metal / non-metal

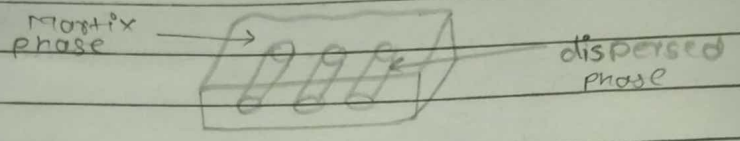
Module - 2

Engineering materials

Composite material: A composite material is a combination of two or more material with different physical and chemical properties

Matrix phase :

- It is the continuous body constituent, which encloses the composite and give it its Bulk Form.



dispersed phase :

- It is the structural constituent, which determines the internal structure of composite.

Application of composite material :

- used in automobile industries
- used in pump part
- used in turbine engines
- used in electronic circuit boards
- used in High speed machinery
- Fabrication of roofs and floors

The matrix phase:

- It is the continuous body constituent, which encloses the composite and gives it its bulk form (particle)
- Matrix phase should be → ductile, → corrosion resistant
- Matrix phase may be → metal, → ceramics, → polymer
- when composite are this matrix are known (two or more material)
  - Metal matrix composites,
  - Ceramic matrix composites,
  - polymer matrix composites
- matrix phase should be → ductile, → corrosion resistant
  - Posses high bonding b/w matrix and dispersed phase

ex:- Al, Cu and commerical thermoplastic and thermosetting polymer mat

Function:

- It binds the dispersed phase together.
- protect the dispersed phase from the environment
- to prevent propagation (spreading) of cracks.
- to act as a medium for distribution of applied load to dispersed phase

Particle :- length, diameter ratio is low

Dispersed phase :

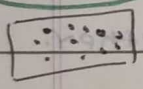
- It is the structural constituent, which determines the internal structure of composite

- The important dispersed phases of composites are (1) Fiber → length, diameter ratio is High
  (2) Particulates
  (3) Flakes
  (4) Whiskers

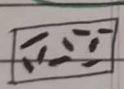
Characteristics :

(1) The length to diameter ratio is very High
(2) High tensile strength.
(3) High Stiffness
(4) They posses low overall density

