Recent Trends in Civil Using Reinforced Fiber Polymer Bars

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Abstract
Corrosion is known to negatively affect the structural integrity of bridges, buildings, and other structures made of concrete. This corrosion damage is both dangerous to the public and expensive to the owner of the structure. This research explores the use of Fiber Reinforcement Polymer (FRP) to improve the structural performance of concrete that has been subjected to corrosion damage. The use of Polymer fibers in the steel improves moment capacity and ductility of the tested steel bars .It is important to first. understand how corrosion damage affects normal reinforced concrete, so that is also investigated To overcome the corrosion problem of steel reinforcement in RC structures, 'Fiber Reinforced Polymer (FRP) rebars' has become a potential solution. Glass Fiber Reinforced Polymer (GFRP) shows, excellent corrosion resistance, very high strength to lower weight ratio, non-conductive/magnetizing nature, etc. However, durability and serviceability of this new material is .still a least understood attribute. Previous nature research shows GFRP possess low immunity in alkaline environment, low modulus of elasticity and has brittle.

Keywords- fibre, reinforcement,corrosion,structure

1 INTRODUCTION

Reinforcement has become the fundamental unit of construction today which is used in numerous ways, some of the larger and better known uses including roadways, bridges, car parks, residential buildings and in industry; for example it is widely used in nuclear power plant. It is in general an excellent construction material . Concrete alone is good in compression, but reinforced concrete greatly increases the scope for making structures required to withstand other form of mechanical forces .In a small percentage of instances reinforced concrete may deteriorate prematurely, but so widespread is the use of the material that problems can be encountered in a wide range of individual applications. It is reliably reported that in North America there are now some 300,000 concrete bridges requiring repairs, with costs estimated in terms of billions of dollars, in addition to the roadways and car parks requiring remedial attention. There are also lesser but significant problems with reinforced concrete in Europe and the Middle East. In India too around 60% of reinforced concrete structures require repair work which is a harm to economy of our country. From a financial aspect the future costs over the next few decades for repairs and replacement throughout the world are likely to be staggeringly high. One is tempted to ask why, if reinforced concrete has been used for so long, is it only now that problems are arising, predominantly, though not exclusively, associated with corrosion of the reinforcing steel bars, or rebars as they are commonly called. Corrosion loss consumes considerable portion of the budget of the country by way of either restoration measures or reconstruction. Moreover, the repair operation themselves are quite complex and require special treatments of the cracked zone, and in most instances the life expectancy of the repair is limited. Accordingly, corrosion monitoring can give more complete information of changing condition of a structure in time. Hence, protection of reinforcement from corrosion will ensures that the structure serves for desired service life. Engineers need better techniques for assessing the condition of the structure when the maintenance or repair is required. These methods need to be able to identify any possible durability problems within structures before they become serious.

2 CORROSION MECHANISM & REASONS

Corrosion is an electrochemical process. In this process oxidation of Iron (Fe + +) molecules naturally occurs immediately after the bars are manufactured and exposed to the atmosphere and will continue long as sufficient oxygen and moisture are available to react with the steel. So corrosion is consists of an anode and cathode process. Following are some reasons of corrosion of reinforcement

2.1 Water Permeability:

Is the single largest factor for ignition and propagation of corrosion. Water not only takes part in chemical reaction but also works as a carrier for transporting harmful chemicals to concrete and rebars such as chloride ions. Higher permeability reduces resistivity of concrete. If the surface of the concrete is subject to longterm wetting, the water will eventually reach the level of the reinforcement, either through diffusion through the porous structure of the concrete, or by traveling along cracks in the concrete. Concrete roof decks, by their nature, are meant to be protected from moisture. However, the presence of moisture on roofing systems may result from failure of the roofing

membrane, poor detailing of drainage facilities, or lack of maintenance of drainage facilities.

