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Indian Institute of Science campus, Bengaluru

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SYNOPSIS

On

ENHANCING FLAME RESISTANCE AND MECHANICAL PROPERTIES OF BIOCOMPOSITES

Submitted By

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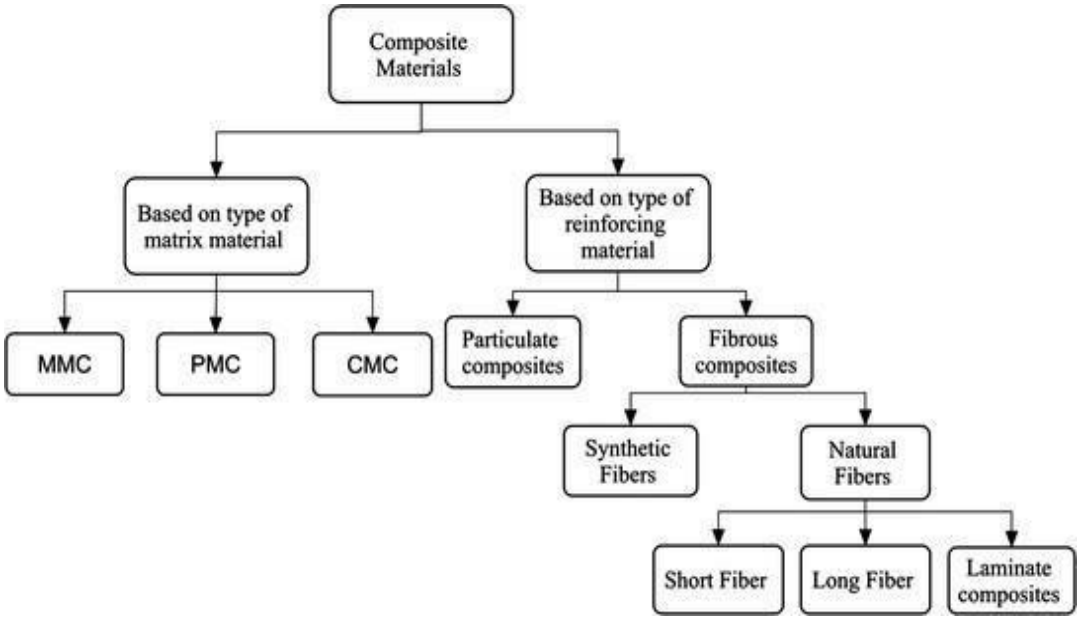
Introduction:

Enhancing flame resistance and mechanical properties of biocomposites has become a significant area of research and development in recent years. Biocomposites, which are composite materials composed of natural fibers and a polymer matrix, have gained increasing attention due to their eco-friendly nature, lightweight characteristics, and potential for various applications. However, one of the major challenges associated with biocomposites is their limited flame resistance and mechanical strength, which restricts their use in high-performance applications.

The need to enhance the flame resistance of biocomposites arises from the growing demand for fire-safe materials in industries such as automotive, construction, and aerospace. Improving their mechanical properties is crucial to ensure structural integrity and durability, enabling biocomposites to withstand heavy loads and harsh environmental conditions. Addressing these limitations requires innovative approaches and the integration of advanced materials and processing techniques.

Classification of Composites:



PROJECT OBJECTIVES.

The overall objective of this project is to develop a high performance composite from Plant fibres and Test them for its mechanical properties as well as its Flame Resistance. It is mainly used for Insulation and Construction application. For usages such as False ceilings, the boards are made up of fibres made from Groundnut shells, Sugarcane Bagasse and as well as the Rice Straws. There are a few methods of recycling or reusing the Plant fibres . The Growing usage of Plant fibres has increasedawareness about the waste disposal methods.