Particle : length to diameter ratio is low

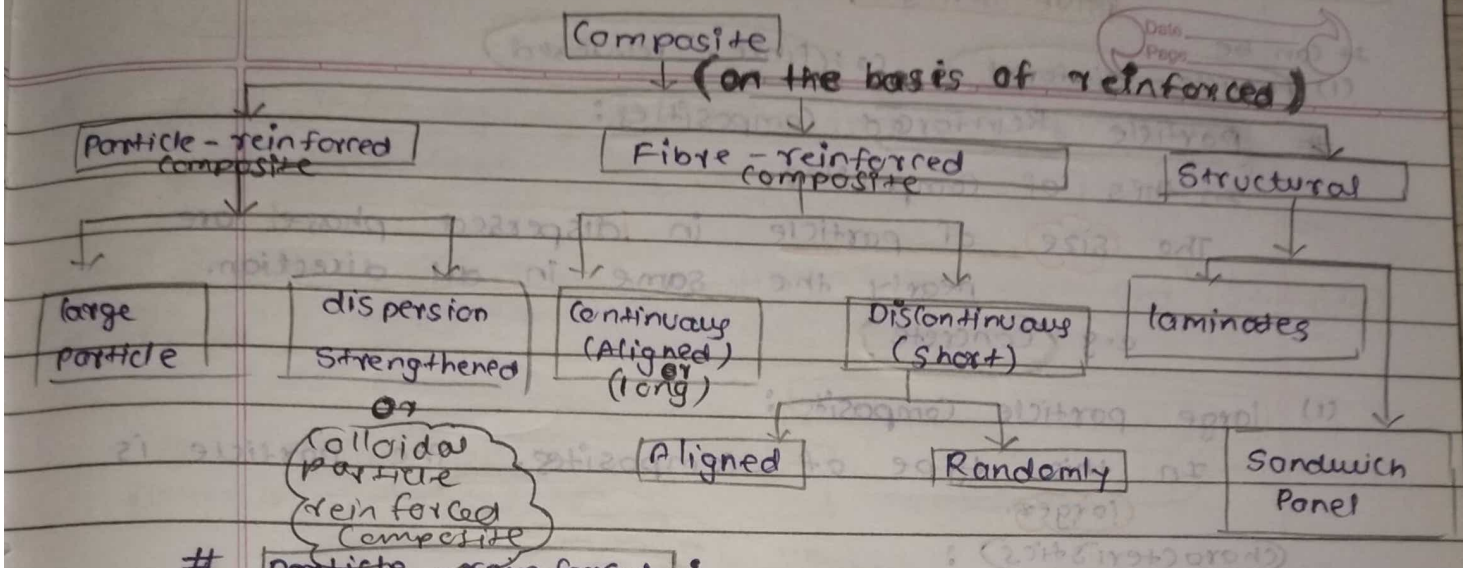


Fibre : → length to diameter ratio is High



→ It is thin filament and long.

Classification of composite :



Particle - reinforced :

In this type of composite ~~the particulate~~ ~~the particles~~ P

Reinforcing : It is the discontinuous phase and give strength to the Composit

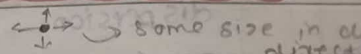
It can be
(1) particle - reinforced
and
(2) Fibre - reinforced.

Reinforcing :- It is the **discontinous phase** and **give strength** to the composite.

It can be
(1) **particle - reinforced** (2) **Fibre - reinforced**

Particle Reinforced Composities:

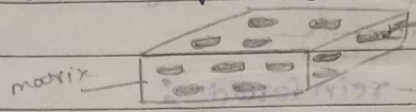
In this of composites,
The **size** of particle in **dispersed phase** are nearly the **same** in all direction.
e.g **Concrete**



(1) **large particle Composite**:

In this type of composites, The particle is **larger**.

Characteristics :



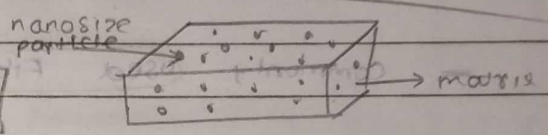
(a) **Stiffer** and **harder** as compared to **matrix phase**. dispersed phase
(b) It **act** as **reinforcing material**. Provide the strength to the composite
(c) The **bond strength** b/w the **2 phases** matrix phase and dispersed phase govern (hold) the **mechanical properties** of the composite

Material	matrix phase	particulate phase	Properties
(1) Concrete	Cement	Sand and gravel	(1) RCC is harder than ordinary cement. (2) Sets well on surface thereby holding structure.
(2) Cermets			
(a) Oxide based	Cr	Al_2O_3	(1) crossed strength (2) very good thermal shock resistance
(b) Carbide based	Co or Ni	Tungsten carbide (WC)	(1) very hard (2) very high surface hardness

(1) The aggregate of coarse rock or gravel embedded in a matrix of cement.

(2) The aggregate provides stifness and strength

(2) Dispersion strengthened composite



- In this type of composite, the particle size is smaller 10 to 100nm
- The metals and allay are made in small particle to given range and are dispersed in the matrix phase. This is achieved by appropiate heat treatement is called precipitation hardening.
- Nanosized particle are added to the matrix phase which make the composite and given harder stronger
- E.g such as allay of Cu-Sn, mg-Al

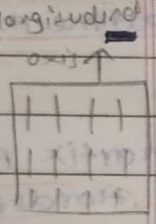
Cu-Sn

Fiber reinforced Composite :-

- In these Composite the dispersed phase in form of Fiber
- These Composite material are made up → polymer matrix, Filament, bonding agent
- Commonly used Fiber are → glass or metallic
- These fibers are either Continous manner and distinous manner
- The Strength and other ~~Epe~~ properties of Fiber reinforced Composites mainly depend → arrangement → orientation
- the fiber Concentration and the distribution

