iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: X Month of publication: October 2017

DOI: http://doi.org/10.22214/ijraset.2017.10134

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887*
*Volume 5 Issue X, October 2017- Available at www.ijraset.com*

# Effects of Glass Fiber on the Mechanical Properties of Hybrid Bocomposite: A Review

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***Abstract: Application of biocomposites is rapidly increasing in various sectors caused by technical, environmental, and economic advantages. Hybridization with synthetic fibers makes them suitable for structural applications such as automobile, aerospace, and constructional work etc. This article focussed on the effects of glass fiber on mechanical properties of PALF, sisal, OPEFB, hemp, and kenaffibers.Outcomes show that addition of glass fiber in biocomposite material lead to increases the tensile, flexural, and impact properties of NFC's.***
***Keywords: Biocomposite; Glass fiber; Mechanical properties***

## I. INTRODUCTION

Environmental issues related to the use of petro based polymer composites have actuated the development of agro based materials. Moreover, government regulations are forcing the manufacturers to reduce the impact on environment by shifting from petroleum based sources to renewable sources [1,2]. Natural fiber reinforced composite (NFRC) have provide opportunities to manufacturers for recyclable, bio-degradable material having low cost, lessenergy requirement for processing, low tool wear, as well as good acoustic & thermal insulation properties [3,4]. Inspite of their wide variety of advantageous properties, NFRC have many shortcomings such as low strength, low stiffness, low processing temperature, and poor moisture resistance which resultsits applications restricted to upholstery purpose rather than structural work. In order to overcome these shortcomings and to enhance the mechanical properties of NFRC, an optimum solution is to hybridize the natural fiber with glass fiberin polymeric resindue to its high strength & stiffness, dimensional stability, and resistance to corrosion. Hybrid composite provide an opportunity to engineers for achieving a balanced combination of mechanical properties i.e. strength, stiffness, and ductility[6]. The performance of hybrid composite is function of various factors such as nature of fiber, nature of matrix, relative composition of reinforcement, fiber-matrix interface, and arrangement of both the fibers& extent to intermingling. Hybrid laminate of E-glass/Flax was more impact resisted than neat flax composite. It was due to the better stress transfer from matrix to fiber. The hybridization of low strain to failure fiber with high strain to failure results in an increase energy absorption and improved impact resistance [7,8]. Hybridization of oil-palm fiber with glass fiber results an increase thermal stability of oil palm/PF composite [5]. This work gives a review on the effects of glass fiber addition on the mechanical properties of natural fiber reinforced composites.

## II. EFFECT OF GLASS FIBER ON TENSILE PROPERTIES OF NFRC

### A. *Tensile Properties*

Important tensile properties of PALF, hemp, sisal, OPEFB, kenaf, epoxy, polyester and glass are shown in Table 1. It is cleared from table 1 that glass fiber have higher tensile properties compared to natural fibers. Addition of glass fiber in natural fiber composites results the increment in mechanical properties.

| Properties | PALF | Hemp | Sisal | OPEFB | Kenaf | Glass | Epoxy | Polyester |
|---|---|---|---|---|---|---|---|---|
| Tensile Strength (MPa) | 413-1627 | 46.4 | 468-640 | 248 | 284-800 | 2000-3500 | 35-100 | 8-19 |
| Young's Modulus (GPa) | 34.5-82.51 | 7.2 | 9.4-22.0 | 3.2 | 21-60 | 70 | 3-6 | 0.58 |
| Elongation at Break (%) | 1.6 | 1.6 | 3-7 | 25 | 1.6 | 2.5 | 1-6 | 1.6 |

Table 1. Mechanical properties of natural fibers and glass fiber

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*B. Tensile properties of EFB/glass fiber hybrid polyester composite*

Abdul Khalil et al. [9] studied the effect of glass fiber on the tensile properties of EFB fiber polyester composite. Figures 1 and 2 shows the variation of tensile properties of EFB/glass hybrid polyester composites.It was observed that tensile properties of hybrid composite was increased with increasing the total fiber content and glass fiber content in the composite. Among all the hybrid composites, a maximum tensile property was observed at 45 wt% glass fiber content. It may be due to effective stress transfer from matrix to fiber and uniform dispersion of fiber takes place in polyester resin. Beyond 45 wt% of glass fiber, fiber-fiber interaction increases which results poor dispersion.

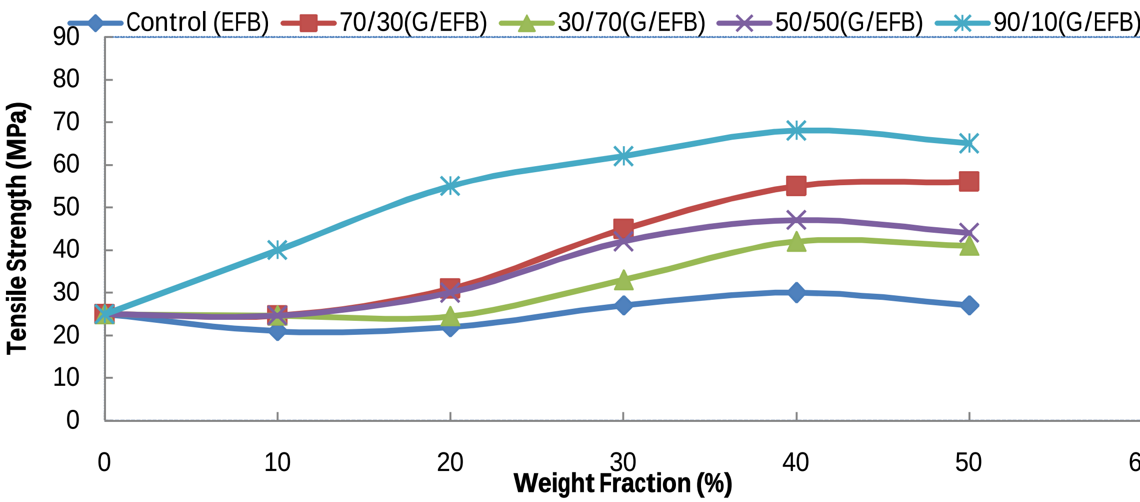


Figure 1.Tensile strength of EFB/glass hybrid composites and EFB polyester composites at different fiber loading.

