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# Experimental Investigation on Tensile Strength of Natural Fiber Composites with Varying Strain Rate

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## ABSTRACT

*In day to day life, various components are made up of plastics and metals. But these materials create environmental problems. Components made from metals are heavy. Hence, alternative materials for these materials with enhanced desired properties are required. Composites have various desired properties such as strength, stiffness, corrosion resistance, etc. People have started to use natural fiber composites for various applications because of their enhanced properties. In this study, an attempt is made to prepare unidirectional composite material using bamboo as reinforcement and polyester resin as the matrix material.Experimental analysis of bamboo/polyester composite was carried out to study the tensile strength of the composite with varying strain rate. The fabrication of composites was carried out by handlay-uptechnique. The strain rate varies in the range of 0.1 mm/min, 0.5 mm/min, 1 mm/min, 5 mm/min, 10 mm/min, 15 mm/min 20 mm/min. Tensile test of the composite is carried out on the universal testing machine and results were obtained. The paper signifies the outcome as the tensile strength of composites gradually increases with increase in strain rate at higher strain rate 1 mm/min to 20 mm/min. At lower strain rate: 0.1mm/min to 1mm/min, the tensile strength increases gradually from 0.1 mm/min to 0.5 mm/min then gradually decreases from 0.5 mm to 1 mm/min.*

***KEYWORDS***

***Natural Fiber Composites, Fabrication of Composites, Tensile Testing, Strain RateVariation.***

## INTRODUCTION

Combining with two or more constituents different from physical and mechanical properties, of composite materials can obtain a desirable characteristic. Composite materials can provide significant functional and economic benefits, ranging from increased strength and durability features to weight reduction. However, the mechanical responses of natural fiber-reinforced composites are sensitive to the rate at which they are loading. In many applications, under dynamic loading conditions, the response of a structure designed with static properties might be too conservative. The main reason is that mechanical properties of composites vary significantly with changing the strain rate. Unlike metals, which have been studied extensively over a wide range of strain rates, only limited amount of information is available on the effects of strain rate on the response of natural fiber reinforced composites [1].

## LITERATURE REVIEW

The use of natural fibers as reinforcements for composite has to attract more interest of industries. Fibers reinforced polymer composites have many applications as aclass of structural materials because of their ease of fabrication, relatively low cost and superior mechanical properties compared to polymer resins.For example, in the automotive industry, the effort to reduce weight in order to improve fuel economy and to comply with tighter governmental regulations on safety and emission has led to the introduction of increasing amounts of plastics and composites materials in place of the traditionally used steels. Natural fibers have

different origins such as wood, pulp, cotton, bark, bagasse, bamboo, cereal straw, and vegetable (e.g., munja, flax, jute, hemp, sisal, banana, pineapple and ramie). These fibers are mainly made of cellulose, hemicelluloses, lignin and pectin's, with a few extractives. Compared to glass fiber and carbon fibers, natural fibers provide many advantages, such as abundance and low cost, biodegradability, flexibility during processing and less resulting machine wear, minimal health hazards, low density, desirable fiber aspect ratio, and relatively high tensile and flexural modulus[2]. Hence, the natural fiber is selected as a scope of thestudy.

