1. Introduction
Composite materials, plastics and ceramics have dominated new technologies over the last thirty years [1]. The volume and number of applications of composites has gradually increased and new markets have been increasingly penetrated and conquered [2]. Modern composite materials represent a large proportion of the demand for engineered materials, ranging from consumer goods to advanced niche applications. The challenge today is to make it inexpensive, although the composites have already proved their value as weight saving materials [3]. Efforts to manufacture commercially attractive composite parts have resulted in many revolutionary manufacturing processes currently being used in the composite industry [4].
It is evident that improvement in manufacturing technology, particularly for composites, alone is not sufficient to overcome the cost obstacle [5]. Integrated efforts must be made in the design, materials, processes, equipment, quality assurance, production and even programme management of composites in order to compete with metal matrix composites, as the name indicates, have a metal structure. Examples of matrixes in such composites include aluminium,
magnesium and titanium. Typical fibre contains carbon and silicon carbide. Metals are primarily strengthened to accommodate the design needs [6-7]. For example, the elastic stiffness and strength of metals can be increased, while the high coefficient of thermal expansion and thermal and electrical conductivity of metals can be decreased by the addition of fibres such as silicon carbide [8].

The composites industry has begun to recognise that the commercial applications of composites continue to deliver a much greater business opportunity than the aerospace sector due to the sheer size of the transport sector. Thus, the transition in composite applications from aircraft to other commercial uses has become important in recent years [9]. Bamboo is one of the fastest green plants with a maturation period of 3-4 years, making it a highly desirable option compared to hardwood forests. Bamboo has a strong ability to turn it into composites as a replacement for solid wood for structural applications [10].

The main objective of this paper is wood ash with a sisal fiber epoxy resin matrix mixed with teak sawdust in the respective ratio of 10 w.t% and 20 w.t%. Once this mixture is done, the hand layup process will be done. It will be processed to various testing such as impact test, hardness resistances test, water absorption test at standard laboratory conditions. And also, the teak sawdust is used as reinforcement because it has less density, long durability as well as it’s very less expensive, excellent mechanical properties and give mechanical strength to their inner and outer physical properties. Wood ash with sisal fiber epoxy resin matrix mixed with teak sawdust having high strength properties and it does not have corrosion resistance than other common natural fiber. The resistance of stress and strain is highly useful in marine engineering. Further, the need for composite for lighter construction materials and more seismic-resistant structures has placed high emphasis on the use of new and advanced materials that not only decreases deadweight but also absorbs the shock and vibration through tailored microstructures. Composites are now extensively being used for rehabilitation, strengthening of pre-existing structures that have to be retrofitted to make them seismic-resistant, or to repair damage caused by seismic activity.

2. Material and methodology

2.1 Teak sawdust
High in natural oil and rubber content protect it against wet and cold weather. It is one of the hardest, strongest, and most durable of all-natural woods. Teak is a close-grained hardwood. This makes it possible to cut the joints very accurately.

2.1.1 Properties
- Common Name- Teak, Burmese Teak
- Scientific Name –Tectonicgrands
- Modulus of Rupture 97.1 MPa
- Elastic Modulus12.28 GPa
- Hardness 4,740 N

2.2 Wood ash
- Ash is strong, durable and generally light in colour
- It is course but the grain is fairly straight, As a result of its strength and durability
- Easy to mix the other materials and good water resistance
- Highly water resistance

2.2.1 Properties
- Common Name: White Ash
- Hardness: 5,870 N
- Crushing Strength: 51.1 MPa
- Modulus of Rupture: 103.5 MPa

2.3 Sisal fiber
- It is highly renewable resource of energy
- Sisal fibre is exceptionally durable and a low maintenance with minimal wear and tear
- It is recyclable.
• It exhibits good sound and impact absorbing properties.
• It is good fire resistance properties.

2.3.1 Properties
- Tensile strength 235 Mpa
- Modulus of elasticity 18 Gpa
- Percentage of elongation 1-1.5

2.4 Material requirement

Table 1 Description of material

| S.no | Materials     | Quantity (Rawmaterials) | Quantity (finished material) |
|------|---------------|-------------------------|------------------------------|
| 01   | Teak saw dust | 500 g                   | 100 g                        |
| 02   | Wood ash      | 500 g                   | 100 g                        |
| 03   | Sisal fibre   | 500 g                   | 280×280 mm(6 layer)          |
| 04   | G P Resin     | -                       | 1 lit                        |
| 05   | Hardener      | -                       | 20 ml                        |
| 06   | Accelerator   | -                       | 10 ml                        |
| 07   | Mica sheet    | -                       | 1 foot                       |

In Table 1 shown Description of finished material which consists of the quantity of raw Materials, Materials names are used to produce composite materials.