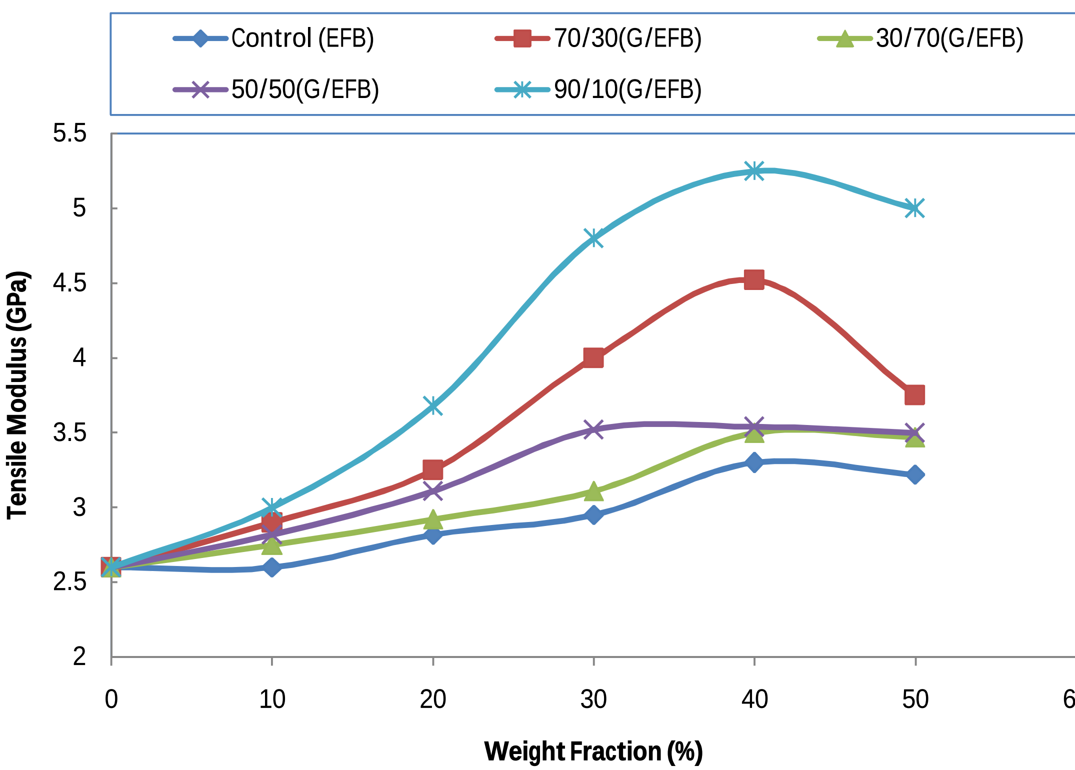


Figure 2.Tensile modulus of EFB/glass hybrid composites and EFB polyester composites at different fiber loading.

### *C. Tensile properties of hemp/glass fiber hybrid composite*

SuharaPanthpulakkal et al. [10] studied the effect of glass fiber content on the tensile properties of hemp/glass fiber hybrid PP composite. Figures 3 and 4 clearly show that as the glass fiber content increased, tensile strength and modulus of hybrid hemp/glassfiber PP composite increases. This is due to the high strength and stiffness of glass fiber compared to hemp fiber. Tensile strength increased by 13% and modulus by 17% with incorporation of 15 wt% glass fiber in hemp/glass hybrid composite.

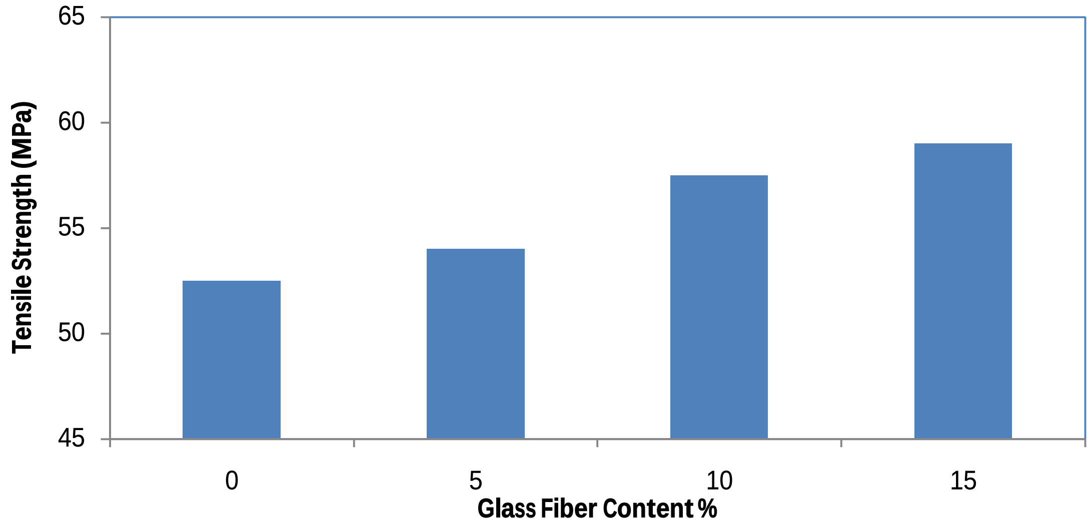


Figure 3.Effect of glass fiber content on the tensile strength of hemp/glass fiber hybrid polypropylene composites.

