Strengthning of RCC Beams using CFRP Laminates

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Abstract -*The strengthening of existing ferroconcrete structures is of most vital so as to satisfy the wants like increasing the load carrying capacity, durability , reliability of the structures. The strengthening method for the prevailing or damaged structures are implemented by surface treatments, external post tensioning, exterior reinforcement and jacket using steel plates or Ferro cement etc., is that the common method followed in housing industry. This method are often effectively replaced by application of Fibre Reinforced Polymer material*

Since lot of research has been finished past years on strengthening of ferroconcrete structures using fiber reinforced polymers and these research experiences are utilized in several practical cases with new technical knowledge and confidence. The research work administered by various engineers round the world within the area of strengthening of ferroconcrete member by various CFRP techniques. On this basis the past research work are going to be administered, which is of utmost interest depending upon the relative field and this acts as motivation for further research work. During this work the most aim is to extend the load carrying capacity of the beams by satisfying the serviceability.

Key Words:

1. INTRODUCTION

This study examines the flexural response of carbon fiber reinforced polymer strengthened reinforced concrete beams within the presence of various schemes of strengthening. Within the present study, through an experimental program, efforts have been made to study the efficiency and effectiveness of various but very practical FRP for increasing further the flexure strength of beams. The failure modes and crack posture are listed to urge better understanding and results on the performance of beams strengthened with multi-layered CFRP laminate.

This study examines the flexural response of carbon fiber reinforced polymer strengthened reinforced concrete beams within the presence of various schemes of strengthening. Within the present study, through an experimental program, efforts have been made to study the efficiency and effectiveness of various but very practical FRP schemes for increasing further the flexure strength concrete beams. The failure modes and crack patterns are noted to urge better understanding on the performance of beams strengthened with multi-layered carbon fiber reinforced polymer laminate Comprehensive experimental investigations conducted in the past have shown that this strengthening technique has several advantages over the ancient traditional ones, especially due to its corrosion resistance, high stiffness-to-weight ratio, improved durability and flexibility in its use over steel plates. Moreover, these composite materials are less suffering from environmental corrosion conditions, known to supply longer life and need less maintenance. the necessity for rehabilitation or strengthening of bridges, building and other structural elements may arise thanks to one or a mixture of several factors including construction or design defects, increased load carrying demands, change in use of structure, structural elements damage, seismic upgrade, or meeting new code requirements. These factors may cause the infrastructure mechanically structurally inefficient and sometimes liable for making the structures functionally obsolete Comprehensive overall experimental investigations conducted in the past history have shown that this type strengthening technique has vital advantages over the traditional and antique ones, especially due to its corrosion resistance. High stiffness and weight ratio, improved durability and flexibility in its use over steel plates. Moreover, these materials are less suffering from corrosive environmental conditions, known to supply more life and need very few maintenance. The necessity for rehabilitation or strengthening of bridges, building and other structural elements may arise thanks to one.

1.1 Need of Study

Rehabitation of existing structures.

The structural design and thus the assembly of structural elements like beams made from ferroconcrete is predicated on forces and loads current in codes of the time. However, during the service lifetime of a structure, various circumstances may require that the service loads are changed due to: 1. Amodification of the structure: cutting of holes in slabs or beams

2. A special use of the structures: from offices to library

3. Ageing of the development materials

4 .Deterioration of the concrete caused by reinforcement corrosion

5. Cutting of pre- or post- stressed reinforcement cables

6. Fire damages

7. Upgrading of building codes

8. Earthquake design requirements

Fortius pultruded CFRP laminates are mostaly used for the post-strengthening of structures to extend the load bearing capacity of structural components (increase of bending tensile force). The increased flexural capacity leads to reduced deflections and therefore the reduction in crack propagation. The utilization of carbon fibre pultruded plate has distinct advantages over the utilization of conventional plate and provides the designer with a singular freedom of design. Carbon fibre plates are mostly applied on the two wooden and concrete beams, columns, slabs and walls for permanent and temporary structural reinforcement. This is often in the two cases both in positive also as negative moment.