2.5 Teak saw dust preparation
Teak sawdust is extracted from the teak, this teak sawdust has carried more unwanted materials, and then the unwanted materials are removed. The grain size of the teak sawdust is more, so reduce the grain size by filtration using the filtration equipment. The materials are shown in figure 1 & 2. Generally sawdust is made from 30-600 microns.

![Figure 1 Teak saw dust (unfiltered)](image)

![Figure 2. Teak saw dust (filtered)](image)

2.6 Wood ash preparation
Wood ash is prepared by the firing the neem wood, the neem is fully burned and it gives the ash, but these ash containing unburned neem sticks, dust. So the unburned materials are removed and to get the required finishing ash. This finishing ash has been further used to making the composite materials. The wood ash material is shown in figure 3. Generally the ash grain size is from 0.2-3 microns.

![Figure 3 Wood ash](image)
2.7 Sisal fiber

It is a highly renewable resource of energy. Sisal fiber is exceptionally durable and low maintenance with minimal wear and tear. It is Recyclable. It exhibits good sound and impact absorbing properties. It is a good fire resistance property. The minimum fiber buying quantity is 500g, but we using 280×280mm in 6 layers. We using the sisal fiber in (0/90/0/90/0/90) degrees. The materials are shown in figure 4.

![Figure 4 sisal fiber](image)

2.8 GP resin

GP resin mean is a general-purpose resin; this resin is a commonly used adhesive material. It is quick curing unsaturated polyester resin of orthophthalic grade spray purpose laminated purposes. The materials are shown in figure 5.

- The hardener (blue colour) is mixed 20 ml in one litter of GP resin. The accelerator (white colour) is mixed 10 ml in one litter of gap resin
- We used 250 ml GP resin + 5 ml hardener+2.5 ml accelerator

![Figure 5 GP resin](image)

2.9 Composite manufacturing through Hand layup process

The hand lay-up technique is the simplest form of composite processing shown in Figure 6. The infrastructural requirement of this approach is also minimal. The processing steps are quite simple and the mixing ratio of materials shown in Table 2. First of all, the resin is sprayed on the surface of the mould to keep the polymer from sticking to the surface. Small plastic sheets are used at the top and bottom of the moulding plate to give the product a good surface finish. The load setup is shown in figure 7.

The reinforcement in the form of the sisal fiber mat is cut as per the mould size and placed on the surface of the mould after the Perspex sheet. Then thermosetting polymer in liquid form is thoroughly mixed in an acceptable proportion with the specified hardening agent and poured onto the surface of the mat already in the mould. The resin is uniformly spread with the help of a brush is shown in figure 8.

The second layer of the mat is then placed on the surface of the polymer and the roller is pushed with a gentle pressure on the mat-polymer layer to remove any air trapped and any excess polymer present. The process is repeated for each layer of polymer and mat until the appropriate layers have been stacked. After the plastic sheet has been mounted, the release gel is sprayed onto the inside the surface of the top moulding plate, which is then deposited on the stacked layers and the pressure is applied.
After curing, either at room temperature or at a particular temperature, the mould is opened or the formed composite component is extracted and further processed. The processed and final composite material is shown in figure 9.

**Table 2.** Mixing ratio of materials

| S.no | Materials      | Mixing ratio in one layer |
|------|----------------|---------------------------|
| 1    | Teak saw dust  | 100 g                     |
| 2    | Wood ash       | 100 g                     |
| 3    | G P resin      | 250 ml                    |
| 4    | Hardener       | 5 ml                      |
| 5    | Accelerator    | 2.5 ml                    |

3. Results and Discussion:

3.1 Brinell hardness test

The Brinell hardness test is most commonly used to test materials that have a structure that is too rough or too coarse to be tested using other test methods and it is thoroughly performed by pressing or applying an external force, specifically all sides of the dimensioned and applied loaded specimen (indenter) into the surface of the material that we are testing the composite material of wood ash with sisal fiber epoxy resin matrix mixed with a different volume ratio of teak sawdust reinforcement. And also, the hardness of composite material is determined by measuring the depth of loaded specimen penetration or by measuring the size of the impression left by a loaded specimen of the composite of the material in the laboratories. And finally, we determine the result of the testing and other values in a very systematic manner.