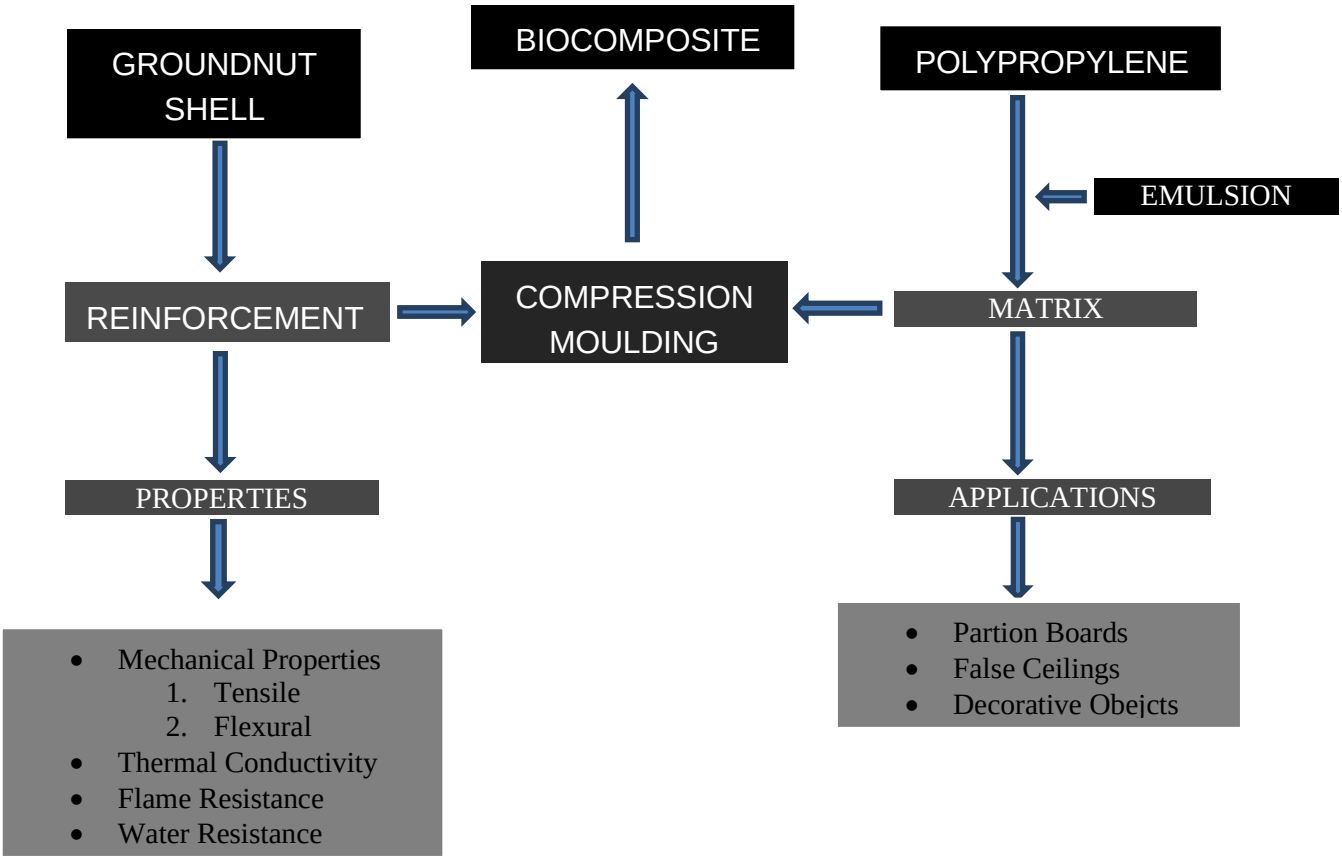
This approach will not only add value to reduction of plant based waste but will also develop products from biodegradable and relatively inexpensive raw materials. Successful completion of this project will lead to the use of these composites to be cost-effectively without causing a negative environmental impact and prevent it from dumping into Landfills and Incineration.

Specific Objective of the Project is To Enhance the Bio composite Materials for

- To Enhance the Mechanical Properties of the Bio Composite Materials.
- To Improve the Flame Resistance of the Bio Composite Materials.
- To Enhance the Water Resistance of the Bio composite Materials.

PROJECT METHODOLOGY.

The Brief Project methodology Process Flowchart is as Shown Below



The methodology of this project involves 3 major steps.

1. Selection of Plant Based Waste and using it for untreated or chemically treatedprocess

2. Preparation of Bio-Composites using these fibres with different composition ratios.

3. Testing of these materials for parameters like Flame resistance , Water resistanceand the

METHODOLOGY [PREPARATION PROCESS]

GROUNDNUT SHELL

SIEVEING

EMULSION

EMULSION BEING POURED TO COAT GNS

MIXING

GNS IN HOT AIR OVEN

POLYPROPYLENE ROLL

CUTTING POLYPROPYLENE

METHODOLOGY [BOARD MAKING]

SPREADING OF GNS

SPREADING POLYPROPELENE

LAYERS OF GNS AND POLYPROPELENE

COMPRESSION MOULDING MACHINE

COMPOSITE BOARD

WEIGHT CALCULATION OF BOARD

MEASURING LENGTH AND BREADTH OF BOARD

CUTTING OF BOARD FOR TESTING

INTRODUCTION TO TESTING PROCESS

MECHANICAL TEST:

