Strengthening And Retrofitting of RC Beam By Using Fiber Reinforced Polymer Composites : A Review

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Abstract- *Strengthening and Retrofitting is technical intercessions in structural building that increase the resistance to seismic forces by developing the strength, stiffness, ductility and seismic loads. Structural strength of the RC members is induced from the structural dimensions, materials used, shape and number of structural elements, etc. Ductility of the RC members is induced from proper detailing, materials used, seismic resistant etc. Earthquake load is procreated from the field seismicity, ductility of RC structural elements importance of structure, degree of seismic resistant etc. Due to the diversity of structural condition of RC building, it is difficult to dilate typical rules for retrofitting. Each structural system of building has distinct approaches depending on the structural deficiencies. Hence, structural engineers are required to analyze and design the retrofitting techniques for RC structures. In the design of retrofitting techniques, the structural engineer must uphold with the building IS codes. This paper shows a delegate overview of the present state of utilizing FRP materials as a retrofitting technique for the RC structures not designed to resist seismic action. It explain the importance's and applications of FRP composite materials in seismic strengthening/retrofitting of RC structures. The merits and demerits along with the design guidelines and the limitations of FRP applications for seismic retrofit are also included in the paper. Different techniques used for strengthening/retrofitting of RC structures are also included in the paper.*

Keywords- Retrofitting, restoration, FRP, strengthening, seismic.

I. INTRODUCTION

A structure is designed for a specific period and its design life distinct depending on the nature of that structure. Now a day, deterioration in concrete structures is a major challenge faced worldwide by the infrastructure and bridge industries. The deterioration of structures is due to environmental consequence which includes corrosion of steel members, loss of strength with aging, repeated high intensity loading, temperature variation and contact with chemicals or salty water. Since the entire replacement/reconstruction of RC structures will involve the more cost. Strengthening or retrofitting is an best solution to strengthen the same.The most useful techniques for strengthening/retrofitting of RC flexural beams is the use of epoxy-bonded external steel plate which increases the flexural strength of the RC beams. Even though technique is very simple and cost-effective but it has the demerits that steel will corrode and hence deterioration of bond occurs in between steel and concrete interface. Other technique includes composition of steel jackets is simple and effective but it increases the overall cross-section of members and increase in self-weight of the structure. To overcome these problems, corrosive resistant and lightweight FRP composite plates replaced steel plates.

In addition, such material could be designed to meet specific requirements by adjusting placement of fibers. The wrapping of Fibre reinforced polymer sheets, retrofitting of RC structure gives a more economical section and it provides high strength, low self-weight, resistance to corrosions, high fatigue resistance, quick and easy assemblage and minimum change in structural geometry. FRP composites can likewise be used in zones with constrained access where traditional retrofitting techniques would be impractical. Successful retrofitting of solid structures with FRP needs an exhaustive learning regarding the matter and accessible easy to use advancements and one of a kind rules. RC beams are the critical sections, which is subjected to flexure, twist and shear in all kind of structures. Similarly, columns are also subjected to axial load combined with or without bending. Therefore, specious inventor works are to be carried out all over the global on retrofitting of these concrete members with externally bonded fibre composites. In addition, a few examinations were directed on retrofitting beams with c fibre reinforced polymer composites (CFRP or GFRP) in order to study the increase of strength and ductility of beam, durability of materials used for beam, confinement effects, arrangement of guidelines for design and experimental enquitry of these members.

II. FIBER REINFORCED POLYMER (FRP)

Fiber reinforced polymers is a mixed composites material, which is produced from two substances: a lattice (matrix), which is generally made of epoxy resin and fiber. The fiber composites are imperative which will give its mechanical properties to the material. Different kinds of fiber mix utilized such as Glass fiber, Carbon fiber or Aramid fiber (Kevlar) and the matrix which is fundamentally a resin made of polyester, epoxy.

