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# Strengthening of Reinforced Concrete Beam Using FRP Technique

Mane Abhijeet Ramesh, K.S.Patil, Dr. N.V. Khadake

PG Student, Department of Civil Engineering, Imperial College of Engineering and Research, Wagholi Pune, India

Professor, Department of Civil Engineering, Imperial College of Engineering and Research, Wagholi Pune, India

**ABSTRACT-** This particular analysis explores the consequence of an experimental investigation for improving the shear capability of reinforced concrete (RC) T beams with shear inadequacies; strengthened with Basalt Fiber Reinforced Polymer (BFRP) sheets that are an economic and new relatively substitute for more expensive fibers widely used around strengthening of RC beams. A maximum of twenty two numbers of concrete T beams are analyzed as well as different sheet configurations as well as designs are analyzed to determine the effects of theirs along the shear capability of all of the beams. One particular beam of the beams is viewed as control beam, while some other beams are strengthened with externally bonded BFRP sheets/strips. In order to cater to services that are essential as electricity cables, all-natural gasoline water lines, water as well as water drainage water lines, telephone lines, air-conditioning, as well as laptop or computer system transverse net opening are essential in contemporary construction building. Thus, the existing analysis investigates the shear behaviour of RC T beams with various kinds of transverse web openings. The different details examined within this specific analysis provided BFRP total as well as distribution, bonded surface, lots of layers of BFRP, fiber orientation, transverse web openings as well as end anchor.

**KEYWORDS:** FRP Composites; properties of FRP composites, Structural design, Repair of structures

## I. INTRODUCTION

### 1.1 GENERAL

The traditional design approaches on the market are steel-jacketing and concrete-jacketing. The concrete jacketing creates the current portion big and therefore gets better the load hauling capacity of the entire framework. Though the strategies have a number of demerits including construction of completely new formworks, extra weight because of enlargement of aisle, higher set up cost etc The steel jacketing has found to become a good method to improve the overall performance of components, though this process calls for tough welding work within the area and also have possible problem of corrosion that increases the cost of upkeep. Now-a-days, FRP composite substances are a fantastic choice being utilized as outside reinforcement due to the high specific stiffness of theirs, substantial particular weight, higher tensile strength, light in weight, opposition to corrosion, excessive longevity as well as simplicity of set up.

### 1.2 FIBER REINFORCED POLYMER (FRP)

FRP composites are, since the title proposes, a make-up of 2 or maybe a lot more components that, when suitably united, form a different material with properties not offered by the single components.

Fiber reinforced composite substances include fibers of higher tensile strength as well as adhesive that binds the fibers in concert to create the structural materials. Widely used fibers are glass, carbon, basalt, and aramid within the civil engineering market. The adhesive that's often utilized is epoxy that shields the fibers, offering longevity as well as placed under the loading problem distributes the load on the fibers. The fibers are oriented within the direction(s) which use them many effectively. The prosperous use of FRP in various areas as aerospace, automobile industries, recreation, and sports stands out as the reason behind the increased need of FRP. The attributes of FRP composites as well as the versatility of theirs have led to substantial effectiveness, dependability as well as cost usefulness in rehabilitation

**The following are advantages and disadvantages of FRP composite.**

#### **Advantages of FRP**

1. Corrosion Resistance.
2. Lightweight.
3. Ease of installation.

- 4. Less Finishing and maintenance.
- 5. High fatigue resistance.
- 6. Ductility of FRP wrapped members improves extensively.
- 7. They are perfect for external application.
- 8. They are durable both environmentally and from service point of view.
- 9. They are available in various forms: sheets, plates, fabric, etc.
- 10. They are available in long lengths that eliminate joints.
- 11. They cure within 24 hours.
- 12. Versatile in nature.

**Disadvantages of FRP**

- 1. High cost, susceptibility to deformation under long-term loads.
- 2. Temperature and moisture effects, lack of design standards, and most importantly, lack of awareness.



