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Fibre Reinforced Polymer in Retrofitting

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Abstract: Retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion etc. Many of the existing reinforced concrete structures throughout the world are in urgent need of rehabilitation, repair or reconstruction because of deterioration due to various factors like corrosion, lack of detailing, failure of bonding between beam-column joints etc. Fibre Reinforced Polymer (FRP) composite has been accepted in the construction industry as a promising substitute for repairing and in incrementing the strength of RCC structures. It stabilizes the current structure of buildings and making them earthquake resistant. This paper presents a representative overview of the current state of using FRP materials as a retrofitting technique for the structures not designed to resist seismic action. It summarizes the scopes and uses of FRP materials in seismic strengthening of RCC structures and masonry retrofitting.
Keywords: Retrofitting, Rehabilitation, Seismic damage, fibre.

I. INTRODUCTION

Fibre reinforced polymer is a composite material which is made up of two entities :a matrix, which is usually made up of thermosetting resins (such as epoxy and vinylester) and fibres. The function of matrix is to transfer forces between the fibres and protect the fibres from detrimental effects. The fibres are essential which will give mechanical properties to the materials. There is a mix of different types of fibre used such as glass, carbon or aramid. The type of fibre frequently controls the properties of FRP. The FRP is often named with the reinforced fibre, for instance carbon fibre reinforced polymer (CFRP) . The most important property that differ between the fibre types are stiffness and tensile strain. The strength of these fibres is of the order of 3000Mpa. Their strength is even higher than that of prestressing steel and stiffness as of aluminium and steel. Fibre does not rust , at least in a same way as steel. In particular, they are resistant to attack by chlorides which is the most advantage of fibres. Other advantages of fibres are durability ,lightweight and negligible amount of creep as compared to steel. Fibre reinforced polymer composites are anisotropic where as steel and aluminium are isotropic. Therefore, there properties are directional, meaning mechanical properties are in the direction of the fibre placement. These materials have a high ratio of strength to density, exceptional corrosion resistance, and convenient electrical, magnetic, and thermal properties. However, they are brittle and mechanical property may be affected by the rate of loading, temperature and environmental conditions. The primary function of fibre reinforcement is to provide the strength and stiffness in one direction. It replaces metallic materials in many structural applications where load carrying capacity is important. FRP allows the alignment of the glass fibres of thermoplastics to suit specific design programs. Specifying the orientation of reinforcing fibres 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 fibres are parallel to the force being exerted, and are weakest when the fibres are perpendicular. Thus, this ability is at once both an advantage or a limitation depending on the context of use. Weak spots of perpendicular fibres can be used for natural hinges and connections, but can also lead to material failure when production processes fail to properly orient the fibres parallel to expected forces. When forces are exerted perpendicular to the orientation of fibres, 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 fibres 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. Depending upon type of fibre used fibre reinforced polymer can be classified as:

A. Carbon Fibre Reinforced Polymer

Carbon fibre reinforced polymer (CFRP) is a combination of extremely thin carbon fibers of 5-10μm in diameter, embedded in polyester resin. In CFRP the reinforcement material is carbon fibre that provides the strength and stiffness and for matrix commonly used polymer resin like epoxy, which binds the reinforcement in organized way. Carbon fibre is an anisotropic material in nature manufactured at 1300°c. The major advantage of fibre includes low density, low conductivity, high fatigue strength, high elastic modulus (200-800 GPA), good creep level resisting to chemical effects and do not absorb water.

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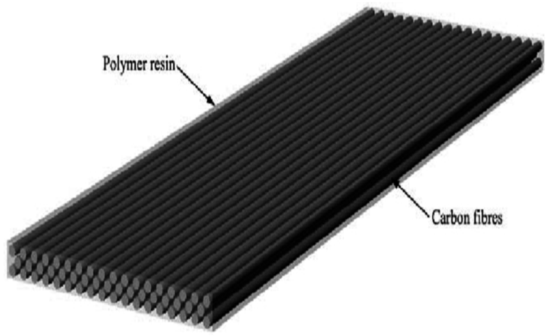
Carbon Fiber Reinforced Polymers are most commonly used in industrial masonry structure for the Retrofitting of old structures that already damaged due to earthquakes, chemical reaction, environment effect etc. Since Carbon fiber Reinforced polymers (CFRPs) are one the stiffest and lightest composite materials so they are much substantial than other conventional materials in many fields of applications. Norazman et al investigated the purpose Of using CFRP is to improve the tensile strength of reinforced concrete, replacing steel, totally and he concluded that the main Advantage of using CFRP as reinforcement is to avoid rusting and corrosion of reinforcement. The use of (CFRP) composite Reinforcement provides a prospective solution like Column wrapping with CFRP composites, is a popular alternative for improving The seismic resistance of columns. At present CFRP Is being used for structural repair for damaged structure due to aging and extreme condition. Because of these advantages, carbon fibre finds great application in many industries such as aerospace, automotive, military and recreational applications.



