Strengthening The Corroded RC Beam In Bending Using GFRP

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Abstract- *Now a days, reinforced concrete infrastructures facing one of the main problem i.e. Corrosion of steel reinforcement & this problem is worldwide. Many structures have experienced unacceptable loss in serviceability or safety far earlier than anticipated due to the corrosion of reinforcing steel and thus need strengthening, replacement or rehabilitation. Fiber reinforced polymer is very effective way to repair and strengthen structures that have become structurally weak over their life span. FRP repair systems provide economically viable alternative to traditional repair systems and material. Experimental investigation on the flexural behavior of corroded RC beams strengthened using glass fiber reinforced polymer (GFRP) sheets are carried out. Corroded reinforced concrete beams with epoxy-bonded GFRP sheets were tested to failure under a symmetrical two point concentrated static loading system. Experimental data on load, deflection, ultimate load carrying capacity and failure modes of each of the beams were obtained.*

Keywords- RC beam, Corrosion,Strengthening, Retrofitting, GFRP sheets.

I. INTRODUCTION

THE reinforce concrete beam can be strengthening (Retrofitting) by FRP (Fiber Reinforced Polymer) are one of the effective technique of strengthen of beam. Now a days, strengthening of beam by FRP is popular. Because of low material cost, corrosion free, light weight and easy of application. The various kinds of FRP available in currant market namely Carbon Fiber Reinforced Polymer (CFRP), Glass Fiber Reinforced Polymer (GFRP) And Kevlar Fiber Reinforced Polymer (KFRP). Plates, sheets and bars are three forms FRP available . FRP plate/ sheets adhesively bonded to the bottom face of simply supported beam for increase in flexure strength. By application of FRP not even flexural strength but also shear strength are extensively increased. As bending moment is highest in middle of the beam, so for increase in flexural strength FRP apply middle of the beams but in actual practice the FRP sheets apply throughout to avoid debonding of sheets. The reason of widely acceptance of FRP is because of comparatively low cast, corrosion resistance, high strength and high fatigue resistance. While GFRP are accepted for their cheap rate over carbon fiber composites still CFRP used were ductility strength and stiffness were necessary. To understand the behavior of FRP researcher carried out experimental, numerical and analytical study in beam. One of the good agreement with experimental results is analytical results. Researcher focused at the same time on recognize and understand the failure modes that reinforced concrete beams strengthen with FRP. Flexure failure of concrete and debonding of FRP are the principle failure modes experimentally identified.

The concrete infrastructure facing a major problem is corrosion of reinforcing steel. An adverse environments have experienced unacceptable loss in safety far earlier than anticipated due to the corrosion of reinforcing steel and thus need rehabilitation or repair, replacement, strengthening in many structures. Due to loss of bond and bond splitting a heavily corroded RC member tends to fail. The expansive forces caused by steel corrosion can cause cracking, spalling and staining of the concrete, and hence loss of structural bond between the reinforcement and concrete. The degree of structural strength may be maintained in a corroding RC beam, if corrosion cracking can be prevented or delayed. Corrosion presents a problem for reinforced concrete (RC) structures for two reasons. There is a corresponding drop in the cross-sectional area as steel corrodes firstly. Secondly, the corrosion products occupy a larger volume than the original steel which exert substantial tensile forces on the surrounding concrete and causes it to crack and spall off.

There are two ways to use FRP for structural application. First ways we can use FRP as a sheet or plate which is to strengthen damage structural member by application of FRP. Retrofitting and strengthening structure member such as beam, column and slab with external application of FRP are an one of the effective method use over a world and another way to use FRP as a bars in reinforced concrete member instead of steel bar.

II. OBJECTIVES

Comparing the moment of resistance of corroded and strengthen RC beam.

Changes in ultimate load carrying capacity of corroded and strengthen RC beam.