Figure 1.1 Different Types of FRP

**1.3 STRENGTHENING USING FRP**

Concrete beams tend to be the primary aspect in structural engineering that are created to transport both horizontal a lot because of seismic or maybe vertical gravity loads and wind. Similar to any other concrete elements they're vulnerable for situations in which there's a rise within structural a lot. Typically reinforced concrete (RC) beams don't succeed within two ways: diagonal tension and flexure failure (shear) disappointment. Flexural disappointment is frequently desirable to shear malfunction while the former is ductile while latter is brittle. A ductile disaster enables stress redistribution and also provides previous discover to occupants, whereas a brittle failure is sudden and therefore catastrophic.

The utilization of outside FRP reinforcement might be categorized as: flexural as well as shear strengthening

**1.3.1 Flexural strengthening using FRP**

For flexural conditioning the laminates of FRP are utilized as well as used with epoxy on the tension zone on the RCC participants that functions as outside tension reinforcements to boost the flexural strength on the RCC participants

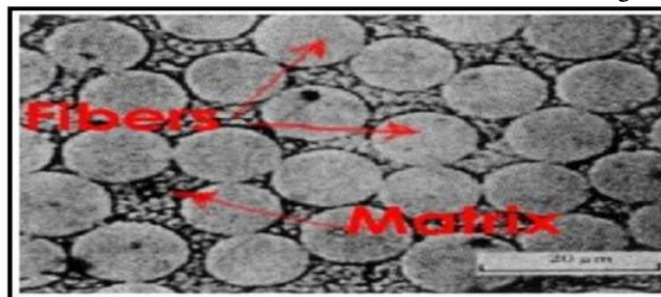


Figure 1.2 Macroscopic Structure of Fiber & Matrix

**1.4 Shear strengthening using FRP**

If the RC beam is deficient for shear, or perhaps when the shear capacity of its is under the flexural capacity right after flexural strengthening, shear strengthening have to be thought about. It's significantly crucial that you look at the shear capacity of RC beams that are suggested to become strengthened.

Despite the much better attributes of FRP, a framework strengthened with FRP is able to not be successful too soon creating deboning of the FRP. Therefore, the FRP doesn't attain the full strength of its. So as to stop the premature failure on the FRP composite, different anchoring methods like U jacketing, spike anchors, mechanical fastening as well as hybrid anchoring methods are designed. With respect to the application program, every type of anchor has caused a few enhancements within delaying early deboning, though the problem hasn't been satisfactorily resolved just yet. These drawbacks have opened upwards an interesting part of research on advancement of anchorage process.

### 1.5 Necessity of FRP

With structures getting old and also the growing bar corrosion, old buildings have started to insist upon extra retrofits to increase their life and durability. In order to meet up the demands latest revolutionary technologies and materials in deep construction sector has started to generate the way of its. Technical engineers all over the world used Fiber Reinforced Polymer (FRP) to fix the structural problems of theirs belonging in an economical and efficient fashion. Within the area of civil engineering, nearly all almost all of the usage of FRP is restricted to strengthening and repairing of components.

### 1.6 PROBLEM STATEMENT

The majority of the analysis works were made investigating flexural and also shear behaviour of RC rectangular beams strengthened with fiber reinforced polymer (FRP) composites. Till particular date absolutely no work have been found studying the shear behaviour of RC T beams making use of externally bonded Basalt fiber reinforced polymer (BFRP) composites. A small work continues to be found about the strengthening of RC T-beams with no study and web openings has become reported on the strengthening of beams with transverse opening by using BFRP composites. A lot of scientists are from the viewpoint which the prior design methods don't have detailed comprehension of the shear behaviour of RC T-beams.

### 1.7 AIM OF THE STUDY

In order to evaluate the shear behaviour of T section RC beams below fixed loading time quality.

In order to look at the shear behaviour as well as modes of failure of RC shear deficient T beams externally strengthened with basalt fiber reinforced polymer (BFRP) sheets

### 1.8 OBJECTIVE OF THE STUDY

The principal objectives of this study are:

- In order to look at the outcome of various details like quantity of layers, bonding surface, various fiber orientation etc. over the shear capacity on the RC T-beams.
- In order to take a look at the outcome of an anchorage pattern over the enhancement of shear capability on the RC T-beams.
- In order to investigate the outcome of a new anchorage scheme over the shear capacity on the beam.