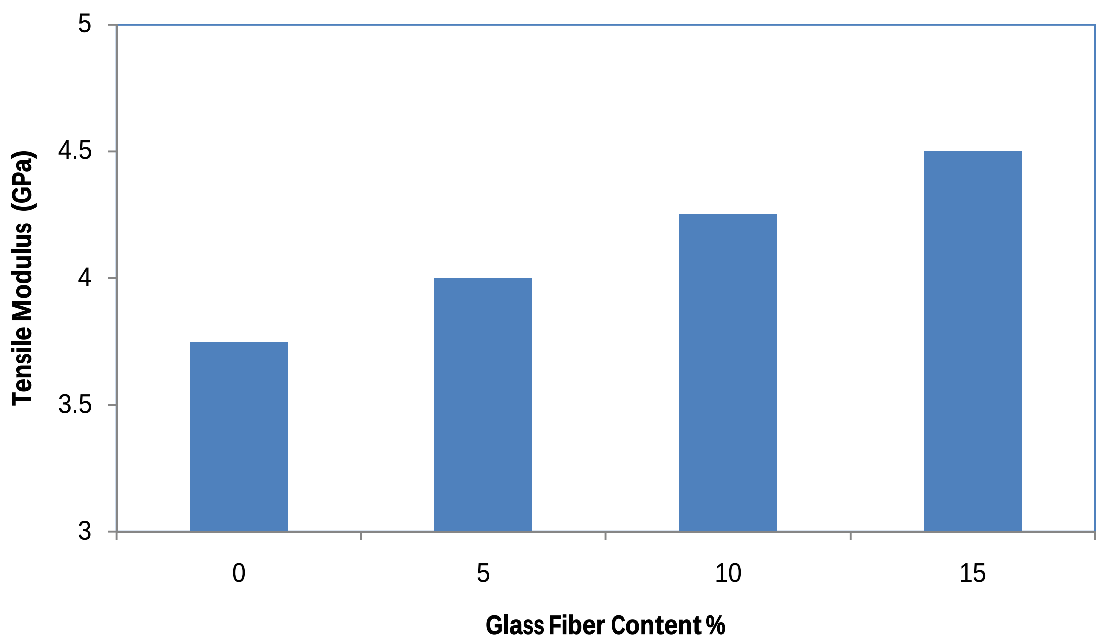


Figure 4.Effect of glass fiber content on the tensile modulus of hemp/glass fiber hybrid polypropylene composites.

### *D. Tensile strength of PALF/glass hybrid polyester composite*

S. Mishra et al. [6] investigate the effect of glass fiber loading on the tensile strength of PALF/glass hybrid polyester composite. Figure 5 shows the variation of tensile strength with glass fiber in PALF/glass hybrid composite. The figure clearly indicates that addition of 8.6 wt% of glass fiberleads to increases the ultimate tensile strength of hybrid composite by about 66% but beyond addition up to 12.9% decreases the tensile strength by 10%.

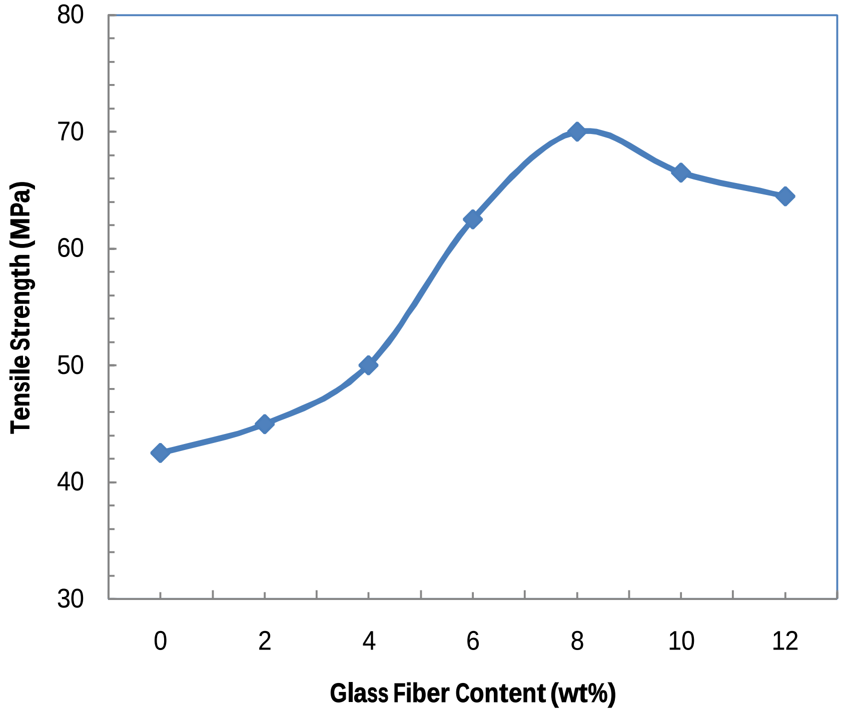


Figure 5. Effect of glass fiber loading on the tensile strength of PALF/glass hybrid polyester composite (total fiber content=25 wt %).

*F. Tensile strength of Sisal/glass hybrid polyester composite*

S. Mishra et al. [6] studied the effect of glass fiber loading on the tensile strength of sisal/glass hybrid polyester composite having 30 wt% of fiber content. Figure 6 shows that tensile strength of hybrid composite increases with glass fiber loading and reached to saturation stage at 5.7 wt% of glass fiber content in sisal/glass hybrid composite. This behaviour is due to the effective stress transfer from high modulus glass fiber to sisal fiber.

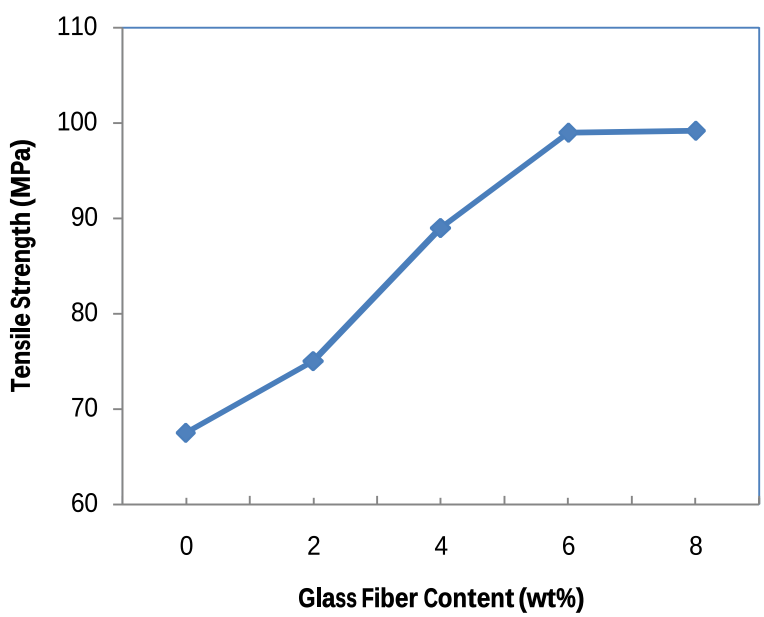


Figure 6. Effect of glass fiber loading on the tensile strength of sisal/glass hybrid polyester composite (total fiber content=30wt %).

