# Fiber Reinforced Polymer : A Smarter Material for the Smarter Constructions

**Dipixa Gajera**
*Diploma Civil Engineer*
*Department of Civil Engineering*
*GTU, Surat, India*

**Parth Desani**
*UG Student*
*Department of Civil Engineering*
*SSASIT, Surat, India*

**Sonal Gosai**
*Adhoc Professor*
*Department of Civil Engineering*
*Mahavir Swami College of Polytechnic, Surat*

## Abstract

Civil Engineering has a very important role in practical life because it creates a safe foundation & provides facility for smooth conduction of life. For that purpose, a material named Fiber Reinforced Polymer (FRP) is introduced. A relatively new class of non-corrosive, high-strength, and lightweight materials, High flexibility and better suitability for all type of structural members, We can get more strength from the components of building by using it. Fiber Reinforced Polymer is characterized with very much tensile strength, application and availability. This material may costly but it gives that much benefits which May worth for its higher cost. FRP is a highly suitable smarter material for the smarter constructions of nowadays.

**Keywords- Fiber Reinforced Polymer, FRP, High Strength, Light Weight, Strengthening, Water Proof, Good Looking, High Flexure Strength, High Tensile**

## I. INTRODUCTION

Concrete obtains many characteristics like, flexure strength, shear stress hardness, toughness, soundness, compressive strength, etc.

Since the early 1990's, interest in the use of Fiber Reinforced Polymer (FRP) materials for structures has increased steadily, and there are currently hundreds of field applications of FRPs in structures around the world. FRP used as:

- Externally-bonded FRP plates, sheets, and wraps for strengthening of reinforced concrete, steel, aluminum, and timber structural members.
- FRP bars, rods, and tendons for internal reinforcement of concrete.
- All-FRP structures
- FRP hybrid structures.

This module presents an introduction into the properties and uses of FRP materials in civil engineering structures with a particular emphasis on their use for reinforcement and strengthening of structural concrete.

### *A. What is Fiber Reinforced Polymer (FRP)?*

Fiber reinforced polymer (FRP) is a composite material made of a polymer matrix reinforced with fibers. The fibers are usually glass, carbon, basalt or aramid, although other fibers such as paper or wood or asbestos have been sometimes used. The polymer is usually an epoxy, vinylester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. FRPs are commonly used in the aerospace, automotive, marine, and construction industries.

Fig. 1: Fiber Reinforced Polymer

 

FRP materials are composites consisting of high-strength fibers encapsulated in a polymeric resin to form a laminate. Fibers in FRP composite materials carry the load, while the resin protects the fibers and keeps them in alignment. In addition to encapsulating the fibers, the resin acts as an adhesive to bond the laminate to the concrete substrate. Commonly available fibers are manufactured of carbon, glass, and aramid. The fibers are typically provided in a woven sheet matrix, pre-cured laminates, or solid bars.

## II. WHY USE FRP?

- FRP strengthening offers several advantages over conventional strengthening for existing reinforced concrete structures.
- FRP materials are relatively thin in their application and hence ideal for areas with limited access, such as applications above drop ceilings or within floor slabs.
- They are relatively easy to install with minimal invasive modifications to the existing structures.
- FRP materials are also lightweight, so increases in dead loads from the strengthening solution are negligible.
- It should be noted that FRP composites provide only a nominal increase in stiffness, so they are generally useful for increased structural strength, rather than deflection control.

Through comparisons with independent test data, the proposed model is shown to be accurate not only for FRP-confined concrete but also for concrete confined with a steel tube, demonstrating the wide applicability of the model to concrete confined with different confining materials. The accuracy of the proposed model is also shown to be superior to existing analysis-oriented stress-strain models through comparisons with test data.

## III. STUDY AREA

Mostly the flexural strength is required to the beam to carry over the external loadings. Therefore here the tests will be done on beams. There are 5 types of beams, which are as follows :

- Simply Supported Beam
- Fixed Beam
- Cantilever Beam
- Continuous Beam
- Over Hanging Beam

### *B. Beams without FRP will Give Following Characteristics*

- Normal durability
- Good tensile and flexural strength
- Damages may occur by heavy loadings
- Less shear strengths
- Cost will be lesser

### *C. Beams with FRP will Give Following Characteristics*

- Good durability
- Higher tensile and compressive strength
- Higher load carrying capacity
- Good flexural strength
- Good shear strength
- Good appearance
- Cost may increase but give more advantages
- Good heat resistivity
- Lesser weight increment

## IV. ADVANTAGES

- Increases out-of-plane flexural strength
- Increases in-plane shear strength
- Confines masonry units, resulting in monolithic action of all units
- Prevents secondary damage from falling debris
- Works as a waterproofing material
- Adds very little weight to the wall
- Increases wall thickness by less than 1/4in. (5 mm)
- Costs less than conventional methods.