1.2 PROBLEM STATEMENT

Carbon fiber Reinforced Plastics laminates are used for the post-strengthening of structures to increase the load bearing capacity of structural components. The increased flexural capacity results in reduced deflections and the lower in crack penetration. The use of carbon fiber plate has typical advantages over the use of ancient steel plate and provides the designer and the researcher with a unique freedom to make the structure. Carbon fibre plates can be applied to the 2 materials wooden and concrete beams, vertical members, slabs and walls for permanent structural and mechanical steel bars reinforcement. It would also be used for reducing the cracks between bricks and beam interacting surfaces. And also the use of Carbon fiber Reinforced Plastics is cost as well as time effective in construction industries

The structural design and thus the production of structural elements like beams made of reinforced concrete is based on forces and loads current in codes of the time. However, during the service life of a structure, various circumstances may require that the service loads are changed due to modification of the structure: cutting of cores in slabs or horizontal members , different use of the structures: from offices to library, decaying of the construction members and materials ,degradation of the concrete caused by reinforcement corrosion ,cutting of post- stressed reinforcement cables in members, fire damages hazards in buildinf , upgrading of building codes by the government , earthquake design requirements for the members.

2.1 Introduction to FRP:

Fiber-reinforced plastic (FRP) may be a material made from polymer that's supported with fibres for added strength. It's commonly utilized in industries like aerospace, construction and marine to create structures that need added resistance so as to stop deformation. Fiber-reinforced plastic is useful in corrosion protection because it helps in preventing corrosion thanks to force application and deformation like corrosion cracking.

Fiber-reinforced plastic is produced employing a wide selection of fibres' counting on the final usage requirements. Fibers are often manufactured and made from glass, carbon, aramid and other. It's vital to make sure that the fibre source of fiber-reinforced plastic suits the appliance that it's to be utilized in.

Fibre Reinforced Polymer (FRP) composite is defined as a polymer that's reinforced with fibre. It represents a category of materials that fall under a category mentioned as composite materials. Composite materials are made by mixing particles of 2 or more materials in different material, which forms infinate network around them.

Fiber-reinforced plastic composites materials are different from antique and daily construction materials like Steel and Aluminium. Fiber-reinforced plastic composites are whereas Steel and Aluminium are unique. Therefore, their properties are directional, meaning that the simplest mechanical properties of the material are within the direction of the material placed.

These materials have a huge ratio between strength and density, great corrosion resistance and convenient electrical, magnetical and thermal properties are unique. However, they're brittle and their mechanical properties could also be passing from the speed of loading, temperature and climatically environmental conditions.

The primary function of fibre reinforcement is to hold the load along the longitude of the fiber and to supply high power and stiffness in unique direction. It replaceses metallic materials in many structural usage where load-bearing capacity is very much importance.

The use of Fiber-reinforced plastic in engineering applications ensures the engineers to get sufficient achievements within the functionality, safety and monry of construction due to their mechanical properties and physical properties.

2.2 CFRP laminates:

Composite materials used for the study which is commercially available World over.

Objectives of using Carbon fiber reinforced polymers laminates:

1. Increase the load bearing capacity & the fatigue strength.

2. Reduce deformation to the working loads (increase in rigidity)

3. Limit or cover the cracking states (increase in durability)

RIPSTAR LAMINATE is out there in 150m rolls with the subsequent width/thickness (mm/mm): (50/1.2); (50/1.4); (80/1.2); (80/1.4); (100/1.2); (100/1.4); (120/1.4)

Types of laminates:

1. Laminates CFK 200/2000.

2. Laminates CFK 150/2000.

Strengthening of beam are often done by carbon fiber reinforced polymers OR GFRP. Which is out there in sort of sheet and laminates. From this strengthening of beams by using carbon fiber reinforced polymers laminates is most ordinarily and widely used method. During this project we used carbon fiber reinforced polymers laminates of (50 mm wide and 1.4 mm thick laminates, laminates CFK 200/2000.