The composite materials with organic matrix found important applications in the shipbuilding industries. New applications of the composites are identified, including their current and potential use in superstructures, platforms and some large military equipment, such as destroyers and aircraft carriers. The mechanical characteristics of these materials are well known for static loading, they are likely to evolve with the strain rate [3].Structural elements reinforced with FRP, however, might be subjected to dynamic loadings, such as wind loads, earthquake loads, explosions, etc. and varying temperature conditions during their service life. Under such conditions, the mechanical properties of FRP involving Young's Modulus, tensile strength, toughness, etc. may suffer great changes [4]. The effect of strain rate on the ultimate tensile strength of glass/polyester composites. They reported the glass/polyester composites to be rate sensitive with the magnitude of the ultimate tensile strength increasing by 55% over the strain rate change [5]. the variation of loading rates the ultimate tensile strength varies but the tensile modulus is mostly unaffected. Furthermore, the strain to failure is also increasing with increase in loading rates[6].High strain rate loading is probably in many of the applications where fiber-reinforced polymer composites find use as candidate materials. It has always been a cause for concern that the mechanical properties of composite materials may be poor at high rates of strain. Hence, thestudy of how the mechanical properties of these composites would change with strain rate is warranted to be able to design structures that would not fail prematurely and unexpectedly at high loading rates[7]. The fracture strain and Young modulus were found to be influenced by changes in the strain rate.Sea mines during detonation can emit underwater shock waves, that can impart severe impact loading to naval ship structures generally made up of glass reinforced polymeric composites. So for the effective use of these materials, their response under different strain rates should be clearly understood[8].The tensile behavior of a polypropylene thermoplastic composite reinforced with woven fabric commingled E-glass was investigated over a strain-rate range of $10^{-4}$ to 70 $s^{-1}$ and it was observed that on increasing the strain rate above 36 $s^{-1}$, the elastic modulus, ultimate strength, and strain to failure of the composite were enhanced significantly [9].The tensile behavior of unidirectional glass fiber/epoxy composites over a wide range of strain rates from $10^{-6}$ to 30 $s^{-1}$ and found that the dynamic strength is three times higher than the static strength and the dynamic modulus is 50% higher than the static modulus[10-11].

Sagar Chokshi etal. (2016) studied the effect of strain rate on tensile strength of natural fibers at higher stain rate starting from 1 mm/min to 20mm/min [12].

Most of the researchers are concentrated on the behavior of the synthetic fiber composites at different strain rate.Even though for comparison purposes some tests are still to be conducted for natural fiber composites.So, here the study is extended of SagarChokshi et al. (2016) by choosing natural fiber composites and including lower strain rate with higher strain rate for study. The range for lower strain rate is in the range of 0.1 mm/min to 1 mm/min and higher strain rate from 5 mm/min to 20 mm/min.Hence,the present study is carried out for the experimental investigation of natural fiber reinforced composites to measure the tensile strength by varying strain rate in the range of 0.1 mm/min, 0.5 mm/min, 1 mm/min, 5 mm/min, 10 mm/min, 15 mm/min and 20 mm/min.

## MATERIALS AND METHOD

The current experimental investigation consists of fabrication of bamboo fiber yarn/polyester composite.MEKP as catalyst and cobalt is used with polyester resin for the initiation of Polymerization process before the fabrication. The bamboo fiber was procured from spinning king India Ltd., Ahmedabad, Gujarat, India as shown in figure 1 and polyester resin was procured from Godadiya enterprise, Surat, Gujarat, India. The bamboo fiber yarn/polyester compositeswas fabricated with 10 layers of bamboo fiber yarns. The

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weight fraction of fiber was achieved as 23% to the weight of the composites. The fibers layers were arranged unidirectionaly to achieve a good strength in one direction as shown in figure 2. The fabrication was done using hand lay-up method. The fabrication steps involve: initially, the resin was poured into the die. Then, one layer of fiber was laid down into the die over resin. Then again resin is poured over the fiber and with the help of roller the resin is spread uniformly among the fibers. Then, one by one all 10 layers were inserted into the die and resin was poured and spread among the die. Then, thepunch is inserted into the die with help of anvil to achieve a thickness of the plate as 4 mm as per the specimen size is required of 4 mm thickness as per the ASTM D3039 standard. Figure 3 shows the die and punch setup used in thefabrication of composites. Figure 4 shows the anvil which is used to press the punch into the die. Figure 5 shows the fabricated plate of bamboo/polyester composites. The achieved size of the fabricated plate is 300 mm * 300 mm * 4 mm.

