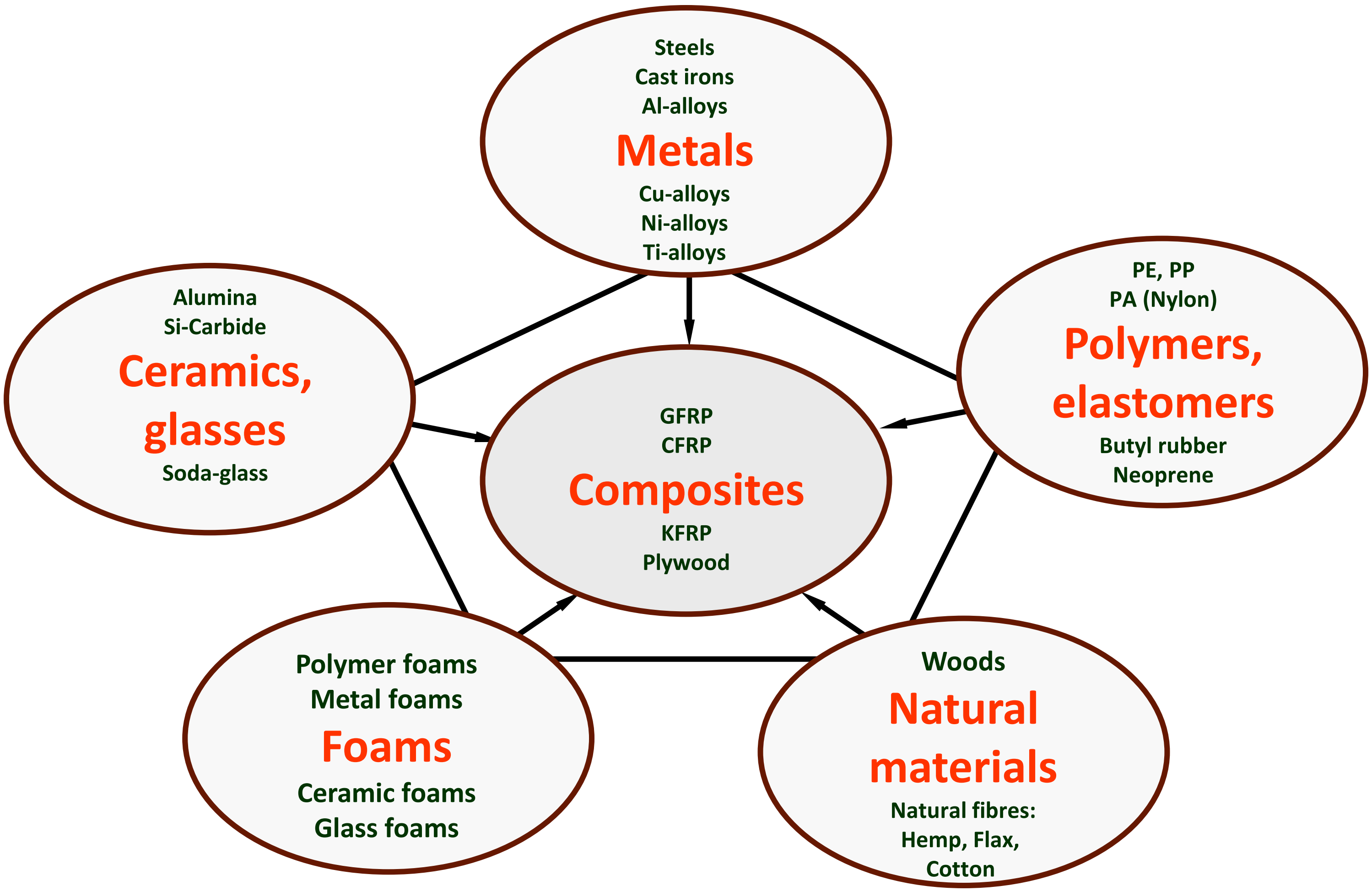
COMPOSITE MATERIALS

The world of materials



Definition

- A broad definition of composite is: Two or more chemically distinct materials which when combined have improved properties over the individual materials.
- The constituents retain their identities in the composite; that is, they do not dissolve or otherwise merge completely into each other, although they act in concert.

Advantages of Composites

- Light in weight
- Strength-to-weight and Stiffness-to-weight are greater than steel or aluminum
- Fatigue properties are better than common engineering metals
- Composites cannot corrode like steel
- Possible to achieve combinations of properties not attainable with metals, ceramics, or polymers alone

Components in a Composite Material

- Nearly all composite materials consist of two phases:

1. Primary phase - forms the *matrix* within which the secondary phase is imbedded

1. Secondary phase - imbedded phase sometimes referred to as a *reinforcing agent*, because it usually serves to strengthen the composite
    - The reinforcing phase may be in the form of fibers, particles, or various other geometries

Functions of the Matrix Material (Primary Phase)

- Provides the bulk form of the part or product made of the composite material

- Holds the imbedded phase in place, usually enclosing and often concealing it

- When a load is applied, the matrix shares the load with the secondary phase, in some cases deforming so that the stress is essentially born by the reinforcing agent

The Reinforcing Phase (Secondary Phase)

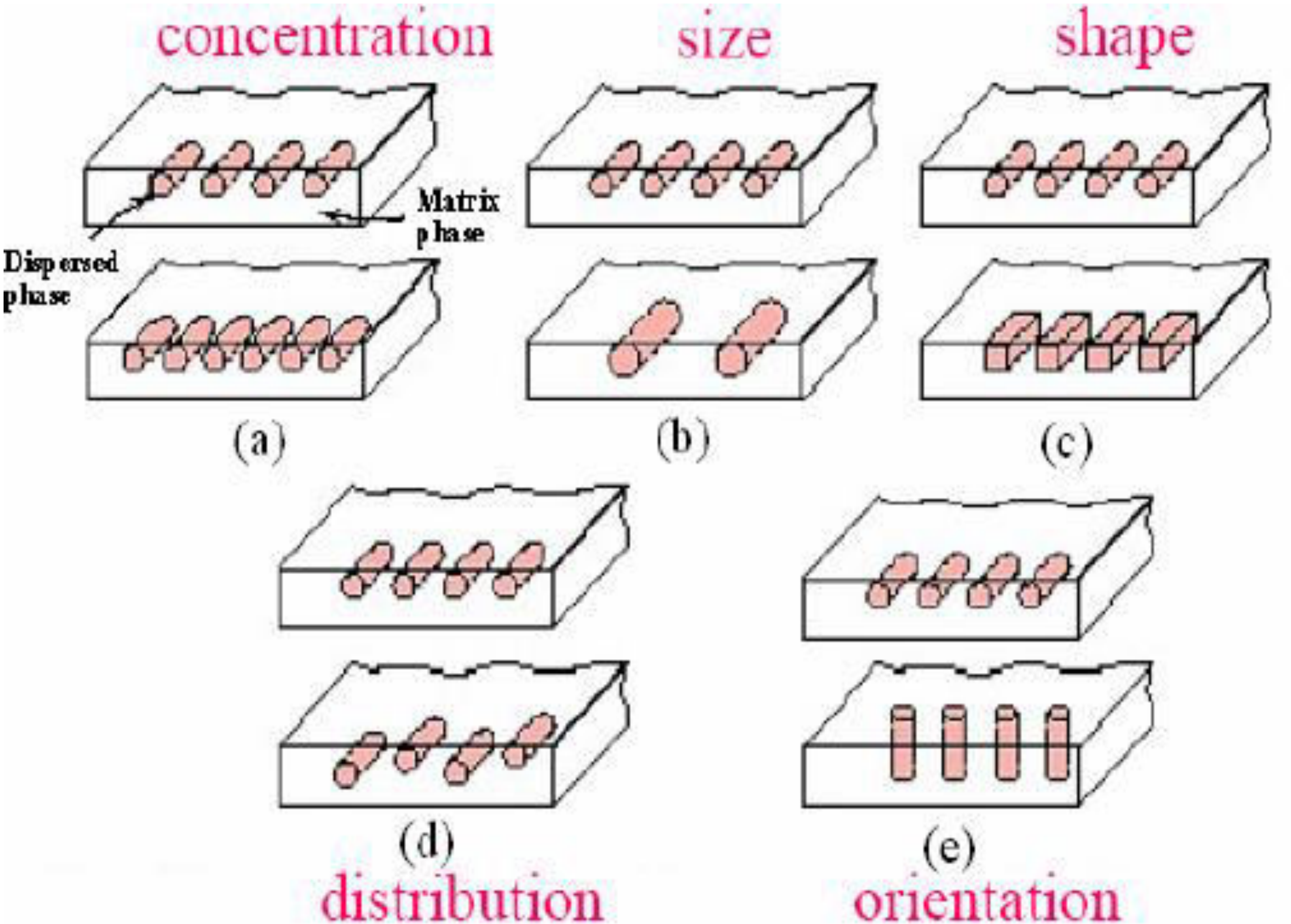
- Function is to reinforce the primary phase
- Imbedded phase is most commonly one of the following shapes:
  - Fibers
  - Particles
  - Flakes

