International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.05, May 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

EXPERIMENTAL EVALUATION ON FLEXURAL BEHAVIOR OF RCC BEAMS WRAPPED WITH FRPS

Nowsheeba Bashir[1], Dr.Tarun Kumar Lohani[2],

Mohammad Zakir[3]

[1]*Mtech Scholar, Dept of Civil Engineering, Universal institute of Engineering and Technology Lalru, Punjab, India.*

[2]*Director, Dept of Engineering, Universal institute of Engineering and Technology Lalru, Punjab, India.*

[3]*PhD Scholar, Dept of Structural Engineering, National Institute of Engineering and Technology, Srinagar, India.*

ABSTRACT: *Safety and serviceability of the civil engineering structures is of great concern nowadays as many structures constructed in India and other parts of the world do not meet the desired specifications leaving them vulnerable to the people. As it is nearly impossible to demolish or reconstruct these structures, these are to be strengthened. One of the most widely used economical material from past few decades is Fibre Reinforced Polymers used for strengthening of damaged RCC structures. This is one of the greatest revolutions in the field of civil engineering as they have high strength, high stiffness, and light weight corrosion resistant in a polymer matrix with a tensile strength 1000-5000MPa in different varieties. To promote the flexural strength of RCC beams, Carbon fiber reinforced polymer sheets (CFRP), glass fiber reinforced polymer sheets (GFRP), Aramid fiber reinforced polymer (AFRP) and Large Rupture Strain FRP namely Polyethylene Terephthalate (PET) FRP are applied to wrap the RCC beams. The experimental programme involved the testing of 15 RCC Beams of size 1200mmX200mmX100mm of grade M30 in which three specimens were taken as control specimens, three specimens were wrapped with CFRP, three were wrapped with GFRP, three were wrapped with AFRP and three with PET FRP. The test results confirmed that, wrapping by above FRP leads to substantial improvement in flexural strength of RCC Beams .Beams wrapped with CFRP improves flexural strength by 33%, , Beams wrapped with Aramid FRP improves flexural strength by 26%, Beams wrapped with GRFP improves flexural strength by 20%, Beams wrapped with PET FRP improves flexural strength by15%.*

KEYWORDS: *AFRP, CFRP, Flexural strength, FRP, GFRP, PET FRP, RCC Beam, Strengthening Composites.*

I. INTRODUCTION

From the last few decades lot of investigations and experiments are going in the field of fiber reinforced polymers to study the behavior of the retrofitted beams and also various parameters have been analyzed which affect their behavior. The application of FRPs for the strengthening of structures was first researched in the middle of 1980s for the flexural strengthening of RC beams using CFRP plates at the Swiss Federal Laboratory for Materials Testing and Research (Meier *et al.* 1993). Michael et.al 1994 found that using external composite fiber reinforcement increased the flexural capacity by 36%-57% and 45%-53% increase in flexural stiffness. Alhusallam et al-2001 concluded that beams strengthened with CFRP laminates require less number of polymer layers than those strengthened with GFRP laminates for same loads. Pannirselvam, *et al*., 2008 concluded test results that the beams strengthened with GFRP laminates exhibit better performance. The increase in first crack loads were 88.89% and 100% for 3 mm and 5 mm of woven rovings GFRP plated. The increase in ductility in terms of energy and deflection was found to be 56.01% and 64.69% for 3 mm and 5 mm thick. Gao et al. (2007) studied various methods developed for strengthening and rehabilitation of RC beams. External bonding of fiber reinforced plastic (FRP) strips to the beam has been widely accepted as an effective and convenient method.

