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FIBER REINFORCED PLASTICS (FRP)

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ABSTRACT-*The conventional approach to improve the corrosion resistance of steel rebar is to apply a coating, like epoxy, that provides a physical barrier to the corroding environment. The overall goal of this study is to optimize this new type of fiber reinforced plastic material coated rebars for the construction of RC structures in various applications and thereby reducing construction and maintenance costs and improving structural performance.*

Keywords - epoxy, rebars, RC structures, corroding environment.

INTRODUCTION

Several mechanical properties of reinforcing bars are important for purposes of design, including strength, ductility, and bond. The yield strength and tensile strength of the reinforcing steel are determined from uniaxial tension tests. The reinforcing steel must have sufficient ductility to enable fabrication and to ensure that structures can deform plastically at the ultimate limit state. The maximum plastic deformation of structures is a function of the maximum plastic strain, which is measured between the yield point and tensile strength. Considering the advantages of steel reinforcing bar, replacement of rebar is not the best methods.

It has been long felt need of construction industry to apply some protective coating on construction steels to protect from corrosion. Recently Fusion bond epoxy re-bar has been sighted in the market but viewing some of its drawbacks, we are doubtful about its successful utility and acceptance over prolonged period.

Corrosion loss consumes considerable portion of the budget of the country by way of either restoration measures or reconstruction. There have been a large number of investigations on the problems of consequent corrosion of steel in concrete. Reinforced concrete is a versatile, economical and successful material. It is durable and strong, performing well throughout its service life. Nevertheless, the corrosion of reinforcing steel in concrete is becoming an issue in the collapse of the concrete structures as engineers maintain an aging infrastructure in recent years.

Many new systems and materials have been developed to delay the onset of corrosion and to increase durability. However it has only limited success in delaying the corrosion. In view of economical and engineering points, quantitative assessment of corrosion is also important.

CORROSION MECHANISM IN CONCRETE

Corrosion is a chemical reaction between metal and surroundings during which the metal is oxidized. It is mainly due to carbonation, chloride, acid, and sulphate attack. Following are the two electrochemical reactions that occur during the corrosion of steel (Jones 1996):

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» Anodic Reaction:

$$Fe \rightarrow Fe^{2+} + 2e^-$$

$$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$$

$$4\,Fe(OH)_2 + O_2 \rightarrow 2Fe_2O_3\,(rust) + 4H_2O$$

» Cathodic Reaction:

$$4e^- + 2H_2O + O_2 \rightarrow 4OH^-$$

$Fe(OH)_2$ is a weak base formed during the reaction and is unstable. In the presence of oxygen, another reduction reaction occurs and $Fe(OH)_2$ is converted into $Fe(OH)_3$ or rust, which precipitates out of solution.

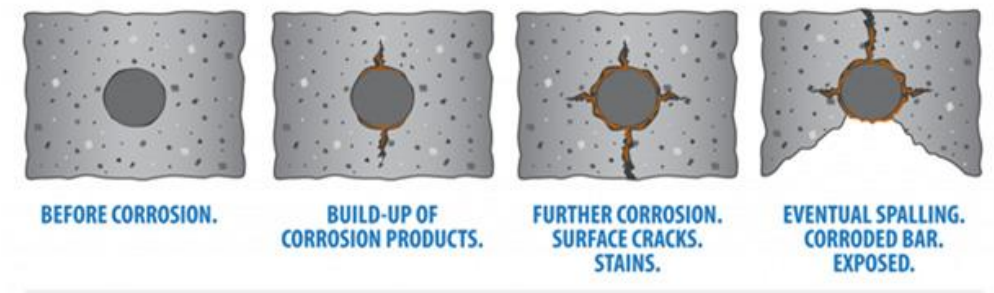


Fig 1.1 Corrosion Mechanism in concrete

Deterioration of concrete due to corrosion is a progressive process. Corrosion byproducts occupy a much larger volume than does the original reinforcing steel. This increase in volume creates high radial pressures and tensile forces in the concrete surrounding the steel and quickly causes cracking. There may be only a few early clues to indicate that corrosion is occurring beneath the surface, such as cracking, staining, or delaminating concrete. As corrosion continues, the concrete cover begins to spall. Structural distress may eventually result owing to the loss of cross-sectional areas of the reinforcement or the loss of bond from continued spalling.

Fig 1.2 Cracking of concrete

Fig 1.3 Spalling of concrete

CORROSION PREVENTION STRATEGIES

Careful attention must be given to the detailing of a structure during design and good construction practices must be followed for the likelihood of corrosion to be minimized. Several details and specifications that enhance corrosion resistance include

» Increased concrete cover.
» Use of low permeability concrete.
» **Coated reinforcing bars.**

- **Polymer-or latex modified concrete.**
- Corrosion inhibitors.
- Limited chloride content of concrete mix ingredients.
- Waterproof membranes.

Each method has its own advantages and disadvantages.

SEQUENCE

The sequences of process that we have followed in our project are.

- ✓ Scope & Objective.
- ✓ Materials & Methodology.
- ✓ Preliminary Tests.
- ✓ Experimental Tests.
- ✓ Results & Conclusion.