Carbon fibre reinforced polymer

B. Glass Fibre Reinforced Polymer

Glass Fibre Reinforced Polymer (GFRP) is a fibre reinforced polymer made up of a plastic matrix reinforced by fine fibres of glass. Glass fibres are basically made by mixing silica sand, limestone, folic acid and other minor ingredients. Based on an aluminium Lime borosilicate composition, glass produced fibres are considered as the predominant reinforcement for polymer matrix composites due to their high electrical insulating properties even at low thickness, low susceptibility to moisture and high mechanical properties as it's specific resistance is greater than steel.

GFRP

Fiber glass is a lightweight, strong, and tough material used in different industries due to their excellent properties. Although Strength properties are lower than carbon fiber and it is less stiff, but material is typically far less brittle and raw materials are much less expensive. GFRP bars have been used magnificently as a main reinforcement in concrete bridges, parking garages, tunnels, and Water tanks . FRP can be realistic to strengthen the beams, columns, and slabs of buildings and bridges, Two techniques are Typically adopted for the strengthening of beams, relating to the strength enhancement anticipated and those are flexural Strengthening & shear strengthening. In many cases it may be required to provide both strength enhancements. For the flexural strengthening of a beam, FRP sheets or plates are applied to the tension face of the member. Glass Fibre reinforced polymer is widely used in electronics, home and furniture, boat and marine, medical and automobile industries.

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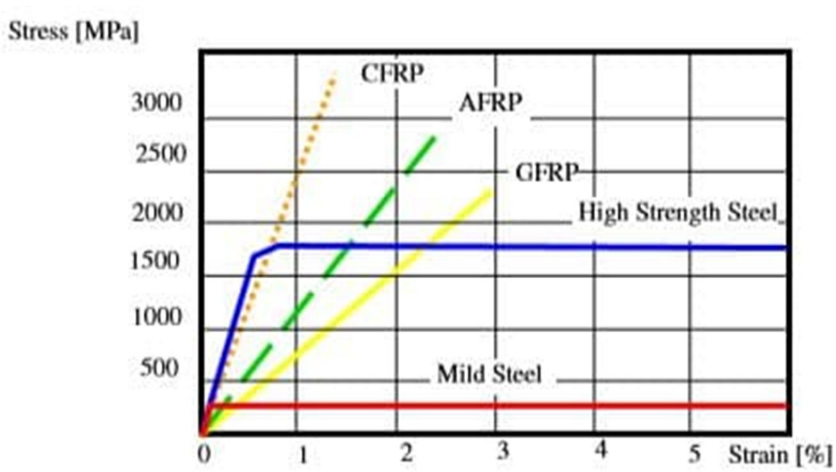
C. Aramid Fibre Reinforced Polymer

Aramid is the short form for aromatic polyamide. Aramid fibre is a synthetic fibre in which the fibre-forming substance is a long-chain synthetic polyamide that has at least 85% of the amide linkages attached directly to two aromatic rings. The substitution of the aliphatic carbon backbone by aromatic groups brings about considerable changes in the properties of the resultant fibers. A well-known trademark of aramid fibres is Kevlar and other brands are Twaron, Technora and SVM.

Aramid fiber was the first organic fiber used as reinforcement in advanced composites with high enough tensile modulus and strength. They have much better mechanical properties than steel and glass fibers on an equal weight basis. Aramid fibers are inherently heat- and flame-resistant, which maintain these properties at high temperatures.

AFRP

The modulus of elasticity of the fibres are 70-200 GPa with an elongation of 1.5-5% depending on the quality. Aramid has fracture energy and is therefore used for helmets and bullet-proof garments. Aramid main advantages are high strength and low weight. Like graphite, it has a slightly negative axial coefficient of thermal expansion, which means aramid laminates can be made thermally stable in dimensions. Unlike graphite, it is very resistant to impact and abrasion damage. They are sensitive to moisture and ultraviolet radiation and therefore not widely used in civil engineering application.