1. TENSILE TEST:

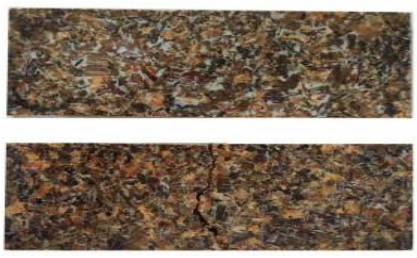
- Tensile Testing measures the force required to break a composite or plastic specimen and the extent to which the specimen stretches or elongates to that breaking point.
- Testing Machine: Universal Tensile Testing Machine, MTS, India.
- Test Standard: ASTM D638-4 standard.
- Dimensions: 100×20×8 mm^3.
- Load: 1000 N.

Fig .Tensile testing.

Fig .Tensile test specimen.

2. FLEXURAL TEST:

- Flexural testing measures the force required to bend a beam of plastic material and determines the resistance to flexing or stiffness of a material.
- Testing Machine: Universal Tensile Testing Machine, MTS, India
- Test Standard: ASTM D638-4 standard.
- Dimensions: 100×40×8 mm^3.
- Load: 1000 N.



FLAME RESISTANCE:

- A Vertical flame test method according to UL-94(Underwriters Laboratories) standard were used to examine the samples. The test specimen of dimension 100mm*20mm is positioned vertically above a controlled flame and exposed for a 10 seconds period of time. Following exposure, the flame source is removed. Measurements are made on the length of self-extinguish flame was recorded. By placing the surgical grade cotton below the burning sample, the dripping of flame test was observed. As per the standards depending on the time taken and particle dripping the flammability ratings were identified.

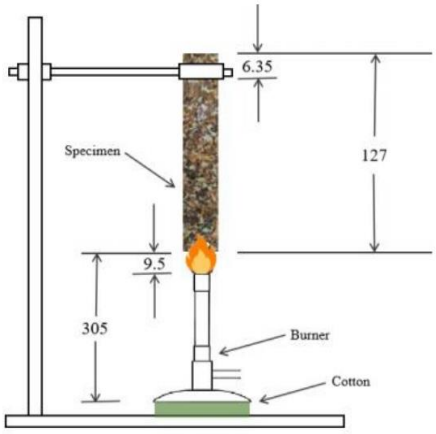


Fig. Flame Resistance testing .

Fig .Benson burner

WATER ABSORPTION:

- The amount of water absorbed under specific conditions is known as Water Absorption.
- Dimensions: $60\times60\times8mm^3$
- Period of time: 24hours
- Formula: $\frac{\text{Final value - Initial Value}}{\text{Initial value}} \times 100$

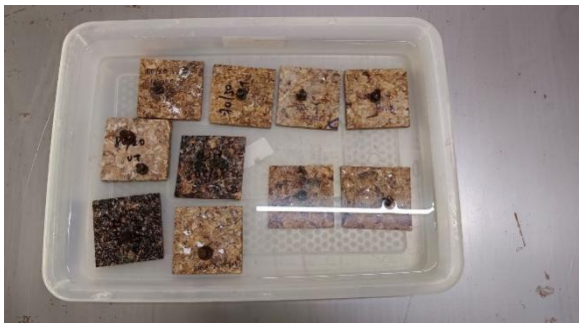


Fig .Water Absorption testing

Fig. Water Absorption test Specimen .

ACOUSTIC TEST:

- Acoustic Testing entitles assessing the performance of the product in real world conditions. After successful testing, it is then determined whether further revisions are to be made to increase the efficiency of sound proofing.
- Testing Machine: Two-microphone impedance tube.
- Test Standard: ASTM E1052-12 standard.
- Dimensions: 29 mm diameter.

Fig 7.1.6.1 Sound Insulation testing Machine

RESULTS AND DISCUSSION:

MECHANICAL TEST:

1. TENSILE TEST:

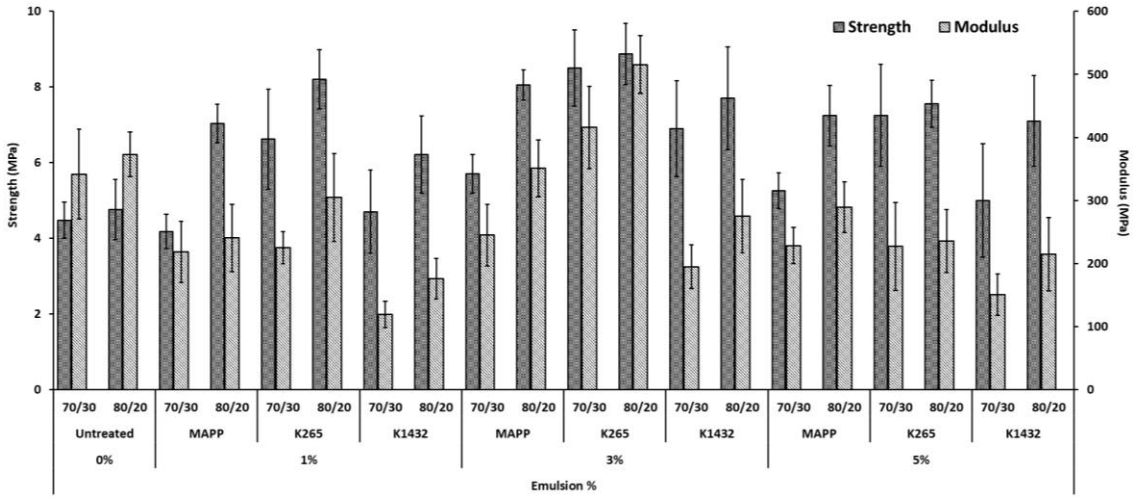


Fig. Tensile Strength and Tensile Modulus.

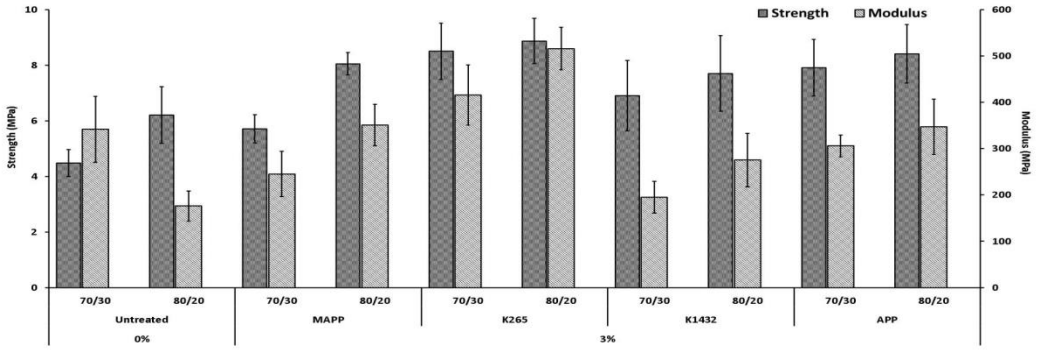


Fig. Tensile Strength and Tensile Modulus

The figures from the figure shows the variation of tensile properties of composite material. For GS/PP the tensile modulus is increased from 119.60N/mm^2 (70/30 – K1432 – 1%) to 515.58 N/mm^2 (80/20 – K295 – 3%). The minimum strength of GS/PP is 4.18N/mm^2(70/30 – MAPP – 1%) and maximum being 8.87 N/mm^2 (80/20 – K295 – 3%).

2. FLEXURAL TEST:

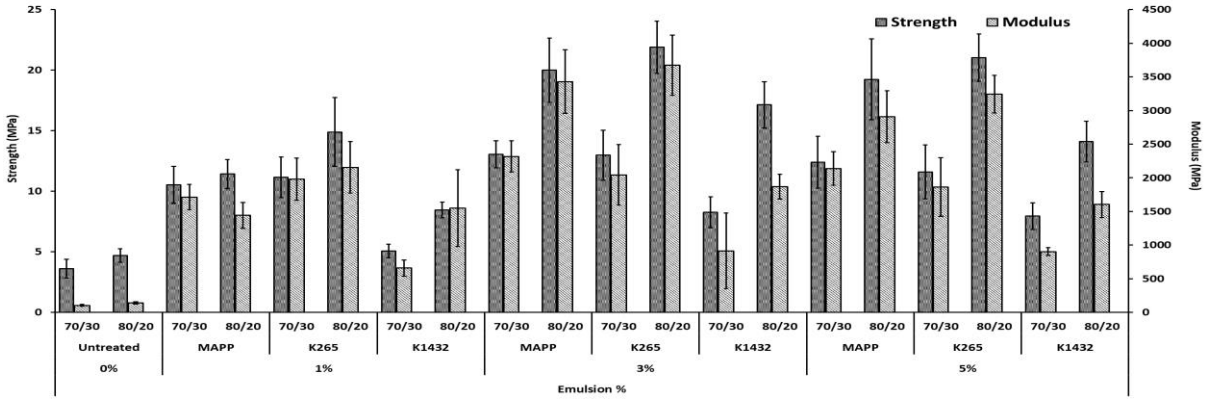


Fig .Flexural Strength and Flexural Modulus.