**Fig 1.bamboo fiber yarn**

**Fig 2. Bamboo fiber layer**

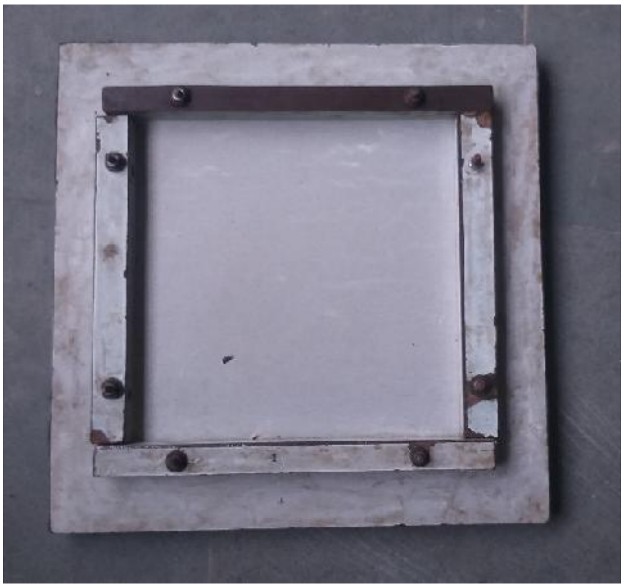

**Fig 3 (a): Die**

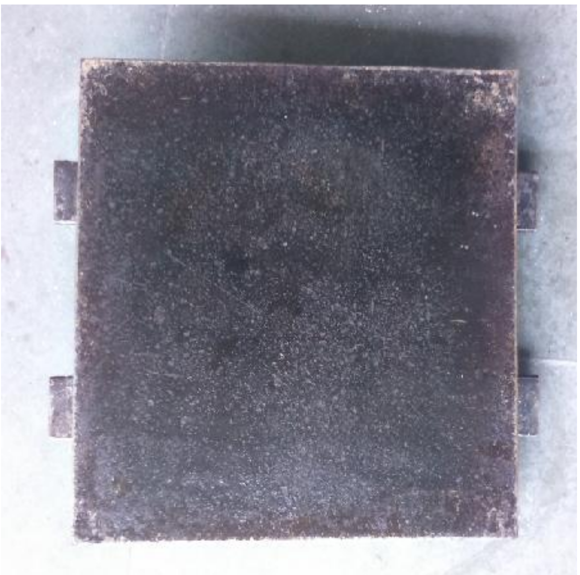

**Fig 3 (b): Punch**

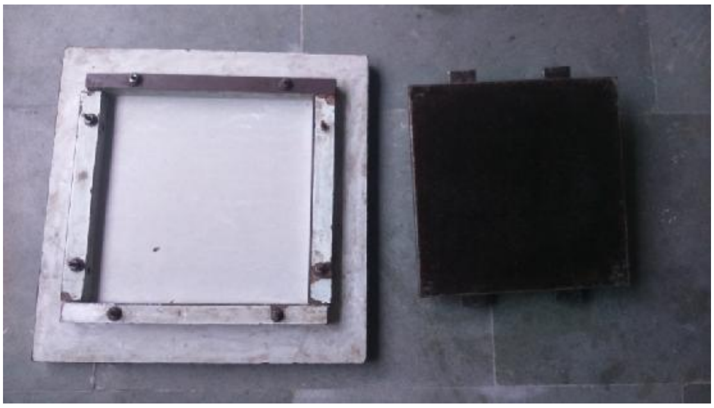

**Fig 3: Die and punch set up for the fabrication of composite plate**

**Fig 4: Anvil**


**Fig 5: Fabricated Bamboo/Polyester Composite Plate**

**TENSILE TEST**

The tensile test was performed on theUniversal testing machine (UTM) as per the ASTM D3039 standard. The size of prepared specimens as per ASTM D3039 was 250 mm * 15 mm* 4 mm. The specimens were cut on CNC vertical machining center.The specimens were tested at room temperature with varying strain rate viz. 0.1, 0.5, 1, 5, 10, 15 and 20 mm/min. The photograph of testing is shown in figure 6. Total 7 samples were selected as a part to investigate the effect of strain rate on tensile strength of composites. Figure 7 and figure8 shows the photographs of thespecimen before testing and after testing. The results of the testing are discussed in below article.