Based on fibers orientation

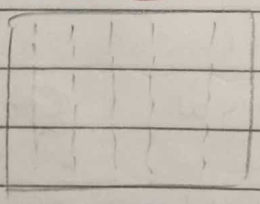
(1) Parallel alignment of the longitudinal ~~for~~ axis of the fibers in a single direction

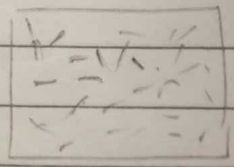


(2) totally random alignment.

discontinous fibers are normally aligned

discontinous fiber may be aligned randomly oriented or partially oriented

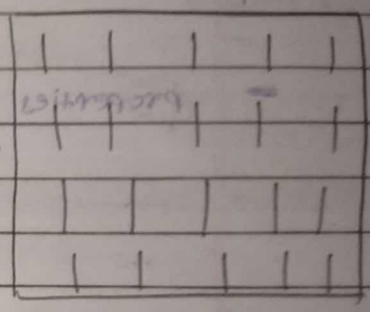




Properties of fiber reinforced Composite

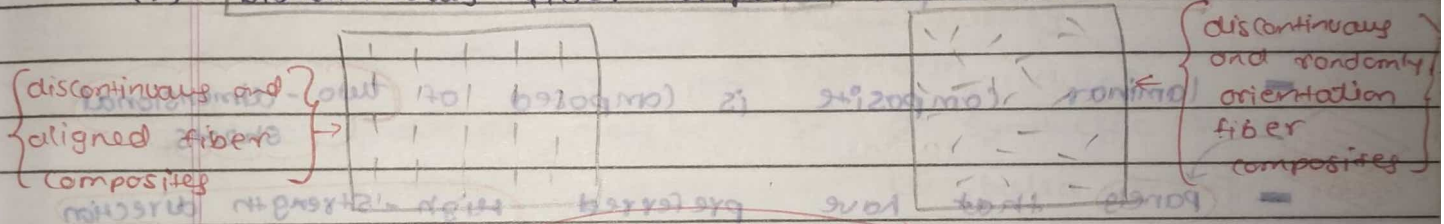
(1) High tensile strength
(2) High specific gravity
(3) stiffness
(4) They posses low overall density
(5) High elosite modulus.

(1) Continuous and Aligned fiber Composite :-



- The properties of Continuous and aligned Fiber composite are highly anisotropic
  - They depend on the direction in which they are measured
- The maximum strength is achieved along the direction of fiber alignment (longitudinal)
- The fiber reinforcement being ~~to~~ virtually non-existent in the direction of transverse
  - relatively low tensile stresses.

(2) Discontinuous fiber Composite :



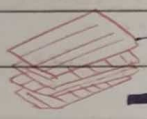
- The fibres are short and discontinuous may be aligned or randomly oriented
- There are two types of discontinuous fiber composite
  (a) Discontinuous and aligned fiber composites
  (b) Discontinuous and randomly oriented fiber composite
- The discontinuous fibers have lower reinforcement efficiency than that for continuous fibers
- discontinuous and aligned fiber composite have greater application in the commerical market compared to continuous and aligned composite

Structural Composite:

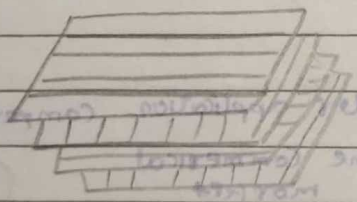
- Structural composite is composed of both Homogeneous material and composite material
- Properties depend on the properties of constituent material and geometric design
- Structural composites can be classified in two part
  (1) laminar composities
  (2) Sandwich panels