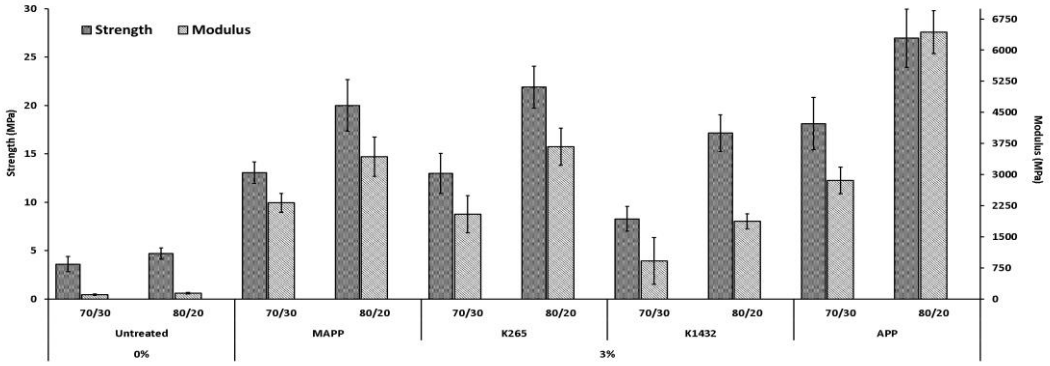


Fig. Flexural Strength and Flexural Modulus.

The figures from the figure shows the variation of tensile properties of composite material. For GS/PP the tensile modulus is increased from 103.91N/mm^2 (70/30 – UT) to 3672.52 N/mm^2 (80/20 – K295 – 3%). The minimum strength of GS/PP is 3.60N/mm^2(70/30 – UT) and maximum being 21.89 N/mm^2 (80/20 – K295 – 3%).

Flame Resistance Test:

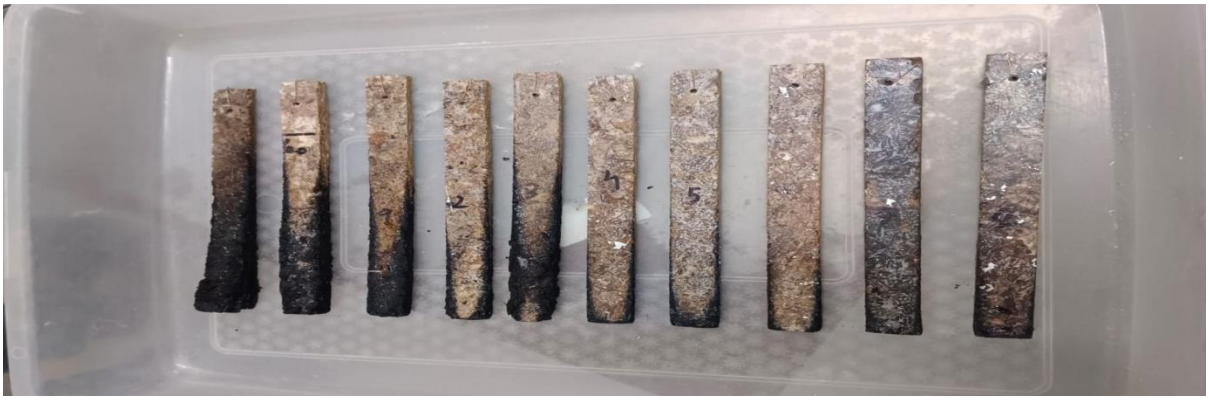


Fig. Flame Resistance test specimen.

Sample Code	Time to Self-Extinguish after Ignition (s)	Observed Dripping	UL-94 Rating	LOI (%)
70/30 UT	<30	YES	V2	22
80/20 UT	<30	YES	V2	23
70/30 K-1432	<30	NO	V1	24
80/20 K-1432	<30	YES	V2	27
70/30 P-MAPP	<30	YES	V2	26
80/20 P-MAPP	<30	YES	V2	26
70/30 K-295	<30	NO	V1	26
80/20 K-295	<30	NO	V1	25
70/30 APP	<30	NO	V0	28
80/20 APP	<30	NO	V0	30

Flame Resistance test results of the Samples.

The digital image of the flame resistance test is shown in the figure. Once the samples were subjected to flame and removed, The components in the V0 category Complete Flame Retardant. The components in the V1 category Catches Fire but Resists Flame. The composite which Sample got Completely Burnt are shown the rating of V2. Additives of various flame retardants can improve the flame resistance and also have positive impact on mechanical property of the composites.