## II. LITERATURE REVIEW

**Hari Akshaya et.al (2020) (1)** The present investigation on behaviour of reinforced concrete beams retrofitted by making use of Ferro cement to increase the overall performance of beams within equally shear as well as flexure. The reinforced concrete beam examples have been casted of dimension 150mmx150mmx1500mm with M25 concrete grade with good strength deformed bars as longitudinal and also shear reinforcement. The management beam was subjected to testing for ultimate load, so the rest of the beams have been preloaded to 60 % of ultimate load, then simply wrapped with double and single level mesh agreement during zero amount orientation as well as retrofitted with 20mm heavy level of Ferro cement. The ton deflection attributes, very first crack load, crack pattern, method of disappointment are analyzed. The test results signify an increased load carrying capacity of 27.66 % within individual level as well as 48.99 % in double level retrofit beams than influence beams, development within flexural strength of approximately 28.59 % in single layer as well as 49.69 % in double layer retrofit beams than control beams, additionally an enhancement contained crack management, stiffness, ductility as well as deflection parameters. of strengthened beams

**Nehal Ashra et.al (2020) (2)** researcher studied Fiber reinforced polymer (FRP) composites are materials that are not the same as the metal reinforcement and also been already popular in structural engineering design as a result of their

many properties making them a top strength materials. Besides strength additionally they have good stiffness, opposition to corrosion therefore becoming a sturdy materials. Within the latest occasions they've been set to make use of around building of completely new or even in fix of pre-existing buildings as structures, bridges, and more. Steel that is currently used as reinforcing components to concrete structures is extremely susceptible to corrosion leading to loss in serviceability of engineering structures. The majority of the corrosion occurs because of chloride episode. The evaluation of reasons for problems on German bridges suggests that reinforcement corrosion set up by chlorides compensates 2/3 of all of the problems captured within the bridge building. For these a world, fibre reinforced polymer (FRP) reinforcement has developed to become a potential replacing of standard steel reinforcement. The newspaper provides an evaluation on studies and research on numerous kinds of FRP composites, their application and properties in structural engineering layout.

**Mohmmad T. Jameel et.al(2017) (3)** writer discovers The Behaviour of FRP and Circularized wrapped hollow concrete examples beneath axial compression load continues to be analyzed within this specific literature. The examination final results show which circularization of hollow sample is akin towards the circularization of reliable sample cuts down on the stress focus in the sides as well as improves the supreme load transporting ductility and capacity The contribution on the supreme axial stress from circularization is much more for each solid and hollow concrete examples compared to by rounding the sides. A simple theoretical model was created to foresee the axial ton of CFRP confined square as well as circularized hollow and solid specimens

**Keertika Sharma, S. S. Kushwah, Aruna Rawat et.al (2016)(4)** , Fibre reinforced polymer (FRP) is a composite substance that includes a polymer matrix fortified with fibers. Probably the most regular fiber types utilized in structural programs are glass (GFRP), carbon (CFRP) along with aramid (AFRP). The GFRP may be the very least costly but has reduced strength plus considerably less stiffness when compared with other options. CFRP may be the stiffest, long-lasting, as well as costlier. AFRP has enhanced admirable impact resistance and durability. FRP reinforcement is accessible in various forms like bars, grids, prestressing tendons and also laminates to deliver a broad range of uses. Earlier the usage of FRP was restricted to defence as well as aerospace engineering due to the high cost of its, but improve in need for the usage of FRP within some other areas across the world has aided the expansion inside investigation for greater functionality of composites in costs that are low.

**Swami P.S, Patil S.S, Kore P.N et.al (2015) (5)** : Completed study on "Behaviour of concrete serious beams with good strength reinforcement" They point out the high end reinforcement will continue to gain wider validation contained business train, because of enhanced physical qualities of new substances. For years, ways of analysis and design of concrete users reinforced with regular strength steel were designed. Lately, reinforcing metal (550 & 550) with strength much higher compared to conventional steel is now commercially accessible. The launch of higher strength reinforcing steel could be helpful to bring down the amount of reinforcement needed, therefore lessening improving constructability and reinforcement congestion

**D.N. Shinde, Pudale Yojana M, Nair Veena V et.al (2014),(6)** Existing concrete buildings might, because a wide range of motives, be discovered performing unsatisfactorily. This may reveal itself by very poor functionality below service loading, inside the kind of increased deflections as well as cracking, or perhaps presently there might be insufficient best strength. Furthermore, changes to come down with structural design as well as loading codes might make numerous buildings earlier believed to become good enough, noncompliant with existing provisions. Within the existing economic climate, rehabilitation of damaged concrete buildings to satisfy the more strict limitations on ultimate strength and serviceability of present codes, as well as strengthening of present concrete structures to transport much higher allowable a lot, appear to be a far more attractive substitute for rebuilding and demolishing.