Properties of Different Types of FRP Compared with Steel

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II. FIELD APPLICATIONS OF FRP

A. Seismic Retrofitting

Seismic retrofitting is the modification of existing structures to make them more resistant in seismic activity, ground motion and soil failure. Seismic retrofitting is the failure mode which will be considered cycle loading effect and particular stress will be made on brittle failure so that the structure is safe in case of any exciting earthquake event. We can also use two different kinds of FRP applications that can be designated as seismic retrofitting. The first case is when a structure has been damaged due to an earthquake it has to be renovated and FRP retrofitting is best alternative and economical solution. The second application is the Improvement of the structure for earthquakes which might appear in the future. One of the weakness part of structure is columns. The lateral movement due to earthquakes creates an important shear stress in the columns. The shear failure occurs mostly in the columns where plastic hinges are developed. Fiber reinforced polymer composites are gradually being used in civil infrastructure from reinforcing rods to tendons, warping for seismic retrofit of columns, beams, and slabs etc . In seismic retrofit of rectangular columns, by using FRP composites the technique of shape modification combined with FRP imprisonment is also attractive for the strengthening of columns subjected to static load which induce either axial compression or combined axial compression and bending in the column.

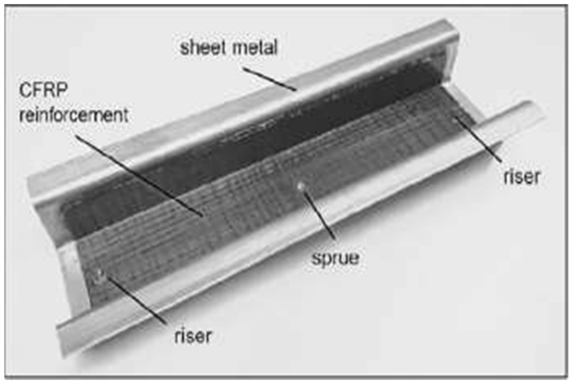
B. Retrofitting of RCC Column

When a Earthquake hits, reinforced concrete columns are considered to be the most vulnerable part of a typical RC structure as they are the major load carrying element of the building. Minimum cross section size and lack of steel reinforcement in under designed columns leads to a weak column-strong beam construction. It is very important to strengthen the columns so that the plastic hinges are formed in the beams since it allows more effective energy dissipation. Moreover, columns should be adequately designed to avoid a soft story collapse of a building due to seismic action. During an earthquake, three modes of RC column failures that can take place due to cyclic axial and lateral loads are – shear failure; flexural plastic hinge failure and lap splice failure. Lack of transverse reinforcement can result in shear failure, which is both brittle and catastrophic in nature. Shear capacity of deficient columns can be significantly enhanced by providing externally bonded FRP laminates with fibers in the hoop direction as shown in fig 2. Researches have shown that an increase in the thickness of CFRP and AFRP jacket proportionally increases the shear strength of the upgraded column or pier. The role of FRP for strengthening of existing or new reinforced concrete Structures is growing an extremely rapid speed of construction and the possibility of application without disturbing the existing functionality of the structure. CFRP & GFRP wrapping can enhance the strength of concrete columns under axial loading compressive strength of the concrete columns increases with Increase in the number of layer of GFRP Confinement by GFRP enhances the performance of rectangular concrete columns.

Fig. 24

C. Retrofitting of RCC beams

Flexural Strengthening of reinforced concrete beams can be done either by external bonding of FRP composites [external bonding (EB) system] or by insertion of FRP strips or bars into grooves cut into the concrete [near surface mounted (NSM) system]. In both methods, bond between FRP and concrete surface must be ensured to attain improvement in flexural strength and stiffness and to avoid premature debonding failure. Flexural strengthening of reinforced concrete beams by bonding FRP laminates at the tension face of the beam. In addition to the strength enhancement the FRP strengthening scheme with anchoring system improves the ductility of the retrofitted beam by confining the concrete. This in turn improves the seismic performance of the retrofitted beams. It has been observed that the shear strength of CFRP retrofitted beams under simulated earthquake loads were enhanced by up to 114% as compared to a similar RC beam without FRP. The bond behavior and load transfer behavior between concrete beam and FRP laminates has significant impact on the failure behaviour and stress distribution of retrofitted beams.