Water Absorption Test:

One of the primary judging parameters for a ceiling tile is the percentage water absorption or resistance to moisture. The lowest absorption value among the composites was seen in the 70/30 GS/PP composite after 24h of immersion. The highest absorption value among the composites was seen in the 80/20 GS/PP composite after 24h of immersion.

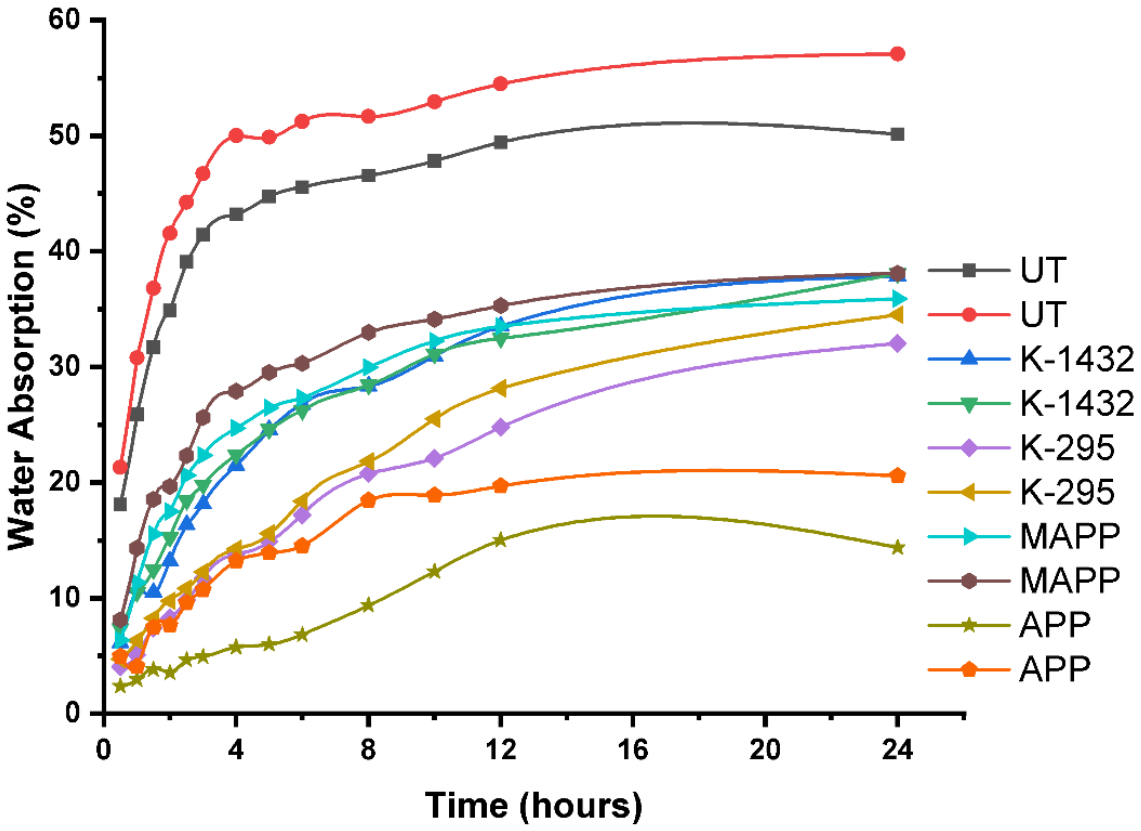


Fig .Graphical Representation of Water Absorption test results.

Sound Absorption Test:

The sound absorption coefficients of the composites are shown in Fig. 7.8. Sound absorption takes place when the incident sound waves causes the composite material to vibrate and subsequently converts sound energy to heat energy due to the friction developed. The highest sound absorption coefficient of 0.48 was observed in the mid 3300 Hz range for the 20/60/20 (SW/CF/PP) ratio.