GLASS FIBERS

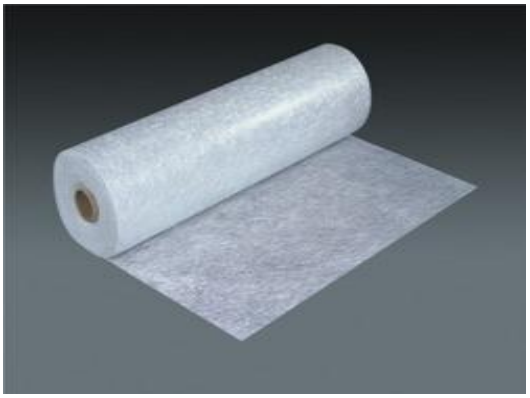
A fiber is material made up of long filament with a diameter generally in the order of 10 μm. The length of glass fiber used ranges from 5cm - 6cm.The aspect ratio of length to diameter can be ranging from thousand to infinity. The peculiar characteristic is their high strength. Glass is mainly made of silicon (SiO_2) with a tetrahedral structure (SiO_4). Some aluminum oxides and other metallic ions are then added in various proportions to either case the working operations or modify some properties.

Material	Density (g/cm^3)	Tensile Modulus E (GPa)	Tensile Strength σ (GPa)	Specific Modulus (E/σ)	Specific Strength	Relative Cost
E-glass	2.54	70	3.45	27	1.35	Low

Properties of E-glass fibers

Glass fiber is also available as thin sheets, called mats. A mat maybe made of both continuous and short fibers randomly arranged and kept together by a chemical bond. The width of this mat ranges from 5cm to 2m. The thickness of CSM is generally 1mm, their density being roughly 0.5 kg/m^2 and young's modulus of 70 GPa. FRP composites based on fiber glass are usually denoted as GFRP.

E-glass chopped strands



E-glass chopped strand mat

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1.6 COATING INSTALLATION PROCESS

There are a few approaches for installing externally bonded FRP systems including either pre-cures or hand layup application. The hand layup method involves saturating the fibre mat with resin, applying the mat to steel bar surface, and then allowing the system to cure in-place. The bonding technique is the manual application of hand layup or wet layup using adhesive bonding. The FRP mat is bonded externally to enhance anti corrosion. The following procedure is followed.

Step #1 surface preparation: The surface of the rebar must be free of scale, oil and grease. The rebar should be dry and properly prepared.

Step #2 Prime the clean surface: The steel bar is protected by brushing on mix isothalic resin and to increase the bonding strength between FRP mat and rebar.

Step #3 Apply the FRP mat: After applying resin, FRP mat as corrosion barrier should be coated. Roll the chopped strand mat (CSM) over the steel rod.

Step #4 Bonding of FRP mat: During application of FRP mat the mix isothalic resin is applied with brush simultaneously. To ensure it bonds effectively and minimize the surface free of pin-holes, air pockets.

Step #5 Finishing: The rebar is left undisturbed to dry for period of 30 to 60 minutes. For best use let it dry for 24 hours.

FRP coated rebars

Side view of coated rebar

STANDARDS USED-

Grade of concrete	: M20
Type of rod	: Turbo Mechanically Treated Steel rod
Type of fibre	: E-glass chopped strand fiber
Type of coating	: E-glass chopped strand mat CSM 350
Mat type	: Continuous filament mat

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Grade of cement	: 53 (OPC)
Size of sand used	: Zone II
Size of aggregate used	: 10mm – 20mm

LITERATURE REVIEW

Vladmir Zivica (April 2003) studied the causes for corrosion on reinforcement are studied where the action carbonation and chloride attack are given preliminary importance.

Ted R. Mortan (December 1973) in this paper talks about fiber glass reinforced plastics used in many applications; from boats to missiles. The article is mainly concerned with the use of fiber glass reinforced plastics for corrosion resistant applications.

Anees U. Malik (March 2001) the paper deals with studies carried out on the corrosion and mechanical behaviour of fusion bonded epoxy (FBE) coating on steel in aqueous media which include product water, distilled water and saline water. The mechanical testing's on coating include adhesion, bending and Cathodic disbondment testing.

Alsayed S.H. (August 2000) studied the role of fiber reinforced plastic (FRP) bars to reinforced concrete structures necessitates the need for either developing a new design code or adopt the current one to account for the engineering characteristics of FRP materials. The paper suggests some modifications to currently used ACI model for computing flexural strength, service load deflection, and the minimum reinforcement needed to avoid rupturing of the tensile reinforcement so as to use them when reinforcement is provided by GFRP bars.

CONCULSION AND FUTUREWORK

The conclusions obtained by investigation carried out in the laboratory were already given in detail at the end of each related chapter. Based on important findings derived from each phase, the following major conclusions can be made regarding the effectiveness of the FRP-coated reinforcing steel bars and glass fiber reinforced concrete.

- Excellent corrosion protection system.
- Extended service life.
- Increase durability of reinforced concrete structures.
- Repair and rehabilitation cost is reduced.
- Easily handled and highly sustainable.
- Increase in flexural strength due to addition of glass fibers.

Based on the test results it is concluded FRP coated application are of great interest for the building industry. This still quite new and needs to be researched further. By our research & experiment, we came to know the usage of Epoxy primer and Zinc primer coated rebar sounds to be an effective method of preventing corrosion and to increase the service life. But in the field once the structure shows any signs of failure the replacement process of these coated bars becomes tedious whereas FRP coated rebar application at the site during repair and rehab process is at ease and its resistance to corrosion also being high it is highly recommendable. Thus the effective means of preventing corrosion in perspective of site usage is by FRP coated rebar application.

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