Fig.1 CFRP laminates

Properties of laminates (CFK 200/2000): from data sheet provided by manufacturer

Table no.1

Physical properties	Value
Modulus of elasticity	210 GPa
Width of laminates	50mm
Thickness of laminates	1.4mm
Tensile strength of laminates	2550 N/mm^2

3.1 Mix design:

The mix design refers to the mixture proportion of cement, crushed sand and aggregate. Proper mix design is necessary for getting a required strength after 28 days curing. Mix design is carried out for required strength M20. A medium strength concrete was prepared using Ordinary Portland Cement (Type I). The aggregate used consisted of coarse crushed gravel and fine sand. The separation of coarse aggregates and fine aggregate particles met the Indian standard code requirements. The concrete mix design was designed according to IS: 10262-2009 specifications. The mix was designed to have a slump of 75 to 100 mm and satisfying 28 days compressive strength as per IS standard specification. The maximum aggregate size considered was 20mm and the water cement ratio in mix design was taken as 0.5. The details of concrete mix are as shown in Table below.

Table no. 2

Concrete mix proportion Cement (kg/m3)	**Fine Aggregates (kg/m3)**	**Coarse Aggregates (kg/m3)**	**Water content (kg/m3)**
495	631.66	1051.33	200.67
1	2.12	1.27	0.405

4.0 Results

Results of flexural strength of control beam and strengthen beams:

Normal beam pusses a really low load carrying capacity than strengthen beams. Near about 50% load carrying capacity of normal beam is increased after strengthen by using carbon fiber reinforced polymers laminates.

4.1 FOR SPECIMEN NO 1:

Table No.3

DESIGNATION	**LOAD IN KN**	
SPECIMEN 1	**CONTROL BEAM**	**STRENGTHNED BEAM**
BEAM 1	68.10	131.38
BEAM 2	67.42	135.21
AVERAGE	67.76	133.29

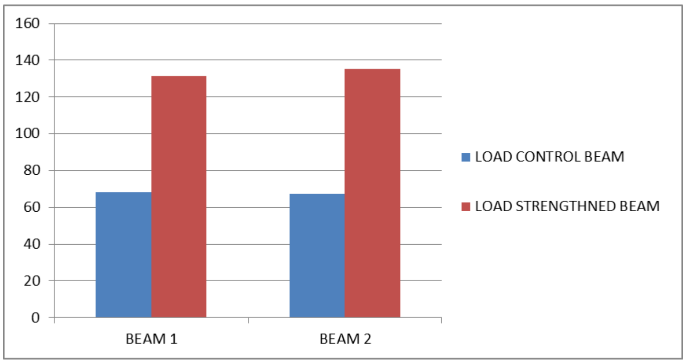

Fig.2 Graph showing variations in Load carried by control and strengthened beams

Remark: From above results, it is observed that the load carrying capacity of a strengthened beam is increased by 50.83%.

Table No.4

DESIGNATION	FLEXURAL STRENGTH IN N/MM²(PL/BD2)	
SPECIMEN 1	CONTROL BEAM	STRENGTHNED BEAM
BEAM 1	8.58	16.56
BEAM 2	8.50	17.04
AVERAGE	8.54	16.80