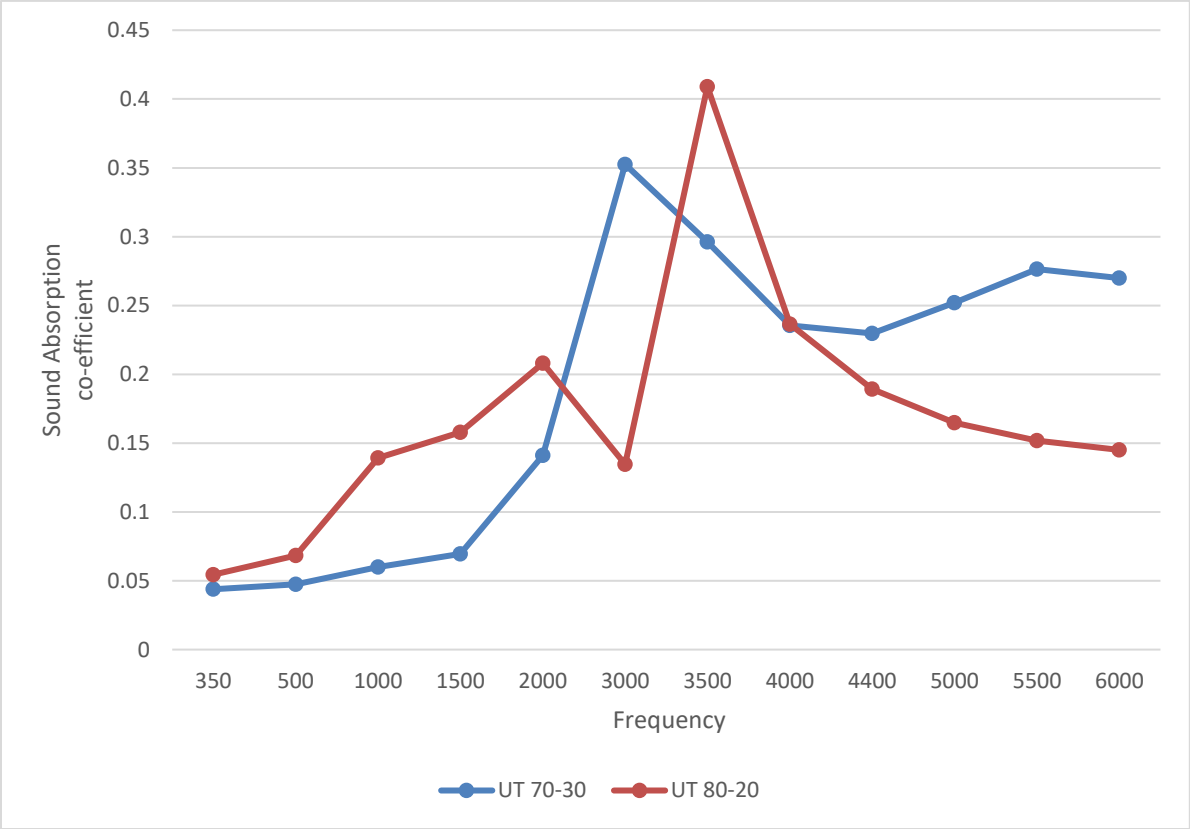


Fig. Graphical Representation of Sound Absorption test results.

