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STUDY ON THE PERFORMANCE OF RETROFITTING TECHNIQUES IN RCC BEAMS

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Abstract - *Reinforced Concrete structures are suffering from various deteriorations like corrosion, cracks, spalling and large deflection. These deteriorations are caused by various factors such as aging, corrosion of steel reinforcement, environmental effects and accidental impacts on the structure. Such unserviceable structures require immediate attention, enquiry into the cause of distress and suitable remedial measures, so as to bring the structures back to their functional use again. This strengthening and enhancement of the performance of such deficient structural elements in a structure or a structure as a whole is referred to as retrofitting. There are several options available for retrofitting the structural members of the existing reinforced concrete structures. Nowadays, wrapping using fibre reinforced polymer sheets on to the damaged members helps to increase load carrying capacity, ductility and stiffness of the damaged structure. Such technique is an effective way to improve the flexural and shear performance of the reinforced concrete damaged structure. Fibre reinforced polymer materials are continuing to show great promise for using strengthening reinforced concrete structures. These materials are an excellent option for use as external reinforcing, because of their light weight, resistant to corrosion and high strength. The main aim of this study is to investigate the flexural characteristic of RC beams using FRP sheets and GFRP sheets. This paper presents experimental results of the RCC beams strengthened in flexure with externally bonded FRP and GFRP.*

***Key Words*: Retrofitting, Reinforced concrete, Strengthening, FRP, GFRP, External reinforcing**

1.INTRODUCTION

Structures deteriorate due to problems associated with reinforced concrete. Natural disasters like Earthquakes have repeatedly demonstrated the susceptibility of existing structures to seismic effect. Implements like retrofitting and rehabilitation of deteriorated structures are important in high seismic regions. Thus retrofitting and strengthening of existing reinforced concrete structures has become one of .the most important challenges in civil engineering. Engineers often face problems associated with retrofitting and strength enhancement of existing structures. For the satisfactory performance of the existing structural system, the need for maintenance and strengthening is inevitable. Complete replacement of an existing structure may not be a cost-effective solution and it is likely to become an increased financial burden if upgrading is a viable alternative. In such occasions, repair and rehabilitation are most commonly used solutions

While many solutions have been investigated over the past decades, there is always a demand to search for use of new technologies and materials to upgrade the deficient structures. In this context, strengthening with Fibre Reinforced Polymers (FRP) composite materials in the form of external reinforcement is of great interest to the civil engineering community. The conventional strengthening methods of RCC structures attempt to compensate the lost strength by adding more material around the existing sections. The strengthening of concrete structures with externally bonded reinforcement is generally done by using either steel plates or Fibre Reinforced Polymer (FRP) or Glass Fibre Reinforced Polymer (GFRP). Each material has its specific advantages and disadvantages. Fibre reinforced polymers offer numerous beneficial characteristics over steel including excellent corrosion resistance, non-magnetic, non-conductive, generally resistant to chemicals, good fatigue resistance, low coefficient of thermal expansion, and high strength to weight ratio as well as being lightweight. FRPs also possess a high specific stiffness and an equally high specific strength in the direction of fibre alignment. Use of FRPs provides a high structural efficiency and their low density makes physical implementation much easier. Unfortunately, FRPs are also expensive, but the higher costs of FRP materials are often offset by savings in reduced periodic maintenance, longer life spans and of reduced labour costs.

2. MATERIALS

2.1 Concrete

For concrete maximum aggregate size used was 20mm. The concrete mix proportion designed by IS method to achieve the strength of 20 N/mm^2 and was 1:1.67:3.33 by weight. The design water cement ratio was 0.47. 18 beams were cast and tested at the time of beam test (at the age of 28 days) to determine flexural strength of beams.

2.2 FRP

FRPs exhibit several improved properties, such as high strength-weight ratio, high stiffness-weight ratio, flexibility in design, non-corrosiveness, high fatigue strength, and ease of application.

Tensile strength = *2700-4200 MPa*
Modulus of Elasticity = *60-80 GPa*
Density = *2100-2400 Kg/m3*
Modulus of elasticity to density Ratio = *31-33*

2.3 GFRP

From the past studies conducted it has been shown that externally bonded Glass Fibre-Reinforced Polymers (GFRP) can be used to enhance the flexural, shear and torsional capacity of RC beams. Due to the flexible nature and ease of handling and application, combined with high tensile strength-weight ratio and stiffness, the flexible glass fibre sheets are found to be highly effective for strengthening of RC beams.

Tensile strength = *3400-4800 MPa*
Modulus of Elasticity = *70-90 GPa*
Density = *2200-2500 Kg/m3*
Modulus of elasticity to density Ratio = *31-33*

2.4 Epoxy Silicone Resin

Silicone is a non-corrosive neutral cure industrial grade silicone sealant which can be used to meet a variety of sealing and gasketing needs. It cures to silicone rubber and adheres to glass, U-PVC, wood, metal, porcelain, ceramic tile, painted surfaces and rubber. It provides excellent adhesion, low odour, non-corossive, uv resistance, fast cure and remain flexible.