Bottom bars – 3 bars specimen
2. 8 mm –Stirrups – @ 100mm c/c
Size of beam – 1000mm X 150mm X 150mm
Strengthening by using GFRP sheet – 3 mm sheet

III. MATERIALS & METHODS

Material used for casting – (Concreting M40 Grade) per m3
Portland Pazzolana Cement – 460kg
Coarse aggregate
20 mm – 570 kg
10 mm – 540 kg
Sand – 660 kg
Water – 175 ltr
Reinforcement required for 1 Beam –
1. 10 mm –
Top bars – 2 bars

Total no of beam sample casted are 15 beams.
Out of which – For
Virgin testing – 3 beams
Virgin corrosion testing @ 1.5mA – 3 beams
Virgin corrosion testing @ 3mA – 3 beams
Retrofitting (Strengthening) testing of corroded beam @ 1.5mA – 3 beams
Retrofitting (Strengthening) testing of corroded beam @ 3mA – 3 beams
The test on beam were carried out as given above.

Here we carried out study to investigate the flexural characteristic of corroded RC beams with help of GFRP sheets. Then RC concrete beams with square cross section of150 × 150 and a span length of 1000 mm were tested. As two of them were tested as a controlled beams. And other are kept in accelerated corrosion setup for current 1.5mA & 3mA. The mode of failure observed in flexure zone due to load increased higher. These cracks gradually increase in height with an increase in load. At last we observed mode of the failure was characterized by intermediate crack debonding of the bottom

GFRP for all the strengthened beams.

Accelerated Corrosion

Corrosion set up fig. 1 shows a general view of the experimental set up. A constant impressed current with an approximate density was applied by Accelerated corrosion .The current was impressed through the main longitudinal rebar, which act as the anode while the stainless steel bar ineaspecimen acts as the cathode. During accelerated corrosion, the specimens were subjected to wet dry cycles to provide water and oxygen that are essential for the corrosion process.

FRP Repair Schemes

Specimens were either strengthened prior to corrosion orrepaired after being corroded using different schemes of Carbon or Glass FRP sheets. The strengthening used in the beams consisted of GFRP flexural laminate bonded to the tension face, with the fiber orientation in the longitudinal direction followed by transverse laminates bonded to the tension face and up each side of the beam, with the fiber orientation in the transverse direction. The transverse laminates fully anchor the flexural laminate along whole length of the beam and thus will prevent any premature delamination.

In the corroded beams, prior to the application of the FRP sheets, longitudinal cracks due to corrosion were sealedusing an epoxy adhesive. Then, FRP sheets were applied for repair where wrapping the specimen intermittently with U-shaped glass (GFRP) sheets around the tension face and the sides, involved flexural strengthening of the corroded

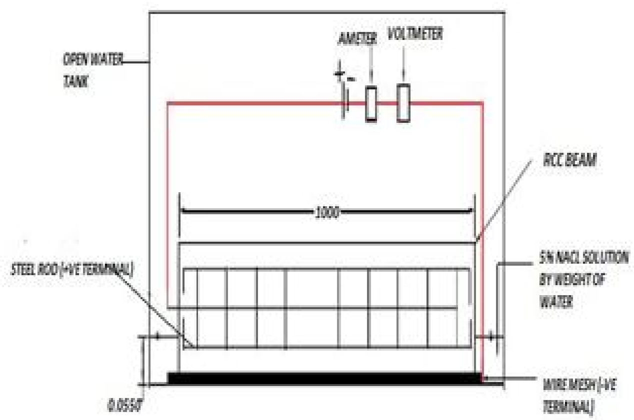


Fig .1 Corrosion Set up

We carried out studied on experimental and numerical investigation of retrofitted corroded reinforced concrete beams using Fiber reinforced Polymer (FRP). We were used GFRP sheets for retrofitting of beam and compared performance between them. Experimental study involves the determination of flexural load by subjected four point loading. Calculation of permissible load by using proper factor of safety on ultimate load. For numerical study of RC beams retrofitted with GFRP were considered and used.

