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ASSESSMENT OF VIBRATIONAL CHARACTERISTICS IN INTERFACIAL BONDING OF GLASS FIBRE REINFORCED POLYESTER COMPOSITE BEAM

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ABSTRACT

This experimental evaluation presents about the interfacial bonding and its vibrational characteristics which has a significant impact on the stability and stiffness of glass fibre reinforced composites used in real-time structural applications. Glass fiber reinforced polyester (GFRP) cementitious composites were developed in this experimental investigation by varying the glass fiber content (30 wt. %, 45 wt. %, and 60 wt. %) in a randomly oriented direction with polyester resign. The vibrational characteristics considering the interfacial bonding of the composites were tested for tensile and flexural strength, vibrational, and damping factor were investigated. The material's tensile and flexural properties were greatly improved as the glass fibre composition raised, according to the law of mixtures. Natural frequency enhanced as the glass fibre quality in GFRP composites increased. Finally, a substance containing 60% glass fibre was discovered to be an ideal structural part replacement for cementitious composites.

Keyword: Interfacial bonding, FRFcurve, Flexural, Stress-strain curve, modal analysis, contact exciter

I. Introduction

Melt spinning methods are often used to create glass fibres. The glass formulation is melted into some kind of platinum cover with tiny gaps enough for particle concentration to pass through. Continuous fibres could be pulled out of the pores and woven into shafts, whereas short fibres could be made by rotating the head that radially drives molten glass out from the holes. Operating conditions like melting temperature and rotating speed will influence fibre measurements and property to a certain degree. This formulation is ideal for fibre formation since the heat range which could be used to create a melting with suitable viscosity is very high. Because of their inherent anisotropy, the dynamic properties have been more favourable than those of specimens with untreated glass fibres chopped glass-fibre mat and glass woven [0/90°] fabric-reinforcing materials [1] GFRP-based polymer composites have superior properties and strength-to-weight performance, as well as the ability to maximize axial load power at the transitive dependency. The evolution of fatigue damage in glass fiber reinforced polymer (GERP), the fatigue characteristics of composite materials in the longitudinal, transverse and in -plane shear direction [2]. Aircraft architecture is a typical example of compact and rigid structure. Even so, the powerful generators produced subsequent to and after the battle intensified the power mostly on aircraft, necessitating quite complicated cockpit and flank structures. Therefore, the component preference changed to recently designed Super alloys. The most essential factor with in airline sector has always been and continues for being carbon fibre, so the use of synthetic fibre in aeroplane systems is growing.

The natural fiber is characterised as substance that has dual macroscopic objects different stages. Natural fibres are by far the most essential building components. The varying layering sizes and layering sequences on the hybrid composites produced a significant effect on the natural frequency and damping ratio. [3] This would be attributable to the reason that certain substances could be made in fibre material with a significantly high stiffness than those in crystalline forms. The benefits of encasing the fibres in a composite materials are it holds it fixed location, allocates weight capacity, and prevents themselves against road debris. Polyesters and epoxy resin are widely to use as matrix components in structured fibre reinforcement. Planks are used to make fibreglass, but both of the fibres are always in the identical path. Since the fibres are typically both thicker and provide strength and stiffness, a plank is stronger and harder in the fibre orientation, making it anisotropic. Even though the weight is mostly in one direction, a chipboard typically includes layers with various fibre patterns. The explanation seems to be that a chipboard with only a single path of fibres will be quite thin throughout the orientation longitudinal to the fibres, and slight flexure weights caused by irregular longitudinal contracting, may cause the chipboard to break. That phrase composite refers to a substance made up of two or even more metal alloys, with resulting tensile characteristics becoming comparable to the characteristics of the actual fabricated composite material. Glass Fiber Reinforced Polymers (GFRPs) are a type of reinforced concrete polymer that is composed of a plastic matrix and fine glass fibres. On the study examined two commercially available GFRP composite beams with a large price difference, almost 5 times. [4] As compared to other materials, its stiffness and load characteristics seem to be very beneficial, and can be easily processed through combining techniques. Natural fibre composite materials, like linen and hemp, nowadays are competing glass fibre due to their ease of availability and low price. Natural fibres are becoming increasingly popular as the area of application expands, particularly in the automobile sector. A number of researches were conducted in the path. The majority of natural fibre research focuses on the individual reinforcement Material and Method.

