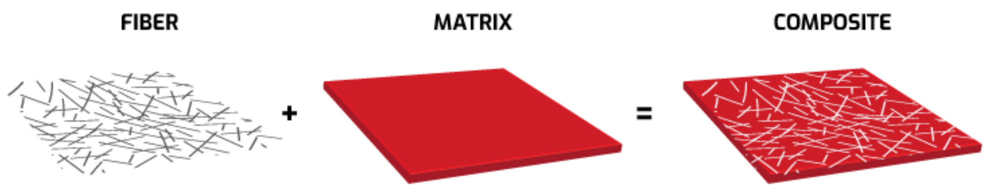
COMPOSITES



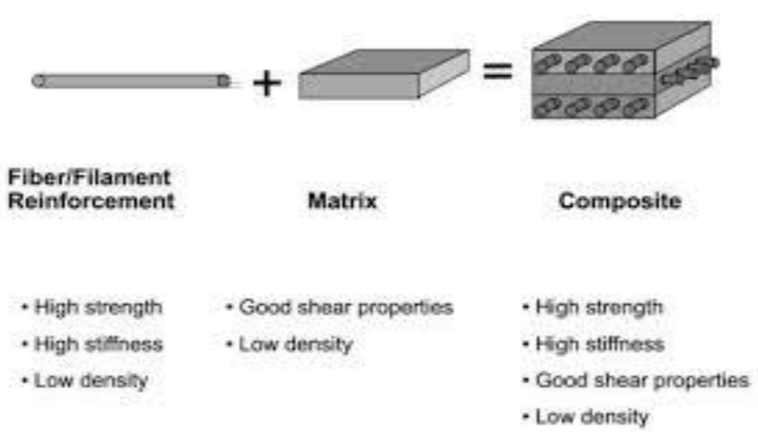
Many of our modern technologies require materials with unusual combinations of properties that cannot be met by the conventional metal alloys,ceramics,and polymeric materials. This is especially true for materials that are needed for aerospace, underwater, and transportation applications.

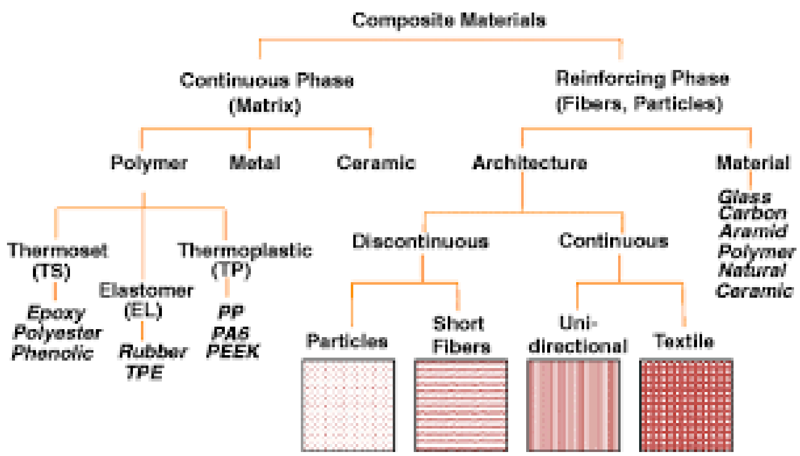
A composite, in the present context, is a multiphase material that is artificially made, as opposed to one that occurs or forms naturally. In addition, the constituent phases must be chemically dissimilar and separated by a distinct interface.

Composites are simply a combination of two or more constituent materials with different physical or chemical properties. When combined, they produce a material with characteristics different from their original properties. The two main components within a composite are **the matrix and fiber**. **The matrix is the base material while the fiber is what reinforces the material**. On top of the fiber reinforcements and matrix, composites can also include core materials, fillers, additives and surface finishes providing unique performance attributes.

In designing composite materials various metals, ceramics, and polymers are combined to produce a new generation of extraordinary materials. Most composites have been created to improve combinations of mechanical characteristics such as stiffness, toughness, and ambient and high-temperature strength.

The properties of composites are a function of the properties of the constituent phases, their relative amounts, and the geometry of the dispersed phase.



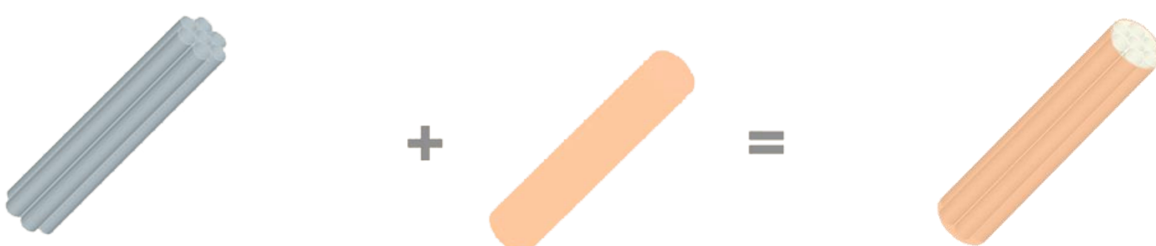


One simple scheme for the classification of composite materials is shown in above Figure, which consists of three main divisions:

Particle-reinforced, fiber-reinforced, and structural composites; also, two subdivisions exist for each. The dispersed phase for particle-reinforced composites is equiaxed (i.e., particle dimensions are approximately the same in all directions); for fiber-reinforced composites, the dispersed phase has the geometry of a fiber (i.e., a large length-to-diameter ratio). Structural composites are combinations of composites and homogeneous materials.

WHAT ARE COMPOSITES MADE OF?