In developing country like India where most of the structures constructed do not actually meet the desired design specifications, it becomes necessary to retrofit or strengthen these structures as it is uneconomical to reconstruct these structures. Strengthening and retrofitting with fibre reinforced polymer has almost rapidly grown over last few decades. These polymers are known to have very high stiffness, high strength, and high strength to weight ratio, ease of installation, environmentally friendly and most importantly they are corrosion resistant unlike steel. Fiber reinforced polymer is a composite comprising of two constituents that is fiber and matrix. Fiber provides strength and stiffness whereas matrix provides environmental protection. Different types of fiber reinforced polymers sheets used for strengthening of concrete structures are Carbon fiber reinforced polymer (CFRP), Glass fiber reinforced polymer (GFRP), and Aramid fiber reinforced polymer (AFRP) and Polyethylene Terephthalate (PET) FRP. These fibers can be used for seismic retrofitting. Carbon reinforced polymers are one of the most amazing fibres as their stiffness and strength have been found to be superior to that of steel. Glass fibres are obtained by treating mixtures of sand, kaolin, limestone and colemanite at high temperatures (1600). The property of glass fiber can be varied by varying the proportion of materials. Glass fibres have ductile behavior which makes them suitable for seismic structural retrofitting. Polyethylene terephthalate, **PET** or **PETE** is a thermoplastic polymer resin. LRS FRP sheet namely PET FRP which is manufactured from products such as plastic bottles has a low tensile strength but possess a higher fracturing strain (more than 10 %) than CFRP (about 1.5 %) , GFRP and AFRP(1%), has drawn a lot attention as a unique alternative to CFRP or GFRP due to its ductile behavior and relatively economical. Due to its large rupture strain it is also known as large rupture strain polymer.

II. MATERIALS USED

Ordinary Portland cement of grade 43 was used in the experiment. Fine aggregates used in the experiment were passing through sieve 4.75mm.The size of coarse aggregates was 20mm. One of the most important and least expensive materials used in concrete is water. Water used in mixing should be tap water that is fit for drinking. 0.30 is the minimum water cement ratio. Concrete is strong in compression but weak in tension because of that steel reinforcement is provided to increase its strength.2 mild steel bars of 10mmØ are used as top reinforcement as 2 mild steel bars of 10mmØ are used as bottom reinforcement. Vertical stirrups of 6mmØ @150mmc/c are used. Fiber reinforced polymers are used to increase the strength of concrete structures as steel gets corroded with time which reduces the load carrying capacity of the structure. In order to increase the strength of the member fiber reinforced polymers are used mostly as they are economical than other methods of strengthening. In this experiment we have used three different types of fibers which are as following:

1. Glass fiber reinforced polymer
2. Carbon fiber reinforced polymer
3. Polyethylene terephthalate reinforced polymer
4. Aramid fiber reinforced

III. TESTING OF MATERIALS

3.1 Cement

Some of the properties of cement used are given below;

Specific gravity	2.91

Normal Consistency	35%
Initial Setting Time	90 minutes
Final Setting Time	530 minutes
Soundness	2 mm expansion
Fineness	1 gm retained in 90 micron sieve

3.2 Fine aggregates

The physical properties of Fine Aggregates obtained are given below;

Physical Property	Value Obtained
Specific Gravity	2.67
Fineness Modulus	2.50
Bulk Density	1470 kg/m

3.3 Coarse aggregates

The physical properties obtained are given below;

Physical Property	Value Obtained
Specific Gravity	2.71
Fineness Modulus	6.7
Bulk Density	1510kg/m3

3.4 Fiber reinforced polymer

Tensile test of 2 FRP coupons were conducted to determine the properties of CFRP, GFRP, AFRP and PET. Their properties are listed below

FRP type	*Slice thickness(mm)*	*Tensile strength(Mpa)*	*Young's modulus(GPa)*	*Rupture strain (%)*
CFRP	0.167	3592	249	0.0155
GFRP	0.167	2132	89	0.0227
Aramid	0.200	2664	131	0.0163
PET	0.519	823.9	62	0.0956

IV. PREPARATION OF SPECIMEN

Fifteen specimens of size 1200mmX200mmX100mm are prepared using cement, fine aggregates and coarse aggregates for a design mix of M30. Mixing of concrete is done thoroughly to obtain a uniform mix. Hand mixing is done with the help of hoe.10% extra cement is added as due to hand mixing there is inadequacy in the mix. Two bars of steel having 10mmØ were used as bottom reinforcement and two steel bars having 10mmØ were used as top

International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.05, May 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

reinforcement. Vertical stirrups of 6mmØ @150mmc/c were placed in all fifteen beams. Sufficient compaction was done with the help of needle vibrator.The beams were cured for 28 days.