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*G. Tensile properties of hemp/glass hybrid unsaturated polyester composite*

AsimShahzad et al. [11] investigate the effect of glass fiber on the mechanical performance of hemp/glass hybrid polyester composite. He found that hybridization of hemp fiber with glass fiber in polyester composite results increment in tensile properties of hemp fiber composite. Table 2 shows the tensile properties of hemp-CSM glass hybrid composite compared to hemp composite. For hemp-skin glass core composite, the tensile strength and modulus is increased by 50% and 15% respectively. While glass skin-hemp core composite, the tensile strength is increased by 75% and tensile modulus is increased by 7%.

| Fiber Configuration | Tensile Strength (MPa) | Tensile Modulus (GPa) | Strain to failure (%) |
|---|---|---|---|
| Hemp Only | 46.4 | 7.2 | 1.03 |
| Hybrid: Hemp skin, glass core | 70.1 | 8.3 | 1.31 |
| Hybrid: Glass skin, hemp core | 81.6 | 7.7 | 1.73 |

Table 2.Comparison of tensile properties of hemp and hemp-CSM glass fiber hybrid composites.

## III. EFFECT OF GLASS FIBER ON FLEXURAL PROPERTIES OF NFRC

*A. Flexural Properties*

In flexural loading, the composites are subjected to tension, compression, and shear stresses. These stresses are mainly carried by glass fiber in hybrid composite which result flexural strength of hybrid composite increases with increasing the glass fiber content. In a three-point flexure test, failure occurs due to bending and shearing.

*B. Flexural properties of EFB/glass hybrid polyester composite*

Abdul Khalil et al. [9] investigate the effect of glass fiber on flexural properties of EFB/glass hybrid composite. Figure 7 and 8 shows the variation of flexural strength and modulus of EFB/glass hybrid composite according to wt% of total fiber content and glass fiber content. It was observed that the flexural properties increase as the glass fiber loading increases up to 35 wt%. At higher loading (>35 wt %) flexural properties decreases due to poor dispersion of fiber in polyester resin and fiber-fiber interaction increases.

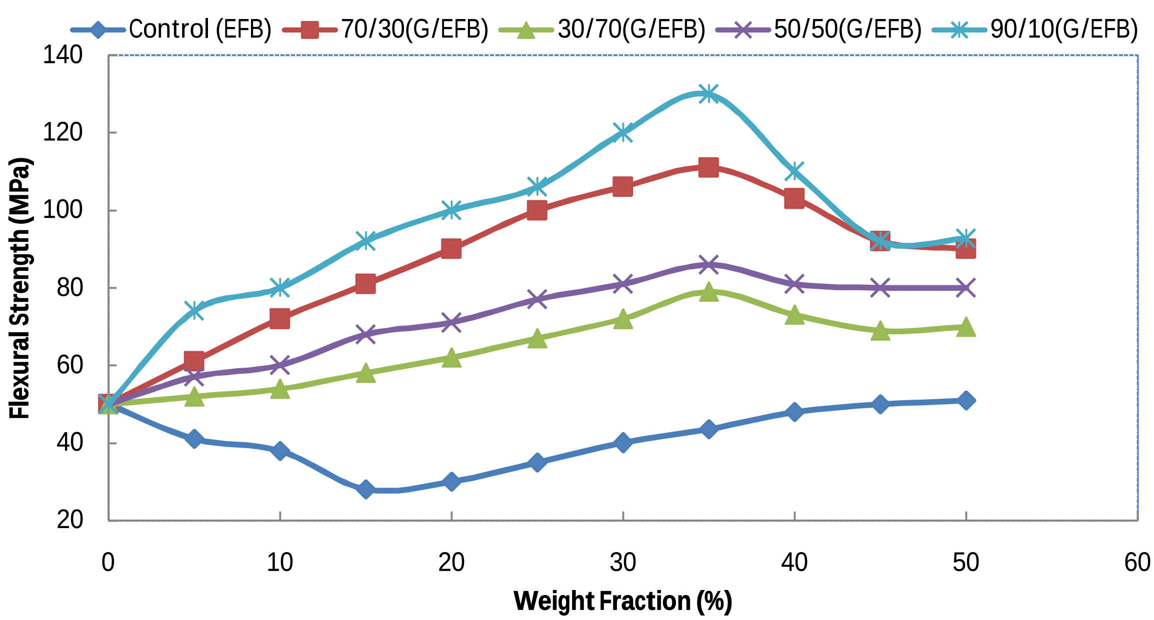


Figure 7.Flexural strength of EFB/glass hybrid composites and EFB polyester composites at different fibers loading.

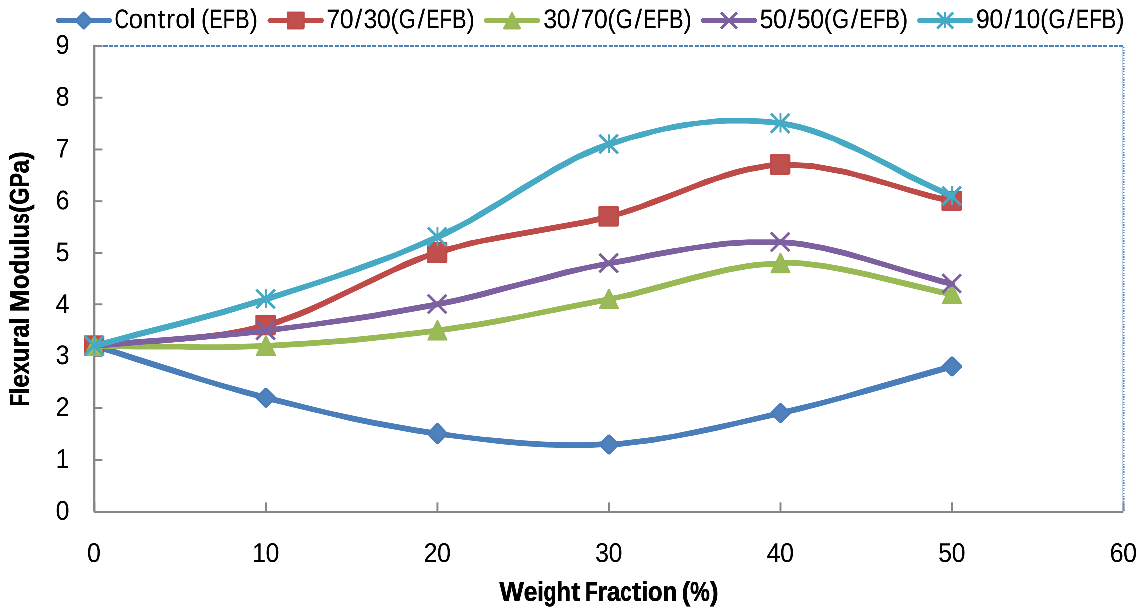


Figure 7.Flexural modulus of EFB/glass hybrid composites and EFB polyester composites at different fibers loading.