Composites, also known as fiber-reinforced polymer (FRP) composites, are made from a polymer matrix that is reinforced with an engineered, man-made or natural fiber (like glass, carbon or aramid) or other reinforcing material. The matrix protects the fibers from environmental and external damage and transfers the load between the fibers. The fibers, in turn, provide strength and stiffness to reinforce the matrix—and help it resist cracks and fractures.



FIBER

Provides strength and stiffness
(glass, carbon, aramid, basalt, natural fibers)

MATRIX

Protects and transfers load between fibers
(polyester, epoxy, vinyl ester, others)

FIBER COMPOSITE MATRIX

Creates a material with attributes attributes superior to either component alone

Natural and synthetic composites

Composites can be natural or synthetic. Wood, a natural composite, is a combination of cellulose or wood fibers and a substance called lignin. The fibers give wood its strength; lignin is the matrix or natural glue that binds and stabilizes them. Other composites are synthetic (man-made).

Plywood is a man-made composite that combines natural and synthetic materials. Thin layers of wood veneer are bonded together with adhesive to form flat sheets of laminated wood that are stronger than natural wood.

The benefits of composites include:

- Lightweight
- High strength
- Corrosion resistant
- High strength-to-weight ratio
- Directional strength - tailor mechanical properties
- High impact strength
- High electric strength (insulator)
- Radar transparent
- Non-magnetic
- Low maintenance
- Rapid installation
- Long-term durability
- Parts consolidation
- Dimensional stability
- Small to large part geometry – styling/design – sculptural form
- Customized surface finish

COMPOSITION OF COMPOSITES

1. FIBER (REINFORCEMENTS)

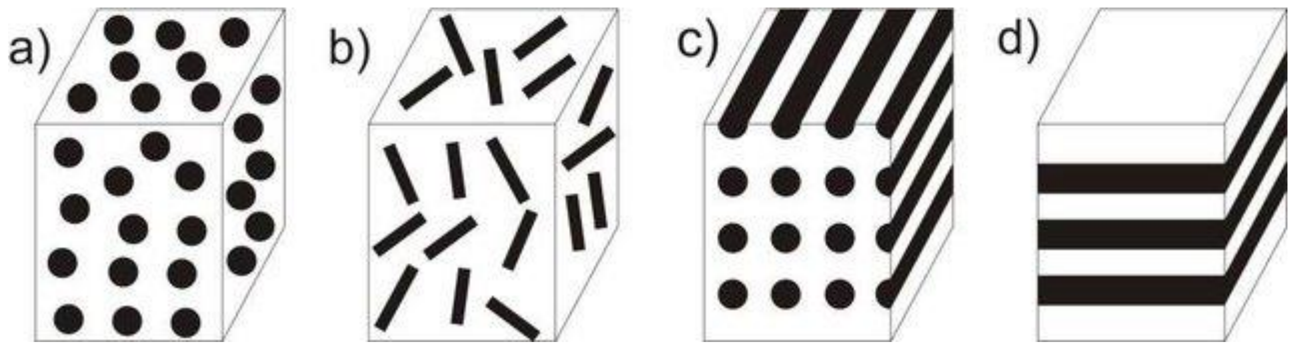
Fiber reinforcement- such as glass, carbon, aramid or other reinforcing material such that there is a sufficient aspect ratio (length to thickness) to provide a discernable reinforcing in one or more directions.

TYPES OF FIBERS

GLASS FIBERS	CARBON FIBERS	ARAMID FIBERS (POLYARAMIDS)
Highly versatile Impact resistance Stronger than steel in certain forms Transparent to radio signals	Lightweight, strong High temperatures High strength Extremely lightweight	Extremely strong, lightweight Low density Damage / impact resistance Compression Heat, electricity insulation

Reinforcement determines the four major types of composite materials and they are as follows

a) Particles (also known as discontinuous reinforcement)
b) Short fiber or whiskers
c) Continuous fibers
d) Plates



Various types of reinforcement in composites: a) particles, b) short fibers, c) continuous fibers, d) plates Reinforcement determines the four major types of composite materials (Figure 5) and they are as follows: a) particles (also known as discontinuous reinforcement), b) short fiber or whiskers, c) continuous fibers, d) plates.

2. Resin

Polymer matrix resin, either thermoplastic or thermoset, such as polyester, isopolyester, vinyl ester, epoxy, phenolic.

There are two major groups of resins that make up what we call polymer materials—thermosets and thermoplastics. Thermoset resins are used to make most composites. Unlike thermoplastics, they are converted from a liquid to a solid through a process called polymerization, or cross-linking. When used to produce finished goods, thermosetting resins are "cured" by the use of a catalyst, heat or a combination of the two. Once cured, solid thermoset resins cannot be converted back to their original liquid form. Thermosets cross link during the curing process to form an irreversible bond.

POLYESTER	**EPOXY**	**VINYL ESTER**	**PHENOLIC**	**POLYURETHANE**
Highly versatile – 75% of all resins used Balance of properties Faster cure / better handling	Strong properties, more complex processing Low shrinkage Corrosion & temperature resistance Superior mechanical, electrical properties Excellent substrate adhesion	Combination of polyester and epoxy properties Mechanical strength, corrosion resistance Better handling / faster cure Easier processing / handling / fabrication than epoxy	High temperature, insulation properties Creep resistance Thermal insulation Corrosion resistance Sound dampening Excellent fire/smoke resistance	Tough, flexible, good adhesion Abrasion resistance Impact resistance Chemical resistant Good substrate adhesion Rapid curing

Additive

Fillers, additives, core materials are added to composites to control the molding process or enhance the physical properties of the final product (color, strength, durability, fire resistance, and many more characteristics).