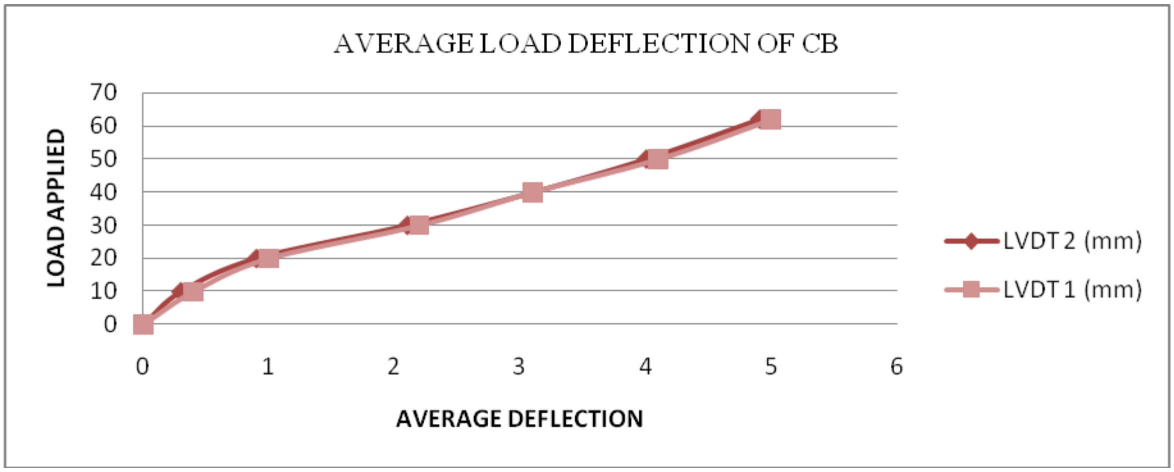
V. EXPERIMENT IN LABORATORY

After curing for 28 days fifteen beams were divided into 4 groups as

Beam type	***No. of specimen***
Control beams, CB	3
Beams wrapped on tension side with CFRP, for flexural	3
Beams wrapped on tension side with GFRP, for flexural	3
Beams wrapped on tension side with AFRP, for flexural	3
Beams wrapped on tension side with PET, for flexural	3

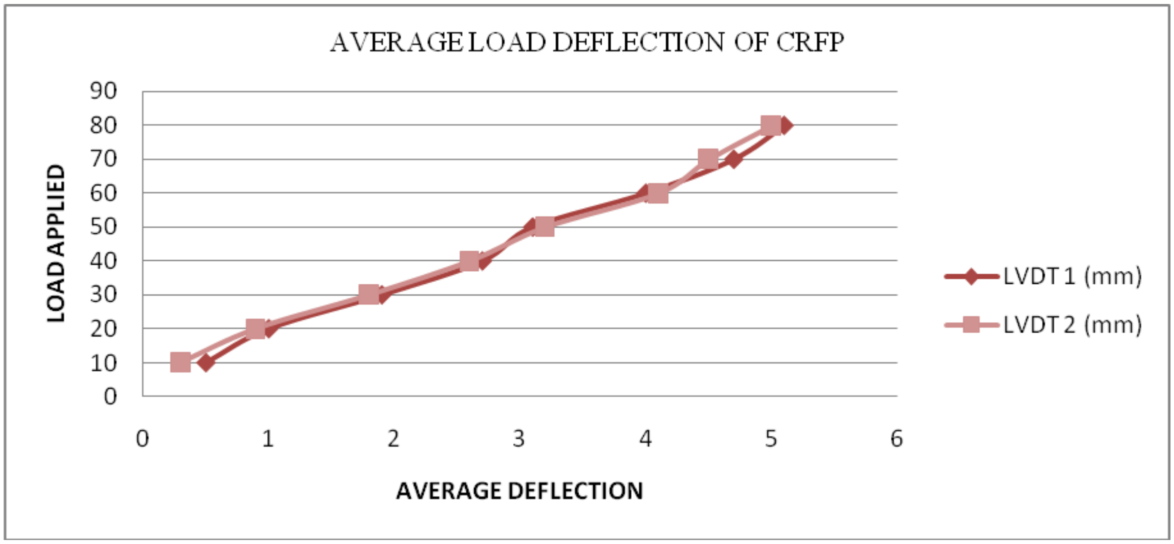
Beams were designed to fail in flexure. Loading was done by hydraulic jack of capacity 20 Tone. Two dial gauges LVDT1 and LVDT2 were placed to record the deflection of the beams, one at the midpoint and other was placed away from the midpoint of the beams. Loads were applied on the beams up to failure and after increasing the load on the beams reading on the dial gauge were noted down.