*C. Flexural properties of hemp/glass fiber hybrid composite*

SuharaPanthpulakkal et al. [10] studied the effect of glass fiber on the flexural strength and modulus of hemp/glass hybrid composite is shown in figures 8 and 9. He was observed that increasing the glass fiber content from 0 to 15 wt%, increased the flexural strength from 97.5 to 101 MPa, and modulus from 4.5 to 5.4 GPa.

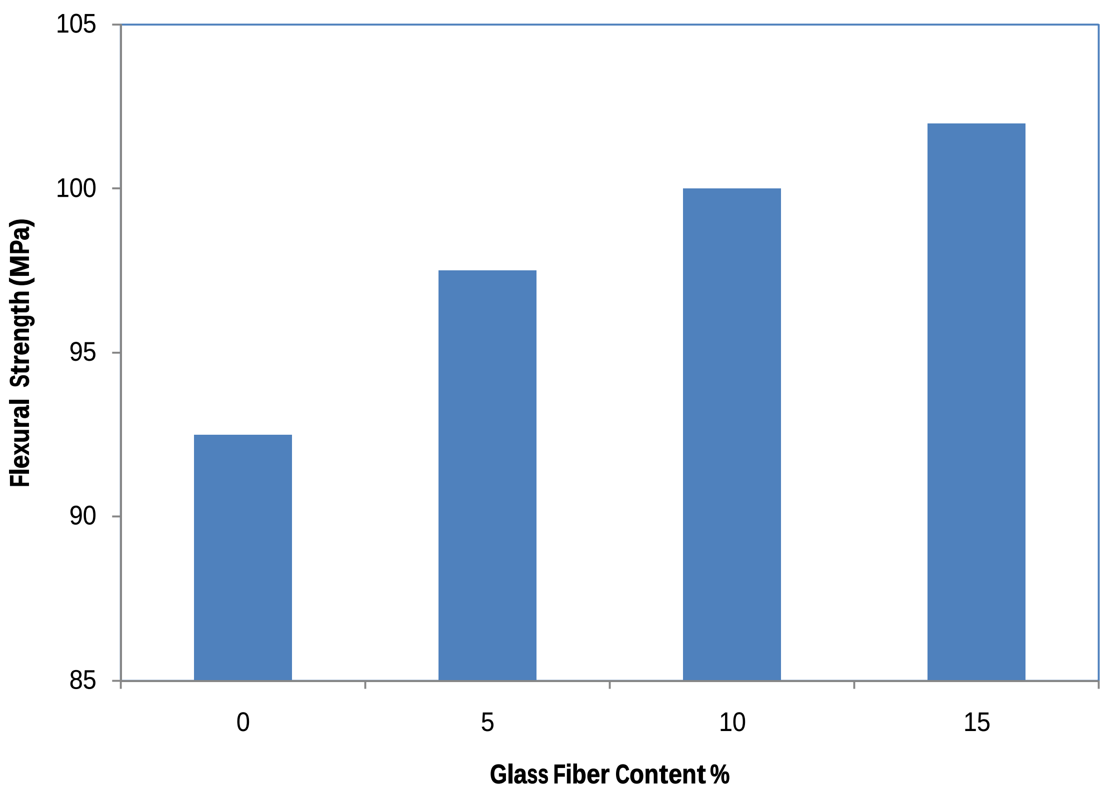


Figure 8.Effect of glass fiber content on the flexural strength of hemp/glass hybrid polypropylene composites.

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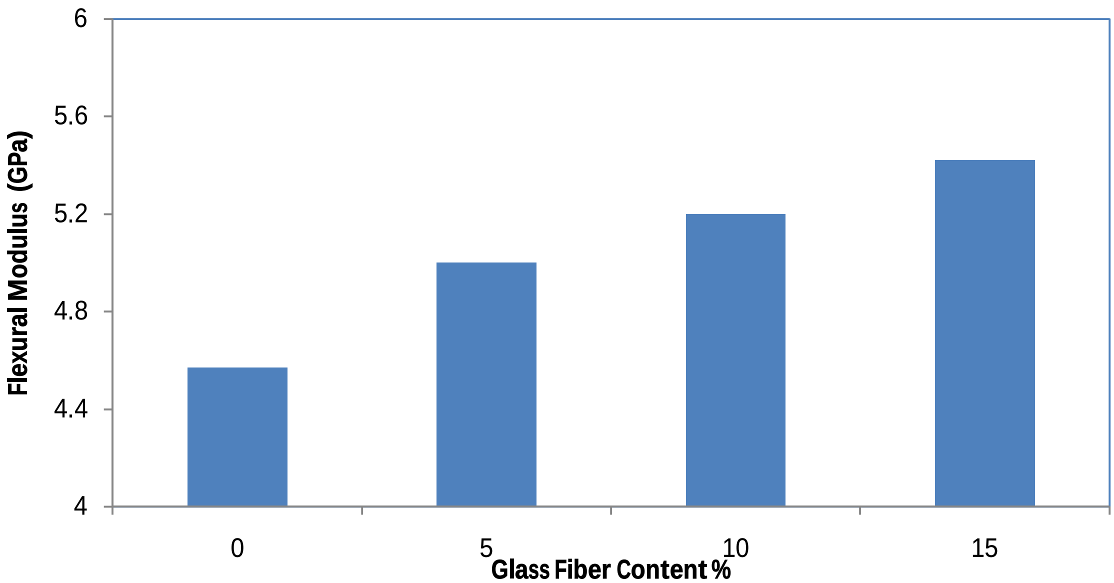


Figure 9.Effect of glass fiber content on the flexural modulus of hemp/glass hybrid polypropylene composites.

*D. Flexural strength of PALF/glass hybrid polyester composite*

S. Mishra et al. [6] investigate the effect of glass fiber loading on the flexural strength of PALF/glass hybrid composite is shown in figure 10. It was observed that addition of 12.9wt% of glass fiber, the flexural strength of hybrid composite increases from 68.29 to 101.25 MPa.

