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# STUDY OF FIBRE REINFORCED CONCRETE

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## ABSTRACT

*The life of concrete structures is reduced due to the effect of corrosion in steel reinforcement when we form the structures using conventional concrete. It also causes high repair costs and can prove to be threat to the structural integrity of the structure itself. Fiber Reinforced Polymer (FRP) offers a number of merits over steel especially when used in salt laden environments. FRP reinforcing bars are slowly finding its wider acceptance as a replacement for conventional steel reinforcement as it offers number of advantages.*

*Technical studies have shown that number of concrete structures (5 to 8 years old) constructed with FRP reinforcement have not been deteriorated from the alkaline environment.*

***Keywords: Brief History, Manufacturing of FRP, Benefits, Difference with Conventional Steel Bars, Resins, Design Standards for FRP***

## I. INTRODUCTION

Reinforced concrete is most commonly used as a building material for the construction of various structures. Though concrete has high compressive strength but it is also weak in tension. To overcome these tensile limitations, reinforcing bars are used in the tension zone of concrete members.

Steel rebar has historically been used as an effective and cost efficient concrete reinforcement. When conventional concrete is not subjected to any salty or chloride ion attack, then steel reinforcement can last for decades without exhibiting any visible sign of degradation.

However, steel rebar is very susceptible to corrosion when exposed to chlorides. Examples of such exposure conditions include construction of concrete structures in coastal areas, aggregates contaminated to salts are used during casting concrete members where invasive chemicals and ground water conditions are present. At low temperature, treating snow with salt is another cause of accelerated worsen of concrete bridge decks, when corrosion of steel rebar occurs, the resulting corrosion products have a volume 2 to 5 times larger than that of the original steel reinforcement. Concrete can't physically retain the high internal tensile stresses developed from this volume increase, hence it may result in cracking and spall of concrete which causing further damage and loss of reinforcement properties ultimately requires potentially significant and high cost repairs and possibly the endangerment of the structure itself.

FRP bars are competitive reinforcing option in reinforced concrete members subjected to flexure and shear. FRP has compelling physical and mechanical properties, corrosion resistance and electromagnetic transparency. The suitable & favourable use of FRP reinforcement is particularly done in case of those structures which operate in aggressive salty environments, such as in coastal regions, or for buildings that host Magnetic Resonance Imaging (MRI) units or other equipment sensitive to electromagnetic fields.

## II. BRIEF HISTORY

Fibre Reinforced Polymers (FRP) have many applications as they have been used for several decades in the aeronautical, aerospace, automotive and other fields. They are being recommended to use in civil engineering works since 1950s when FRP bars were first investigated for structural use. However, FRP bars did not finally considered till 1970s for structural engineering applications. But its superior performance over epoxy coated steel was identified after 1970s. The first applications of FRP were not up to the markdue to its poor performance within thermosetting resins cured at high moulding pressures. Many new FRP materials have come into play with a range of different forms such as bars, fabrics, 2D grids, 3D grids or standard structural shapes.

## III. MANUFACTURING OF FRP

'Pultrusion' is a manufacturing process which is most common technique used for the formation of continuous lengths of FRPbars that are of constant or nearly constant in profile. Continuous strands of reinforcing materials are drawn from roving bobbins. A veil is introduced and they pass through a resin tank, where they are saturated with resins followed by a number wiper rings to remove excess resins. The strands are then led to a pre-former and then formed to their final shape and cured by a heating dye. The speed of pulling through the dye is pre-determined by the curing time needed. The surface of the bars is usually coated with sand to ensure a good bond with concrete, and then these bars are cut to length. The application of sand coating is an additional process, a layer of resin is applied (but not under heated conditions) and then the bar is coated with a thin layer of sand.FRP bars are produced in different diameters analogous to reinforced steel bars, depending on the manufacturing process. The surface of the rods can be spiral, straight, sanded-straight, sanded-braided and deformed. The bond of FRP bar with concrete is equal to or better than the bond of steel reinforcing bars in case of conventional RC concrete.

