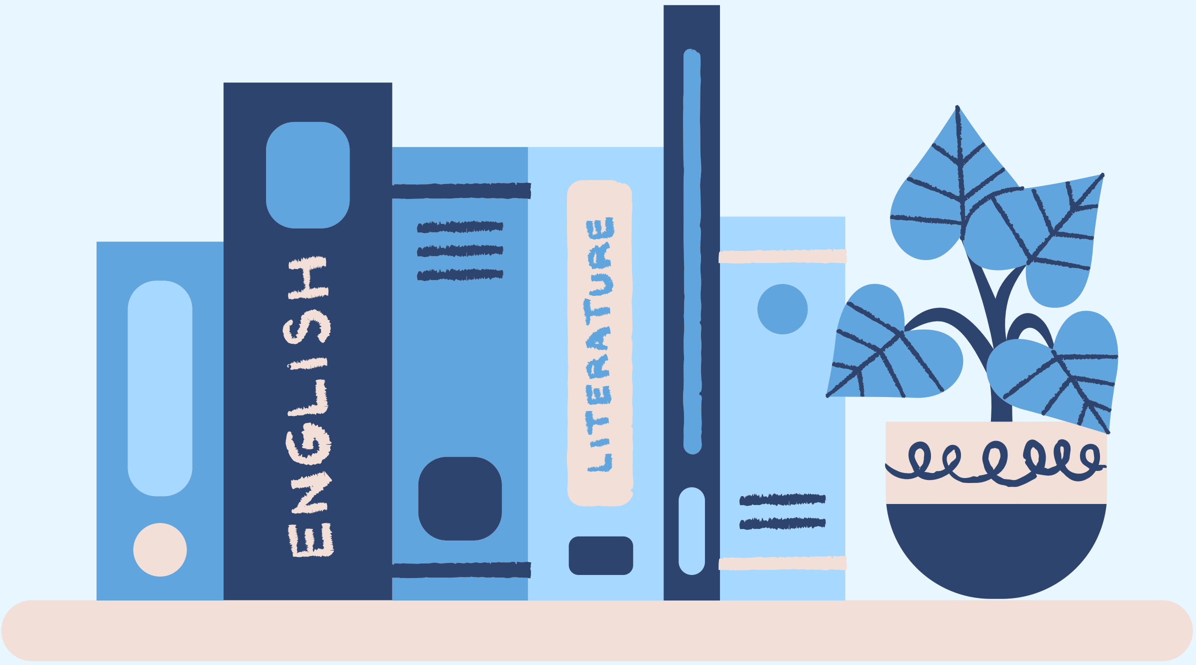
COMPOSITE MATERIALS: AN INTRODUCTION

Presented by Sweshareefa Mahakul, Assistant Prof.
ME



WHAT ARE COMPOSITE MATERIALS?

A composite material is an engineered material made from two or more constituent materials with significantly different physical or chemical properties. When combined, they produce a material with characteristics superior to those of the individual components. The constituents retain their separate identities within the finished structure, yet act together to provide enhanced performance. Composites typically consist of a reinforcement phase (e.g., fibres or particles) embedded within a continuous matrix phase.

Sweshareefa Mahakul | Assistant Prof., ME

CLASSIFICATION BASED ON STRUCTURE

- Particulate Composites: Composed of particles (spherical, flake, or irregular) dispersed in a matrix. Examples include concrete, metal-matrix composites with carbide particles, and polymer composites with filler particles.

- Fibrous Composites: Reinforced with fibers (continuous or discontinuous) such as glass, carbon, or aramid fibers. Laminar Composites: Consist of layers/laminae bonded together, e.g., plywood, bimetallic strips, and fiber-reinforced laminates.

OVERVIEW

- Polymer Matrix Composites (PMC): Most widely used class of composites. The matrix is a polymer resin (epoxy, polyester, nylon). Reinforced with glass, carbon, or aramid fibers. Lightweight, corrosion-resistant, and easy to fabricate. Used in aerospace, automotive, and sporting goods.

- Metal Matrix Composites (MMC) & Ceramic Matrix Composites (CMC): MMC use metals like aluminum or titanium as the matrix, offering high strength and thermal resistance. CMC use ceramic matrices for extreme high-temperature applications. Both provide superior stiffness and durability over conventional materials.

ADVANTAGES

Composites offer an exceptional high strength-to-weight ratio, making them significantly stronger than metals like steel and aluminum while being much lighter. This property is critical in aerospace, automotive, and structural applications where weight reduction directly improves performance and fuel efficiency.

Composite materials exhibit outstanding corrosion resistance compared to metals. They do not rust or degrade easily when exposed to moisture, chemicals, or harsh environmental conditions, resulting in longer service life and reduced maintenance costs in marine, chemical, and infrastructure applications.

Composites offer remarkable design flexibility, allowing engineers to tailor mechanical, thermal, and electrical properties by selecting appropriate fiber orientations, matrix materials, and reinforcement types to meet specific functional requirements of a given application.

APPLICATIONS

Aerospace Applications: Composite materials are widely used in aircraft structures (fuselage, wings, tail sections), spacecraft components, satellite structures, and rocket motor casings due to their high strength-to-weight ratio and fatigue resistance.

Automotive Applications: Composites are used in body panels, hoods, drive shafts, leaf springs, and chassis components. They reduce vehicle weight, improve fuel efficiency, and enhance crash resistance and durability.

APPLICATIONS

Construction & Infrastructure: Composite materials are widely used in bridges, reinforcement bars, and structural panels. Carbon and glass fiber composites offer high strength-to-weight ratios, corrosion resistance, and durability, making them ideal for modern civil engineering projects.

Sports Equipment & Medical Devices: Composites enable lightweight, high-performance sports gear such as rackets, bicycles, and helmets. In medicine, carbon fiber composites are used in prosthetic limbs, orthopedic implants, and surgical tools due to biocompatibility and strength.

FUNCTIONAL REQUIREMENTS OF REINFORCEMENT

Mechanical Properties: Reinforcement must possess high strength and high stiffness (modulus of elasticity) to carry applied loads effectively. It should have low density to ensure lightweight composite structures without compromising structural performance.

Compatibility & Stability: Good interfacial bonding with the matrix is essential for efficient stress transfer. Reinforcement must exhibit thermal stability, chemical resistance, and dimensional stability under service conditions to maintain composite integrity.

FUNCTIONAL REQUIREMENTS OF MATRIX

- Load Transfer to Reinforcement: The matrix must effectively transfer applied loads to the reinforcement fibers or particles. It distributes stress uniformly across the reinforcement, ensuring the composite utilizes the high strength of the reinforcing phase and prevents localized failure under mechanical loading conditions.

- Protection & Binding: The matrix protects reinforcement from environmental degradation such as moisture, chemicals, and oxidation. It binds the reinforcement together, maintains their relative positions, provides cohesion to the composite structure, and ensures dimensional stability and integrity of the material.

THANK YOU

SWESHAREEFA MAHAKUL
Assistant Prof., Department of Mechanical Engineering