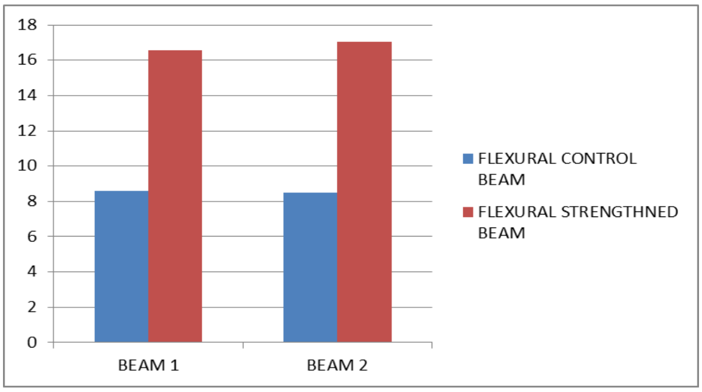

Fig.3 Graph showing variations in flexural strength between control and strengthened beams

Remark: From above results it is observed that the flexural strength of strengthened beam is increased by 50.83%.

Table No.5

DESIGNATION	SHEAR STRENGTH IN N/MM(V/BD)	
SPECIMEN 1	CONTROL BEAM	STRENGTHNED BEAM
BEAM 1	1.97	3.81
BEAM 2	1.95	3.92
AVERAGE	1.96	3.86

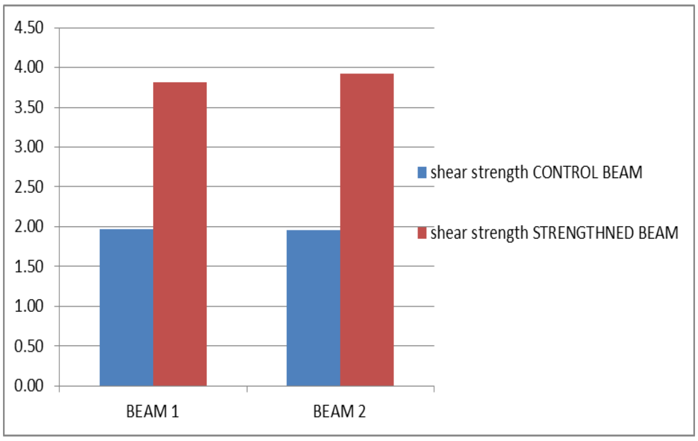

Fig.4 Graph showing variations in shear strength between control and strengthened beams

Remark: From above results it is observed that the shear strength of strengthened beam is increased by 50.77%.

4.2 FOR SPECIMEN NO 2:

Table No.6

DESIGNATION	LOAD IN KN	
SPECIMEN 2	CONTROL BEAM	STRENGTHNED BEAM
BEAM 1	79.63	165.28
BEAM 2	83.42	161.81
AVERAGE	81.53	163.55

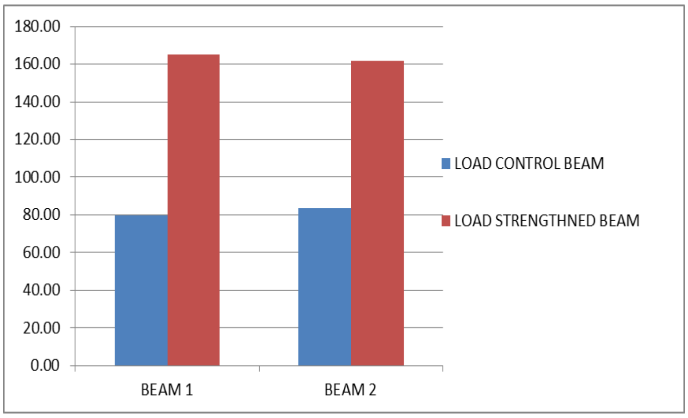

Fig.5 Graph showing variations in Load carried by control and strengthened beams

Remark: From above results, it is observed that the load carrying capacity of a strengthened beam is increased by 49.85%.