Uncured specific gravity = *1.03*
Setting time = *1 hr*
Full cure = *7 days*
Density = *0.8-1 Kg/m3*

3. EXPERIMENTAL WORK

Eighteen beams of 80 x 135 mm cross section and 1000 mm long were tested up to failure by single point load and udl. All beams were reinforced with 1Φ8mm as tension reinforcement. Non retrofitted beams were tested with central point load and udl with five numbers each.

Failure loads for Non Retrofitted specimens,

Loaded with central point load = 1.02T
Loaded with Uniformly Distributed Load = 1.22T

3.1 Preparation of Retrofitted Beams

After cleaning the surface, preparation of the surface of beam was done with the help of a chisel and hammer One layers of GFRP/FRP sheet was wrapped on the surface of the beam. These layers were pasted with the help of mortar or epoxy adhesive named silicone. Retrofitting is done on both newly casted as well as on beams failed on loading. 4 specimens were bonded with mortar and 4 with silicon in each case. The GFRP/FRP retrofitted beam specimens named as, NCM for newly casted and mortar bonded; FM for failed and mortar bonded; and NCS and FS respectively for silicon bonded beam specimens. These were tested for maximum load by applying point load and udl using UTM.

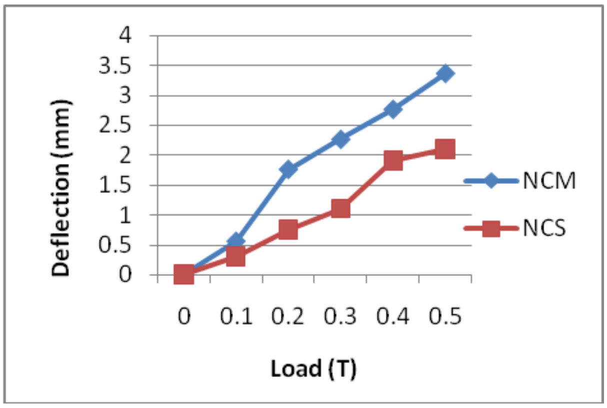
3.2 Test Results of FRP And GFRP Retrofitted Beams

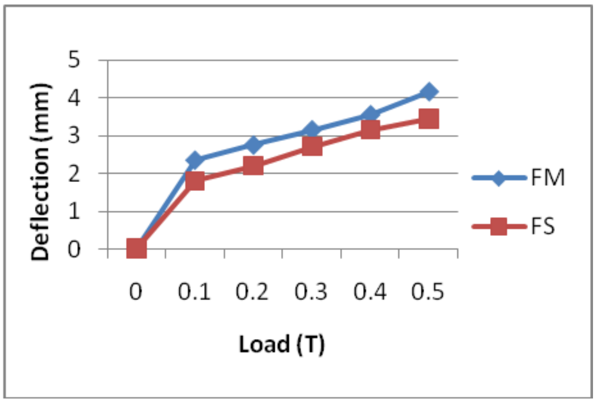
Table 1. Test result for GFRP Retrofitted Beams

LOAD (T)	DEFLECTION (mm)			
	NCM	NCS	FM	FS
0	0	0	0	0
0.1	0.56	0.3	2.34	1.80
0.2	1.76	0.75	2.74	2.20
0.3	2.26	1.1	3.14	2.72
0.4	2.76	1.9	3.54	3.16
0.5	3.36	2.1	4.15	3.46