II. Materials and method

E-glass fibre, polyester resin with methyl ethyl ketone peroxide-MEKP is an unsaturated isophthalic polyester resin with a curing agent and as a hardening agent, and catalyst cobalt naphthenate were utilized in this research. Table 3 lists the properties of the E-glass fibre and polyester resins used in this study. The polyester resin has been used as a matrix process in this study. As a catalyst, MEKP was being used in a 1.6 percent mixing ratio with polyester. The different steps involved in the hand lay-up technique for fabricating composites. On the mould, glass fibres were uniformly arranged in different material as seen in table 2, and resin was sprayed onto the fibres until the mould was sealed and compressed at 17 MPa. To allow the resin to cure, the setup was left undisturbed for 24 hours at room temperature.

Table 1: Properties of E-glass and polyester resin

Property	**E-glass**	**Polyester resin**
Tensile strength (MPa)	1950	110
Strain to failure %	4.5	2
Elastic Modulus (GPa)	73	3.8
Density (g/cm3)	2.6	2.4
Areal density (g/m2)	2.16	2.1

Table 2: Weight fraction and density of composites

Specimen	**Weight fraction %**		**Density of Composite beam (ρ) kg/cm3**
	Fibre	**Matrix**	
GFRP 1	30	70	1580
GFRP 2	45	55	1720
GFRP 3	60	40	1890

III. Testing of fabricated samples

3.1. Tensile test

Tensile tests were performed on fabricated glass fibre reinforced polymer samples with specifications of 165 mm * 17 mm * 5 mm, with a load applied velocity of 10 mm/min and a device span of 50 mm, according to the ASTM D638 standard. Tensile properties such as tensile and yield strength were determined by experiments with differing fibre and polyester substance. The higher modes of frequencies are more sensitive to cumulative fatigue damage and thus are expected to have better accuracy if used in residual fatigue life prediction. [5]

3.2 Flexural Test

The 3-Point Bend Test was used to determine the flexural quality of the fabricated specimens (PBT). The test was carried out on a UTM with a 3PBT set up in accordance with ASTM D 790 and a load applied speed of 5 mm/min. The specimen length, breadth and thickness used for 3PBT had measurements of 85mm, 16.5mm and 5mm. The fabricated sample's flexural strength and load to fracture (P) were determined by performing tests at three separate locations uniformly. Equation 1 represents the statistical equation for the beam's flexural power (FS).

$$FS = \frac{3Pl}{2bt^2} \qquad (1)$$

3.3 Modal analysis

The procedure of modal analysis is being used to measure and examine the vibration properties of GFRP manufactured samples. The WS-ZHT2 Experiment Set was used to investigate the natural frequency of the fabricated GFRP samples. As seen in Figure 2, the modal research setup includes an accelerometer, touch exciter, frequency analyser, channel charge amplifier, monitor, and fabricated sample. The measurements of the GFRP samples length, breadth and thickness are 215mm, 17mm and 5mm. The exciter receives a 100mA output current from the power amplifier. The Exciter then emits a sweeping frequency of 20Hz to 1000Hz at a set position in order to perform the sample examination. The signals from the accelerometer and exciter were acquired and recorded by a frequency analyzer, which was used to plot the sine wave mode with natural frequency and damping factor using vibration detailed experiment tools.

