International Journal of Research in Engineering, Science and Management
Volume 4, Issue 9, September 2021
https://www.ijresm.com | ISSN (Online): 2581-5792

An Analytical Research on the Nature of Glass Fiber Reinforced Plastic Bridge Deck

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***Abstract*: GFRP composite have many benefits over traditional materials when utilized for reinforcing projects have contributed to its popularity. Since the early 1990s, researchers have been testing a range of shear strengthening strategies to improve shear capacity of reinforced concrete beams. Shear is a highland sheep breed. For the repair and rehabilitation of reinforced concrete structures, the technique of attaching steel plates with epoxy adhesives is recognized as an effective and convenient method. Studies have been done to study the characteristics of E-Glass - Epoxy Composite. FEA software, was used to select and assess multicellular bridge deck panels with diverse cross-sectional profiles for IRC Class A wheel load. Multicellular bridge deck panels were preserved at 1250 mm x 333 mm x 150 mm in overall length, width, and depth. Finally, it can be stated that E-Glass fibres reinforced with ISO and ER may be manufactured as symmetric GFRP bridge decks by hand layup.**

***Keywords*: GFRP, Bridge, Deck panel.**

1. Introduction

Bridges are essential components of a nation's infrastructure development, and they are made up of a variety of components including decking slabs, girders, trusses, bearings, abutments, and piers. A bridge deck is a structural component that distributes and transfers live loads to girders and ultimately to the bridge's substructure (El-Hacha, rt al., 2001). The bridge decks are the most badly damaged components, necessitating the most frequent maintenance. Corrosion and consequent deterioration are likely to be the main causes of frequent maintenance. Aside from these considerations, there has been a significant growth in traffic volumes. As a result, the bridges that were built previously are now subjected to high loads (Federal Highway Administration (FHWA et al., 2002).

The magnitude of this phenomena, as well as economic reasons, prompted the development of innovative solutions to prevent steel corrosion. Various strategies were used, including cathodic protection, epoxy-coated bars, and galvanised steel, however the new protective techniques did not totally prevent corrosion (Vistap M et al., 2007). This highlighted the need for high-performance construction materials, prompting researchers to focus their efforts on developing novel materials and technologies.

GFRP stands for Glass Fiber Reinforced Polymer, whereas CFRP is for Carbon Fiber Reinforced Polymer. Fibers have a variety of qualities that make them ideal for various applications. For reinforced concrete constructions such as cast in-place and pre and post-tensioned bridges, precast concrete pipes, columns, beams, and other components, FRP systems are becoming a more popular alternative to steel reinforcement (Benmokrane et al., 2005) Composite. Fiber Reinforced Composite Polymers are made up of long, continuous fibres (such as glass, carbon, and other materials) that are bound together by a resin matrix. Fibers provide composites their distinctive structural features. The resin acts as a bonding agent, preserving the fibres while also dispersing the weight. Polyesters, vinyl esters, and epoxies are the most prevalent types of resins (C.W., et al., 2007)

FRP offers a lot of potential and has a lot of advantages over traditional materials and retrofitting approaches for RC structures. The increased usage of FRP for RC structure retrofitting can be ascribed to their benefits, which include great corrosion resistance and ease of handling and installation (hence substantially reduced working time). However, some constraints limit its widespread usage, including as expensive material costs, a lack of design rules for FRP in many countries, such as India, and a lack of understanding of or unwillingness to accept existing reports, recommendations, and technical publications currently in use around the world (Al-Ghulilani, N et.,2004).

1. Tensile strength is high and tunable
2. Young modulus is high and adjustable
3. Electric and magnetic neutrality
4. High tensile strength
5. Low weight
6. Corrosion resistance
7. High dynamic strength
8. Excellent corrosion resistance

Had Scientific evaluation and simulation results of a syntactic foam/glass-fiber composite sandwich by ENRICO PAPA., et al (2000) - The author experimental and numerical examination of the mechanical behavior of a composite sandwich originally planned for marine engineering purposes is reviewed. The sandwich skins are comprised of glass fiber/polymer matrix composites, with interlaced thread piles that traverse the sandwich core connecting the inner layers. A syntactic foam comprised of hollow glass microspheres embedded in an epoxy matrix makes up the core. Experiments were carried out, as well as numerical finite element (FE) simulations.

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2. Methodology

The appeal of FRP composites as construction materials stems from a set of benefits derived from the material's tailor ability, which is achieved by the synergistic mixing of fibres in a polymeric resin matrix, where the fibre reinforcements can be customized.

E-glass fibres have been used in this study. Composite laminates with five and eight-harness satin weaves are popular, especially in lighter weights that are better suited to many highly stressed designs. Cloths are more difficult to enter and consolidate than random mats due to their tighter fibre structure. WR fabrics are engineered to fulfil the most stringent performance, processing, and cost specification.

A. Chopped Strand Mat (Emulsion)

CSM is made up of 50mm lengths of random yet evenly distributed strands cut from continuous "E" Glass fibres and glued using "Emulsion binder." It has a high level of surface bonding efficiency. These mats are ideal for hand lay-up moldings since they have approximately identical qualities in all directions in the structure's plane.

B. Catalyst

As a catalyst, 50 percent solutions of methyl ethyl ketone peroxide (MEKP) in pithalate plasticizer were chosen.