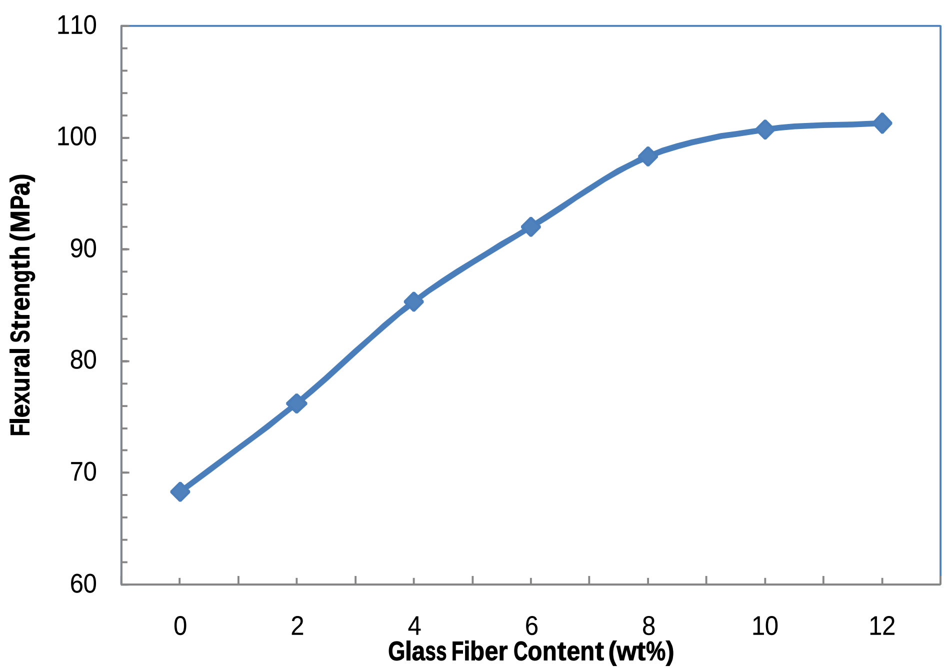


Figure 10. Effect of glass fiber loading on the flexural strength of PALF/glass hybrid polyester composite (total fiber content=25 wt %).

*E. Flexural strength of Sisal/glass hybrid polyester composite*

S. Mishra et al. [6] studied the effect of glass fiber loading on the flexural strength of sisal/glass hybrid composite is shown in figure 11. The flexural strength of sisal/glass hybrid composite was increased with the small wt% of glass fiber (2.8 wt%) by about 25 %.

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Further addition of glass fiber increases the flexural strength as compared to sisal-polyester composite which saturate at 5.7 wt% of GF content.

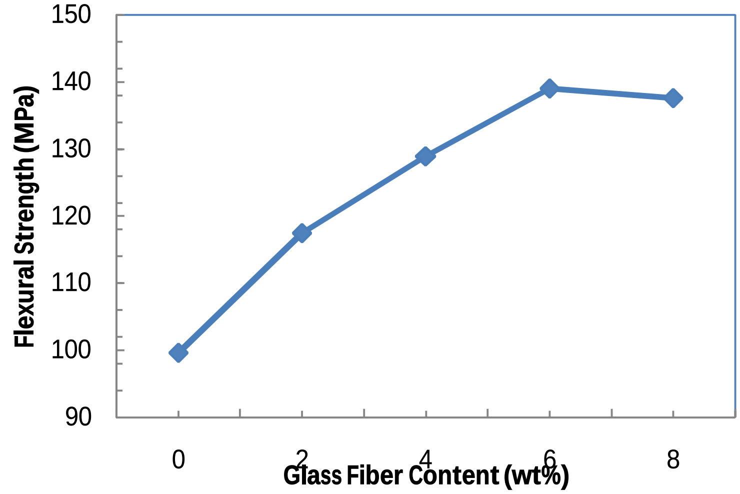


Figure 11. Effect of glass fiber loading on the flexural strength of sisal/glass hybrid polyester composite (total fiber content=30 wt %).

## IV. EFFECT OF GLASS FIBER ON IMPACT STRENGTH OF NFRC

### A. *Impact Strength*

Impact strength of a material is related to toughness of material and it is the ability of material to resist fracture failure under stress applied at high speed. Work of fracture of composite is greatly influenced by interlaminar and interfacial strength. The impact energy is dissipated by fiber and/or matrix fracture, fiberdebonding and pulls out. Ifthe applied load on a composite exceeds the interfacial bond strength, fiber-matrix debondingresults which lead to ultimate failure of composite [12-14].

### B. *Impact strength of EFB/glass hybrid polyester composite*

Abdul Khalil et al. [9] studied the effect of glass fiber content on the impact strength of hybrid EFB composite is shown in figure 12. It was observed that fracture resistance of composite under impact load was increased with an increase in the fiber content of composite up to 35 wt%. At higher loading (>35 wt%), inter fiber interaction increases which result decrease the effective stress transfer from matrix to fiber. It was found from the figure 12 that incorporation of glass fiber in EFB/polyester composite results to increment in impact strength. Maximum impact strength was achieved at (90:10, glass:EFB) high loading of glass fiber.

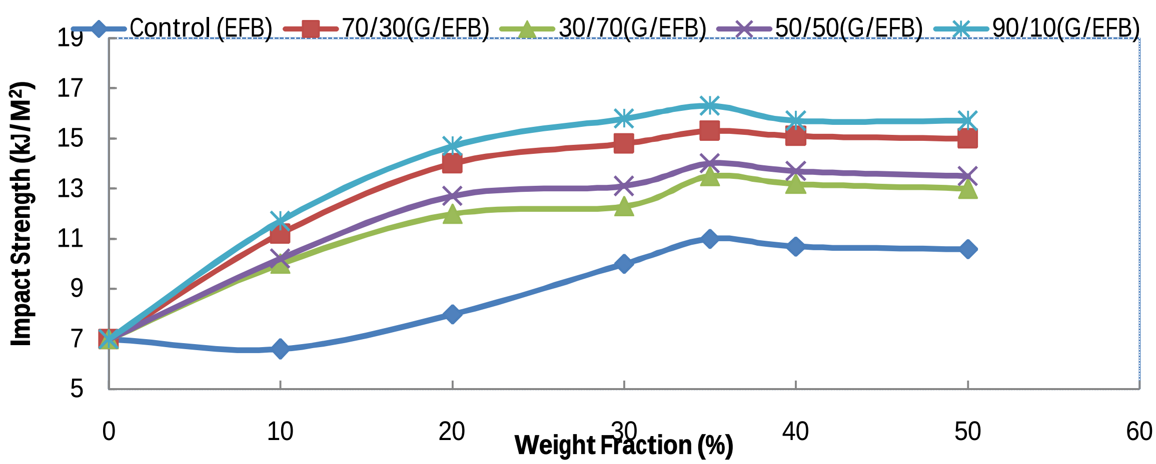


Figure 12.Impact strength of EFB/glass hybrid composites and EFB polyester composites at different fibers loading.