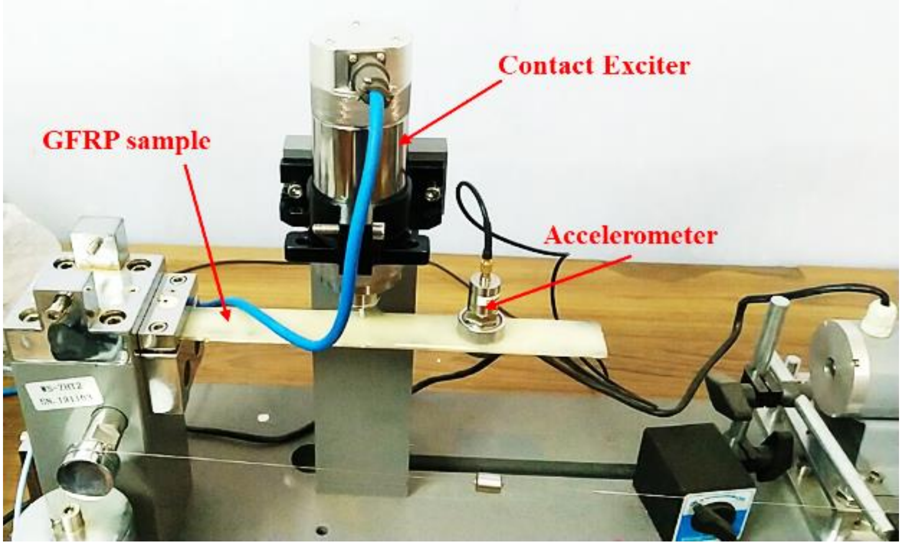

Fig. 1 Experimental Setup

IV. Result and Discussion

4.1 Evaluation of Tensile property

Specimens are subjected to a tensile evaluation. Table 4 demonstrate the impact of glass fibre content on the yield and tensile strength of GFRP samples. It is clear that increasing the glass content resulted in an improvement in tensile strength. A significant growth in the tensile strength of the GFRP specimen are observed from Tensile Stress-strain curve as presented in Figure 2 The maximum tensile strength was observed for 60 wt. percent glass fibre content in the GFRP, which was 155% greater than 30 wt. percent glass fibre content. It is thought to be the explanation for the GFRP composites' superior tensile capacities at higher fibre loading (60 wt. percent). Yield intensity increases by 103 percent after the glass fibre content is raised from 30 wt. percent to 45 wt. percent, but it decreases by 59 percent after the glass fibre content is raised from 45 wt. percent to 60 wt. percent.

Table 3: Tensile properties of specimen

Specimen	Max. Load (kN)	Yield strength	Tensile strength
GFRP-1	4.75	20.32	50.82
GFRP-2	5.29	21.08	56.53
GFRP-3	7.368	12.54	78.83

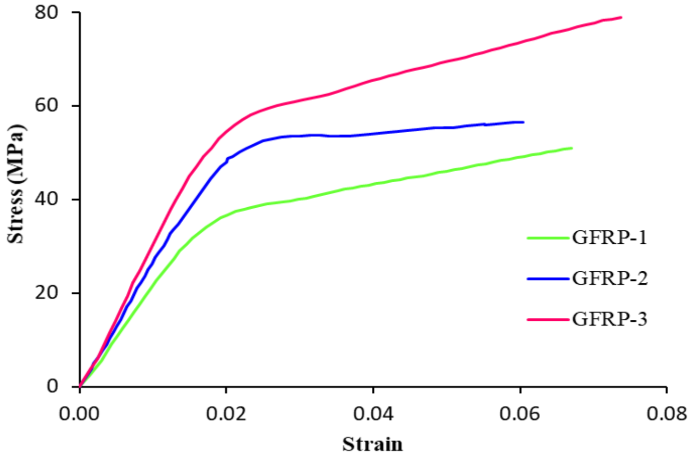

Fig. 2 Stress-Strain relationship of different specimen

4.2 Evaluation of Flexural strength

The flexural properties were evaluated using the load to failure on the stress side of the specimen during 3PBT. Changing the glass fibre material resulted in a significant change in flexural properties. The weight fraction of glass fibre and polyester composite samples determines the degree of flexural resistance. The innermost film of the composite sample is subjected to bending due to the tender of flexural loading, while the outer coat is attributed to compressive conduct. An increase in the weight percent of glass fibre and a decrease in the weight percent of polyester in a composite will cause the sample to absorb both compression and shear, resulting in an increase in flexural strength magnitude. Bending tension is the most common cause of flexural loss in composites under investigation. Table 4 shows the experimental and theoretical flexural power of different GFRP composites at full load. Flexural intensity increases by 109 percent when glass fibre content is increased from 30 to 45 percent, and it increases by 132 percent when glass fibre content is increased from 45 to 60 percent. Figure 3 depicts the maximum load and deflection of the fabricated sample.

Table 4: Flexural properties of specimen

Specimen	Maximum Load (N)	Flexural strength (MPa)
GFRP 1	243.3	83.08
GFRP 2	384.5	90.55
GFRP 3	495.4	119.23

