CHAPTER 3
MATERIALS USED

3.1 Materials Used

Various materials used in this research work and the ways of fabrication are discussed in detail in this chapter. Hand layup method is used to fabricate the composite specimen which is less economic and easy to fabricate.

Materials used in this research work are as follows:

- Kevlar Fiber
- Kenaf Fiber
- Neem Fiber
- GFRP
- Resin and hardener

3.2 Kevlar Fiber

Generally there are various amazing materials in the real world which are given by nature to alter the conventional materials in order to reduce the weight, cost and facility to manufacture the product. Especially in the modern world we need to face challenges to reduce the burden of the society to make the product more feasible and strong. Hence, we face the problems where nature cannot be anticipated. So we need to go for synthetic materials known as Kevlar. Kevlar is a plastic strong synthetic material being five times stronger than steel on an equal weight basis. Kevlar is made from hundreds of
synthetic plastics through polymerization process i.e. joining together long chain molecules. It has excellent properties because of its internal structure, the molecules are arranged in regular and parallel lines and finally it made into fibers that are knitted tightly together. Figure 3.1 shows the Kevlar fiber.

![Figure 3.1 Kevlar fiber](image)

Kevlar is a proprietary material made from Dupont Company and introduced by Stephen kwolek. Kevlar and nomex are the best examples of chemicals called synthetic aromatic polyamides or Aramid. Kevlar comes in varieties namely, Kevlar, Kevlar 29 and Kevlar 49.

Aromatic means Kevlar molecules have a strong ring like structure like benzene. Polyamide means ring like aromatic molecules connect together to form a long chain.

Kevlar is a man made organic polymer obtained from spinning solid fiber from a liquid blend. Kevlar has got impact resistance, lower modulus, which can be used in ballistic materials. Kevlar is made from the chemical called poly para phenyleneterephthalamide. Here amides of organic acids replaces with one of the hydrogen atoms in ammonia. Hence ammonia reacts with organic acid is called condensation process which fuse together which
makes the structure super strong. Figure 3.2 is the chemical structure for Kevlar.

![Figure 3.2 Kevlar Structure](image)

### 3.2.1 Production of Kevlar

Kevlar fibers are nematic behavior where all the polymers are linked in the same direction. Kevlar polymers are turned into fibers by wet spinning process which involves forcing a hot and concentrated solution of poly para phenylene terphthalamide through a spinner and to make the long, thin and strong. Then they are wound onto drums. Then the fibers are cut into length and woven into a tough Mat which makes Kevlar a super strong and stiff material.

![Figure 3.3 Hydrogen atoms of Kevlar](image)

Aramid fibers are available in the form of roving ranges from tex 20 to tex 800. Aramid fibers are treated with a finish which consists of rubber compatible finish, water proof finish in case of ballistic armor. Figure
3.3 shows the hydrogen atoms present in the structure which yields very strong in nature.

3.3 Grades and Applications of Kevlar

3.3.1 Kevlar

It is used as a reinforcement material for car tyres and cycle tyres. It is used to reduce the wear and puncture rates.

3.3.2 Kevlar 29

It is used to manufacture of body armour plates for light weight military vehicles. It protects the soldiers inside the vehicle.

3.3.3 Kevlar 49

It is used to manufacture of boat hulls an aerospace industry. It has high impact resistance and excellent torque and tensile stress resistance.

3.3.4 Advantages of Kevlar fibers

i. Relatively low weight and high strength

ii. Impact and scratch resistant.

iii. It holds high flexibility used in racing cars.

iv. It absorbs moisture when combined with moisture resistant materials.

v. It reacts well in tensile force but badly under compressive force.

vi. It is difficult to cut and shape, unless the special tools and equipment were used.
3.3.5 *Properties of Kevlar fibers*

i. High strength to weight ratio and high tenacity.

ii. High rigidity modulus of 130-180 GPa.

iii. Resistant to organic solvents except chlorine.

iv. Good resistant to abrasion and cutting.

v. Resistant to thermal degradation and low flammability.

vi. Good fabric integrity.

3.3.6 *Applications of Kevlar fibers*

i. Ropes and cables

ii. Flame resistant clothing

iii. Protective clothing and helmets

iv. Body armors

v. Reinforcement of tiers and rubbers.

vi. Sporting goods.

vii. Drum heads

viii. Speaker woofers

ix. Bow strings.

3.4 *Kenaf Fiber*

![Kenaf Fiber](image3.4.png)

*Figure 3.4 Kenaf fiber*
Figure 3.4 shows kenaf fiber belongs to hibiscus family which is 4000 years old crop and originated in ancient Africa. Kenaf plant can grow with a average height of 1.5m to 4.5m tall in the duration of 5 months yielding 500-1000 kg of dry fiber/acre. Kenaf is very much suitable as biological resources, fossil fuels, wood pulp etc due to its extensive application in engineering field.

