_2O	0.3	
Total Chloride Content	0.05	<0.10%
Physical Properties		
Fineness	349	225 M^2/Kg Min
Consistency	32%	
Initial Setting Time	50 min	30 minutes Minimum
Final Setting Time	320 min	600 minutes Maximum
Soundness	1	10mm Max
Compressive Strength 3 Days	18	16 MPa Min
Compressive Strength 7 Days	24	22 MPa Min
Compressive Strength 28 Days	36	33 MPa Min

Table 2: Properties of Aggregate

Properties	**Fine Aggregate**	**Coarse Aggregate**
Fineness Modulus	2.602	4.08
Sp. Gravity	2.60	2.63
Bulk Density	1.479	1.61
Moisture content (1day)	1%	3%
Impact value	-	25.37%
Zone	II	

Table 3: Properties of Reinforced bar

Ultimate Tensile Strength @ 8mm Ø (MPa)	Modulus of Elasticity 8mm Ø (kN/mm^2)
62.240	61.68

3. Methodology

b. Sampling

A mix of M20 grade of concrete is design for making precast concrete specimen of size 150mm X 150mm X 700mm and quantity are shown in "Table-4". Allowed for submerged curing for the aging of 7days and 28days. After air dried cleaning and roughing of outer surface carried out by using sand paper for better interfacial bonding between composite material and the beam specimen. Fiber sheet were cut into desired size and wrap in outer surface of the specimen by the help of resin and hardener and allowed for dried for a period of 24hr or a day.

Table 4: Mix proportion

Cement	FA	CA	Water
372 Kg	833 Kg	1125 Kg	186 lit.
1	2.23	3.03	0.5

c. Experimental Setup

For investigate the modulus of rupture flexural test of two-point loading methods were conducted in flexural testing apparatus as specified by Indian standard. One control set specimen were also tested for conducting comparative study between pre and post treatment of rehabilitating beam specimen. While increasing the load initial visible crakes were obtained and recorded in observation register and applied load was increasing till achieving its maximum fracture load. By computing could be predict the betterment of the structure pre and post rehabilitation process. Average of three specimen were noted the flexural or modulus of rupture of the specimen. Experimental setup was shown in "Figure 2".

Figure 2: Experimental Setup

4. Result

From the experimental investigation we can found some result about strengthening technique in India. The results are shown in "Table-6" and "Figure 3".

A. Compressive Strength

After removing from curing tank and allowed for drying in air compressive strength of mortar cubes was determined using the universal testing machine according to IS 516-1959[10]. Average of three cubical samples was calculated and the results are shown in "Table-5".

Compressive strength (MPa) = Fracture Load / Cross sectional area of specimen (Mpa). (1)

Table 5: Compressive strength of concrete

7days Compressive strength	28days compressive strength
24.44 N/mm^2	36.0 N/mm^2

B. Flexural Strength Test

Pre-cast reinforced beam after sampling allowed axial load using two-point loading system in flexural testing machine for finding out the fracture load of the specimen. By computing the load using formula given below easily calculated the modulus of rupture of flexural strength of the given specimen. As per Indian standard specification average of three samples were considered [10].

$$\textit{Flexural strength} = \frac{3pl}{2bd^2} \quad (2)$$

Where

p: fracture load of the specimen in Newton
l: length of the sample specimen in mm
b: breadth of the specimen in mm
d: depth of the sample specimen in mm

Table 6: Flexural Strength

Sl No	Specimen ID	7days N/mm^2	28days N/mm^2	Changes (%) at 28days
1	S-1[Control]	18.92	25.96	Ref.
2	SS-2[Synthetic Single Bottom wrap]	21.35	29.01	10.51
3	SS-3[Synthetic Single u-wrap]	22.10	29.24	11.22
4	SC-1[Cotton Single Bottom wrap]	19.33	26.43	1.78
5	SC-2 [Cotton Single u-wrap]	20.69	28.42	8.66

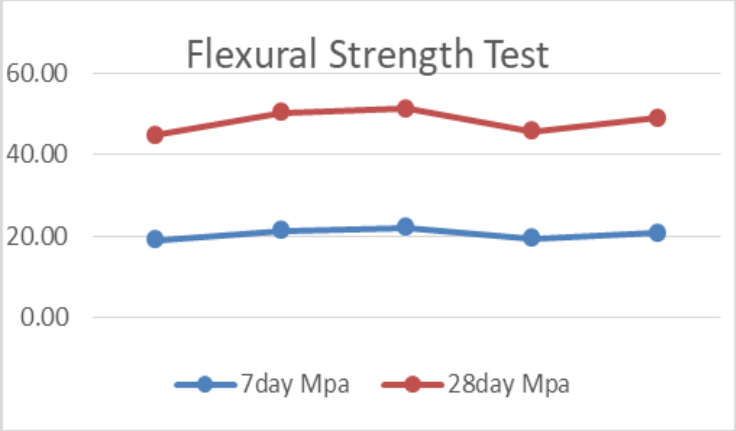

Figure 3: Flexural Testing result

C. Result

Compressive strength of concrete mix achieves its target strength at the age of 28 days i.e. 36.0 N/mm^2 whereas flexural strength 25.96 N/mm^2.

- Single synthetic fiber sheet bottom wrap gives 21.35 N/mm^2 and 29.01 N/mm^2 at the age of 7days and 28days which is 10.51% greater than control specimen.
- But, in case of single synthetic u-wrap improve its flexural strength 11.22% compared to reference specimen.
- Apart from synthetic wrap, cotton fiber sheet wraps single bottom system improve slightly from control

5. Discussion And Conclusion

From this investigation, it is shown that ultimate fracture load of beam specimen can be achieved impressively by laminate FRP sheets. We observed that, retrofitting with synthetic fiber sheet single U-wrap improved flexural strength of 11.22% as compared to control specimen. Whereas, in bottom wrap improve 10.51% which is quite impressive as compared to cotton fiber sheet wrap retrofitting techniques. Cotton single bottom wrap technique improve fracture load upto 1.78% as compared to control specimen which is least result noted in this investigation. We concluded that by using waste textile fiber sheet and hardener could be one of the economic techniques as compared to any other retrofitting technique.

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