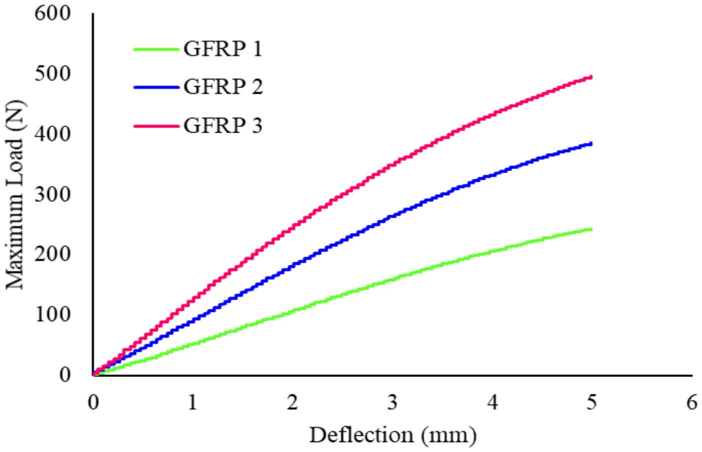

Fig. 3 Flexural strength of different specimen

4.3 Vibration characteristics

The contact Exciter technique was used in this analysis to measure the normal frequency and damping. A touch exciter was used to transfer a sweeping frequency at the free end of the fabricated GRPF samples for this technique. Natural frequency and damping for glass fibre reinforced polyester (GFRP) composites are seen in Table 5. The essential mode shapes of composites specimens will help you choose the right material for your structural needs. The composite specimen's natural frequency was improved by a mix of high glass fibre and low polyester materials. Figure 4 displays the FRF curve of the GFRP-3 sample's vibration characteristics, which has three peaks labelled mode 1, 2, and 3. Figure 4 depicts the GFRP specimen's free vibration response in the time domain, which was used to obtain the natural frequency corresponding with each Mode form as seen in Table 5. It's also worth noting that the GFRP-3 composite sample's Mode 3 yields the highest natural frequency.

Table 5: Natural frequency of specimen

Specimen	**Natural frequency(Hz)**		
	Mode 1	**Mode 2**	**Mode 3**
GFRP-1	35.66	223.47	625.71
GFRP-2	41.87	262.45	734.85
GFRP-3	47.92	300.36	841.02

The stiffness of composite samples is a key factor in determining the normal frequency and damping factor when dynamic loading is applied. These findings suggest that glass fibre reinforced polymer composite hardness is solely influenced by the glass fibres. For various specimen, Mode 2 and Mode 3 followed a common trend in terms of natural frequency. As a result, every higher mode form is largely determined by the structure's fundamental mode shape. The Young's modulus, mass, and area moment of inertia of a structure, rather than the measuring state, determine stiffness. Chemical treatments of fibres, binding agent additions, layering pattern, and fibre quality all influence these parameters in hybrid systems.

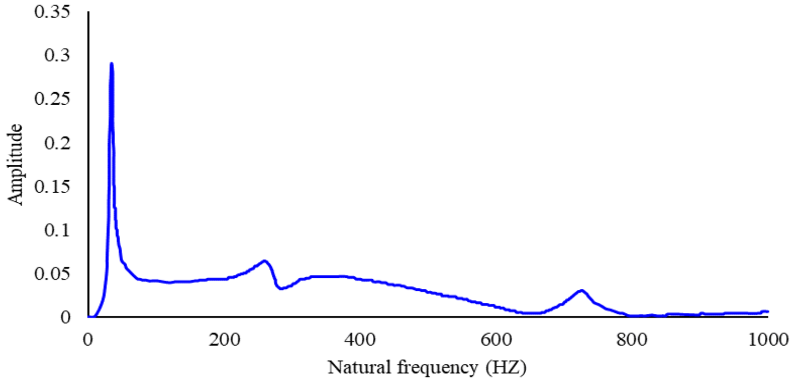

Fig. 4 FRF curve of GFRP-3 specimen

V. Conclusion

GFRP composites were designed using a cost-effective approach then applied to mechanical and dynamic characteristics in order to meet the growing need for providing reliable materials. The following conclusions have been drawn as a result of the analysis:The composite of 60 wt. percent glass fibre content had a maximum increase of 155 percent and a reduction of 59 percent in tensile and yield strength as compared to 30 wt. percent. It may be caused by an increase in the area of increased interfacial bonding among the glass fibre and the epoxy resin, resulting in an increase in accumulated stress transfer. With an increase in glass fibre content, the stress and strain relationship also showed an increasing trend.

The inclusion of 60 wt% glass fibre content with 40% polyester resign resulted in the strongest flexural strength trend. The natural frequency of the GFRP composites increased with increasing fibre packing, and 60 wt. percent GFRP exhibited the highest natural frequency of the composites tested, according to the complex characteristics experimentation. Composites with 60 percent glass fibre content have improved mechanical and elastic properties, making them a viable substitute for cementitious composites in low-strength structural applications.

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