Carbon Fiber is a composite Polymer matrix reinforced with carbon fibers, which are very strong and light. Carbon, aramid and glass fibers is more strong having strengths as fibers of 3000 Mpa. These strengths are higher even in Pre-stressing steels and there is no uncertainty that they are appealing to structural engineers. The stiffness's of fibers are so sufficiently high as they are solid as aluminum and steel. A fiber does not rust, at any rate similarly as steel. Specifically, they resistant to chloride attacks, which are the significant favorable circumstances of fibers. Some other merits of fibers are durable, chemical resistance and light weight. Every one of these materials creep, yet studies have demonstrated that the measure of creep is negligible for reinforced concrete and gives losses of force for Pre-stressed concrete that is similar to the structures with steel tendons.

III. THE DIFFERENT TYPES OF FIBERS

3.1 Glass Fiber :-

Glass Fiber is a composite fiber made up of a plastic matrix reinforced by fine drawn fibers of glass. Fiberglass is a lightweight, strong, and intense material utilized in various industries because of their magnificent properties. In fact, that strength properties are lower than carbon fiber and it is less stiff, however material is regularly far less weak and crude materials are substantially less costly. Nowadays, glass fiber bars are becoming more popular in the construction industries because the cost is less than other kind of FRP materials. Furthermore, the expense of GFRP bars has dropped lately, for the most part because of a bigger market and more prominent challenge. Glass fiber bars have been utilized greatly as a main reinforcement in bridges, parking garages, tunnels, silos, bunker and water tanks. FRP can be realistic to strengthen the RC beams, slabs and columns of RC buildings and RC bridges. Two systems are ordinarily embraced for the strengthening of beams, identifying with the strength increase anticipated and those are flexural strengthening & shear strengthening.

Figure.1 – Glass Fiber Reinforced Polymer Sheet

3.2 Carbon Fiber :-

CFRPs are composite materials. In this situation the composite comprises of two sections: a lattice (matrix) and a reinforcement. In CFRP the reinforcement is carbon fiber, which gives the strength. The matrix is generally a polymer resin, for examples epoxy, to tie the reinforcements together. Because carbon fiber comprises of two different ingredients, the properties of material depends on these two ingredients. Reinforcement gives strength and rigidity for members; measured by the strength and young modulus respectively. In CFRP the reinforcement material is carbon fiber that gives the strength and stiffness and for matrix ordinarily utilized polymer resin like epoxy, which ties the reinforcement in a composed manner. Along these, the CFRP is a mix of extremely thin carbon fibers of 5-10μm in diameter, embedded in polyester resin. At present CFRP is being utilized for structural repair of damage structure due to aging and extreme condition. The purpose of using CFRP is to increase the tensile strength of reinforced concrete structure replacing steel and he concluded that the main benefit of utilizing CFRP as reinforcement is to eliminate corrosion and rusting of reinforcement. The utilization of carbon fiber(CFRP) composite reinforcement gives a forthcoming arrangement like Column wrapping with CFRP composites, is a well known option for increasing the resistance to seismic loads of column sections.

Figure.2 – Carbon Fiber Reinforced Polymer Sheet

3.3 Aramid Fiber :-

Aramid composite fibers is a good-smelling polyamide that is a natural man-made fiber for composite reinforcements. Aramid fibers offer great mechanical property at a less density with the additional favorable position of damage/impact or toughness resistance. They are described as having reasonable high tensile strength, medium youngs modulus and less density than the carbon and glass fiber. The flexural/tensile strength of aramid fibers are higher than glass fibers and the modulus around 50% higher than glass fiber. These fibers improve the impact resistance of composites and provide higher tensile strengths.