3.4.1 **Cultivation and harvesting of kenaf**

Kenaf is cultivated in more than 30 countries. Kenaf fiber is well adapted in many soil types and in various climatic conditions. Kenaf has the most annual crop source of fiber for the application of paper and pulp industry, because of excellent cellulose fiber content. It has required less energy, chemical treatments for processing and cultivation of kenaf is shown in figure 3.5.

![Figure 3.5](image)

**Figure 3.5 Cultivation of kenaf fiber**

3.4.1.1 **Kenaf stalks**

It yield normally ranges from 11 to 18 tons over dry weight.
3.4.1.2 Kenaf leaves

Figure 3.6 Kenaf leaves and their types

Kenaf produces simple leaves with serrated edges on stem and along the branches. There are two leaves produced. The divided leaves are deeply lobed leaves whereas entire leaves produce that are shallow lobed leaves which are basically as heart shaped. Figure 3.6 shows the types of kenaf leaves.

3.4.1.3 Kenaf flowers

Figure 3.7 Kenaf leaves    Figure 3.8 Kenaf seeds

Kenaf plant produces large and light yellow creamy colored flower which is in the form of bell shaped structure as shown in Figure 3.7. The flowers are 8 to 13 cm in diameter with 5 petals and in borne in stem of the plant.
3.4.1.4 Kenaf seed

Kenaf seed as shown in Figure 3.8 with capsules are formed about 1.9 to 2.5 cm long and 1.3 to 1.9 cm in diameter. They are enclosed with small, fine, loosely held hairy structures which are very irritating in nature when it is to be held with skin.

3.4.1.5 Stages of Processing Kenaf fiber

Figure 3.9 shows various stages in processing of kenaf fibers.

a. Kenaf Plantation
b. Fiber in Warehouse
c. Fiber Drying in Field
d. Fiber Preparation
e. Kenaf Storage Area
f. Fiber Packing
g. Fiber Packed
h. Onboard to Shipment

Figure 3.9 Various Stages in processing of kenaf fiber
3.5 Neem fiber

Figure 3.10 (a) Neem tree  Figure 3.10 (b) Neem Leaves

Figure 3.10 (c) Neem fibers

Figure 3.10 shows the neem tree, neem leaves and neem fiber respectively. It is also known as miracle tree from which fiber is extracted. It is available throughout India. It is a tall evergreen tree with small bright leaves. It can be easy grown in dry, stony and shallow soils. It has been grown with more contribution of sunlight with minimum water resources.
3.6 Glass Fiber Reinforced Polymer

GFRP consist of minute particles of fiber glass. The main advantage of using this fiber is due to its light weight, robust and strong in nature. It can be easily molded to any shape. The particles called as filaments which are formed and bundled together to form a roving like structure. Bulk strength and weight properties are also very favorable when compared to metals. Figure 3.11(a) shows the glass fiber and figure 3.11 (b) shows the woven roving mat.

3.7 Resin and Hardener

In this research work, resin used is Epoxy LY556 at room temperature. The main primary function of the resin is used to transfer the stresses from the
reinforcing fibers and it should have the better interfacial adhesion between the fibers. Also, due to heavy loads, it resist damage occurred in the composite laminate. The optimum condition ratio for resin and hardener is 10:1. The resins are low molecular weight polymers having the glycidal or oxirane groups from petroleum derived raw materials. Resin is vapour pressure is less than 0.01 Pa at 20°C and also exist in liquid state. It is insoluble in water. The boiling point is around 200°C. Hardener (HY951) has minimum viscosity which is having better mechanical and chemical properties. Figure 3.12 shows the resin and hardener for matrix medium.

Vinyl ester resin (Density - 1.4 g/cm³), polyester resin (Density -1.2 g/cm³). Among all the resins, epoxy resins (Density - 1.44 g/cm³) are high in density and it is easily capable of incorporating the resin into the composite laminate for high adhesion between the fibers.

The main objective of this work is to combine Synthetic (Kevlar fiber) and Natural fiber (kenaf fiber). In order to utilize the both material properties they are combined in this work which may be resulted with high mechanical properties.

Kevlar fibers are used exclusively in military and defense applications. Kenaf fibers are used where high mechanical properties are required. If it is used in the marine applications, the fibers will absorb moisture and it may lead to failure which focused only on load bearing application. If neem fiber is used, then it can be used for marine applications too as it has got high saline resistance and low corrosion in nature. Hence, three fibers used to make the applications wide.