e-ISSN: 2455-5703

Strengthening of Simply Supported Concrete Beam using Fiber Reinforced Polymer

[1]Parth Desani [2]Mansi Soni [3]Nidhi Gandhi [4]Vivek Mishra
[1,2,3,4]U. G Student
[1,2,3,4]Department of Civil Engineering
[1,2,3,4]S.S.A.S.I.T., Surat, Gujarat, India

Abstract

Civil Engineering has a very important role in practical life because it creates a safe foundation & provides facility for smooth conduction of life. So it's very important that the structure under which the people breathe should resist all worst conditions and provide them safety. For that purpose, for a maximum safety, to achieve good strength of components of building during its maximum life period, here we introduce a material Fiber Reinforced Polymer (FRP). A relatively new class of non-corrosive, high-strength, and lightweight materials, have, over the past 15 years or so, emerged as practical materials for a number of structural engineering applications. Fiber Reinforced Polymer has a very important role in construction work. We can get more strength from the components of building by using it. Also we can increase the load carrying capacity of the components of buildings. When an FRP specimen is tested in axial tension, the applied force per cross sectional area (stress) is proportional to the ratio of change in the specimen's length to its original length (strain). When the applied load is removed, FRP returns to its original shape or length. In other words, FRP responds linear – elastically to axial stress.
Keyword- Fiber Reinforced Polymer, FRP, High Strength, Light Weight

I. INTRODUCTION

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.

FRP composites were first developed during the 1940s, for military and aerospace applications. Considerable advances have been made since then in the use of this material and applications developed in the construction sector. FRPs have been successfully used in many construction applications including load bearing and infill panels, pressure pipes, tank liners, roofs, and complete structures where FRP units are connected together to form the complete system in which the shape provides the rigidity.

Fig. 1: Fiber ingredients of FRP

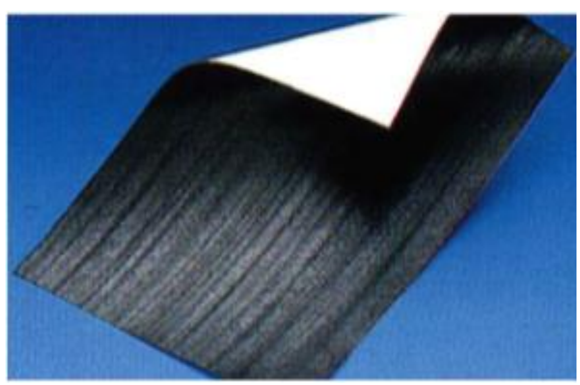

Fig. 2: Prepared FRP

In the last decade, polymer composites have found application in the construction sector in areas such as bridge repair, bridge design, mooring cables, structural strengthening and stand-alone components. These composites are materials often referred to as advanced composites and have properties considerably superior to those of earlier composites. The term is ambiguous, however, because it does not identify any specific material combination. In the construction industry, the term is generally used for polymers reinforced with high strength high modulus continuous fibers of glass, carbon or aramid laid up in layers to form an engineered material.

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.

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, vinyl ester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. FRP commonly used in the aerospace, automotive, marine, and construction industries.

Composite materials consist of two or more distinct physical phases, one of which, the fibrous, is dispersed in a continuous matrix phase. Composites offer the designer a combination of properties not available in traditional materials. It is possible to introduce the fibers in the polymer matrix at highly stressed regions in a certain position, direction and volume in order to obtain the maximum efficiency from the reinforcement, and then, within the same member to reduce the reinforcement to a minimal amount at regions of low stress value. Other advantages offered by the material are lightness, resistance to corrosion, resilience, translucency and greater efficiency in construction compared with the more conventional materials.

II. NEED OF STUDY

FRP composites have found increasingly wide applications in civil engineering due to their high strength-to-weight ratio and high corrosion resistance. One important application of FRP composites is as a confining material for concrete, particularly in the strengthening or seismic retrofit of existing reinforced concrete columns by the provision of a FRP jacket.

FRP confinement can enhance both the compressive strength and the ultimate strain of concrete significantly. This project will indentify that FRP wrapped concrete in which the responses of the concrete core and the FRP jacket as well as their interaction are explicitly considered. Such a application is referred to as an analysis-oriented study material. The key novel feature of the proposed analysis-oriented material, compared to existing materials of the same kind, is a more accurate and more widely applicable lateral strain equation based on a careful interpretation of the lateral deformation characteristics of unconfined, actively confined, and FRP wrapped concrete.