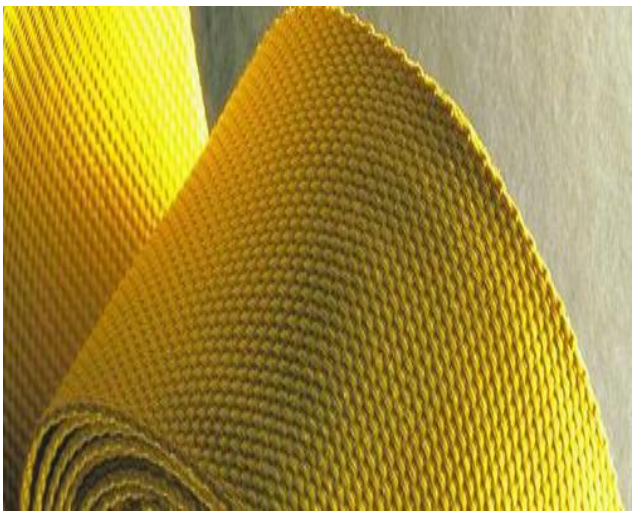

Figure.4– Aramid Fiber Reinforced Polymer Sheet

IV. FIELD APPLICATION OF FRP

4.1 Retrofitting Of Column By Using FRP-

As of late, the repair of un-strengthened and damaged reinforced concrete section by externally bonding of FRP laminates has built up impressive consideration. Utilization of fiber reinforced polymer has expanding prominence in structural retrofitting field due to merits such as lightweight, high load carrying capacity and straight forwardness of use. One of the important appealing uses of FRP is wrapping existing reinforced concrete columns or bridge piers to improve their axial deformation capacity especially at the potential plastic pivot locales and the retrofit of already existing concrete columns by the provision of FRP jackets. Such jackets are normally framed in a wet lay-up procedure, with the fibers being available just or dominatingly in the loop direction. Column is the most defenceless load carrying component of the structure, however because of Minimum cross-section and absence of required steel reinforcement in under designed RC columns results to a weaker RC column construction. The main importance of strengthening the RC column sections with the goal that the formation of hinges(plastic) in the beams.

Figure.5 – Wrapping of CFRP Sheets on Column

4.2 Retrofitting Of RC Beam By Using FRP–

The utilization of FRP composites and reinforcement for reinforcing RC beams can altogether amend the flexural strength, fatigue and the serviceability of the RC beam sections compared to un-reinforced beam sections. Strengthening and retrofitting activity by utilizing manufactured synthetic fibers for example, glass/carbon/aramid is getting to be well known everywhere throughout the world. The mostly utilized strengthening techniques are carbon fiber or glass fiber composite materials for low weight and their high tensile strength. Shear strengthening parametric assessment of strengthened concrete beams retrofitting utilizing two distinctive wrapping systems

utilizing bio technique based woven jute fibers, and artificial carbon fibers and glass fibers, by full wrapping and strip wrapping strategies. Glass fiberreinforced polymers composite sheets are as a rule progressively utilized in commonly high flexural strength-weight ratio, resistance to corrosion and fatigue.

The flexural strength and maximum load capacity of the RC beams improved because of outside strengthening of beams utilizing carbon fiber sheets is observed to be more effective. The dependability for this material application relies upon how well they are fortified and can transfer stress from the RC concrete component to CFRP laminate and the strengthening technique provides an economical, high load capacity and versatile remedy for increasing the service existence of RC (reinforced concrete) structures. Glass fiber reinforced polymer composite laminates are progressively being connected for the restoration and strengthening of infrastructure in conventional repair techniques for example, steel plates holding. Two essential kinds of fiber systems are utilized when the hand blending method is utilized for FRP strengthening which is unidirectional tow sheets and multi-directional woven or fixed textures. FRP bars brought about by their less youngs modulus and less transverse strength and stiffness than the conventional steel bars.

Figure.6 – Retrofitting of RC Beam by GFRP Sheets

4.3 Retrofitting Of RC Slabs By Using FRP-

The restoration and strengthening of basic individuals structural members with composite materials has as of late gotten extraordinary consideration. Decreased material costs, combined with work investment funds inalienable with its lightweight and similarly straightforward simple installation, its high rigidity, less relaxation, and invulnerability to rust, have made FRP an attractive option to conventional retrofitting techniques. One of the alluring utilizations of FRP materials is their utilization as confining devices for solid concrete slabs. CFRP laminate shear reinforcement showed a significant increment in shear strength, malleability, and energy dissipation. The utilization of corrosion consumption free fiber composites(FRP) as reinforcement to concrete is as of now being viewed as a promising option to produce durable concrete structures. In any case, there exists almost no valid data about its field application and execution. Extensive utilization's of the FRP composite materials as new development materials have been as of late cultivated. Different kinds of FRP materials, carbon fiber composites and glass fiber composites are utilized broadly in the structural engineering field.