Table No.7

DESIGNATION	FLEXURAL STRENGTH IN N/MM^2(PL/BD^2)	
SPECIMEN 2	CONTROL BEAM	STRENGTHNED BEAM
BEAM 1	10.04	20.83
BEAM 2	10.51	20.39
AVERAGE	10.27	20.61

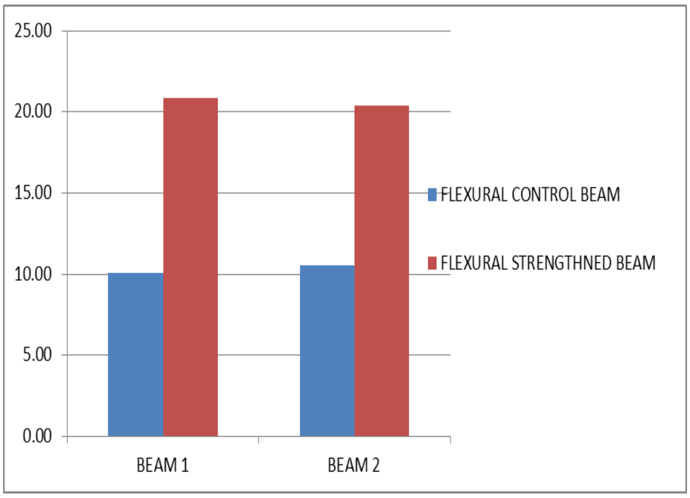

Fig.6 Graph showing variations in flexural strength between control and strengthened beams

Remark: From above results it's observed that the flexural strength of strengthened beam is increased by 49.83%

Table No.8

DESIGNATION	SHEAR STRENGTH IN N/MM(V/BD)	
SPECIMEN 2	CONTROL BEAM	STRENGTHNED BEAM
BEAM 1	2.31	4.79
BEAM 2	2.42	4.69
AVERAGE	2.36	4.74

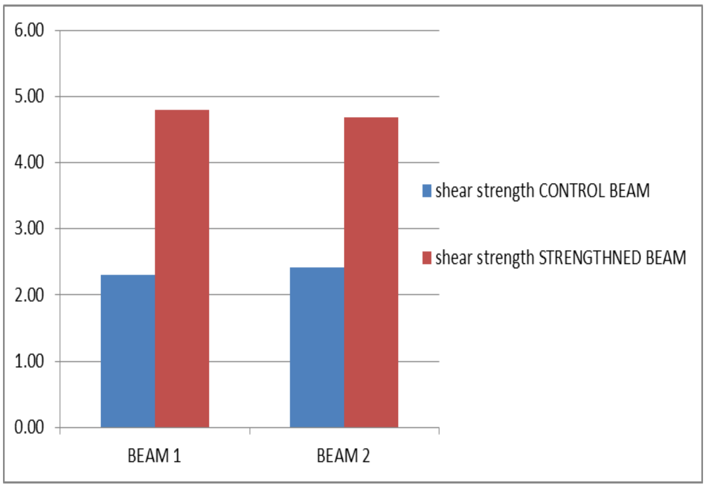

Fig.7 Graph showing variations in shear strength between control and strengthened beams

Remark: Remark: From above results it's observed that the shear strength of strengthened beam is increased by 49.78%.

5. CONCLUSIONS

Following conclusions are drawn from the discussions on experimental studies and therefore the corresponding test results.

1. A 50% increase in load carrying capacity is observed for reinforced concrete beams deficient in flexure when CFRP laminates are used.

2. R.C. beams deficient in flexure and strengthened by CFRP laminates shows ductile failure whereas the beams deficient in shear and strengthened by this laminates failed in brittle mode.

3. The results of the practical study indicates that externally bonded CFRP laminates are often used most commonly to the strength in ferroconcrete beams. Regarding the effect of number of layers, an increase in stiffness and flexural strength is achieved with the rise of CFRP layers. All the strengthened beams don't show any inter-layer in any type.

4. Regarding the effect of load transfer through edge strip, significant improvement in flexural strength was noted and hence the de-bonding of laminates occurred just before the ultimate failure.

5. This investigation revealed that strengthening of reinforced concrete beams using CFRP laminates is an efficient and easy solution for R.C. beams deficient in flexure.

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