A. Effects In Beam with FRP

- FRP sheets have been increasingly used as externally bonded reinforcements in the rehabilitation of concrete structures.
- The efficiency 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 study report 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 re-bonding 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.

III. SCOPE OF STUDY

The future holds unlimited promise for the use of FRPs in structural engineering applications. One of the most exciting recent advances is the development of smart materials and smart structures. 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. These FOS can be used to measure variations in strain and temperature within the structure itself, and can provide information to engineers on its short and long-term performance. These materials can be considered an emerging technology, although several smart structures have already been built in Canada and are currently under observation. Smart structures and materials will undoubtedly become more important and widespread in the future.

A. Why Use FRP

- The fiber reinforced polymer composites (FRP) are increasingly being considered as an enhancement to and/or substitute for infrastructure components or systems that are constructed of traditional civil engineering materials, namely concrete and steel.
- FRP composites are lightweight, non-corrosive, exhibit high specific strength and specific stiffness, are easily constructed, and can be tailored to satisfy performance requirements.
- Due to these advantageous characteristics, FRP composites have been included in new construction and rehabilitation of structures through its use as reinforcement in concrete, bridge decks, modular structures, formwork, and external reinforcement for strengthening and seismic upgrade.

- When considering only energy and material resources it appears, on the surface, the argument for FRP composites in a sustainable built environment is questionable.
- 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.

However, such a conclusion needs to be evaluated in terms of potential advantages present in use of FRP composites related to considerations such as:

- Higher strength
- Lighter weight
- Higher performance
- Longer lasting
- Rehabilitating existing structures and extending their life
- Seismic upgrades and defense systems
- Space systems
- 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 in Ocean environments
- Adds very little weight to the wall
- Increases wall thickness by less than 1/4in. (5 mm)
- Costs less than conventional methods

B. Advantages and Limitations

FRP allows the alignment of the glass fibers of thermoplastics to suit specific design programs. Specifying the orientation of reinforcing fibers can increase the strength and resistance to deformation of the polymer. Glass reinforced polymers are strongest and most resistive to deforming forces when the polymers fibers are parallel to the force being exerted, and are weakest when the fibers are perpendicular. Thus this ability is at once both an advantage or a limitation depending on the context of use. Weak spots of perpendicular fibers can be used for natural hinges and connections, but can also lead to material failure when production processes fail to properly orient the fibers parallel to expected forces. When forces are exerted perpendicular to the orientation of fibers the strength and elasticity of the polymer is less than the matrix alone. In cast resin components made of glass reinforced polymers such as UP and EP, the orientation of fibers can be oriented in two-dimensional and three-dimensional weaves. This means that when forces are possibly perpendicular to one orientation, they are parallel to another orientation; this eliminates the potential for weak spots in the polymer.

C. Application of FRP

For the shear strengthening of a beam, the FRP is applied on the web (sides) of a member with fibers oriented transverse to the beam's longitudinal axis. Resisting of shear forces is achieved in a similar manner as internal steel stirrups, by bridging shear cracks that form under applied loading.

FRP can be applied in several configurations, depending on the exposed faces of the member and the degree of strengthening desired, this includes: side bonding, U-wraps (U-jackets), and closed wraps (complete wraps). Side bonding involves applying FRP to the sides of the beam only. It provides the least amount of shear strengthening due to failures caused by de-bonding from the concrete surface at the FRP free edges.

For U-wraps, the FRP is applied continuously in a 'U' shape around the sides and bottom (tension) face of the beam. If all faces of a beam are accessible, the use of closed wraps is desirable as they provide the most strength enhancement. Closed wrapping involves applying FRP around the entire perimeter of the member, such that there are no free ends and the typical failure mode is rupture of the fibers. For all wrap configurations, the FRP can be applied along the length of the member as a continuous sheet or as discrete strips, having a predefined minimum width and spacing.

IV. TYPES OF FRP

A. Carbon-Fibre-Reinforced Polymers

The binding polymer is often a thermo set resin such as epoxy, but other thermo set or thermoplastic polymers, such as polyester, vinyl ester or nylon, are sometimes used. The composite may contain other fibers, such as aramid e.g. Kevlar, Twaron, aluminum, or glass fibers, as well as carbon fiber. The properties of the final CFRP product can also be affected by the type of additives introduced to the binding matrix (the resin).