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*C. Impact strength of hemp/glass fiber hybrid composite*

SuharaPanthpulakkal et al. [10] studied the effect of glass fiber addition on the impact strength of hemp/glass hybridcomposite is shown in figure 13. Impact strength of hybrid composite was increased by 35% with the addition of glass fiber (15 wt %) and this may be attributed to high fracture resistance offered by glass fiber in hemp/polypropylene composite.

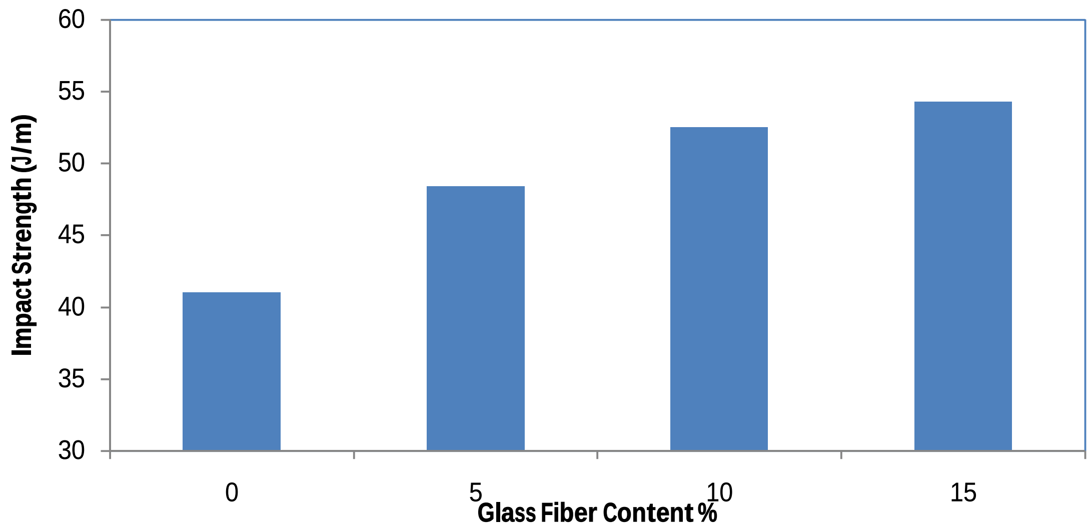


Figure 13.Effect of glass fiber content on the impact strength of hemp/glass hybrid polypropylene composites.

*D. Impact strength of PALF/glass hybrid polyester composite*

S. Mishra et al. [6] investigate the effect of glass fiber loading on the impact strength of PALF/glass hybrid composite is shown in figure 14. Work of fracture increase with the glass fiber loading and increases by 87% with the 8.6 wt% glass fiber content in hybrid composite. With further glass fiber loading, there is no significant increase in impact strength.

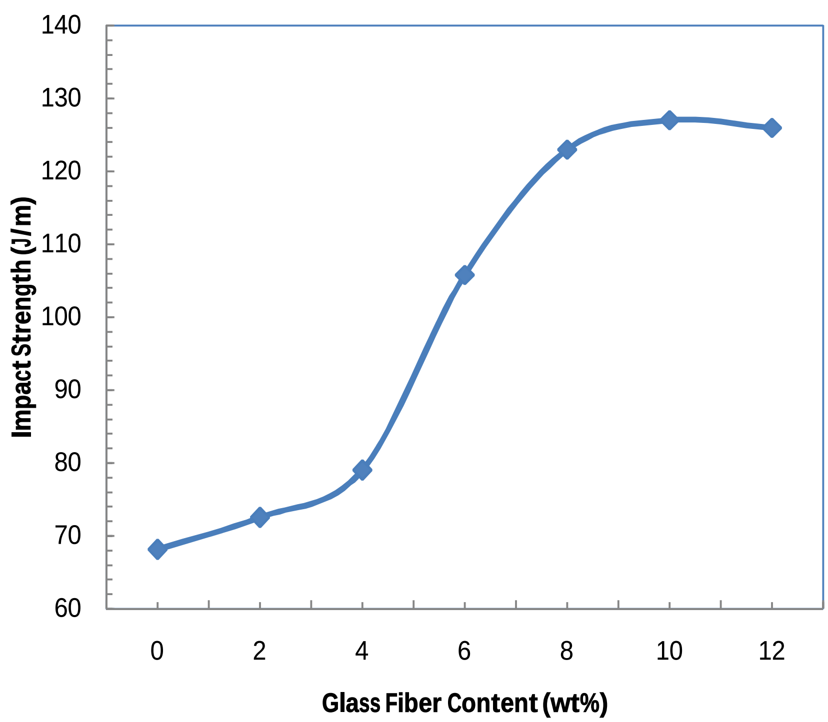


Figure 14. Effect of glass fiber loading on the impact strength of PALF/glass hybrid polyester composite (total fiber content=25 wt %).

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*F. Impact strength of Sisal/glass hybrid polyester composite*

S. Mishra et al. [6] investigates the effect of glass fiber loading on the impact strength of sisal/glass hybrid composite is shown in figure 15. Impact strength of sisal/glass hybrid composite was increased by 34% with the loading of glass fiber from 0 to 8.5 wt%.