Factors in Creating Composites

Matrix material

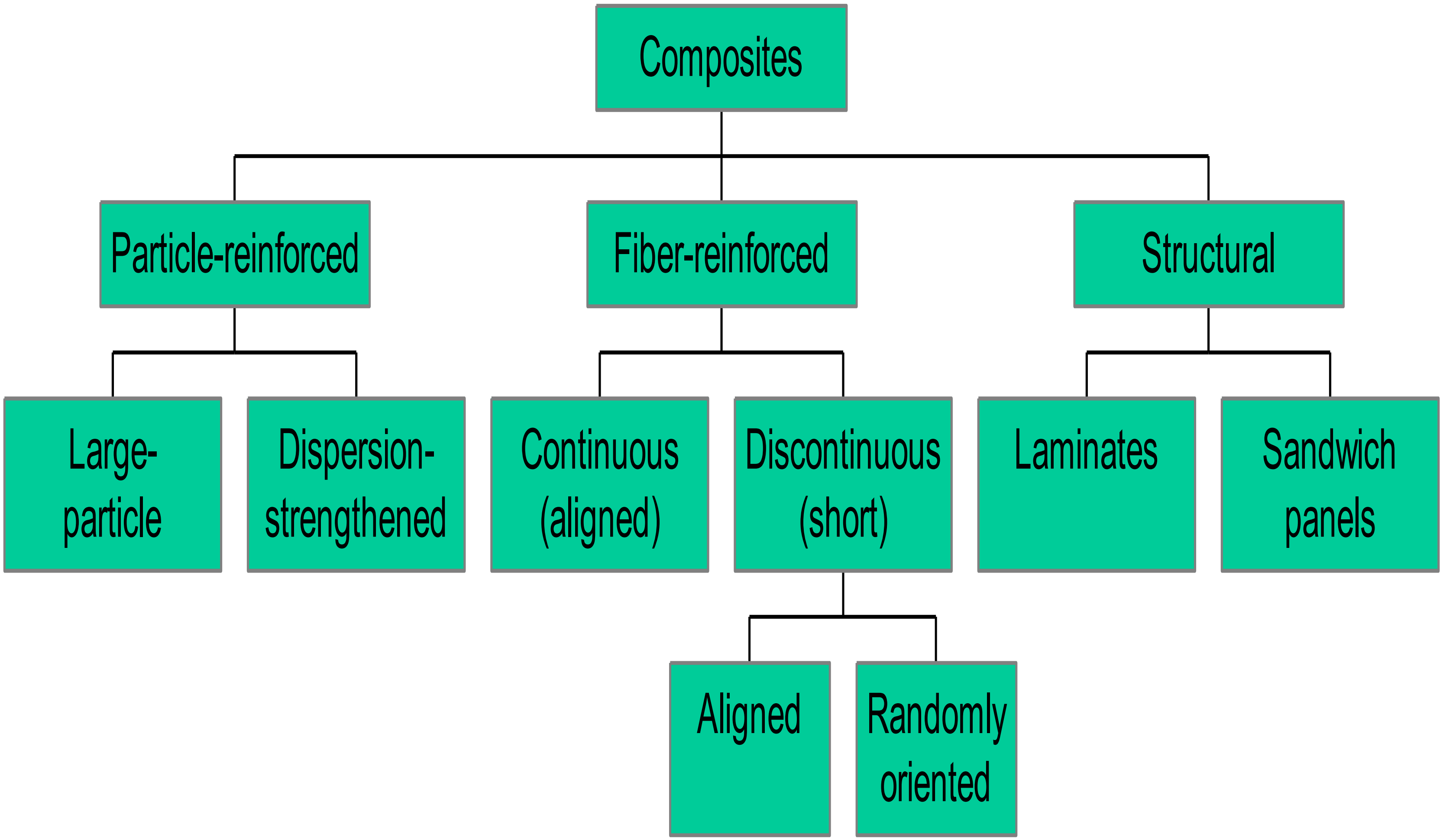
Reinforcement material

- *Concentration*
- *Size*
- *Shape*
- *Distribution*
- *Orientation*


concentration
size
shape
Matrix phase
Dispersed phase
(a)
(b)
(c)
(d)
(e)
distribution
orientation

Classification

Based on type of reinforcement



Large particle reinforced composites

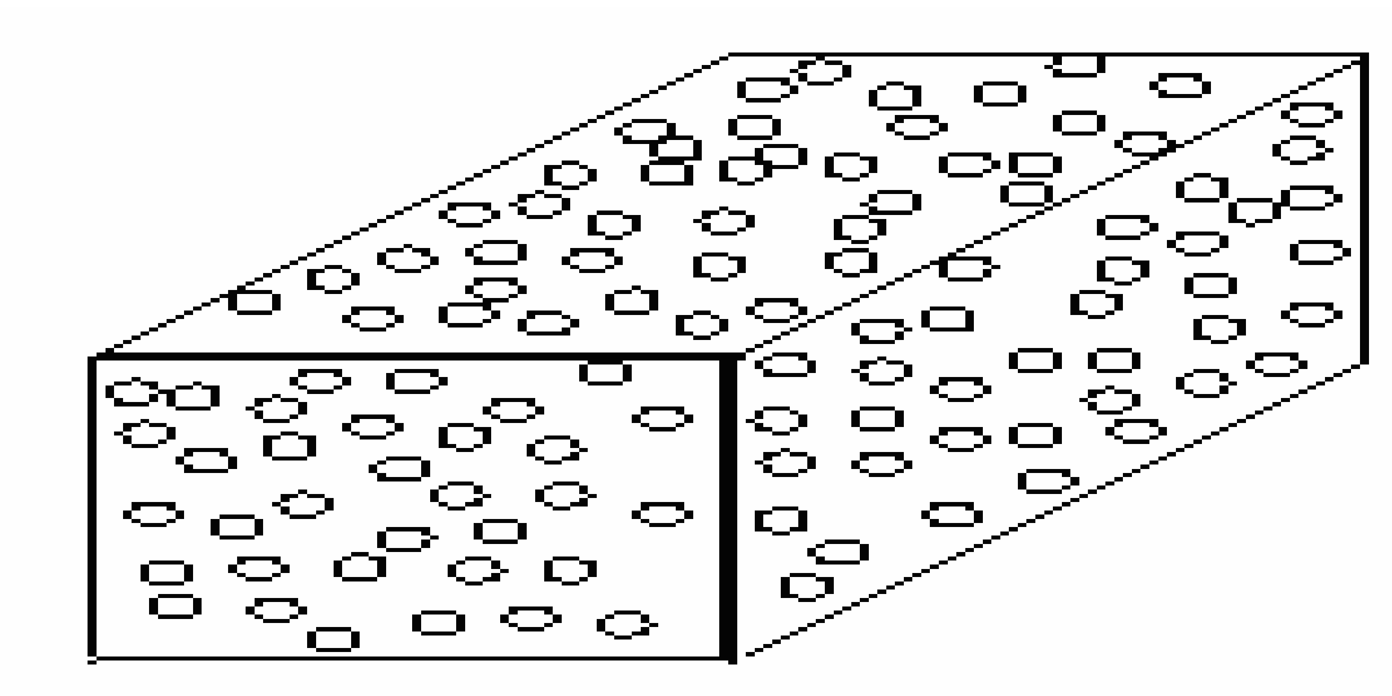
- Particle size is 1-50μm
- Concentration usually ranges from 15-40% by volume
- The particulate phase is harder and stiffer than the matrix.
- Particles provide strength to the composite by restraining the movement of the matrix