**Fig. 6: Tensile testing setup of UTM.**

Fig 7: specimens before testing

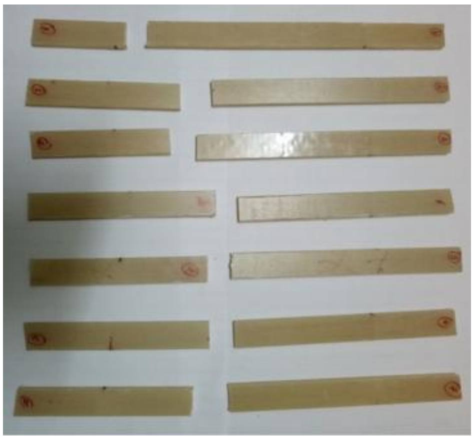

**Fig. 8: specimens after testing**

## RESULT AND DISCUSSION

The results through the testing are shown in table 1.The individual specimen results, obtained from the horizon software which is attached to UTM machine are shown in figure 9-15. The effect of strain rate on tensile strength of composites is graphically represented in figure 16.

**Table 1:Results for tensile strength of bamboo/polyester composites.**

| Sr. No | Strain Rate (mm/min) | Tensile Strength (MPa) |
|---|---|---|
| 1 | 0.1 | 54.9 |
| 2 | 0.5 | 56.9 |
| 3 | 1 | 55.8 |
| 4 | 5 | 58.9 |
| 5 | 10 | 60.8 |
| 6 | 15 | 68.3 |
| 7 | 20 | 69.4 |