B. Glass-Fibre-Reinforced Polymers

The glass fibers are divided into three classes -- E-glass, S-glass and C-glass. The E-glass is designated for electrical use and the S-glass for high strength. The C-glass is for high corrosion resistance, and it is uncommon for civil engineering application. Of the three fibers, the E-glass is the most common reinforcement material used in civil structures. It is produced from lime-alumina-borosilicate which can be easily obtained from abundance of raw materials like sand.

C. Aramid-Fibre-Reinforced Polymers

These are synthetic organic fibers consisting of aromatic polyamides. The aramid fibers have excellent fatigue and creep resistance. Although there are several commercial grades of aramid fibers available, the two most common ones used in structural applications are Kevlar 29 and Kevlar 49. The Young's Modulus curve for Kevlar® 29 is linear to a value of 83 GPa but then becomes slightly concave upward to a value of 100 GPa at rupture; whereas, for Kevlar 49 the curve is linear to a value of 124 GPa at rupture. As an anisotropic material, it's transverse and shear modulus are an order of magnitude less than those in the longitudinal direction. The fibers can have difficulty achieving a chemical or mechanical bond with the resin.

D. Comparison of Beam Without Apply FRP And Beam with Apply FRP

Sr. No.	*Beam without FRP*	*Beam with FRP*
1.	*Cost of construction is less of beam without applying FRP*	*Cost of construction of beam with FRP sheet is more.*
2.	*Beam can crack easily.*	*Beam can not crack easily, because FRP sheet opposes the load.*
3.	*Beam without FRP can not bear more load.*	*Beam with FRP can bear more load.*
4.	*Tensile strength of beam is less.*	*Tensile strength of beam is more.*
5.	*Beam without FRP has low compressive strength.*	*Beam with FRP has high compressive strength.*
6.	*Materials: Sand, Cement, Aggregate, Reinforcement.*	*Materials: Sand, Cement, Aggregate, Reinforcement, FRP sheet.*
7.	*No Special Material required.*	*Fiber Reinforced Polymer Sheet required.*
8.	*Construction time is lesser than beam with FRP sheet.*	*Construction time is more due to setting of FRP sheet.*
9.	*Beam without FRP has low shear strength.*	*Beam with FRP has high shear strength.*
10.	*Beams without FRP has low flexure strength.*	*Beam with FRP has high flexure strength.*

V. CONCLUSION

Externally bonded FRPs are an effective strengthening method for use in the retrofit and rehabilitation of existing structures. These fiber wrap materials have been used for civil engineering applications for more than 20 years and have a well- documented performance record. By understanding the basic engineering principles and practices needed to implement this technology, designers can feel more confident implementing its use. With the use of well-tested materials, expert installation crews, and proper design guidelines, fiber wrap will provide a unique solution to many structural problems.

FRP pultruded structural shapes, plates, and building products have been successfully worldwide for over fourty years. These materials, and structures utilizing these materials, are now considered proven by engineers, constructors, and code officials. As the codes and standards bring these materials to the next level of recognition, structural engineers will continue to become increasingly familiar with the design, characteristics and benefits of pultruded structural FRP.

REFERENCES

[1] Strengthening of RC Continuous Beam Using FRP Sheet bySoumya Subhashree, Master of Technology in Civil Engineering (Structural Engineering), Department of Civil Engineering National Institute of Technology Rourkela Rourkela-769008, Odisha, India, May 2012
[2] Fibre Reinforced Polymer Composites as Internal and External Reinforcements for Building Elements by TaranuNicolae, Oprişan Gabriel, IsopescuDorina, EnţucIoana, Munteanu Vlad and BanuCatalin.
[3] Performance of Different Types of FRP Sheets Bonded to Concrete Using Flexible Adhesive, Hesham M. Diab, Civil Engineering Department, Assiut University, Egypt.
[4] Experimental Investigation of RC Beams Strengthened with Externally Bonded FRP Composites, Nadeem A. Siddiqui, Department of Civil Engineering, KingSaud University, Riyadh 11421, Saudi Arabia.
[5] Why Fiber Reinforced Polymer (FRP) Structural Shapes Have Become a Material of Choice, By Daniel A. Witcher, P.E., S.E.
[6] Fiber Reinforced Polymer (FRP) Composites for Infrastructure Applications. Focusing On Innovation, Technology Implementation and Sustainability, Ravi Jain, Luke Lee, Springer 2012.