- **Cermets**-tungsten carbide or titanium carbide
- **Vulcanized rubber-** carbon black in rubber
- **Concrete**- sand and gravel particulate in a surry of cement matrix.

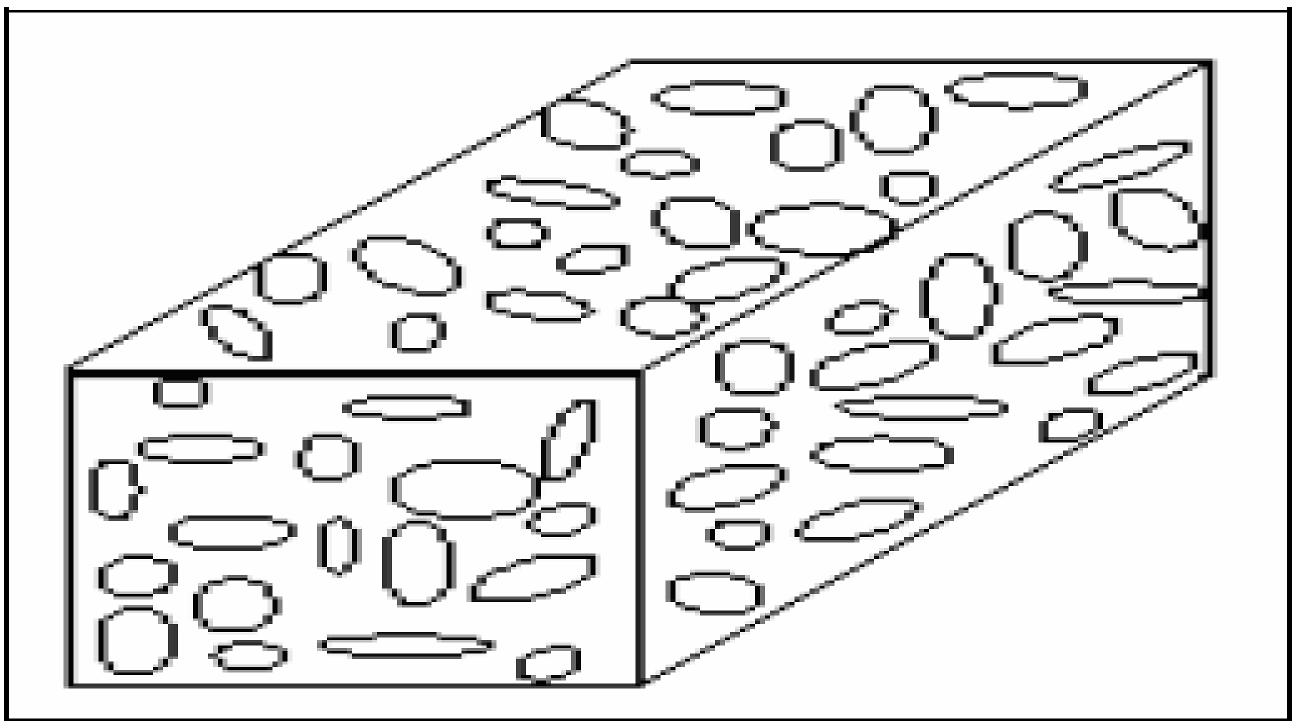
Dispersion strengthened composites

- Uniformly dispersed fine, hard and inert particles of size less than 0.1μm are used as reinforcement
- The volume fraction is between 5-15%
- These particles are stronger than the pure metal matrix and can be metallic, inter-metallic or nonmetallic.
- Matrix is the load bearing phase
- Eg. SAP, TD-Nickel, Cu-Al_2O_3, Cu-Zn-Al_2O_3

Particules as the reinforcement (Particulate composites)



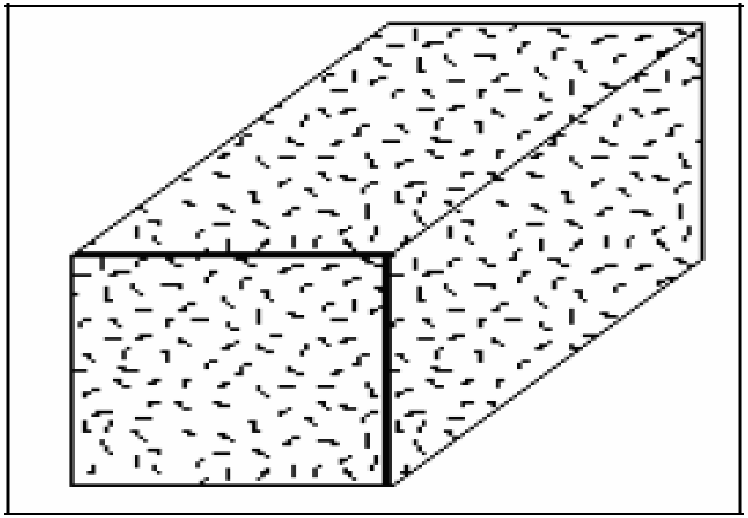
Fillers as the reinforcement (Filler composites)