The utilization of glass fiber composite bars as internal reinforcement is a conceivable solution to corrosion of steel bars. Notwithstanding their noncorrosive properties, GFRP bars have higher strength than steel bars and are light and simple to deal with, which makes them alluring as as reinforcement for certain solid concrete slabs. Fiber reinforced polymer composite bars in development industry as a substitution to steel bars gives a better material which is competent than conquered corrosion issues larger deflections and more extensive crack widths in concrete.The maximum load capacity of glass fiber composites reinforced slabs is boosted, the relating strains, crack width and deflections are diminished by expanding the thickness, grade of concrete, reinforcement ratio of the slabs.

4.4 *Retrofitting Of Beam-Column Joints :=*

Beam-column joint retrofitting is a significant part of increasing the seismic resistance a structure. Constrainment and wrapping of reinforced concrete beam-columns with FRP materials will enable the plastic pivots form in the beam region which will advance an increasingly adequate flexible and energy dissipating failure mechanism during a seismic tremor. Strengthening of columns for the most part brings about better structural performance as far as worldwide conduct since the goal of neighborhood update of a single element is to get better and more ductile worldwide behavior. Full-scale test studies have likewise demonstrated that FRP can altogether strengthen outside beam-column joints with with lack in shear strength.

V. FLOW OF RETROFITTING PROCESS

Retrofitting of structures will continue as pursues:

(1) Know require performance of the already existing structure to be retrofitted and draft a general plan for

assessment through selecting the proper retrofitting methods, complement of retrofitting work and design of retrofitting RC structure.

(2) Investigate the existing structure for retrofitting.
(3) Based on the consequences of the investigation, assess the performance of the structure and check that it satisfies performance requirements or not.
(4) If the structure does not satisfy performance requirements, and whenever proceeded with utilization of the structure through retrofitting is wanted, continue with plan of the retrofitting structure.
(5) Select a proper retrofitting technique and build up the materials to be utilized, structural specifications and construction strategy.
(6) Investigate the structural performance subsequent to retrofitting and confirm that it will satisfy performance requirements.
(7) If it is resolved that the retrofitting structure will be capable of satisfying performance requirements with the chose retrofitting and construction techniques, actualize the retrofitting work.

VI. CONCLUSION

In this paper a comprehension of the properties and exhibitions of fiber reinforced polymer composites(FRP) has been created through the investigation of their various applications for basic retrofitting. Design guidelines and recommendations ought to be made all the more promptly accessible to guarantee increasingly quick and successful utilizations of FRP as a seismic material. This innovative method demonstrates an incredible potential when interruption of traffic or action of the structure is beyond the realm of imagination or just temporarily. In fact, applying fiber reinforced polymers (FRP) layers is exceptionally snappy and does not require particular equipment's (crane, etc). With growing affirmation by the industry over the previous years, have ended up being typically utilized in various kinds of basic retrofitting. The standard correlation features the restrictions of the utilization of fiber reinforced polymers as a large portion of the distinctions in the calculation come from security coefficient related to the adherence of the fiber reinforced plates to the concrete.

More innovative work should be directed tending to issues identified with mechanics, structure, and durability of FRP retrofitted concrete and and steel frameworks toguarantee a legitimate utilization of FRP composites in seismic retrofitting/strengthening applications. An improved comprehension of the structural demeanour of FRP fitted structures alongside with their failure mode, which are regularly brittle in nature through test and numerical re-enactment, is important. Effect of cyclic and fatigue loading on the FRP strengthened member performance must be described and represented in the structural design procedure. Design manuals and codes of practice ought to be refreshed to contemplate these issues. Related personnel ought to be prepared appropriately to ensure an effective seismic application of FRP materials for retrofitting and restoration purpose. Notwithstanding, before applying any seismic retrofit technique to a damaged or inadequate structure, an appropriate and precise evaluation of the seismic exhibition and current condition of the structure is fundamental.

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