## V. SCOPE OF THE STUDY

Smart structures are those in which sensors are installed to continuously monitor the performance of the structure throughout its lifetime. Recently, FRP materials have been developed which include Fiber-Optic Sensors (FOS) as part of their internal structure. As described, FRP is a smarter material which improves flexural strength it may be checked and identified that how much flexural strength Fiber Reinforced Polymer will improve to the beam. So, many more structural damages can be prevented which may fails because of heavy loading. By using FRP, Strength of whole structures can be increased. FRP with multiple advantages may help to prevent structures from the damages due to different reasons. Some damages of structures are shown below.

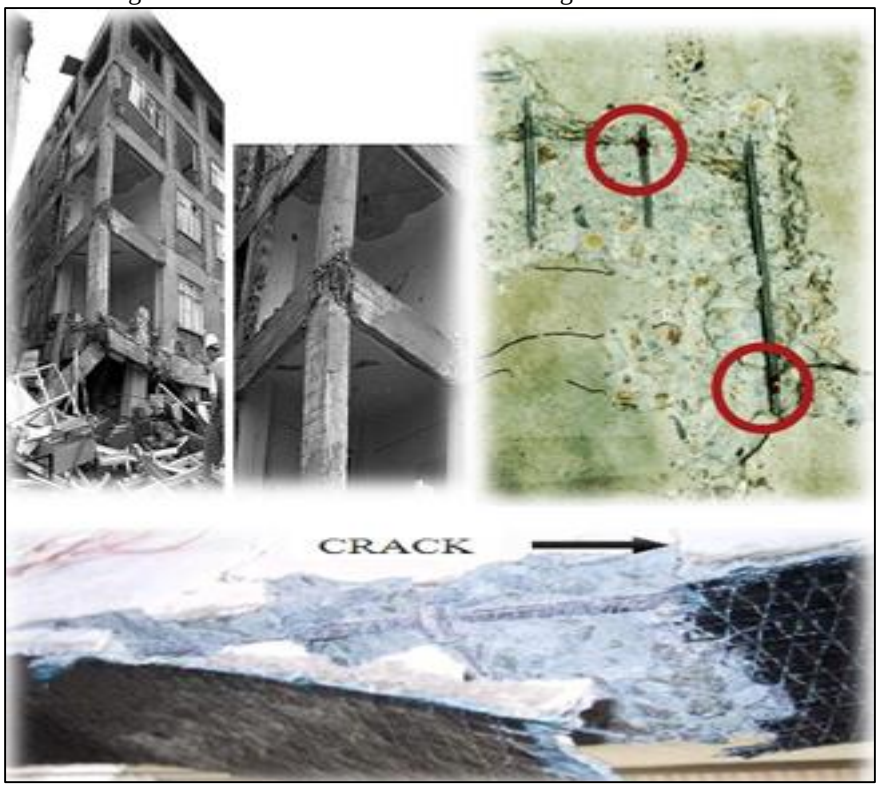


Fig. 2: Damages of Structures

## VI. AVAILABILITY OF FPR PRODUCTS

Fiber Reinforced Polymer (FRP) is a thermoplastic material which is available in all the form therefore it may applied as per requirement as,

- Liquid polymer,
- Flexible resin polymer sheet,
- Hard FRP sheet,
- Fiber (FRP) Rods,
- FRP Strings(Stirrups),
- Raw FRP dust,
- FRP Band, etc.