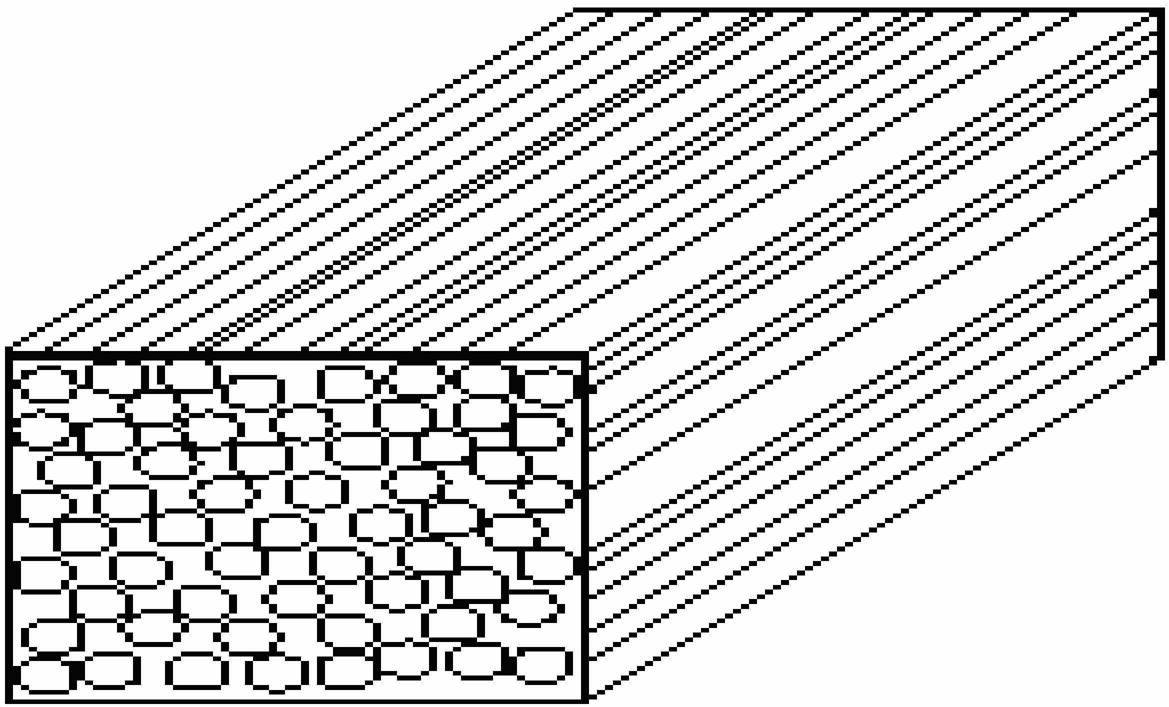
Fibre Reinforced Composites(FRP)

1. Continuous fibre reinforced composites
2. Discontinuous fibre reinforced composites

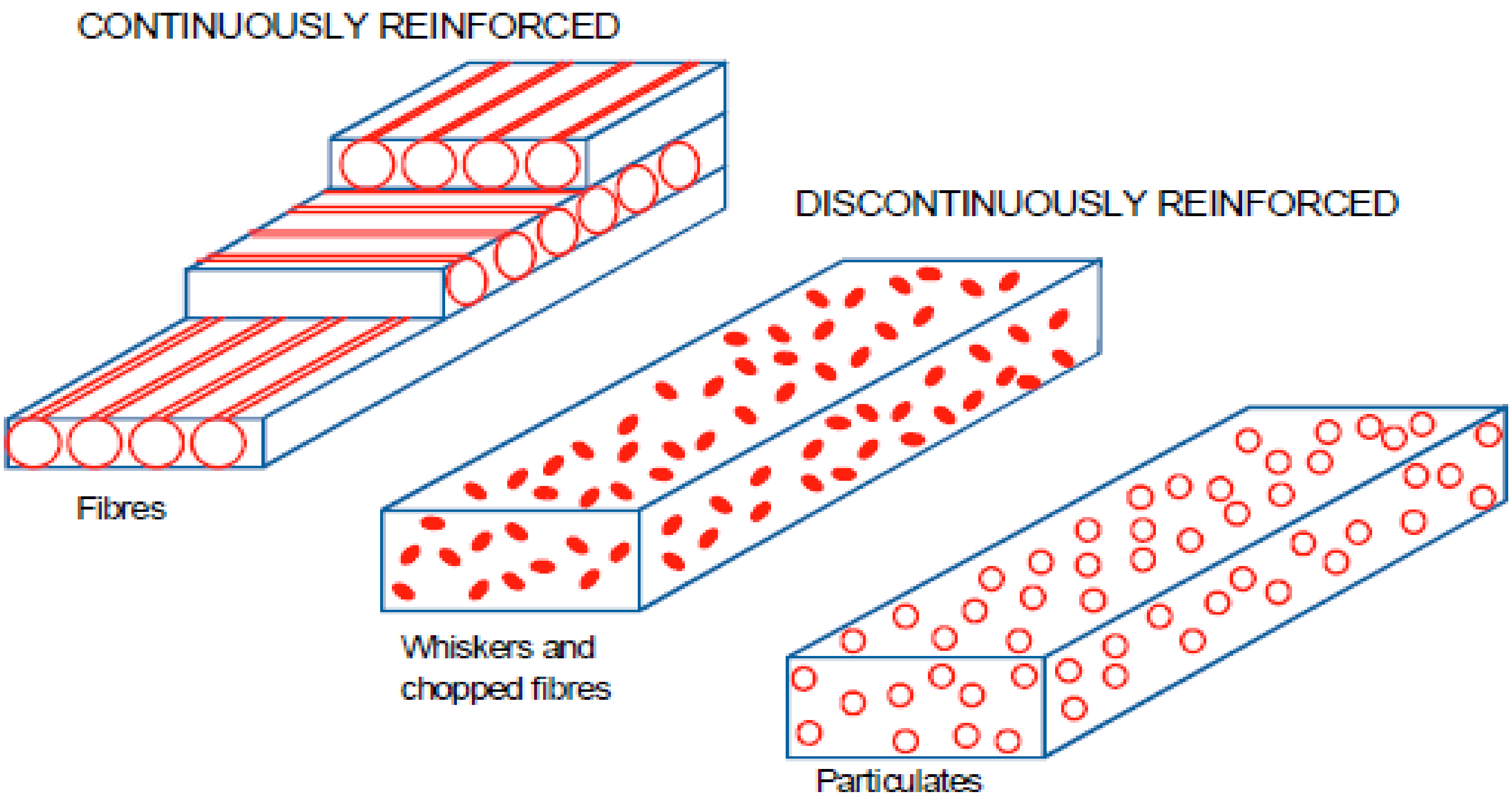
Random fiber (short fiber) reinforced composites



Continuous fiber (long fiber) reinforced composites

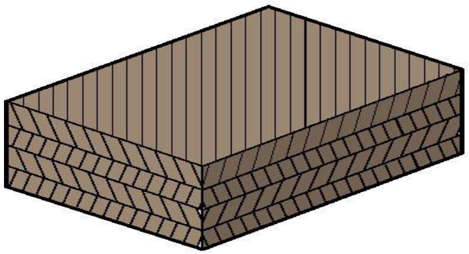


Typical Reinforcement Geometries for Composites



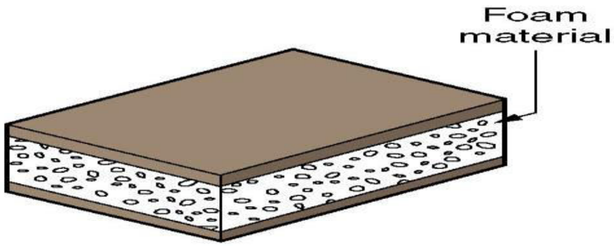
OTHER COMPOSITE STRUCTURES

Laminar composite structure :- *Two or more layers bonded together in an integral piece*

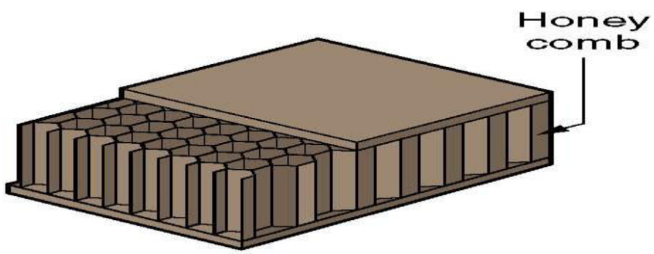


(a)