**Iman Chitsazan, Mohsen Kobraei, Mohd Zamin Jumaat and Payam Shafiq et.al (2010) (7)**, As it's identified, fiber reinforced polymer (FRP) bars are generally very totally different from all those of metal bars and so they rely primarily on equally fibers and matrix kind, and also on their amount fraction; although commonly, FRP bars have reduced fat, reduced modulus of suppleness, but greater power compared to metal. Within the various other hands, FRP has down sides, for instance: absolutely no yielding just before brittle rupture as well as minimal transverse strength.

**Bukhari et al. (2010)(8)** evaluated the contribution of CFRP sheets along the shear capability of constant reinforced concrete beams and also assessed the current design guidelines for shear strengthening of beams applying CFRP sheets and also proposed a changes to Concrete Society Technical Report TR55. A maximum of seven, two span constant concrete beams have been cast with rectangular cross section. Out of the beams one particular beam was considered as

management beam and also the leftover beams have been strengthened with the use of different configurations of CFRP sheets

### III. METHODOLOGY

The variables selected for the experimental works are BFRP amount and distribution (i.e., continuous wrap versus strips), bonded surface (i.e., lateral sides versus U wrap), number of layers of BFRP, fiber orientation (i.e., 0° direction versus 90° direction versus 45° direction), Transverse web openings of shape that is different (i.e., circular versus square versus rectangular) and end anchor (i.e., U wrap with and with no end anchor).

#### 3.1 Test Specimens

22 reinforced concrete T beams are considered in this study with dimensions as follows:

Span= 1300mm Width of web= 150mm Depth of web= 125mm Depth of flange= 50mm Effective depth= 125mm The steel reinforcement in the beams consists of two numbers of sixteen mm  $\phi$  and one number of twelve mm  $\phi$  HYSD bars as tension reinforcement. 4 numbers of ten mm  $\phi$  bars are provided as hanger bars.

The depth and length of the beam have been taken as 1300 mm and 175mm, respectively as a result of the limitation of the loading system obtainable in the Structural Engineering laboratory, NIT Rourkela. The beams are overdesigned in flexure as per Indian code IS: 456 2000 to be able to guarantee a shear failure. The effect of length parameter on the load carrying of beam hasn't been studied because of above limitation.

#### 3.3 Casting of Specimens

The beam specimens are made from the nominal mix of the concrete of grade M20 with mix proportions as per IS: 456 2000 [thirty] and also presented in Table 3.1. For mixing purpose, the concrete mixer is used and the water cement ratio is fixed at 0.55. 3 numbers of 150x150x150 mm concrete cube specimens are cast along with each beam and cured for twenty eight days to decide the compressive strength of concrete.

Table 3.1 Nominal Mix Proportions of Concrete

Description	Cement	Sand (Fine Aggregate)	Coarse Aggregate	Water Cement Ratio
Mixproportioning (Byweight)	1	1.67	3.33	0.55
Quantitiesofmaterials in beam(kg)	19.64	32.79	65.38	10.8