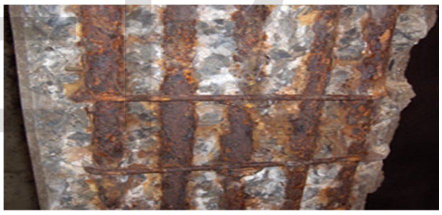
2.2 Oxygen Permeability:
Oxygen is very much an essential part for corrosion to occur; it also plays an important role in setting up corrosion cells. Oxygen permeability produced due to cracks, difference in cover thickness and heterogeneity of concrete.

2.3 Carbonation:
Is the major cause of corrosion. Carbonation of concrete has dual effect or reducing the alkalinity of concrete as well as releasing more water. Effect of carbonation increases with porosity of concrete, period of exposure and reduces with moisture in surrounding area. t is well known that if bright steel is left unprotected in the atmosphere a brown oxide rust quickly forms and will continue to grow until a scale flakes from the surface. This corrosion process will continue unless some external means is provided to prevent it. One method is to surround the steel with an alkaline environment having a pH value within the range 9.5 to 13. At this pH value a passive film forms on the steel that reduces the rate of corrosion to a very low and harmless value. Thus, concrete cover provides chemical as well as physical protection to the steel. Concrete is permeable and allows the slow ingress of the atmosphere; the acidic gases react with the alkalis (usually calcium, sodium and potassium hydroxides), neutralizing them by forming carbonates and sulphates, and at the same time reducing the pH value. If the carbonated front penetrates sufficiently deeply into the concrete to intersect with the concrete reinforcement interface, protection is lost and, since both oxygen and moisture are available, the steel is likely to corrode. The extent of the advance of the carbonation front depends, to a considerable extent, on the porosity and permeability of the concrete and on the conditions of the exposure.

2.4Chloride Ingress:

The best known and most damaging factor leading to corrosion is the chloride ingress (i.e. chloride entrance) most of failures are attributed ti this structures in cold climates where salt is used as deicing agent has reportedly shown distress due to this factor. The chloride ingress can be by diffusion, capillary suction as well as by permeation. Diffusion of chloride ions occurs through slow moments through simple absorption can suck in large amounts of chloride permeation of chloride ions is through cracks in concrete. Chloride ions react with iron compound and create a iron – chloride complex (fecl2) which also react with hydroxides (OH-) and form hydrated iron oxide compounds. Simultaneously oxygen (O2) react with water (H2O) and formed hydroxides. Together, this two reactions form a corrosion cell. At low levels of chloride in the aqueous phase, the rate of corrosion is very small, but higher concentration increases the risks of corrosion.

3 CORROSION IN RCC STRUCTURES



3.1 Remedial Measures

The deterioration of concrete may be due to either corrosion of concrete/ reinforcement steel or formation of expansive chemical compounds such as calcium silicate hydrate (C-SH) or ettringite in aggressive environments. The loss due to corrosion of steel is heavy. To produce the durable concrete and resist the harmful effects of aggressive environment, the concrete should be produced with almost care. The following steps, implemented scientifically will help to produce durable concrete.
By Adopting the rich mix:
Adopting the Best Mix Proportion:
Increasing Depth of Concrete Cover to Reinforcement
Concrete Coating and Sealers
Galvanizing
Fusion Bonded Epoxy Coating (FBEC)
Coating of Re bars

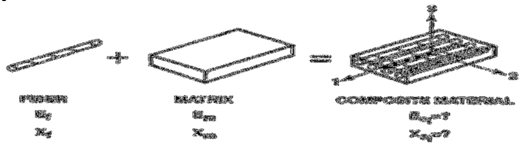
3.2 Fiber Reinforced Polymer Reinforcing bars (FRP)