Sandwich structure:- *foam & honey cores*



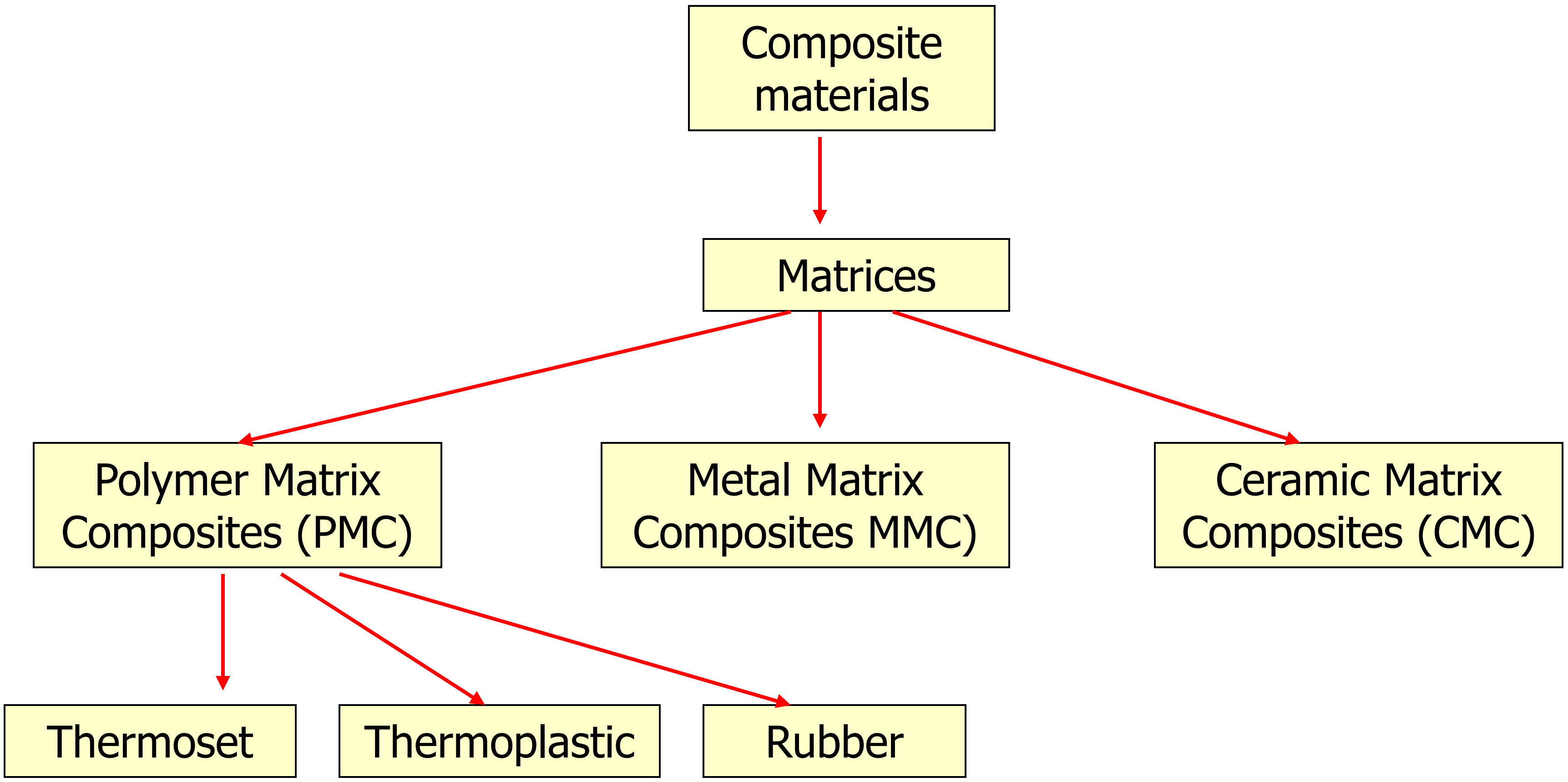
(b)



(c)

Consists of a thick core of low density foam bonded on both faces to thin sheets of a different material

Classification based on Matrices



Role of matrix phase

- Primary function of the matrix phase in a composite is to hold and bind the reinforcing phase in position within it
- Act as a medium through which the external load is transmitted and distributed to the reinforcing phase.
- It separates fibres from each other
- Protects the individual fibres from surface damage due to abrasion and oxidation
- Improves fracture toughness of the composite
- Withstand heat or cold, conduct or resist electricity, control chemical attack

Polymer Matrix Composites

In PMCs *polymer* is the primary phase in which a secondary phase is imbedded as fibers, particles, or flakes

- Commercially, PMCs are more important than MMCs or CMCs
- Low density, high specific strength, high specific stiffness, ease of fabrication.
- *Examples:* Rubber reinforced with carbon black and fiber-reinforced pastic (FRPs)

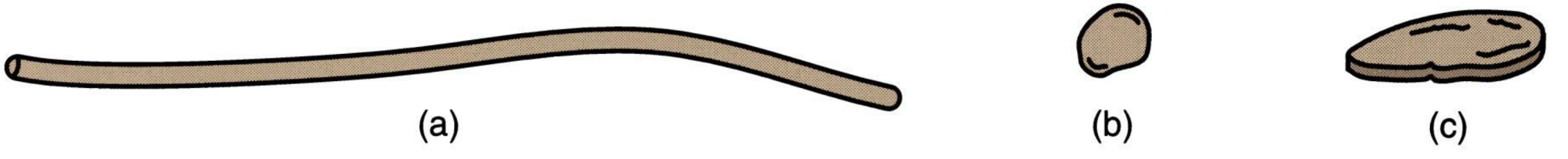
MATRIX & REINFORCEMENT

MATRIX

- Thermosetting polymers are the most common matrix materials
  - Principal TS polymers are:
    - Phenolics – *used with particulate reinforcing phases*
    - Polyesters and epoxies - *most closely associated with FRPs*
- Nearly all rubbers are reinforced with carbon black

REINFORCEMENT

- Possible geometries - (a) fibers, (b) particles & (c) flakes



- Particles and flakes are used in many plastic molding compounds
- Of most engineering interest is the use of fibers as the reinforcing phase in FRPs

Glass fibre reinforced polymer composites

- Contains glass fibre as reinforcing phase in a polymer matrix
- Glass fiber
    - Continuous or discontinuous
    - Dia b/w 3-20µm
- Lim: not very stiff and rigid
- Automobile and marine bodies, storage containers, plastic pipes, industrial flooring

Carbon fibre reinforced polymer composites

- Contains carbon fibre as reinforcing phase in a polymer matrix
- Advantages
    - High specific strength and specific modulus
    - Higher strength at elevated temperatures
    - Not affected by moisture or acids
- Applications
    - Aerospace application
    - Sports and recreational equipments
    - Pressure vessels

Aramid fibre reinforced polymer composites

- Aramid-polyamide-kevlar or nomex
- Advantages
    - High toughness and impact resistance
    - Resistance to creep and fatigue failure
- Applications
    - Bullet proof vests and armor
    - Sports goods, missile cases
    - Pressure vessels, clutch linings and gaskets

Metal matrix composites

- Metals with low density and low temperature toughness are preferred as matrix metal.
- Aluminium, titanium, magnesium and their alloys
- Advantages
    - Higher operating temperatures
    - Non flammability and creep resistance
    - Greater resistance to degradation by organic fluids.
- Applications
    - Aerospace application
    - Gas turbine blades
    - Electrical contacts

Ceramic Matrix Composites

- Primary objective for developing CMCs was to enhance the toughness while retaining the high temperature properties.
- High melting points and good resistance to oxidation
- But low tensile strength, impact resistant and shock resistance
- eg. Small particles of partially stabilized Zirconia are dispersed within a matrix material Al_2O_3

Hybrid composites

- Obtained by using different kinds of fibers in a single

Applications

1. Aircraft and aerospace applications
2. Automotive applications
3. Marine applications
4. Sporting industries
5. Biomaterials
6. Industrial applications

Lower Drag Brace for the F16

Lower Drag Brace of F16:

- Landing gear
- Titanium Matrix Composite
- Monofilament SiC fibres in a Ti-matrix.