In the hand lay-up procedure, a liquid resin, usually epoxy, was applied to the final surface of an open mould, coupled with reinforcement. By "hand working," the layers of reinforcement was solidified, and the resin hardens, allowing the part to be withdrawn from the mould. The number of layers and types of reinforcements was determined by mechanical property requirements, surface finish, thickness, and production rate, among other factors.

C. Chalk

Many methods, particularly sheet and bulk moulding compounds, use it as a filler. Its job is to replace a section of the resin matrix. Surface finish is improved by decreasing heat and cure shrinkage. These Fillers are also less expensive than either the resin or the paint.

3. Results and discussion

Table 1
Characteristics of E-Glass Fibre, ISO and ER

Characteristics	E-glass	ISO	Epoxy resin
MOE	71200	3250	5000
Fraction of volume	32.3%	65.6%	65.6%
Poisson's ratio	0.21	0.32	0.31

Materials ingredients (i.e. reinforcing fiber, matrix) and their volume fractions determine the characteristics of GFRP composites. In order to calculate, you can use any of the Based on its characteristics, the composite material has certain material attributes constituents.

Micromechanics:

i. Streamlined composite micromechanics equivalences (Chamis)
ii. Carpeting Plots
iii. Calculations given by Tsai – Hahn

It is possible to use the techniques (1), (2) and (3) for E-Glass - ISO composites, and methods (1), (2) and (3) for E-Glass - ER composites, respectively.

Table 2
E-Glass - Isophthalic Polyester Composite Material Properties

Property	Micromechanics	Simplified composite micromechanics	Carpet plots (WR)	Carpet plots (CSM)
Ex (in GPa)	25.322	25.322	26.70	14.90
Ey (in GPa)	5.022	7.553	7.60	14.80
Gxy (in GPa)	2.33	2.80	3.01	5.30
V_{xy}	0.270	0.290	0.286	0.40
Vyx	0.050	0.080	0.086	0.40

Table 3
Material Properties of the E-Glass - Epoxy Composite

Property	Micromechanics	Simplified composite Micromechanics	Tsai Hahn's Equation
Ex (in GPa)	27.365	27.365	27.365
Ey (in GPa)	7.140	10.730	6.40
Gxy (in GPa)	3.40	4.05	4.30
Vxy	0.280	0.280	0.280
Vyz	0.066	0.110	0.040

Analysis technique:

A span of 600 mm was used for the angle and channel sections, while 900 mm was used for hollow and I section in the test.

At midspans and intermediate spans, reflect meters were used to quantify deflections.

As a result, the supports were tested for zero deflections using the Linear Variable (LVDT).

Loads varying in size and weight were used to measure

Loading was carried out until fracture occurred, and the ultimate load was Failure pattern for the glass fibre reinforced polymer

Table 5
Load for various section

Sample	Ultimate Load (in kN)			
	Section	Hollow	Angle	Channel
I	5.82	8.2	7.4	3.2
II	5.75	8.5	7.6	3.1

Table 6
Flexural strength

Sample	Ultimate Load (in kN)			
	Section	Hollow	Angle	Channel
I	198	278	170	182
II	200	276	178	185

Table 7
Prototype profile

Sample	Profile			
	Section	Hollow	Angle	Channel
Width	170	185	165	182
depth	225	278	300	325
length	5000	5000	5000	5000

Table 10
Analysis for two lane GFRP (E-Glass +ER) bridge deck panels

Width (in m)	**No. of cells**	**Depth (in mm)**	**Deflection (in mm)**	**Maximum Principal stress (in MPa)**	**Maximum shear stress (in MPa)**	**Ultimate load (in N/mm^2)**	**Factor of Safety against Deflection**
1	3	430	5.483	4.5	7.02	30.66	1.2
2	6	320	7.17	4.09	6.1	31.8	1.0
3	9	410	2.92	3.13	5.04	40.2	2.02
4	11	620	1.605	2.15	2.14	82.04	5.2
5	14	700	0.8	1.15	1.07	10.23	10.13

The following observations are based on investigations conducted on various parts made up of GFRP. Flexural members made of GFRP can be employed. Steel is a good example. In comparison to open portions, GFRP members have strong strength in closed sections.

Table 8
Calculated load carrying capacity and ultimate load carrying capacity for all three models for both long edge and short edge supported hinge circumstances

Sample		**FLC capacity**	**ULC capacity**
Flexure	CS1S1	40	192
	WR1R1	40	233
Shear	CS1S2	40	212
	WR1R2	40	142

Table 9
Dimensions of bridge deck panels

Width (in mm)	**Depth of the Panel (in mm)**	**Number of cells**
5000	250, 420	3
2000	450, 500	4,6
3000	420, 750	6,4
1500	500, 800	9, 12

4. Conclusion

A complete report on the static and fatigue behavior of hand-lay-up prototype multicellular GFRP composite bridge deck panels under IRC wheel conditions.

This paper presents a lot of data.

1. Multicellular GFRP composite bridge deck panel preparation.
2. FRP composite materials are characterized.
3. Picking multicellular bridge deck panels with the right cross-sectional profiles
4. Multicellular GFRP composite bridge deck panel preparation
5. Characterization, GFRP member preparation, structural performance and various facts were covered. Only a few studies have attempted to analyse the static and fatigue behaviour of pultruded multicellular FRP composite bridge deck panels, according to a critical evaluation of the literature. ANSYS, a general-purpose FEA software, was used to select and assess multicellular bridge deck panels with diverse cross sectional profiles for IRC Class A wheel load. Multicellular bridge deck panels were preserved at 1250 mm x 333 mm x 150 mm in overall length, width, and depth.

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