FRP Bars are intended for use as concrete reinforcing in areas where steel reinforcing has a limited life span due to the effects of corrosion. They are also used in situations where electrical or magnetic transparency is needed. In addition to reinforcing for new concrete construction, FRP bars are used to structurally strengthen existing masonry, concrete or wood members. Corrosion of steel reinforcement in concrete structures causes deterioration of concrete resulting in costly maintenance, repairs and shortening of the service life of structures. Government agencies throughout the world have recognized the potential benefits to society if our infrastructure can last longer and are thus funding significant amounts of research in the field of FRP's. Corrosion of steel reinforcement in RCC makes its use very limited in corrosive environment, and it becomes important to choose such a reinforcing material which is non-corrosive. FRP re bars have demonstrated strong promises in this context. The main advantage of FRP is its excellent corrosion resistance, very high strength to weight ratio, and its non-Magnetizing/conductive nature, etc. FRP has also become more popular because of its diverse varieties available in the market. However for these advanced composite material with above advantages having some limitations also, FRP is a material having low elastic modulus, it shows linear stress vs strain behavior up to failure with no discernible yield point, and hence shows large deflections and wide cracks when loaded, reduced ductility of RCC members causes brittle failure. FRP is typically a two-component composite material consisting of high strength fibres embedded in a polymer matrix

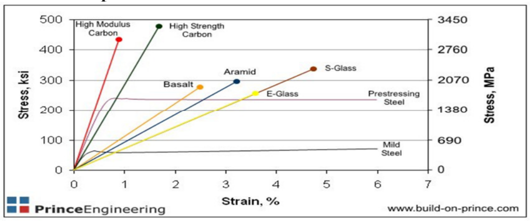
The use of FRP reinforcements for concrete structures depends on their ability to perform reliably under service loads .The mechanical properties, e.g., strength and toughness properties, of the reinforcements are the most important properties if the reinforced structures are used as load-bearing members. It is known that for reinforced concrete structures the presence of FRP reinforcements may have little effect on the initiation of a crack, but they do provide considerable resistance to both propagation and opening of the crack. Cracks generally initiate at the locations where the principal tensile stress (or the strain energy release rate) exceeds the material tensile strength (or the fracture toughness) under service loads. Further propagation of these cracks will depend on the distributions and magnitudes of both principal tensile stress and material fracture resistance. In general, the mechanical performance, failure modes, and loading capacity of a reinforced concrete structure depend on, not only its structural geometry and loading conditions, but also the amount, location, and orientation of the FRP reinforcement used.

3.2 Fiber Reinforced Polymer (FRP) Composites

Definition:Fiber-reinforced plastic (FRP) (also *fiber-reinforced polymer*) is a composite material made of a polymer matrix reinforced with fibers.

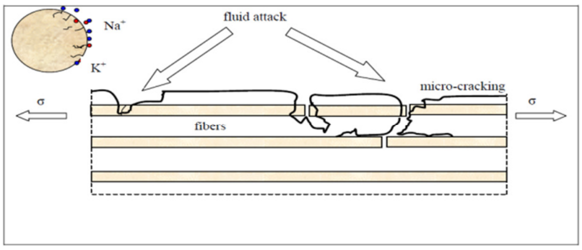


The fibers are usually glass , carbon basalt or aramid although other fibers such as paper or wood or asbestos have been sometimes used. The polymer is usually an epoxy ,vinylester or polyester thermosetting plastic and phenol formaldehyde resins are still in use.In the last decade, there has been a considerable increase in the interest of FRP (Fibre Reinforced Polymers) for concrete reinforcement in the construction industry. The most frequently used fibres for FRP reinforcement are carbon (CFRP), aramid (AFRP) and glass (GFRP). The most obvious benefit of FRP is that, unlike steel it is not susceptible to carbonation- or chloride initiated corrosion in concrete. This fact makes the use of FRP reinforcement an interesting option for increasing the service life of concrete structures in severe environments. However, unlike steel FRP reinforcement may deteriorate due to the alkaline environment of concrete.The following chart shows the stress-strain relationship for various fiber materials in use