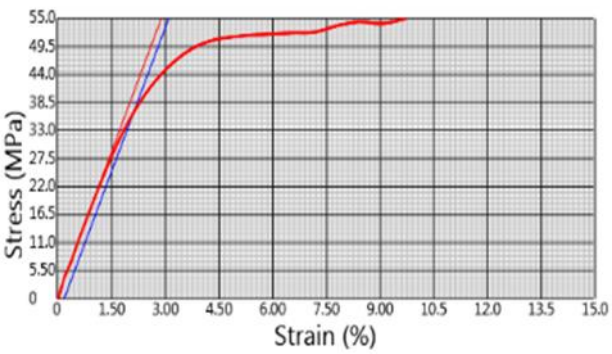


**Fig. 9: stress vs. strain at 0.1 mm/min**

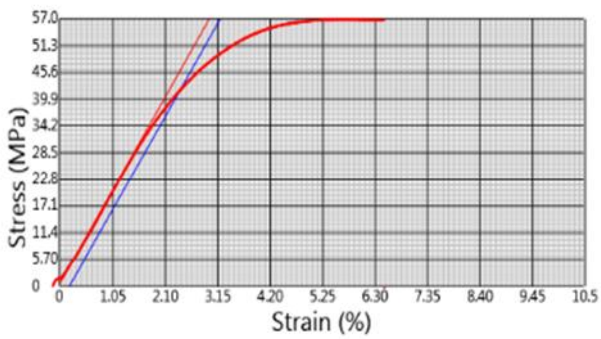


**Fig. 10: stress vs. strain at 0.5 mm/min**

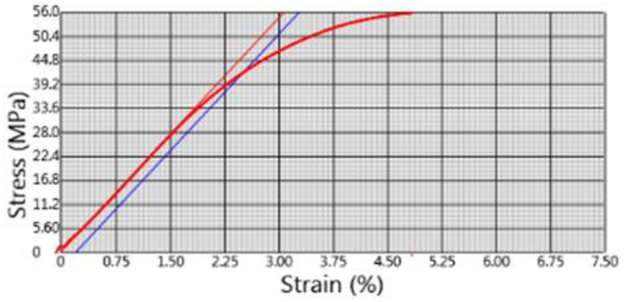


**Fig. 11: stress vs. strain at 1 mm/min**

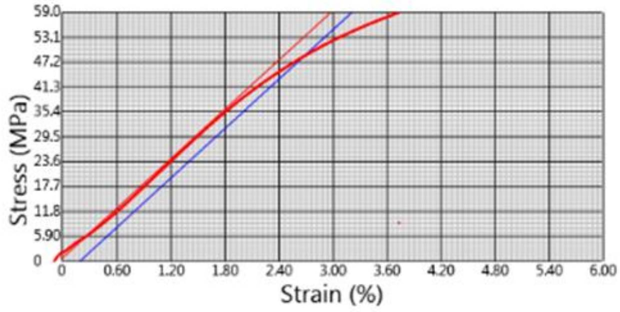


**Fig. 12: stress vs. strain at 5 mm/min**

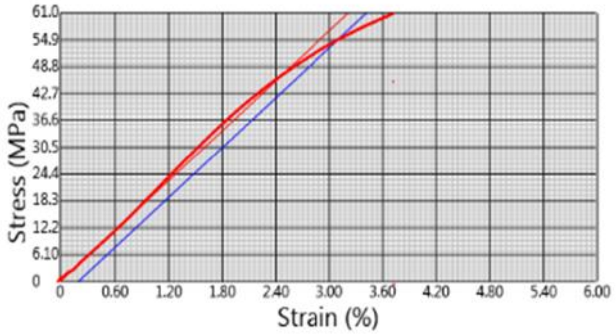


**Fig. 13: stress vs. strain at 10 mm/min**

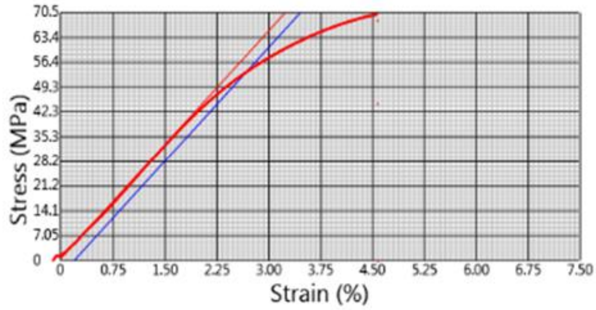


**Fig. 14: stress vs. strain at 15 mm/min**

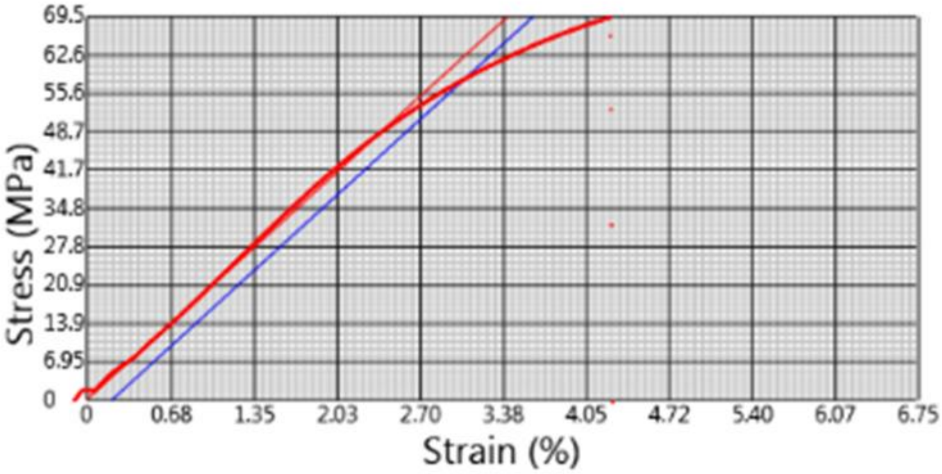


**Fig. 15: stress vs. strain at 20 mm/min**

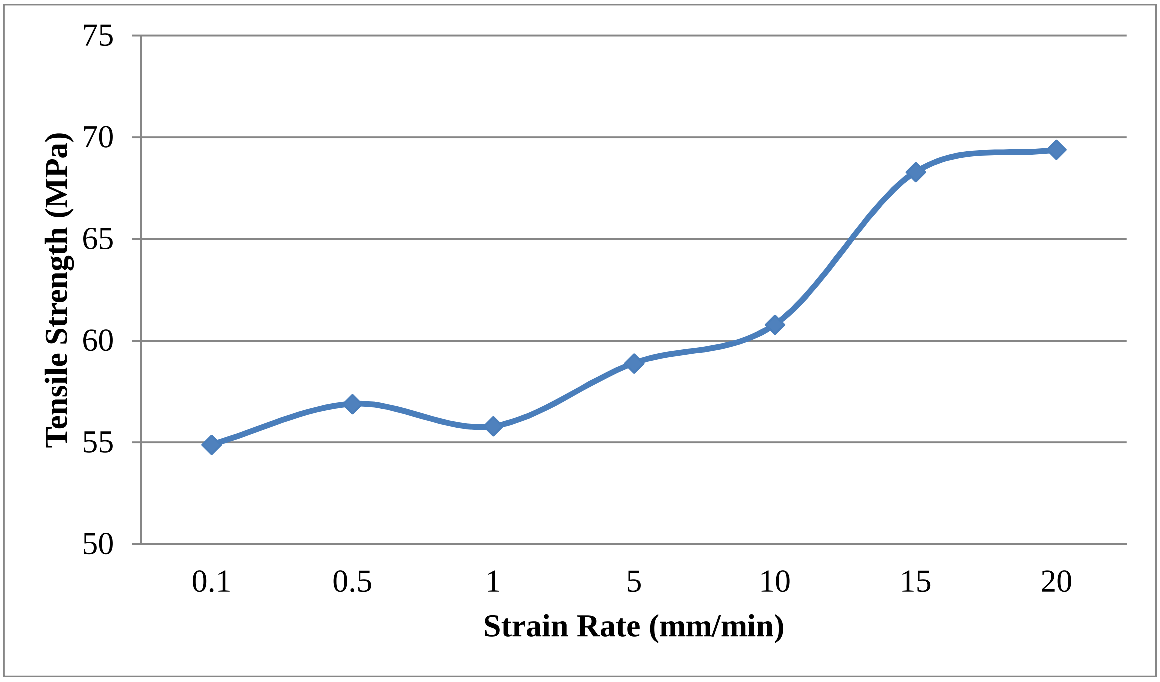


**Fig. 16: Effect of strain rate on tensile strength of bamboo/polyester composites.**

From figure 16, It is observed that initially at lower strain rate: 0.1 mm/min to 1 mm/min, the composite strength gradually increases with increase in strain rate from 0.1 mm/min to 0.5 mm/min and the composite strength gradually decreases with increase in strain rate from 0.5 mm/min to 1 mm/min. It is also observed that at higher strain rate: 1 mm/min to 20 mm/min, the composite strength gradually increases with increase in strain rate from 1 mm/min to 20 mm/min.

## CONCLUSION

The investigation on the effect of tensile properties of bamboo/polyester composites comprises the following conclusions.

- At lower strain rate: 0.1 mm/min to 1 mm/min, the composite strength gradually increases with increase in strain rate from 0.1 mm/min to 0.5 mm/min and the composite strength gradually decreases with increase in strain rate from 0.5 mm/min to 1 mm/min.
- At higher strain rate: 1 mm/min to 20 mm/min, the composite strength gradually increases with increase in strain rate from 1 mm/min to 20 mm/min.

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