4. COMPOSITES - DEFINITION

Composite materials, are a combination of two or more materials that are different in chemical composition. The materials are blended to create a material with superior structure and better properties than the constituent materials.

Composite materials can be a combination of various materials, such as plastics, metals, fibers or ceramics.

However, the properties of a composite material depend on the properties, structure, and proportion of the constituent materials. Figure 4.1 shows how two different materials combine to form a composite material.

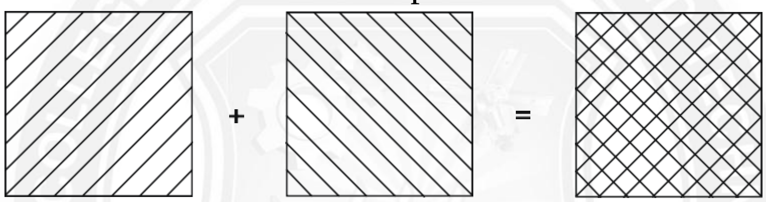


Fig. 4.1 Combining Two or More Materials to form a Composite Material

Composites usually consist of two parts, the **matrix** and the **reinforcements**. The matrix holds the reinforcements, transfers the load to the reinforcements, and protects them from mechanical and environmental damage. The reinforcements carry most of the load and provide stiffness.

Some composite materials exhibit better properties than the constituent materials, such as metals or plastics. Therefore, composite materials are preferred over other materials in applications such as aircraft manufacturing, space vehicles, electronics and sporting goods.

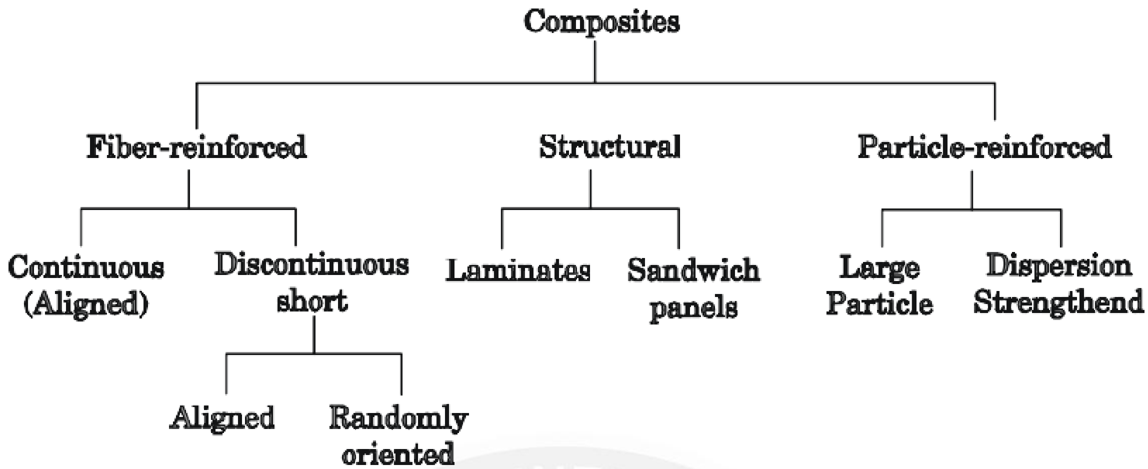
CLASSIFICATION OF COMPOSITES

Based on the reinforcement techniques, composites are classified as:

(a) Fiber-reinforced

(b) Structural

(c) Particle-reinforced



Fiber - Reinforced

Fiber-reinforced composites consist of thin fibers of a material, which are suspended in a matrix of another material. Matrix is the medium or the substance in which the fibers are suspended.

Matrix distributes the stress across the fibers. The thin continuous or discontinuous fibers provide strength to the composite. Matrix also provides toughness to the fiber-reinforced structure.

Example:

Figure 4.2 shows the structure of fiber-reinforced composites.

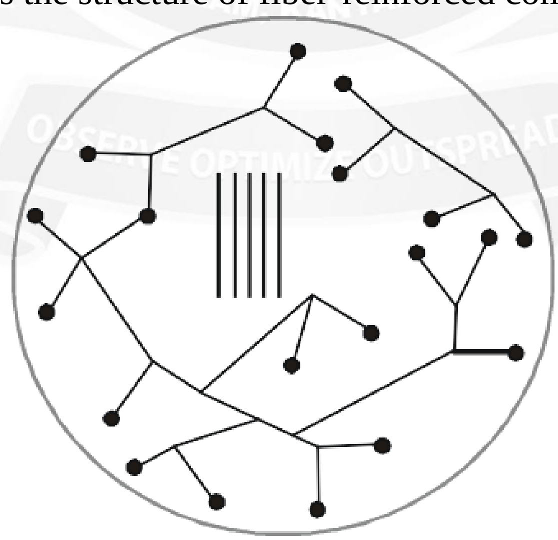


Fig. 4..2 Structure of Fiber-Reinforced Composites

- One of the most common natural fiber-reinforced composites is bamboo, where cellulose fibers are suspended in a matrix of lignin.
- One of the manmade fiber-reinforced composites can be been in a car tyre, where nylon or steel wires are suspended in rubber matrix.
- Concrete is another manmade composite, where iron rods are used as reinforcing material with sand and gravel in the cement matrix.

Some commonly used reinforcing fibers are Kevlar, graphite, and glass.

The properties of a composite vary with the proportion of fiber used for reinforcement. Advanced fiber-reinforced composites may contain fiber content as high as 50%. Due to high fiber content, such composite materials are strong, stiff and lightweight.