## IV. RESINS

A very important issue in the manufacture of composites is the selection of the optimum matrix because the physical and thermal properties of the matrix significantly affect the final mechanical properties as well as the manufacturing process. In order to be able to exploit the full strength of the fibres, the matrix should be able to develop a higher ultimate strain than the fibres.

There are two types of polymeric matrices commonly used for the FRP composites thermosetting and thermoplastics. Thermosetting polymers are used more often than thermoplastics. They are low molecular weight liquids with very low viscosity and with their molecules joined together by chemical cross links, hence, they form a rigid three dimensional structure that once set, can't be re-shaped by applying heat or pressure. Thermosetting polymers are polyesters, vinyl esters and epoxies. These materials have good thermal stability and undergo low creep and stress relaxation. The vinyl ester resin pre-dominantly cures during the pultrusion manufacturing process as the bar is drawn through the heated dye. By the time the bar reachesroom temperature, it is considered to be fully cured. Thermosetting polymers have relatively low strain to failure, resulting in low impact strength. Two major demerits are their short life and long manufacturing time.

## V. DESIGN STANDARDS FOR FRP

The three main differences in designing reinforced concrete structures using FRP reinforcement are:

- FRP does not yield in a similar way as steel does
- FRP bars have lower modulus of elasticity than steel
- Further, IS codes do not allow the use of FRP reinforcement in columns due to insufficient research in that area

## VI. BENEFITS OF FRP

The main advantages of using FRP rebar are as follows:

- Corrosion resistance- FRP does not react with salt, chemical products or alkali when bonded in concrete. FRP is not manufactured from steel and hence, it does not rust.
- Superior tensile strength- The tensile strength of FRP rebar is up to twice that of normal structural steel in conventional RC concrete.
- Thermal expansion- FRP rebar offers a level of thermal expansion comparable to that of concrete due to its 80% silica content.
- Electrical and magnetic neutrality- As FRP rebar does not contain any metal, it will not cause interference with strong magnetic fields or when operating sensitive electronic equipments& instruments.
- Thermal insulation- FRP rebar creates a thermal insulation within structures.
- Lightweight- The weight of FRP rebar is about one-fourth the weight of steel bar of equivalent strength. It offers significant economy due to ease in its transportation and installation.

Utilizing these intrinsic advantages, FRP rebar has a cost effective application on concrete reinforcing bars in the following markets on a life-cycle cost basis:

- Reinforced concrete exposed to corrosive environments- car parking structures, bridge decks, parapets, curbs, retaining walls, foundations, roads and slabs.
- Structures built in or close proximity to the sea water- quays, retaining walls, piers, jetties, boat ramps, caissons, decks, piles, bulkheads, floating structures, canals, roads and buildings, offshore platforms, swimming pools.
- Applications subjected to other corrosive agents- waste water treatment plants, petro-chemical plants, pulp/paper mills, liquid gas plants, pipeline/tanks for fossil fuel, cooling towers, chimneys, mining operations of various types, nuclear power plants.
- Applications requiring low electrical conductivity or electromagnetic neutrality- aluminium and copper smelting plants, manholes for electrical and telephone communication equipment, basis for transmission/telecommunication towers, airport control towers, MRI in hospitals, railroad crossing sites and special military structures.
- Mining/tunnelling/boring applications- temporary concrete structures, mining walls, underground rapid transit structures, rock anchors and wash down areas.

- Weight sensitive structures- concrete construction in areas of poor load bearing soil conditions, remote geographic locations, sensitive environmental areas, or active seismic sites posing special issues that necessitate the use of lightweight reinforcement.
- Thermal sensitive applications- apartment patio decks, thermally insulated concrete housing and basements, thermally heated floors and conditioning rooms.

## VII. SUMMARY AND CONCLUSION

FRP play a very prominent role in concrete structural industry if reinforcement in concrete structures exposed to alkaline environmental conditions where traditional steel reinforcement could corrode. The unique physical properties of FRP makes it suitable where conventional steel would be unsuitable. Detailed laboratory studies of samples taken from reinforced concrete structures, aged from five to eight years old, have confirmed that FRP has performed extremely well when exposed to harsh field conditions.

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