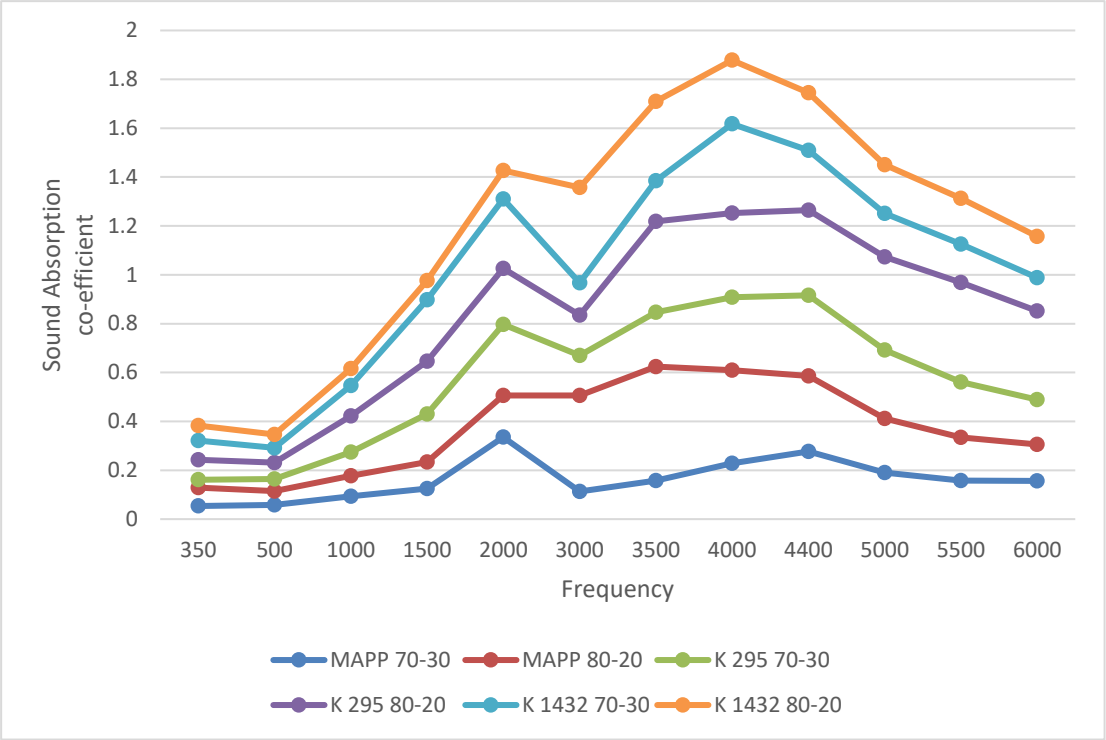


Fig 8.5.2 Graphical Representation of Sound Absorption test results.

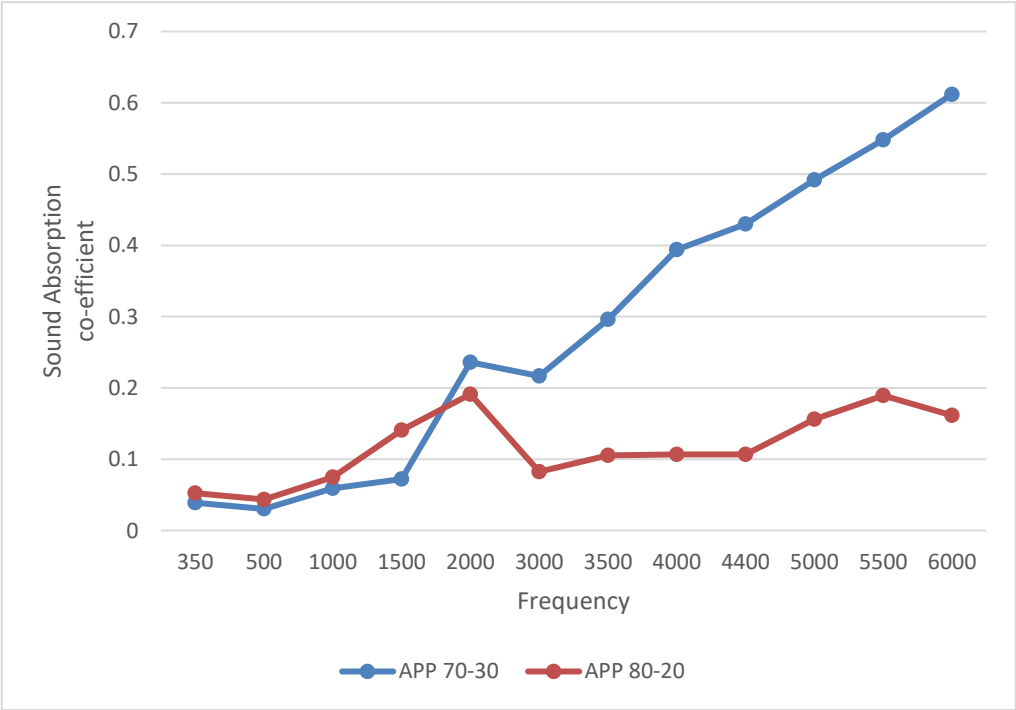


Fig 8.5.3 Graphical Representation of Sound Absorption test results.

COMPARISON AND CONCLUSION:

Parameter	Gypsum Board	Bio Composite Board
Tensile Strength	5.4 ± 0.5 Mpa	6.57 ± 0.88 Mpa
Flexural Strength	9 ± 0.7 Mpa	12.47 ± 1.67 Mpa
Flame Resistance UL - 94 Rating	V-0	V-2/V-0
Water Absorption (%)	58.60%	35.85%
Sound absorption Co-efficient	0.4-0.6	0.057-0.23

Table 8.4 shows a comparison of the properties of GS/PP composites with gypsum-based materials reported. The results clearly demonstrated that the biocomposite board exhibited superior mechanical properties, such as higher tensile strength and flexural strength, when compared to the gypsum board. Additionally, the biocomposite board showcased enhanced fire resistance and moisture resistance, making it more suitable for a wider range of applications, including areas where fire safety and moisture control are prominent.

Considering the combination of superior mechanical properties, enhanced fire and moisture resistance, environmental sustainability, and potential cost-effectiveness, it is clear that the biocomposite board represents a promising alternative to gypsum board in various construction applications.

In conclusion, the results of this project demonstrate the substantial potential of biocomposite board as a superior alternative to gypsum board, offering enhanced performance characteristics, environmental sustainability, and potential cost advantages. The findings pave the way for future advancements and wider adoption of biocomposite board in the construction industry.