COMPOSITE MATERIALS

What is composite?
A composite is a solid material that results when two or more materials are combined (physically, not chemically) with strong bonding between them to create a new material whose properties are superior in a specific application those of the original materials. One of the constituent is called the MATRIX which surrounds other constituent often called the REINFORCING or DISPERSED phase.
Example: concrete reinforced with steel.

Why study composites?
With a knowledge of the various types of composites, as well as an understanding of the dependence of their behaviors on the

- Characteristics
- Relative amounts
- Geometry / distribution
- And properties of the constituent phases.

It is possible to design materials having property combinations that are better than those found in metals alloy, ceramics, and polymeric materials alone.
Classification of composite according to the nature of MATRIX (HOST)

**Polymer**
- Polymer-Matrix (PMC)
  - Ex: (tyre) rubber reinforced with carbon black

**Ceramic**
- Ceramic–Matrix (CMC)
  - Ex: concrete

**Metal**
- Metal–Matrix (MMC)
  - EX: Al reinforced with carbon
Classification of composite according to the FILLER

- Particle-reinforced
  - Dispersion strengthened Particle diameter (0.01-0.1)μm
  - Particulate reinforced Particle diameter >1 μm
- Fiber-reinforced
- Laminate-reinforced
  - Continuous (Oriented)
  - Discontinuous (random) Short fiber, Whiskers
  - Hybrid
The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties or replace some of the polymer volume with a less expensive material - the filler. It is very important to remember that these components are highly or strongly bonded together or stuck together, and are close and strong contacts with each other when performing.

### Composite properties

<table>
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<tr>
<th>Properties of matrix and dispersed phase</th>
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<td>Amount of matrix and dispersed phase (volume fraction)</td>
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<tr>
<td>Shape, orientation and size of dispersed phase</td>
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<td>The bond between the reinforcement and its matrix</td>
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### Material design

To design a composite material to fulfill a certain desire of a certain user, one may ask about the conditions (mechanical, thermal, chemical, …..) under which the composite will perform. Accordingly the constituents may choose and their volume
fractions may be calculated. Moreover, their production process may choose.

Fiber – reinforced composites are mainly used for mechanical (tensile strength) applications. This means that the designer would choose to reinforce with fibers, when the tensile strength of a matrix must be enhanced. The long fiber will make the composite very strong in certain direction but not very strong in the other direction. Hence, the material will be anisotropic.

Anisotropic: materials which have directionality in their properties. The values of their properties depend on directions.

When a powder dispersed within a matrix, then in this case the designer intend to modify of the physical properties of the matrix. The designer would chose to use laminated composite if a structural material with a very high (strength/ weight) ratio, like sandwich panels, or honey comb structures.

If chopped fibers are used to reinforce a matrix, then its tensile strength will be enhanced the way in all directions. It may be assumed that:

1/3 of the fibers are aligned in the X direction.
1/3 of the fibers are aligned in the Y direction.
1/3 of the fibers are aligned in the Z direction.

Hence, the resulting composite will be equally reinforced in all directions, it is considered as isotropic material.
Isotropic: materials which have no directionality in their properties.

**History of composite materials**

The earliest man-made composite materials were straw and mud combined to form bricks (unfired) for building construction. The history of modern composites probably began in 1937 when a salesman from the Owens Corning Fiberglass Company began to sell fiberglass (had been made, almost by accident in 1930) to interested parties around the United States.

**Natural composites**

There exist natural composites among the materials present in nature. Wood is a natural composite of cellulose fibers in a matrix of lignin. The bone also is a natural composite of calcium fibers bonded together within a natural matrix.

**Dispersion-Strengthened Composite**

Dispersed particle-matrix interactions that lead to strengthening occur on the atomic or molecular level. Metal may be strengthened and hardened by the uniform dispersion of several volumes present of fine particles of a very hard and inert material.
**Particle-Reinforced Composites**

Strengthening is not improved by interference of particles with dislocation. They tend to restrain movement of the matrix in the vicinity of the particle.

The matrix transfers some of the applied stress to the particles, which bear a fraction of the load.

**Fiber-Reinforced Composite**

The mechanical characteristics of a fiber–reinforced composite depend not only on the properties of the fiber, but also on the degree to which an applied load is transmitted to the fibers by the matrix phase. Important to the extent of this load transmittance is the magnitude of the interfacial bond between the fiber and matrix phases. Under an applied stress, this fiber-matrix bond cases at the fiber ends, yielding a matrix deformation, there is no load transmittance from the matrix at each fiber extremity.