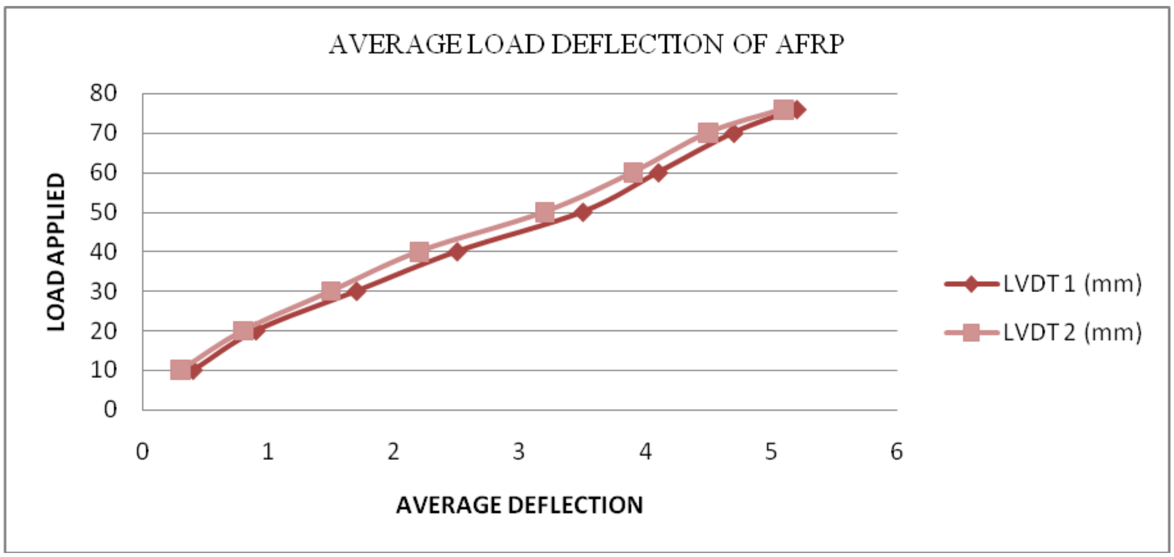
VI. RESULTS



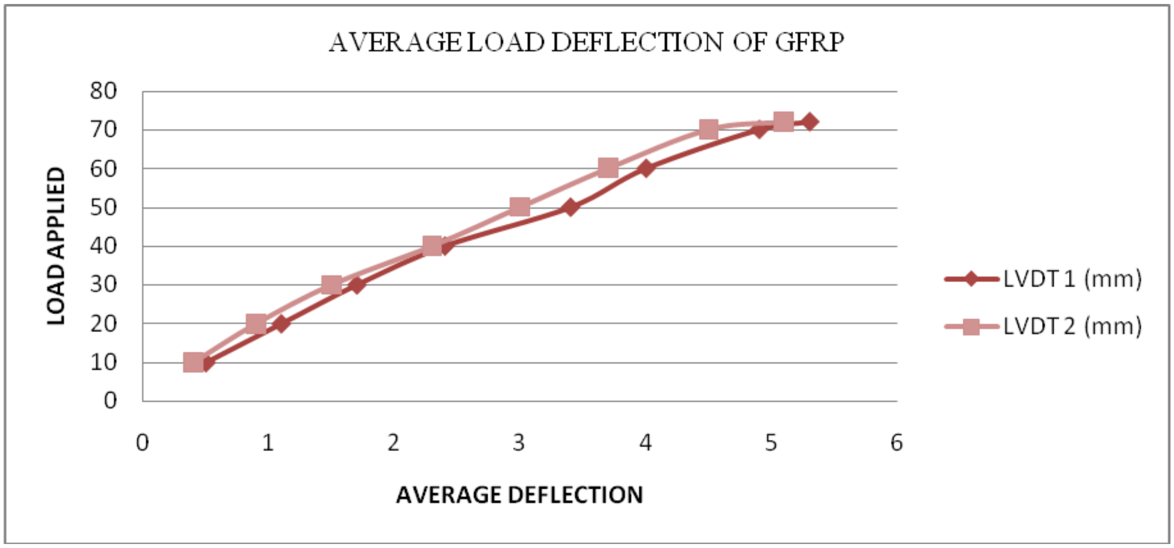
From the above results it is evident that control beams were weak in flexure but strong in shear. In control beams no FRP wrapping was done. Initial cracks started to come at 25KN load. In control beams cracks were widely spaced. Control beams failed at 65KN on an average of three beams.