Lightweight Composite Core for Power Lines

Lightweight Aluminum Conductor Composite Core (ACCC)

- Composite Technology Corporation (CTC)
- Twice the amount of electric power as conventional power lines.

Brake rotors for high speed train

Brake rotors for high speed train

- particulate reinforced Aluminium alloy (AlSi7Mg+SiC particulates)
- Weight of cast iron rotor is 120 kg/piece while MMC it is 76 kg/piece

Cylinder liner

Boxter engine block

- Cylinder liner AlSi9Cu3 alloy with 25% Si.
- Squeeze casting infiltration

F-16 Fuel Access Door Covers

- High specific strength and stiffness good bearing strength

- Al Composites
- 6092/SiC/17.5p
- Wrought P/M material

- Elimination of the skin cracking problem

F-16 Ventral Fins

- High specific stiffness and strength

- Al-matrix composites
- Rolled P/M
- 6092/SiC/17.5p

- Decreased deflections provide an increase in fin life

Recreational products

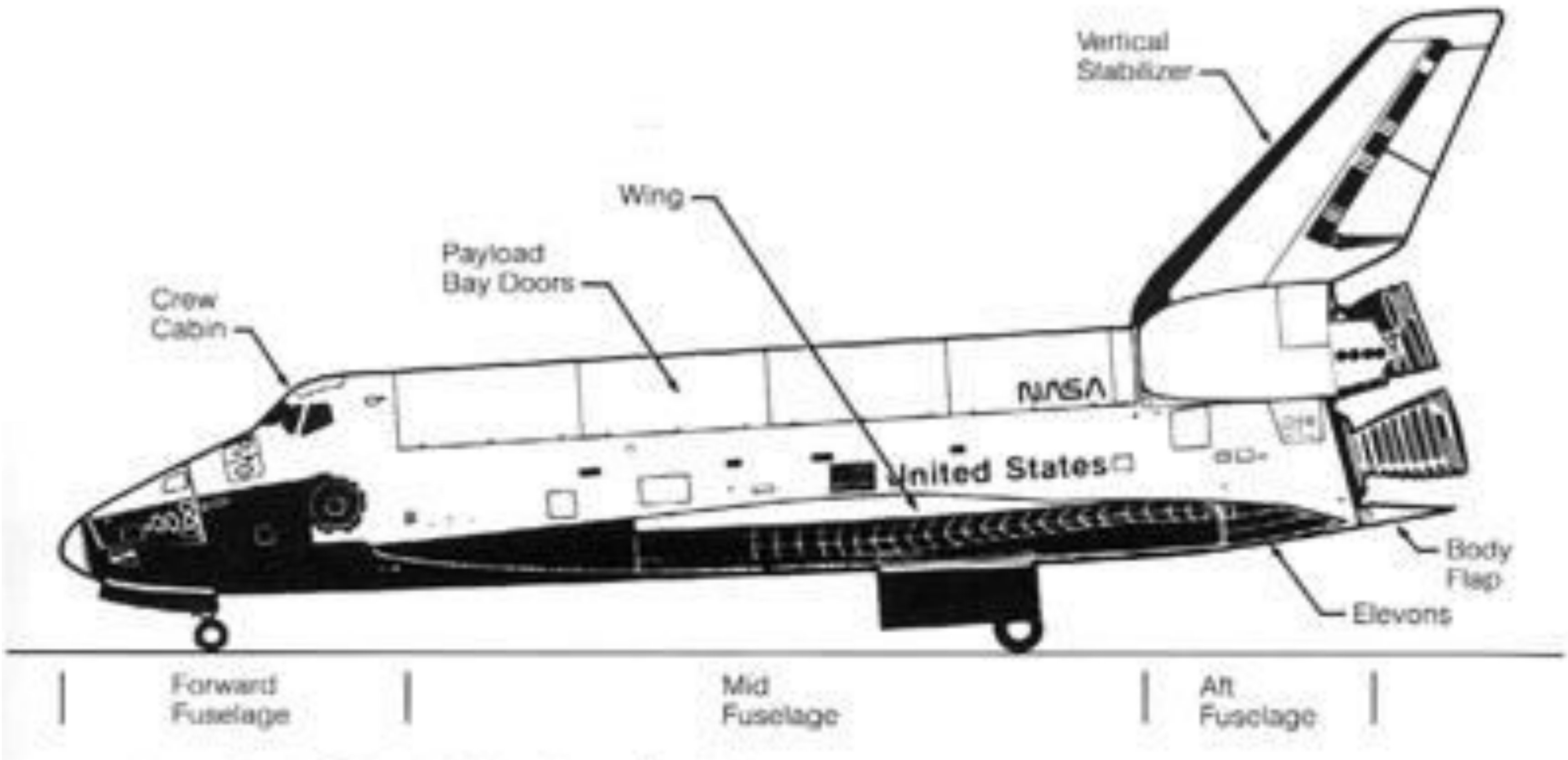
Skating shoe

Base ball shafts

Horse shoes

Bicycle Frames

Space Shuttle



Sketch of Space Shuttle Orbiter in the landing configuration viewed from -Y position identifies aerodynamic flight surfaces

