rehabilitation of structures through its use as reinforcement in concrete, bridge decks, modular structures, formwork, and external reinforcement for strengthening and seismic upgrade. The applicability of Fiber Reinforced Polymer (FRP) reinforcements to concrete structures as a substitute for steel bars or prestressing tendons has been actively studied in numerous research laboratories and professional organizations around the world.

FRP reinforcements of- fer a number of advantages such as corrosion resistance, non magnetic properties, high tensile strength, lightweight and ease of handling. However, they generally have a linear elastic response in tension up to failure (described as a brittle failure) and a relatively poor transverse or shear resistance.

They also have poor resistance to fire and when exposed to high temperatures. They loose significant strength upon bending, and they are sensitive to stressrupture effects. Moreover, their cost, whether considered per unit weight or on the basis of force carrying capacity, is high in comparison to conventional steel reinforcing bars or prestressing tendons. From a structural engineering viewpoint, the most serious problems with FRP reinforcements are the lack of plastic behavior and the very low shear strength in the transverse direction.

Such characteristics may lead to premature tendon rupture, particularly when combined effects are present, such as at shear cracking planes in reinforced concrete beams where dowel action exists. The dowel action reduces residual tensile and shear resistance in the tendon. Solutions and limitations of use have been offered and continuous improvements are expected in the future.

The unit cost of FRP reinforcements is expected to decrease significantly with increased market share and demand. However, even today, there are applications where FRP reinforcements are cost effective and justifiable. Such cases include the use of bonded FRP sheets or plates in repair and strengthening of concrete structures, and the use of FRP meshes or textiles or fabrics in thin cement products. The cost of repair and rehabilitation of a structure is always, in relative terms, substantially higher than the cost of the initial structure.

Repair generally requires a relatively small vol- ume of repair materials but a relatively high commitment in labor. Moreover the cost of labor in developed countries is so high that the cost of material becomes secondary.

Thus the highest the performance and durability of the repair material is, the more costeffective is the repair. This implies that material cost is not really an issue in repair and that the fact that FRP repair materials are costly is not a constraining drawback.

When considering only energy and material resources it appears, on the surface, the argument for FRP composites in a sustainable built environment is questionable. However, such a conclusion needs to be evaluated in terms of potential advantages present in use of FRP composites related to considerations such as:

* Higher strength
* Lighter weight
* Higher performance
* Longer lasting
* Rehabilitating existing structures and extending their life • Seismic upgrades
* Defense systems
* Space systems
* Ocean environments

In the case of FRP composites, environmental concerns appear to be a barrier to its fea- sibility as a sustainable material especially when considering fossil fuel depletion, air pollution, smog, and acidification associated with its production. In addition, the ability to recycle FRP composites is limited and, unlike steel and timber, structural components cannot be reused to perform a similar function in another structure.

However, evaluat- ing the environmental impact of FRP composites in infrastructure applications, specifi- cally through life cycle analysis, may reveal direct and indirect benefits that are more competitive than conventional materials.

Composite materials have developed greatly since they were first introduced. However, before composite materials can be used as an alternative to conventional materials as part of a sustainable environment a number of needs remain.

• Availability of standardized durability characterization data for FRP composite materials.

• Integration of durability data and methods for service life prediction of structural members utilizing FRP composites.

• Development of methods and techniques for materials selection based on life cycle assessments of structural components and systems.

Ultimately, in order for composites to truly be considered a viable alternative, they must be structurally and economically feasible. Numerous studies regarding the structural feasibility of composite materials are widely available in literature .

However, limited studies are available on the economic and environmental feasibility of these materials from the perspective of a life cycle approach, since short term data is available or only economic costs are considered in the comparison. Additionally, the long term affects of using composite materials needs to be determined.

The byproducts of the production, the sustainability of the constituent materials, and the potential to recycle composite materials needs to be assessed in order to determine of composite materials can be part of a sustainable environment.

Article

Fiber Reinforced Polymer (FRP)

Dr. F Nayeb Morad

Fibre reinforced polymer(FRP), also Fibre reinforced plastic, is a composite material made of a polymer matrix reinforced with fibres.

The fibres are usually glass, carbon, or aramid, although other fibres 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. FRPs are commonly used in the aerospace, automotive, marine,equipments , sports equipment and construction industries.

Composite materials are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct within the finished structure.

Most composites have strong, stiff fibres in a matrix which is weaker and less stiff. The objective is usually to make a component which is strong and stiff, often with a low density. Commercial material commonly has glass or carbon fibres in matrices based on thermosetting polymers, such as epoxy or polyester resins. Sometimes, thermoplastic polymers may be preferred, since they are moldable after initial production.

There are further classes of composite in which the matrix is a metal or a ceramic. For the most part, these are still in a developmental stage, with problems of high manufacturing costs yet to be overcome.

Furthermore, in these composites the reasons for adding the fibres (or, in some cases, particles) are often rather complex; for example, improvements may be sought in creep, wear, fracture toughness, thermal stability, etc .

Fibre reinforced polymer (FRP) are composites used in almost every type of advanced engineering structure, with their usage ranging from aircraft, helicopters and spacecraft through to boats, ships, sports equipment and offshore platforms and to automobiles, sports goods, chemical processing equipment and civil infrastructure such as bridges and buildings.

The usage of FRP composites continues to grow at an impressive rate as these materials are used more in their existing markets and become established in relatively new markets such as biomedical devices and civil structures. A key factor driving the increased applications of composites over the recent years is the development of new advanced forms of FRP materials. This includes developments in high performance resin systems and new styles of reinforcement, such as carbon nanotubes and nanoparticles.

This book provides an uptodate account of the fabrication, mechanical properties, delamination resistance, impact tolerance and applications of 3D FRP composites.

The fibre reinforced polymer composites (FRPs) are increasingly being considered as an enhancement to and substitute for infrastructure components or systems that are constructed of traditional civil engineering materials, namely concrete and steel. FRP composites are lightweight, nocorrosive, exhibit high specific strength and specific stiffness, are easily constructed, and can be tailored to satisfy performance requirements. Due to these advantageous characteristics, FRP composites have been included in new construction and