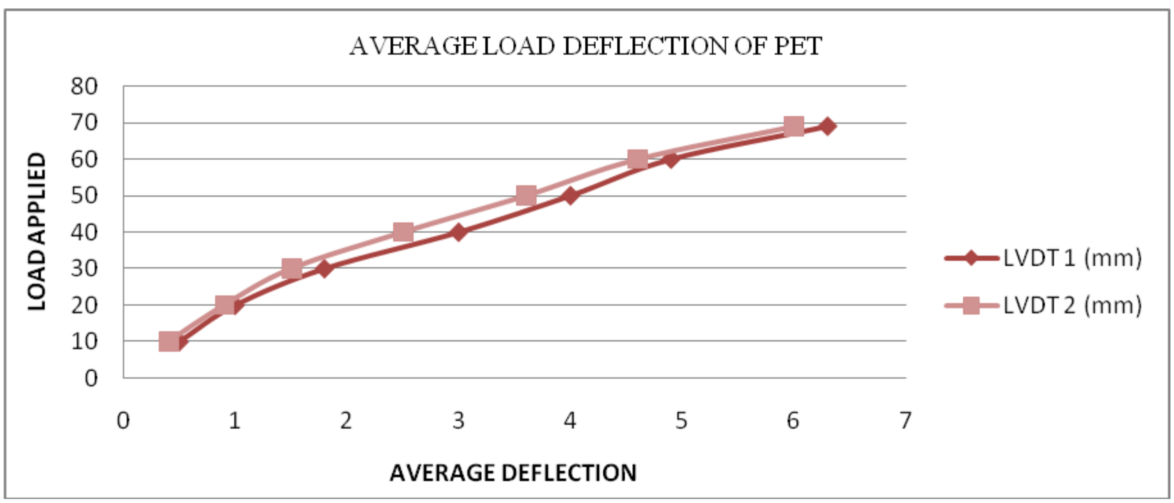
International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.05, May 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354





International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.05, May 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354





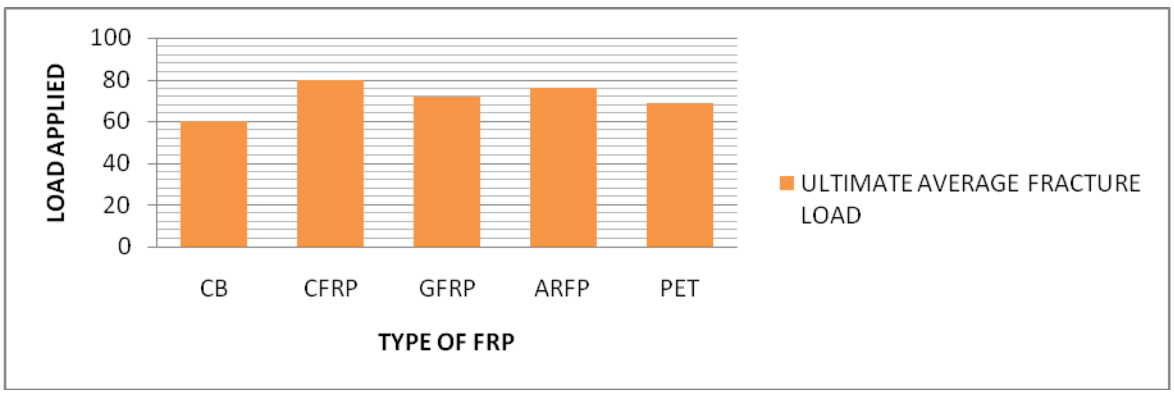
VII. DISCUSSIONS

In GFRP, CRFP, PET and ARFP beams the cracks are not initially visible. These beams failed in flexure. CRPF failed at the load of 80KN, GRFP failed at load of 72KN, ARFP failed at the ultimate load of 76KN where as PET failed at the ultimate load of 69KN, Out of which CFRP beams carried maximum load. It was seen that that the beams wrapped with FRP on tension side gave sufficient warning before ultimate failure. Cracks were closely spaced. Firstly the debonding of fibre took place in all beams wrapped with FRP. After that the outer concrete crushing took place .On further application of loads interior concrete also crushed and the beam failed thus giving sufficient warning before failure.