Fig. 3: FRP Products

## VII. EFFECTS OF FRP ON BEAM

- Fiber reinforced polymer (FRP) sheets have been increasingly used as externally bonded reinforcements in the rehabilitation of concrete structures.
- The efficacy of the FRP bonding technology highly depends on the bond integrity between the FRP sheets and the concrete.
- The bond performance may directly influence the cracking of the concrete, whereas the presence of concrete cracks would impair the bond between the FRP sheets and the concrete.
- This paper aims to clarify the effect of interface bond properties on the performance of FRP-strengthened reinforced concrete (RC) beams in terms of concrete cracking, interface stress transfer, and failure mechanisms using nonlinear fracture mechanics based finite element analyses.
- To represent the typical crack patterns and capture the local interaction between FRP rebonding and concrete cracking, a specially designed structural model with uniformly distributed cracking is used within the frame of the discrete crack approach.
- A detailed parametric study is performed to investigate the effects of interface bond properties in terms of stiffness, strength, fracture energy (or toughness), and bond curve shape.
- It is concluded that bond fracture energy (or toughness) is the main parameter influencing the structural strength and ductility.
- This study may serve as a valuable reference for optimization of the FRP-concrete bond interface in practical applications.

## VIII. CONCLUSION

FRP strengthening techniques, when implemented correctly, can offer significant performance enhancement for existing structures. With the use of well-tested materials, expert installation crews, and proper design guidelines, FRP will provide a unique and sustainable solution for the many structural problems.

FRP is a properly suitable material which provide many more benefits to the construction and makes the easy use of it in any form as desired. FRP will be considered by engineers, constructors, and code officials. Designers and structural engineers will become increasingly familiar with the design, characteristics and benefits of used structural FRP.

## REFERENCES

[1] Togay Ozbakkaloglu (University of Adelaide, Adelaide, SA 5005, Australia), Jian-Fei Chen (Queen's University Belfast, Belfast BT7 1NN, UK), Scott T. Smith (Southern Cross University, Lismore, NSW2480, Australia), and Jian-Guo Dai (Hong Kong Polytechnic University, Kowloon, Hong Kong), (2016), Applications of Fiber Reinforced Polymer Composites, Hindawi Publishing Corporation, International Journal of Polymer Science – Volume 2016

[2] Gevin McDaniel, P.E. Roadway Design Standards Administrator, Chase Knight, PhD, Composite Materials Research Specialist, Fiber Reinforced Polymer Composites, Ravi Jain, Luke Lee (2012), "Fiber Reinforced Polymer (FRP) Composites For Infrastructure Applications. Focusing On Innovation, Technology Implementation And Sustainability", School of Engineering and Computer Science, University of the Pacific, Stockton, California

[3] Pre-Standards for Load and Resistance Factor Design (LRFD) of Pultured Fiber Reinforced Polymer Structures, American Composites Manufacturers Association (ACMA), November – 2010.

[4] [1]Sami Rizkalla, [2]Tarek Hassan and [2]Nehla Hassan (2003), "Design Recommendations for the Use of FRP for Reinforcement and Strengthening of Concrete Structures, [1]North Carolina State University Raleigh, NC, USA, [2]Ain Shams University, Cairo, Egypt.

[5] Taranu Nicolae, Oprişan Gabriel, Isopescu Dorina, EnţucIoana, Munteanu Vlad and Banu Catalin, "Fibre Reinforced Polymer Composites As Internal And External Reinforcements For Building Elements", University of Construction and Architecture, Indonesia.

[6] Code of Standard Practice, Industry Guidelines for Fabrication and Installation of Pultured FRP Structures, published by American Composites Manufacturers Association (AMCA).

[7] Performance Of Different Types Of FRP Sheets Bonded To Concrete Using Flexible Adhesive, Hesham M. Diab, Civil Engineering Department, Assiut University, Egypt.

[8] Strengthening Of RC Continuous Beam Using FRP Sheet by Soumya Subhashree, Master Of Technology in Civil Engineering (Structural Engineering), Department Of Civil Engineering National Institute Of Technology Rourkela Rourkela-769008, Odisha, India, May 2012

[9] Experimental Investigation Of RC Beams Strengthened With Externally Bonded FRP Composites, Nadeem A. Siddiqui, Department Of Civil Engineering, King Saud University, and Riyadh 11421, Saudi Arabia.

[10] Why Fiber Reinforced Polymer (FRP) Structural Shapes Have Become A Material Of Choice, By Daniel A. Witcher, P.E., S.E.

[11] Prof. Dayal R. Parhi (2013), "Diagnosis of Damages in Beam Structures using Vibration Parameters and Artificial Intelligence Techniques", Department of Mechanical Engineering, National Institute of Technology, Rourkela