(Fig. 2) Experimental Setup of Accelerated Corrosion

IV .RESULTS

Analytical Calculations

Calculation of RC beam :-

Size of beam – 1000mmX150mmX150mm

Ast :- 3#10mm

2#10mm (Fe 500)

$C = T$

$0.36*fck*b*Xu = 0.87*fy*Ast$ $0.36*40*150*Xu = 0.87*500*\pi/4*3*1.01^2$

$Xu = 54.22mm$

Xu max = 0.53d for Fe250

=0.48d for Fe415

=0.46d for Fe500 So,

Xu max = 0.46

=55.2mm

$Xu < Xu\ max$

Section is under reinforced.

*Mu lim = 0.87*fy*Ast*(d-.42Xu) Mu lim = 9.965 KN.m*

So, Ultimate moment resistance is (Mu lim)u = 1.5 Mu lim*

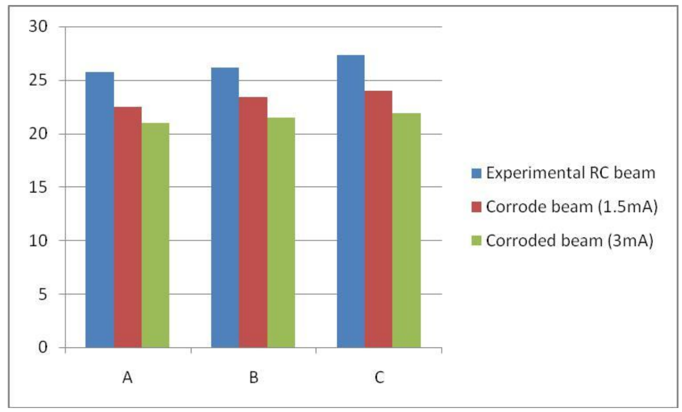
*Analytical Ultimate Moment Resistance = 14.9475 KN.m Mu lim = W*l/3*

Hence W = 29.895KN

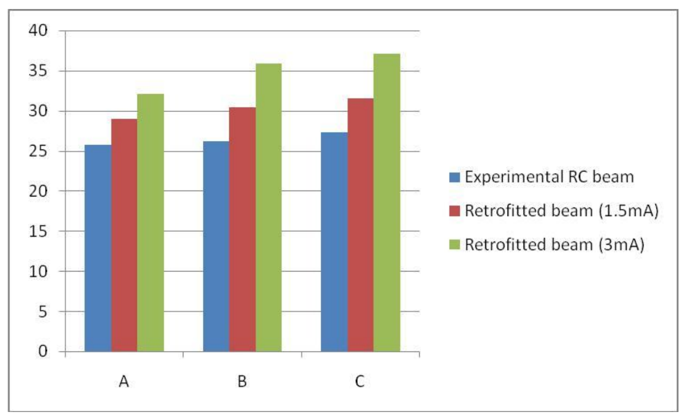
*So, Ultimate load = Wu = 1.5*W Wu = 44.8425KN.*

Table 1 Ultimate Resistance Table

Sample		RC Beam (Experimental) KN	RC Beam (Analytical) KN	Corroded Beam		Retrofitted Corroded Beam	
				1.5mA/cm2	3mA/cm2	1.5mA/cm2	3mA/cm2
A	Ultimate Moment Resistance	25.74	14.9475	22.5	21	28.95	32.1
B		26.145		23.4	21.45	30.45	35.85
C		27.3		24	21.9	31.5	37.05



Graph 1 Graph between experimental RC beam and corroded beam



Graph 2 Graph between experimental RC beam and retrofitted beam

V. CONCLUSION

Analytical analysis is also carried out to find the ultimate moment carrying capacity and compared with experimental results. It was found that analytical analysis predicts lower value than the experimental findings.

In general, compared to the corroded un-repaired specimens, the performance was greatly enhanced due to the addition of the GFRP flexural sheet in spite of the high corrosion experienced by the main rebar. The ultimate load increased by an average of 28%.

VI. APPENDIX

Notation

The following symbols are used in this paper.

Ast = Area of steel

C = Compression

T = Tension

Fck = Characteristic compressive strength of concrete

Fy = Characteristic strength of steel

Mu = Moment

Wu = Ultimate load

VII. ACKNOWLEDGMENT

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