By comparing the graph and test results of all beams, we notice that beams wrapped with FRPs yielded successful results as compared to the control beam .we observe that control beam has maximum deflection which means it has low load carrying capacity whereas carbon fiber reinforced polymer has least deflection which means it has more load carrying capacity.

Ultimate Load, corresponding deflection values and type of failure

Type of beam	*Ultimate load (KN)*	*Type of failure*
Control Beam	65	Flexural failure
CFRP Beam	80	Flexural failure and crushing of concrete
GFRP Beam	72	Flexural failure and crushing of concrete
AFRP Beam	76	Flexural failure and crushing of concrete
PET beam	69	Flexural failure and crushing of concrete



VIII. CONCLUSION

This paper presents an experimental study on the flexural behavior of beams casted with different types of fibre reinforced polymers.

1. For applying FRPs such as CFRP, GFRP, AFRP and PET FRP for improving the strength of rcc beams it is very important to observe the effect of these materials on properties of beams such as crack width, deflection as different FRPs have different elastic stiffness and ultimate elongation.

2. Additional strength was obtained in the specimens wrapped with FRPS as compared to control beam.

3. Control beams on an average failed at 65kn whereas beams strengthened with CFRP failed at 80kN, beams strengthened with GFRP failed at 72kN, beams strengthened with AFRP failed at 76kN and beams strengthened with PET failed at 69kN. This indicates that Load carrying capacity depends on the type of fiber.

4. From the test results we noticed that among the four FRPs, CFRP is having high stiffness but low strain, due to which it can be used as a material to strengthen rcc beam but cannot be used to improve ductility whereas synthetic FRPs, PET-FRP has a low tensile strength but possess a higher fracturing strain (more than 8 %) compared with (1.5-2%) CFRP, GFRP and AFRP.

5. Because of large rupture strain LRS FRPs can be used to increase the ductility of concrete members as compared to conventional FRPs.

6 The test results confirmed that ,wrapping by above frp leads to substantial improvement in flexural strength of RCC beams .Beams wrapped with CFRP improves flexural strength by 33%, , beams wrapped with Aramid FRP improves flexural strength by 26%, beams wrapped with GRFP improves flexural strength by 20% beams wrapped with PET FRP improves flexural strength by15%.

7. FRPs are the promising and well as most widely used materials nowadays for strengthening and retrofitting of damaged concrete structures. However still a lot of research needs to be done in this field to further understand their properties

IX. REFRENCES

1. Flexural strengthening of reinforced concrete beams using fibre reinforced polymer laminates by Murali G. and Pannirselvam N.2011.
2. Hawileh, r. a., Rasheed, h. a., Abdalla, j. a., Al-Tamimi, a. k. (2014) behavior of reinforced concrete beams strengthened with externally bonded hybrid fiber.
3. Chambers, R.E., ASCE design standard for pultruded fiber reinforced-plastic (FRP) structures', Compos Construct, 1 (1): 26-38.1997.
4. Arduini M, and Nanni A, "Behaviour of pre-cracked R. C. beams strengthened with carbon FRP sheets", ASCE Journal of Composites for Construction,vol. 1, No. 2, pp. 63-70, 1997.
5. Grace NF, Sayed GA, and Saleh KR, "Strengthening of continuous beams using fibre reinforced polymer laminates", American Concrete Institute, Farmington Hills, Mich, pp.647-657, 1999.
6. Ashour AF, El-Refaie SA, and Garrity SW, "Flexural strengthening of RC continuous beams using CFRP laminates", Cement and Concrete Composites, vol. 26, pp. 765-775,2003.
7. Murali G.et al flexural strengthening of reinforced concrete beams using fibre reinforced polymer laminate: a review, arpn Journal of Engineering and Applied Sciences, 2011.