- Mid fuselage frames of Space Shuttle was made of MMCs

Common MMCs and Applications

TABLE 9.3

Metal-Matrix Composite Materials and Applications

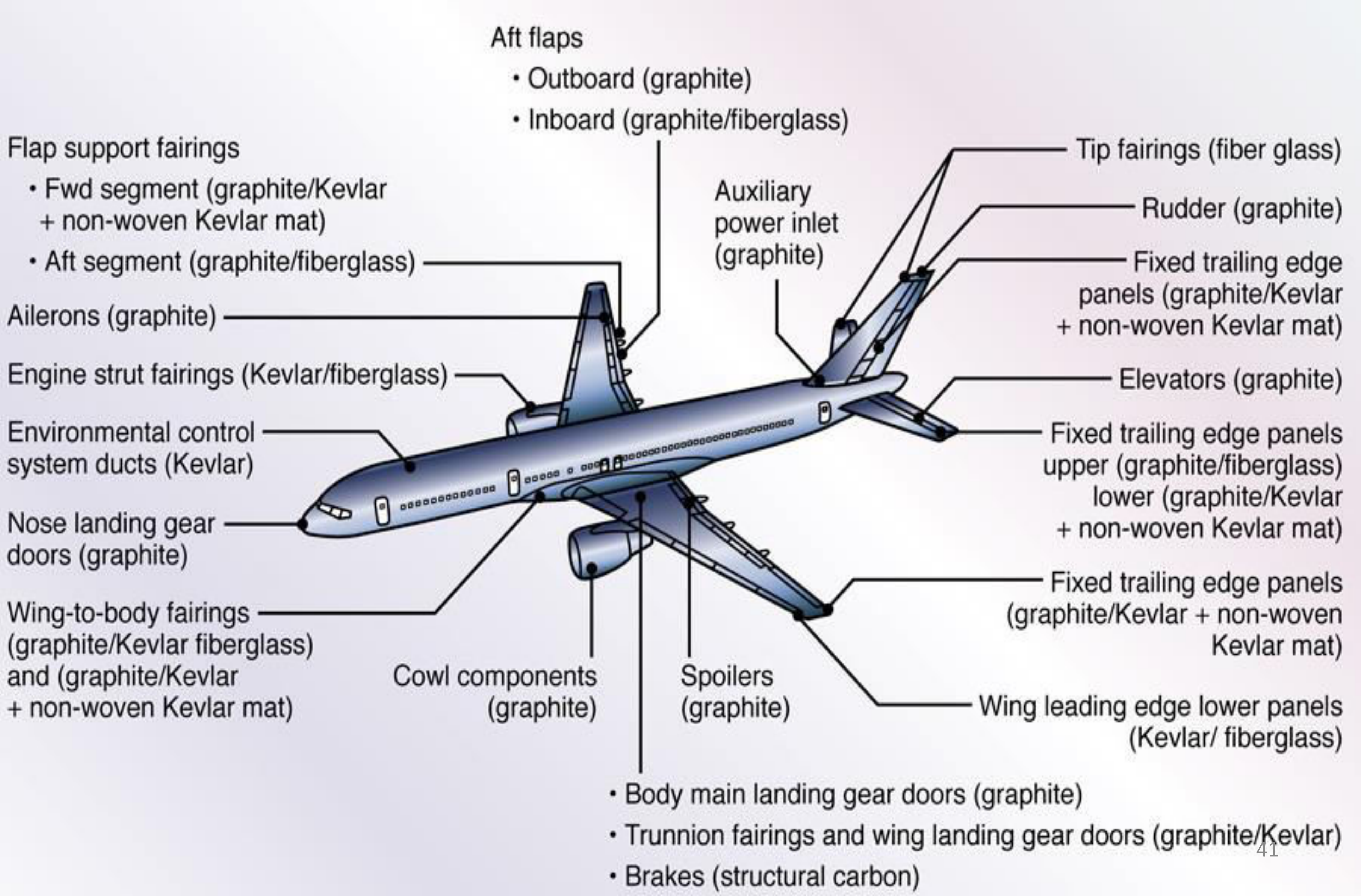
Fiber	Matrix	Applications
Graphite	Aluminum	Satellite, missile, and helicoter structures
	Magnesium	Space and satellite structures
	Lead	Storage-battery plates
	Copper	Electrical contacts and bearings
Boron	Aluminum	Compressor blades and structural supports
	Magnesium	Antenna structures
	Titanium	Jet-engine fan blades
Alumina	Aluminum	Superconductor restraints in fission power reactors
	Lead	Storage-battery plates
	Magnesium	Helicopter transmission structures
Silicon carbide	Aluminum, titanium	High-temperature structures
	Superalloy (cobalt-base)	High-temperature engine components
Molybdenum, tungsten	Superalloy	High-temperature engine components

Metal Matrix Automotive Brake Caliper

Aluminum-matrix composite brake caliper using nanocrystallyne alumina fiber reinforcement.

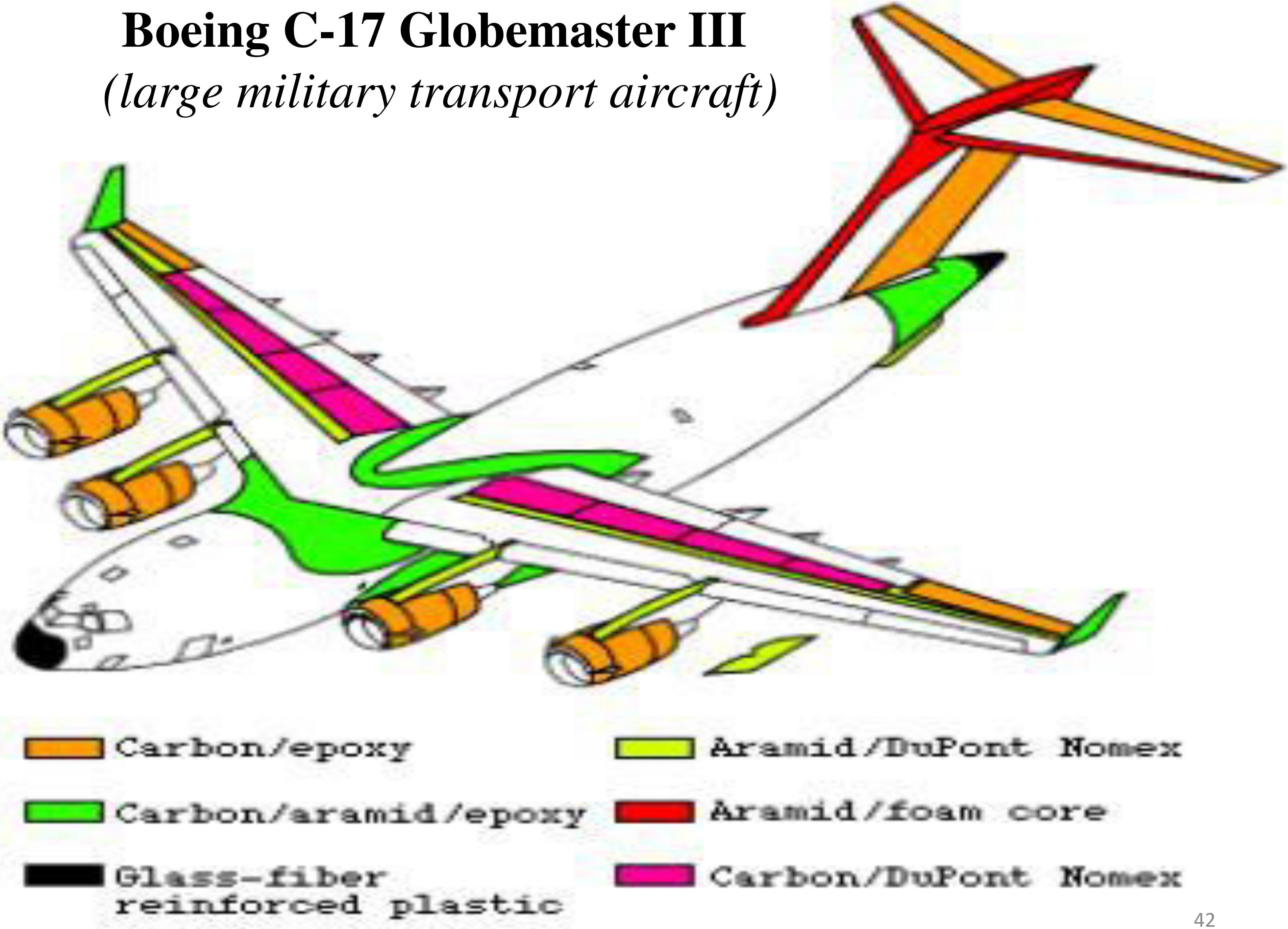
Application of advanced composite materials in Boeing 757-200 commercial aircraft.

Source: Courtesy of Boeing Commercial Airplane Company.