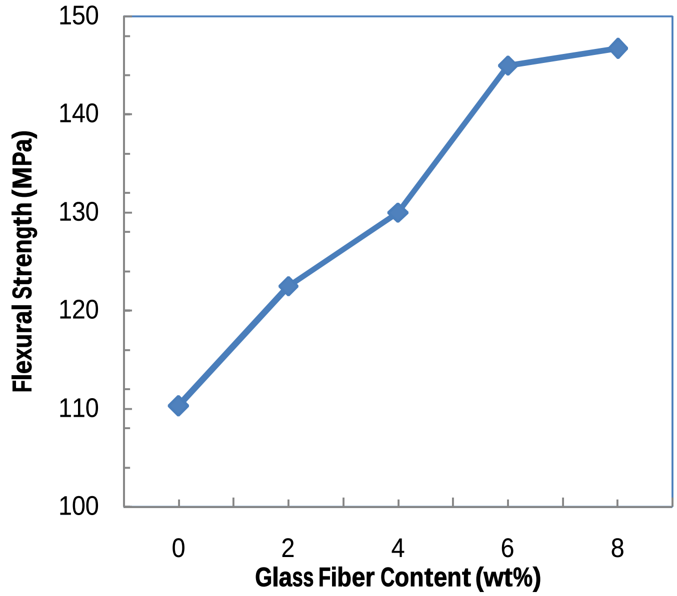


Figure 15. Effect of glass fiber loading on the impact strength of sisal/glass hybrid polyester composite (total fiber content=30 wt %).

## V. CONCLUSIONS

This paper presents the effects of glass fiber content on the mechanical properties of hybrid biocomposites. The conclusions from this study are summarized as follows:

Hybridization of EFB fiber with glass fiber in polyester matrix has resulted in the improvement of tensile, flexural, and impact strength of the composites. Composites showed the highest impact and flexural properties at 35 wt% of glass fiber loading but tensile strength was increased up to 45 wt% of glass fiber content. Mechanical properties of composite were increased with addition of EFB and glass fiber.This is due to the effective stress transfer from matrix to fiber and better dispersion of fiber.Incorporation of glass fiber in hemp-polypropylene composite leads to enhance the mechanical properties of composite. Tensile strength and modulus increased by 13 and 17% respectively with the addition of 15 wt% glass fiber. Work of fracture and flexural strength of biocomposite is alsoincreased with the optimum loading (15 wt%) of glass fiber. This is due to the high fracture and shearing .Mechanical properties of PALF/glass and sisal/glass hybrid polyester composites showing positive hybrid effect with small amount of glass fiber loading. Optimum glass fiber content in PALF/glass hybrid polyester and sisal/glass polyester composites are 8.6 and 5.7 wt% respectively under which significant improvement in mechanical properties takes place.

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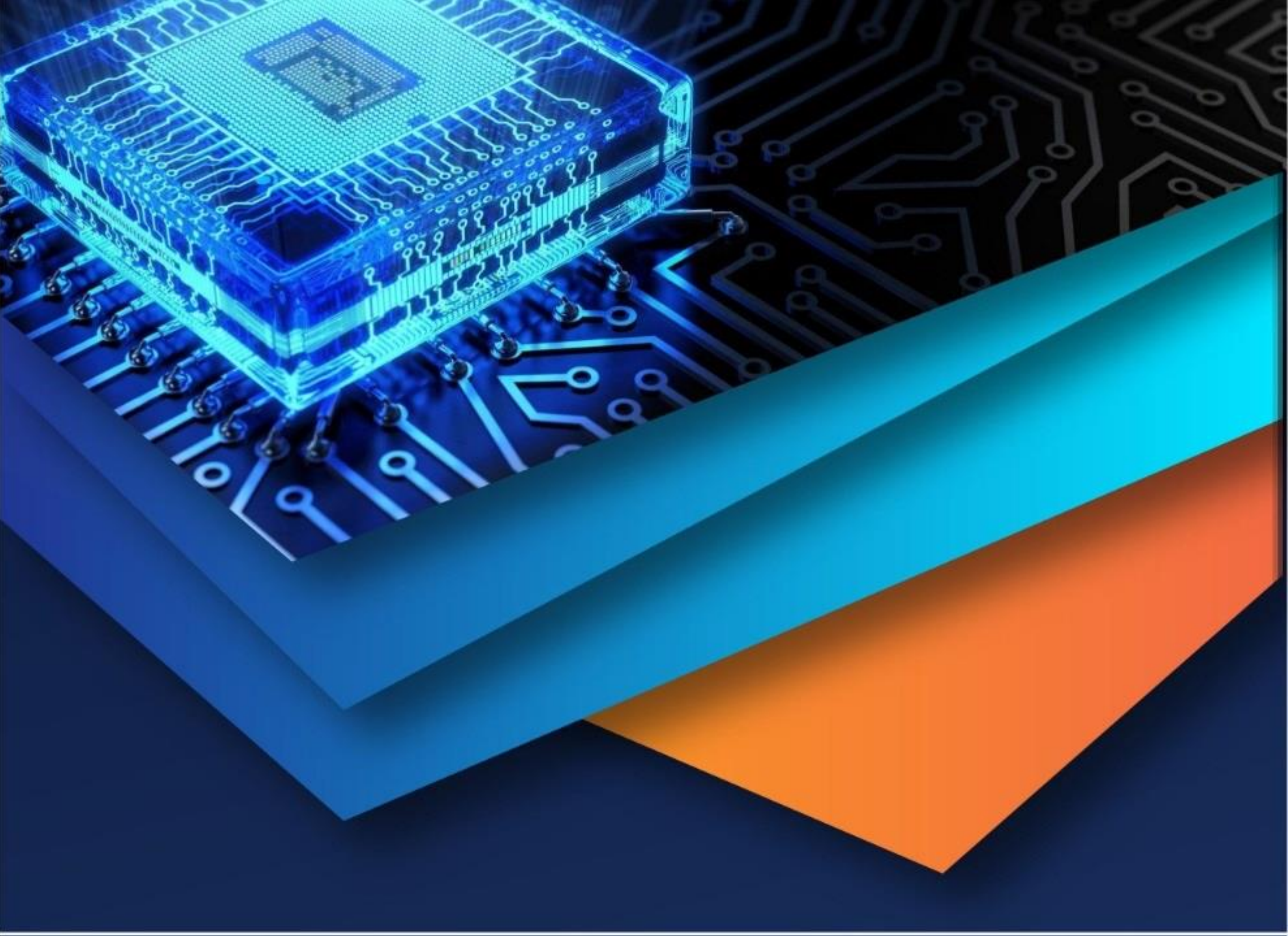


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