In Table 3, shown wood ash with sisal fiber epoxy resin matrix mixed with a different volume ratio of teak sawdust reinforcement and different hardness values have been carried out such as 10 BHN (R1) and 20 BHN (R2)
Table 3. Brinell hardness test

| S.No | Materials Composition                                                                 | BHN |
|------|---------------------------------------------------------------------------------------|-----|
| R1   | Wood ash+Sisal fiber+ Epoxy resin matrix with 10 w.t% teak saw dust reinforcement     | 10  |
| R2   | Wood ash+Sisal fiber+ Epoxy resin matrix with 20 w.t% teak saw dust reinforcement     | 20  |

Figure 10 Wood ash with sisal fiber epoxy resin matrix with different vol. ratio of teak saw dust reinforcement compositions vs Hardness value

In Figure 10, the Brinell hardness test graph clearly shows that the specimens containing 10 wt% composite materials (R1) and 20 wt% composite materials (R2) in wood ash with sisal fiber epoxy resin matrix and different Brinell hardness values have been carried out such as 10 BHN and 20 BHN. And also, it is indicated that the R2 hardness value is greater than R1.

3.2 Rockwell hardness test

The Rockwell hardness test tests the hardness in the easiest way possible: by pressing the indenter on the surface of the composite material with a particular load, and then by measuring how deep the indenter was able to penetrate. The indenter normally consists of steel or a diamond ball.

Table 4 Rockwell hardness test

| S.No | Materials Composition                                                                 | RHN |
|------|---------------------------------------------------------------------------------------|-----|
| R1   | Wood ash+Sisal fiber+ Epoxy resin matrix with 10 w.t% teak saw dust reinforcement     | 63  |
| R2   | Wood ash+Sisal fiber+ Epoxy resin matrix with 20 w.t% teak saw dust reinforcement     | 65  |

In Table 4 shown wood ash with sisal fiber epoxy resin matrix mixed with a different volume ratio of teak sawdust reinforcement and different hardness values have been carried out such as 63 RHN (R1) and 65 RHN (R2).

Figure 11 Wood ash with sisal fiber epoxy resin matrix mixed with different vol. ratio of teak sawdust reinforcement compositions Vs Hardness value
In Figure 11 shows the Rockwell hardness test graph clearly shows that the specimens The teak sawdust contained 10 wt% composite material (R1) and 20 wt% composite material (R2) in wood ash with sisal fiber epoxy resin matrix and different Brinell hardness values have been carried out such as 63 RHB and 20 RHB. And also, it is indicated that the R2 hardness value is greater than R1.

3.3 Charpy impact test

The impact test signifies the toughness of material that is the ability of a material to absorb energy during plastic deformation. Toughness takes into account both the strength and ductility of the material. Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force. The test measures the impact energy or the energy absorbed prior to fracture. The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a the composite material of wood ash with sisal fiber epoxy resin matrix with a different volume ratio of teak sawdust reinforcement during fracture. The result of Charpy test values are shown in Table 5.

The teak sawdust contained 10 wt% and 20 wt% in ash epoxy resin matrix and different impact strength values have been carried out such as 2.145 J/mm² and 2.187 J/mm².

**Table 5** Charpy Impact test

| S.No | Materials Composition                                                                 | Impact Strength(J/mm²) |
|------|--------------------------------------------------------------------------------------|------------------------|
| R1   | Wood ash+Sisal fiber+ Epoxy resin matrix with 10 w.t% teak saw dust reinforcement     | 2.145                  |
| R2   | Wood ash+Sisal fiber+ Epoxy resin matrix with 20 w.t% teak saw dust reinforcement     | 2.187                  |

In Figure 12, The Charpy impact test graph clearly shows that the specimens The teak sawdust contained 10 w.t% composite materials (R1) and 20 w.t% composite materials (R2) in wood ash with sisal fiber epoxy resin matrix and different impact strength values have been carried out such as 2.145 J/mm² and 2.187 J/mm². And also, it is indicated that R2 impact strength value is stronger than R1.