3.3 Durability of FRP Reinforcement

FRP rebar is a composite material made up of high strength fibers embedded in a protecting matrix. It possesses very high strength to weight ratio and non-conductive/magnetizing nature. Glass Fiber Reinforced Polymer (GFRP) is an economically viable form of FRP and is being promoted widely as reinforcement for concrete. GFRP rebars are available in the market with high ranges of strength (up to 1500 MPa). FRP rebars are available in different surface texture (i.e. ribbed, sand coated, deformed, etc.) to achieve better bond strength with concrete and are manufactured by pultrusion process GFRP bars can be used in the area like coal and mining industries, tunneling, coastal construction, road construction, corrosive construction, etc. Fibre reinforced polymer (FRP) reinforcing bars offer a potentially attractive alternative to steel reinforcing bars. The former are non-corrosive and generally of a higher strength than their steel counterparts, however, at the expense of no ductility (i.e. no yield point and plastic plateau) and a reduced modulus of elasticity in the case of glass FRP (GFRP) bars. Fibrereinforced polymer bars have most commonly been used in aggressive environments such as coastal environments and water treatments plants instead of steel. Such structures may include dry-docks, sea walls, wharfs, box-culverts, reinforced piles, floating piers, tanks, facades, and retaining walls. Use of FRP bars has been made in Canada in recent years in bridge decks and roads owing to the seasonal use of de-icing salts which causes traditional steel reinforcement to corrode. Some concrete structures may be required to be devoid of metal, like all other engineering materials, FRP reinforcements can also be subjected to mechanical and physical deterioration throughout its life. When FRPs are used as reinforcement within concrete members, they can be expected to be exposed to a variety of potentially harmful physical and chemical environment. Although FRPs are not susceptible to electrochemical corrosion, it can be significantly damaged by other chemical or physical form of degradation if used improperly. The mechanical, physical and bond properties of FRP reinforcement may alter or remain unchanged in a particular combination of chemical and physical exposure condition. Unfortunately durability of FRPs is not a straight forward issue and even might be more complex than corrosion of steel. Durability of FRPs depends on fiber type, resin type and there interface bond behavior. Furthermore, there are a variety of types of FRPs available commercially in the market thus different fibers and resins are characterized by their different behavior in elevated temperatures, environmental exposure and long-term phenomena. Durability of this material is severely affected by highly alkaline environment of concrete (pH=12.4-13.7), moisture and aqueous solutions, elevated temperature, freeze-thaw cycles, ultra-violet (UV) radiation, fatigue and impact loads Lots of research are going on in this context, but reliable design rules are still lacking.



4 CONCLUSION

FRP as a reinforcement demonstrates very strong promises and seems to take the lead over conventional steel reinforcement on the issue of corrosion. But the previous studies indicate some serious limitations of this material which hinder its compatibility with concrete. The main objective of this study is to have a detailed examination of these limitations through an experimental study. This study is aimed to examine the durability and serviceability behavior of the GFRP reinforced concrete beams. The serviceability was measured mainly in two terms, i.e. Deflection and Cracking. The beams were subjected to three different exposures to examine the durability performance of GFRP reinforced beams.

Durability and serviceability of GFRP reinforcement and GFRP reinforced concrete members have been a popular area of research in past few years. However, no consensus has been made reached till date, literature shows conflicting results. The results available in this context are very limited and do not give any clear understanding. All these issues demand for more research in this field in order to examine long term behavior for ensuring safety and comfort to occupants. It should be noted that a highly durable material will not compulsorily show good serviceability and vice-versa are also not true. Hence it is important to study both the aspects and try to investigate compatibility of this material with concrete.

Thus, this study describes an experimental program performed to examine durability and serviceability of GFRP reinforced beams. Primary variables in this study were type of exposures and properties of FRP, six different type of exposures were chosen for GFRP and steel tensile specimens and three types of exposure were chosen for GFRP reinforced beams. On the basis of this, the whole study deals with the serviceability and durability of GFRP reinforced concrete beams.

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