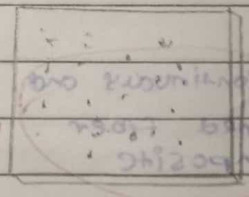
(1) Laminar Composities:

- laminar composite is composed of two-dimensional sheets



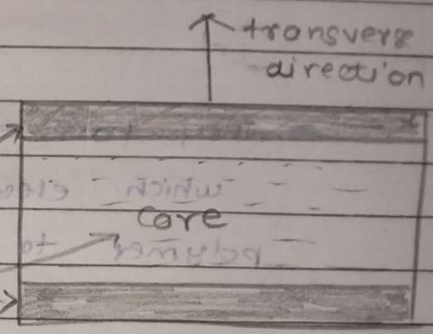
- panels that have preferred high-strength direction such as is found in wood and continuous and aligned fiber-reinforced plastics
- e.g adjacent wood sheets in plywood
- laminar composite has relatively high strength in a no. of direction in the two-dimensional plane.
- The strength in any given direction is lower than all the fibers were oriented in that direction



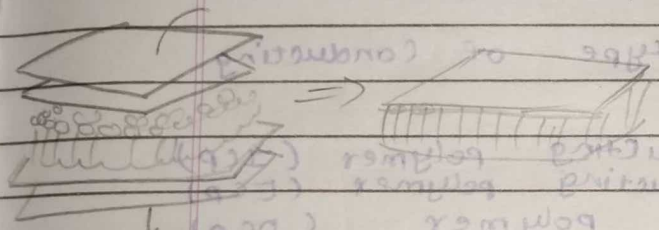


(2) **Sandwitch Composites:**

- Sandwitch panels are designed to be light-weight beams.
- have relatively High Stiffness, Strength
- A Sandwich panel consists two outer sheets are called faces
- Faces that are separated by thicker core



- Face are made by :- ① fibre-reinforced plastic
  ② plywood
  ③ steel
  ④ plywood
  ⑤ aluminum alloy
  ⑥ titanium



- Core material may be :- ① Synthetic rubber
  ② balsa wood
- Core consist of a "Honeycomb" structure thin foils formed into (interlocking hexagonal cell)
- Honey comb are formed by interlocking Hexagonal cell and with axes oriented ⊥ to the face plane
- Honey comb material Normally either aluminum alloy or aramid polymer
- Honeycomb of Stiffness and Strength depend upon Cell size, Cell wall thickness
- application of Sandwich panel
  roofs, floors and wall of building, aeroplanes and aircraft (for wings, fuselage and tail-plane skin)

Conducting polymers:

- A polymers which are conduct electricity is called conducting polymer
  or
- They can be made conductive by doping with an electron donor and electron acceptor
- They have extended P-orbital system through which electrons can move from one end of the polymer to the other.
- e.g Polyacetylene, polyaniline etc.
- There are following type of conducting polymer.
  (1) Intrinsically conducting polymer (ICP)
  (2) Extrinsically conducting polymer (ECP)
  (3) Doped conducting polymer (DCP)
  (4) Co-ordination conducting polymer (CCP)

Application:

(1) Rechargeable batteries
(2) Solar cells
(3) photovoltatic cells
(4) Antistatic coating
(5) Sensors
(6) transistor
(7) optical fibres

Nanowires :-

- Nanowires are defined the structures which have the diameter order of a nanometer

- These also called quantum wires → { they have different quantum mechanical effect
- There are different types of Nanowire
  - Carbon nanowires,
  - molecular nanowires,
  - metallic nanowires

Application

- They are useful in digital computing
- They are also use to prepare electrical component like p-n junction, logic gates
- High-density data storage.