3.4 Izod impact test

Izod test specimens vary depending on the material. Metallic samples tend to be square in cross section, while polymeric test specimens are often rectangular, being struck parallel to the long axis of the rectangle. Izod test sample usually have a V-notch cut into them, although specimens with no notch as also used on occasion. The result of Izod test values are shown in table 6. The teak sawdust contained 10 w.t% and 20 w.t% in wood ash with sisal fiber epoxy resin matrix and different impact strength values have been carried out such as 1.60 J/mm² and 1.75 J/mm².
Table 6 Izod impact test

| S.No | Materials Composition                                                                 | Impact Strength (J/mm²) |
|------|---------------------------------------------------------------------------------------|-------------------------|
| R1   | Wood ash+Sisal fiber+ Epoxy resin matrix with 10 w.t% teak saw dust reinforcement     | 1.60                    |
| R2   | Wood ash+Sisal fiber+ Epoxy resin matrix with 20 w.t% teak saw dust reinforcement     | 1.75                    |

Figure 13 Wood ash with sisal fiber epoxy resin matrix with different vol. ratio of teak saw dust reinforcement compositions Vs Impact strength

In Figure 13, the Izod impact test graph clearly shows that the specimens The teak sawdust contained 10 w.t% composite materials (R1) and 20 w.t% composite materials (R2) in wood ash with sisal fiber epoxy resin matrix and different impact strength values have been carried out such as 1.6 J/mm² and 1.75 J/mm². And also, it is indicated that R2 impact strength value is stronger than R1.

3.5 Water absorption test

Water absorption is used to determine the amount of water absorbed under specified conditions. The specimen size is 0.125 inch to 0.250 inches. For the water absorption test, the specimens are dried in an oven for a specified time and temperature and then placed in a desiccator to cool. Immediately upon cooling the specimens are weighed. The material has then emerged in the water at agreed-upon conditions, often room temperature for 24 hours or until equilibrium. Specimens are removed, patted dry with a lint free cloth, and weighed.

Table 7. Water absorption test

| S.No | Materials Composition                                                                 | Distilled water (in %) | Sea water (in %) |
|------|---------------------------------------------------------------------------------------|-------------------------|-------------------|
| R1   | Wood ash+Sisal fiber+ Epoxy resin matrix with 10 w.t% teak saw dust reinforcement     | 0%                      | 2%                |
| R2   | Wood ash+Sisal fiber+ Epoxy resin matrix with 20 w.t% teak saw dust reinforcement     | 0%                      | 2%                |

In Table 7, the water absorption test, both the composite material of 10 w.t% and 20 w.t % has the same value as the result, in distilled water there is zero absorption of water and the saltwater is absorbed in 2 % of absorption of water but very low in the sample

4. Conclusion

In this paper, we focused on using the teak sawdust as reinforcement and wood ash with a sisal fiber epoxy resin matrix to mix in a different 10% and 20% volume ratio. After that, the composite materials manufactured by hand layup method The property of this composite is
low density, good wear resistance, good impact strength, and against corrosion resistance. The
Hardness strength will also be taken into consideration. For the achievement of the above, an
 experimental set up is prepared where all the necessary inputs will be made. In this work, a
composite is developed by adding teak wood saw in wood ash with a sisal fiber epoxy resin
matrix with different volume ratios.

- The composite has to be prepared by a hand layup technique and has to be analyzed
  various properties such as hardness test, Impact test, water absorption test, and in
  these two different volume composite has been taken and compared and as well we
  analyzed all the various testing values.
- And finally, we got to know that composite material is having high strength and also,
  wood ash with sisal fiber epoxy resin matrix with 20 w.t% teak sawdust (R2) has
  optimal mechanical properties can be achieved than wood ash with sisal fiber epoxy
  resin matrix with 10 w.t% teak sawdust (R1).
- This study has been found the teak sawdust hardened material with 20 w.t%
  containing epoxy resin has more mechanical properties of Brinell hardness strength
  with a value of 20 BHN and Rockwell hardness strength with a value of 65 RH.
  The notched impact strength of Charpy and Izod tests are 2.1875 J/mm² and 1.75 J/mm².
  The water absorption test, both the sample of 10 w.t% and 20 w.t % has the same value
  as the result, in distilled water there is zero absorption of water and the saltwater is
  absorbed in 2 % of absorption in the sample. These composite prototypes are efficiently
  in price value and its durability is very strong enough to build a boat hull.

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