Matrix materials

In composites, the matrix phase serves important functions. First it binds the reinforcement (fibers) together. It acts as a medium and transmits and distributes the external loads to the fibers.

Only a very small proportion of applied load is sustained by the matrix phase. The reinforcement takes up the bulk of the applied load. The matrix material should be ductile.

The second function of the matrix is to protect the individual fibers from surface damage due to mechanical abrasion or chemical reaction with the environment.

Finally the matrix separates the fibers. Due to its relative softness and plasticity. It prevents the propagation of brittle cracks from fiber to fiber which may result in catastrophic failure.

In order to minimize fiber pull out, it is essential to have high adhesive forces between the fiber and matrix.

The strength of the resulting composite depends to a large extent on the magnitude of bonding strength between fiber and matrix. The bonding ensures proper stress transmittance from the weak matrix to the strong fibers.

Reinforced materials

In composite materials, the reinforcement is responsible for higher strengths. Two main forms of reinforcements used are:

(a) Fibers

(b) Particles

(a) **Fibers:** The materials used for reinforcing fibers have high tensile strengths. Based on the diameter and character, fibers are classified as follows.

(i) **Whiskers:** These are very thin crystals with extremely large length to diameter ratios. Because of their small size they have perfect crystalline structure and are free from flaws.

Due to this they have exceptionally high strengths and perhaps they are the strongest of all known materials. Some of the common whisker materials include graphite, silicon carbide, silicon nitride and aluminium oxide.

(ii) **Fibers:** The fibers are either polycrystalline or amorphous materials having small diameters. Fibrous materials are generally either polymers or ceramics.Some common fibers used are polymer aramids, glass, carbon, boron, aluminium oxide, silicon carbide etc.

(iii) **Wires:** Wire have relatively large diameters compared to fibers. Typical materials include steel, molybdenum and tungsten.The arrangement or orientation of the fiber, fiber concentration and distribution, all have a significant influence on the strength of the composites. The three types of orientation of fibers are shown in fig. 4.3.

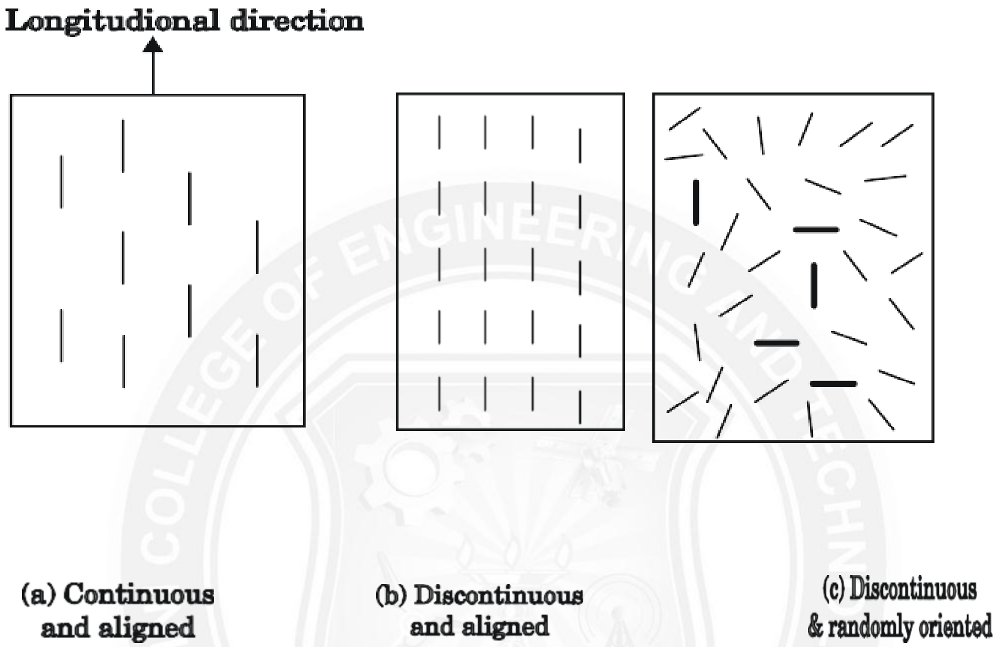


Fig. 4.3 Fiber orientation

(b) **Particles:** The particles having size of upto 1μ m or more in the concentrations of 20 to 40% have been used in composites.

Several metal particles such as tungsten, chromium, molybdenum etc, can be suspended in ductile matrix.

Non metallic particles such as ceramics can be suspended in metal matrix. The several metal oxides and carbides in the form of particles are used to produce metal matrix composites (MMC's).

Types of composites

Based on the matrix material

- ***Polymer matrix composites:*** In this the matrix material is a polymer, reinforced by ceramic. for example carbon or glass fiber reinforced with plastics.

Typical polymer matrix resins are epoxy, polyester, polyamide, and thermoplastics. Reinforcements are glass, quartz fiber and Kevlar.

- ***Metal matrix composites:*** In this composite, the matrix is a pure metal or an alloy and the reinforcement is a ceramic phase. Typical examples of metal matrix composites are Al – Al_2O_3 and Al-SiC.

- ***Ceramic matrix composites****:* The matrix and reinforcements are generally ceramics.

In these composites the stiffness and hardness of ceramics is combined with toughness of polymers or metals. Typical examples of ceramic matrix composites are glass-and carbon-fiber-reinforced plastics.