Nano material → 10^{-9} → one-billionth of a meter

↳ As material with atleast one dimension between 1nm to 100nm are known as Nano material

Properties of Nonomaterial

(1) Surface to volume ratio :

- They have a high surface area compared to their volume

them highly reactive and useful for catalysis

Bulk material → Nano material

(2) The opaque substance become transparent

(3) Material when reduced to nano size display very different properties

(4) Melting point :-

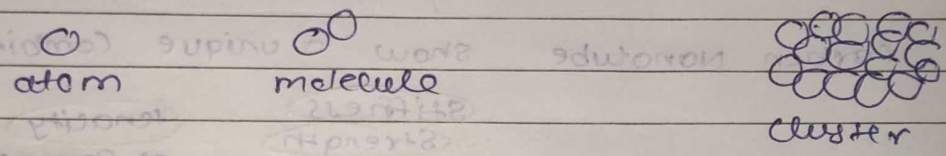
Nano material → often → lower m.p due to their size which can be advantageous in specific application

(5) Electrical behaviour :- Depending on their size, composition, nanomaterial can be improved electrical conductivity

Types of Nanomaterial

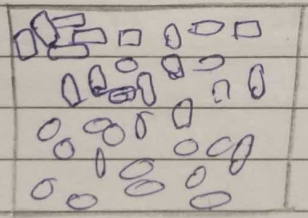
(1) **Nanocluster**

- A nanocluster is a tiny group of atom or molecule
  - usually ranging from few to 100 nm in size
- Nanocluster exhibit unique properties.
- They have a
  - ⊕ High surface to volume ratio
  - ⊕ lower m.p
    - ↳ as compared to Bulk material
- ⊕ display varying electrical behaviour → due their size and composition



(2) **Nanorods**

- A Nanorods are extremely small • rod-shaped structure at the nanoscale.
- Nanorods exhibit unique properties
- They have a
  - High surface to volume ratio
  - different m.p
    - ↳ as compared to bulk material
- Electrical behaviour of nanorods can vary
  - depending on their composition and dimensio

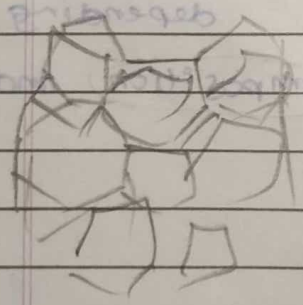


(3) Nanotubes → cylinder from one or more layer of graphene

- A Nanotube is an extremely small tube-shape structure
  - usually of the form <1mm to 50nm
- It can be made of different material like of carbon.
- Carbon Nanotube is a tube-shaped material structure, made up of carbon, having diameter ranging form <1hm to 50nm
- Carbon Nanotube show a unique combination of Stiffness, Strength, tenacity as compared to other fibre material
- as High Thermal and electrical conductivity as compared to other conductive material

Carbon Nanotube → Single-wall Nanotube (SWNT)
↳ These may be zigzag, arm chair, chiral depending on the manner which the graphene sheet are rolled

→ multi-wall nanotube MWNT
↳ It consist several single walled nanotube with different diameter



application:

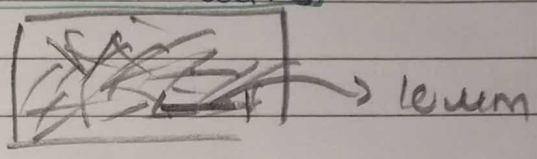
- Nanotube can potentially replace indium tin oxide in Solar cells to generate photocurrent

- SWNT → used in transistor and solar panel

- MWNT → used in lithium ion batteries
  ↳ To increase cycle life

- Parallel CNT → used to create loudspeaker

- CNT → used to produce nanowires



(4) Nanowires

- Nanowires is an extremely thin wire-shape structure with a diameter on the order of Nanometer (1 to 100 nm)

- It is also called quantum wire
  ↳ They have different quantum mechanical effect

- type →
  - Carbon Nanowire
  - molecular Nanowire
  - metallic Nanowire

application:

- They are useful in digital computing
- They are also use to prepare electrical components like p-n junction, logic gates
- High-density data storage