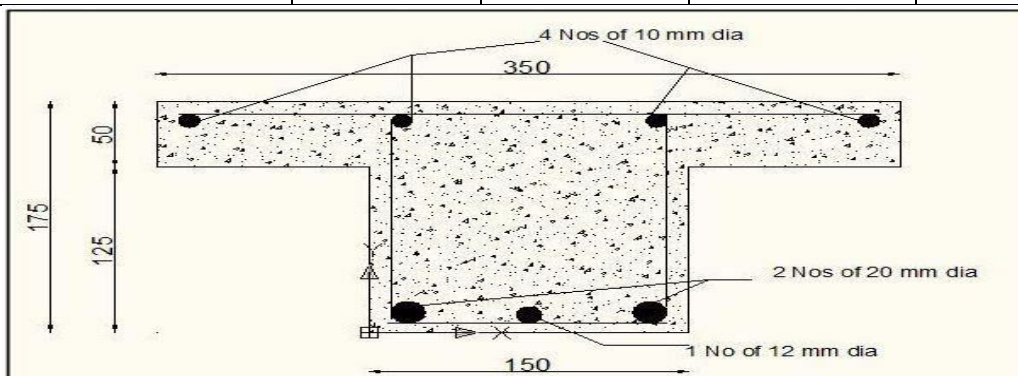


Figure 3.1 Cross-section and reinforcement details of the control beam

#### IV. RESULT

The results obtained from the experimental investigation The series A comprises of the shear strengthening of the RC beams with T shaped cross-section with no transverse openings The behaviour of the RC T beams with respect to initial crack load, ultimate load carrying capacity, crack pattern, deflection is studied throughout the test and their failure modes are described.

Except the control beams, all of the beams are strengthened with different configurations of unidirectional BFRP sheets/strips. All of the beams are made as shear deficient ones..

##### 4.1 Load-deflection history

To assess the effectiveness of the proposed strengthening schemes, the mid span deflections and deflection under point loads of the shear deficient beams are measured at different load steps for the control beam and beams strengthened with BFRP sheets/strips. The load deflection histories are presented in Figures 4.23 to 4.44. It's found the midspan deflections are higher compared to the deflections under the point loads. The load deflection profile remains straight at first which represents the linear behaviour up to certain load step and after that becomes nonlinear with further increase of load.

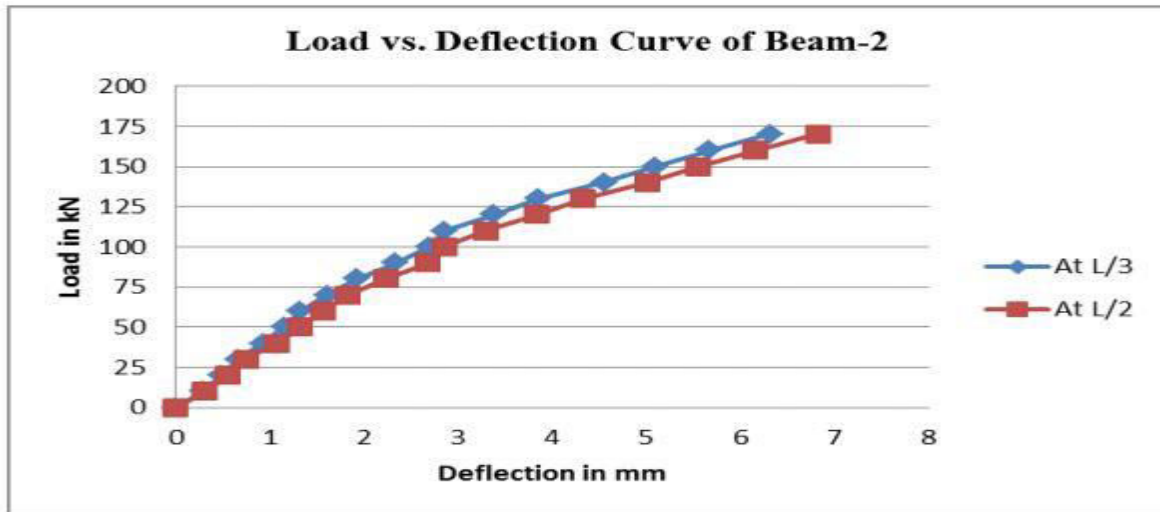


Figure 4.24 Load vs. Deflection Curve for SB1.

#### V. CONCLUSION

The primary goal of the existing investigation is usually to study the contribution of basalt fiber reinforced polymer (BFRP) composites on the shear capacity of the T shaped cross section RC beams externally strengthened with BFRP composites with and with no transverse web openings and to study the impact of a new mechanical anchorage system comprising of BFRP laminated composite plates with nuts and bolts arrangement on the shear capacity of RC T beams. Twenty two numbers of beams divided into a Series are tested under four point static loading system up to failure. Series A, discusses about the shear strengthening of the RC T beams with no transverse openings. I

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