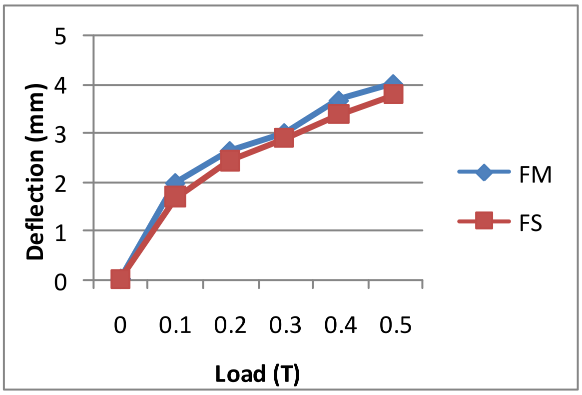
Failure loads

NCM = 1.75T
NCS = 2.35T
FM = 1.05T
FS = 1.6T





Load – Deflection graph for GFRP Retrofitted Beams

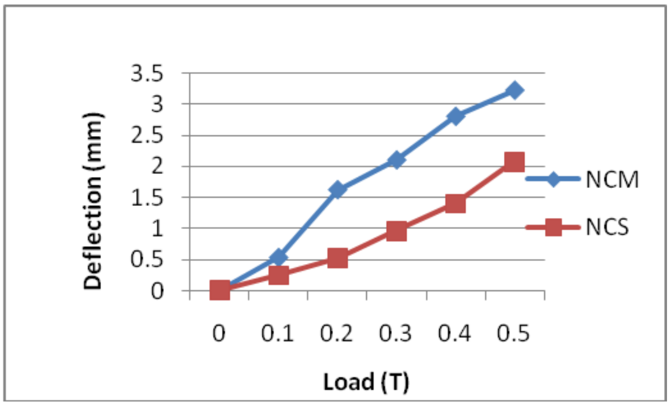


Load – Deflection Graph for FRP Retrofitted Beams

Table 2. Test results for FRP Retrofitted Beams

LOAD (T)	DEFLECTION (mm)			
	NCM	NCS	FM	FS
0	0	0	0	0
0.1	0.53	0.24	1.97	1.68
0.2	1.62	0.52	2.63	2.42
0.3	2.10	0.96	3.0	2.90
0.4	2.80	1.40	3.67	3.38
0.5	3.22	2.08	4.01	3.78

Failure loads
NCM = 1.45T
NCS = 2.15T
FM = 0.95T
FS = 1.45T



4. RESULTS AND DISCUSSIONS

First of all the specimens of beams were tested to ultimate load. The average ultimate load of the non-retrofitted beams with concentrated load was observed to be 1.05T and with UDL wa observed to be 1.25T. In case of GFRP retrofitted beams with mortar bond, the average ultimate load was observed to be 1.8T and for silicon bonded it was found to be 2.2T. In case of FRP retrofitted beams with mortar bond, the average ultimate load was observed to be 1.45T and for silicon bonded it was found to be 2.15T.

When GFRP retrofitting is done on failed beams, the average ultimate load for mortar bond was obtained as 1.1T and for silicon bond it was observed as 1.9T, while FRP retrofitting is done on failed beams, the average ultimate load for mortar bond was obtained as 0.95T and for silicon bond it was observed as 1.45T.

It can be observed from the experimental data and corresponding graphs that there is a significant increase in the ultimate load carrying capacity of FRP and GFRP retrofitted beams when comparing with non-retrofitted ones. The mortar bonded retrofitted beams gives us 44% increase in the ultimate load carrying capacity for GFRP and 16% increase for FRP. While silicone bonded give 76% increase for GFRP retrofitted and 72% for FRP. In case of failed beams, both regain about 100% of its load carrying capacity by retrofitting technique.

5. CONCLUSIONS

Based on the results of the experimental investigation carried out we conclude that

1. GFRP & FRP jacketed beams show an increase in ultimate load carrying capacity

2. GFRP jacketed beams show an increase of nearly 44% in the ultimate load carrying capacity for mortar bonded beams.
3. GFRP jacketed beams show an increase of nearly 76% in the ultimate load carrying capacity for silicone bonded beams.
4. FRP jacketed beams show an increase of nearly 16% in the ultimate load carrying capacity for mortar bonded beams.
5. FRP jacketed beams show an increase of nearly 72% in the ultimate load carrying capacity for silicone bonded beams.
6. Failed beams show about 100% regaining of its load carrying capacity by retrofitting with both GFRP & FRP sheets. Hence it can be reused.
7. While comparing the results of GFRP & FRP sheets, GFRP sheets give more results in both newly casted as well as on failed beams.

This undoubtedly proves that GFRP & FRP retrofitting techniques are efficient and effective methods for strengthening and rehabilitation of structures.

REFERENCES

[1] Balasubramanian.K,Krishnamoorthy.T.S,Bharatkumar B.H,Udhayakumar.V andLakshmanan.N (2007) "Investigations on the RC Structural Elements Retrofitted Using FRP Wraps", Journal Of Structural Engineering ,vol. 34, pp 63-69.
[2] T.Manikandan, G.Balaji ponraj ,“ Strengthening Of RC Beam Using GFRP Wraps”, International Journal of Engineering Trends and Technology (IJETT) - Volume4Issue5- May 2013.
[3] Tarek H. Almusallam and Yousef A. Al-Salloum, “Use Of Glass FRP Sheets As External Flexure Reinforcement In RC Beams”, Department of Civil Engineering, King Saud University.
[4] N. F. Grace, G. A. Sayed, A. K. Soliman and K. R. Saleh, “Strengthening Reinforced Concrete Beams Using Fiber Reinforced Polymer (FRP) Laminates”, ACI Structural Journal.
[5] Rahimi H and Hutchinson A, “Concrete Beams Strengthenined with Externally Bonded FRP Plates” J. Compos. Constr., 10.1061 (ASCE)1090-02685:1(44),44-56. Volume 5, Issue 1 (February 2001).
[6] Buyukozturk O and Hearing B, “Failure Behavior of Precracked Concrete Beams Retrofitted with FRP” J. Compos. Constr., 10.1061 (ASCE)1090-0268:3(138),138-144. Volume 2, Issue 3.