III. CONCLUSION

FRP proves to be a wonder material as it has many advantageous properties as compared to Traditional/ conventional materials. However, despite a considerable number of field applications and Laboratory research on FRP, the research results have not yet been fully getting its place into teaching Curricula. There are not sufficient engineers who are knowledgeable enough to design structures with Composite materials or to specify them for construction projects. FRP really is still a specialty item in many Countries. Providing sufficient training on unique features of FRPs so that engineers could design or specify Them in construction will improve the scenario. There is a need of Government-Industry-Institute Partnership to take advantage of full potential of FRP. The increase in use of FRP for retrofitting is inevitable Because of its potential. At last but not the least, works of researchers and authors are hereby duly acknowledged, using which this paper could get this form.

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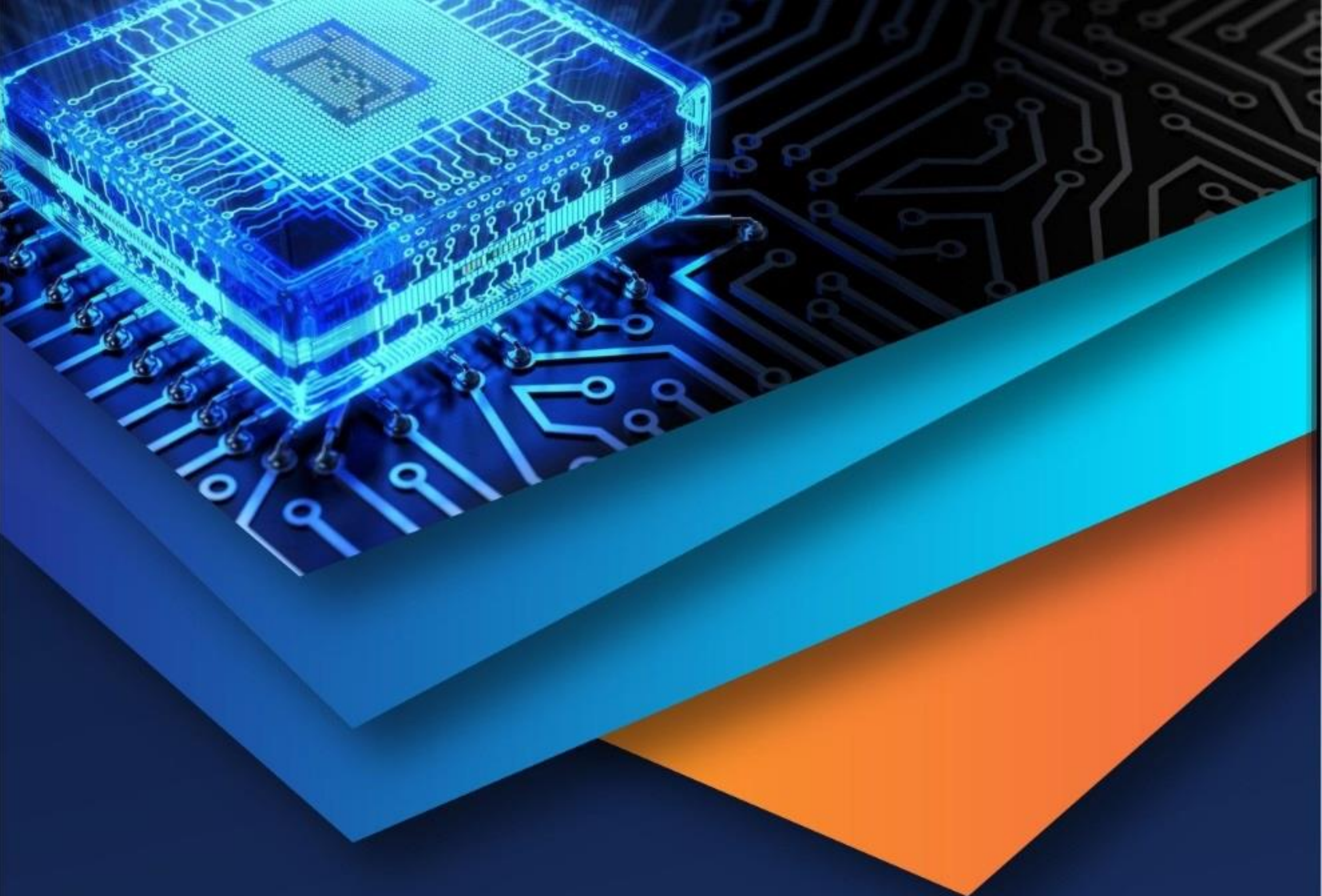

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