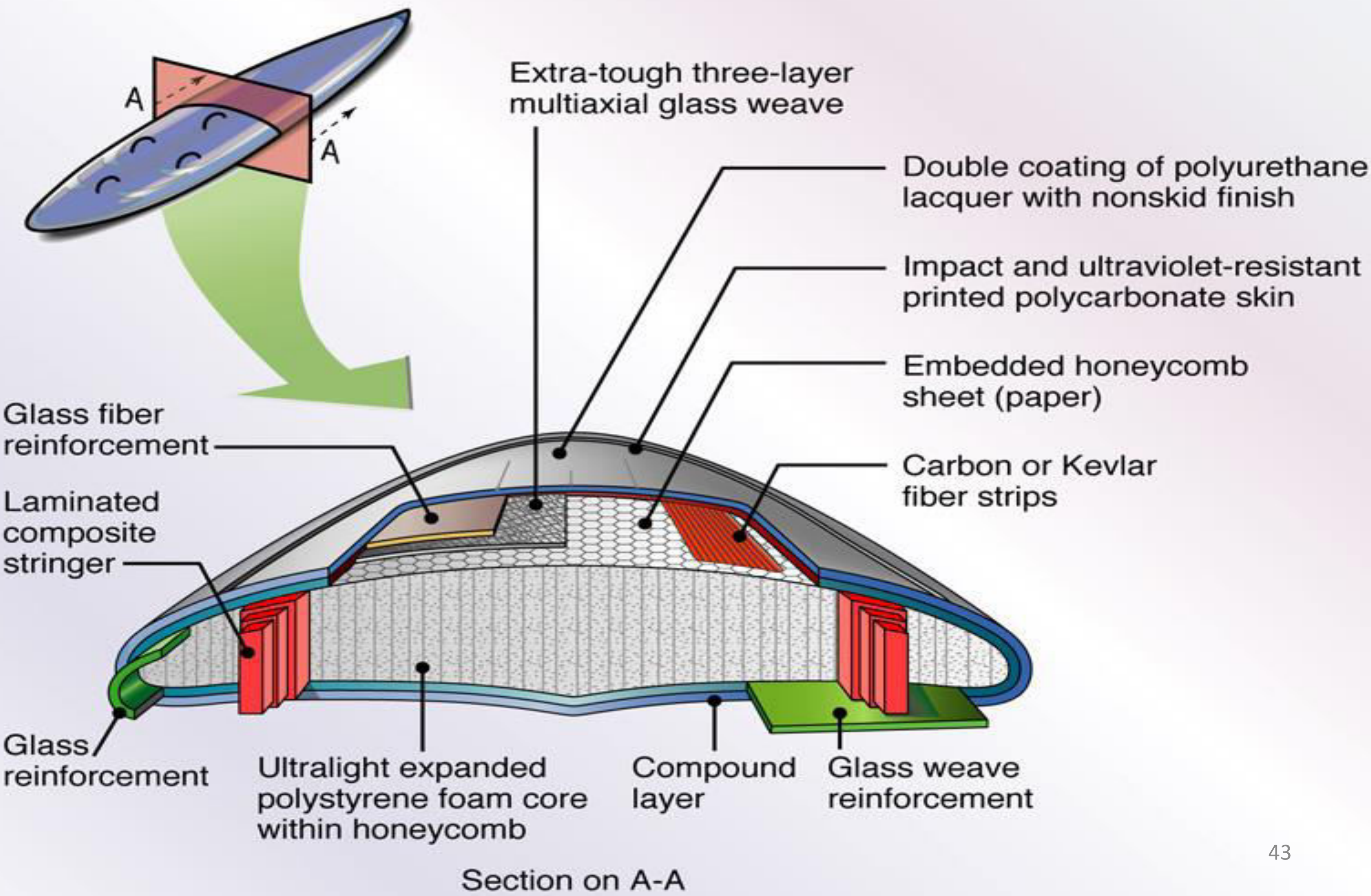
Boeing C-17 Globemaster III

(large military transport aircraft)

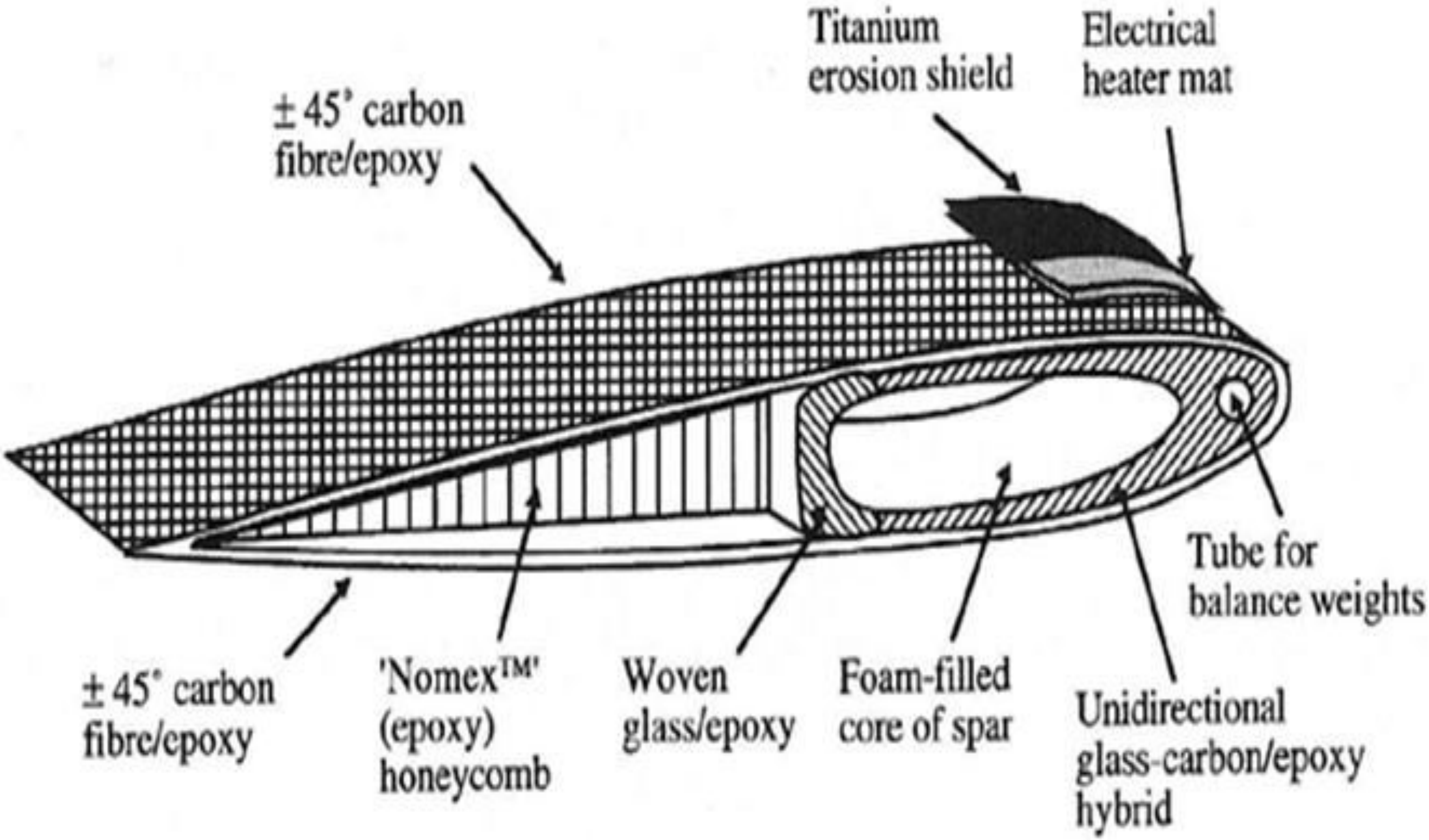


Cross-section of a composite sailboard.

Source: K. Easterline, *Tomorrow's Materials* (2nd ed.), p. 133. Institute of Metals, 1990.



Helicopter rotor blade



Schematic section through a typical composite construction for a helicopter rotor blade. (Courtesy of Westland Helicopters.)

Wing Panel

Automotive structure

Aerospace parts

Sporting goods

Delta IV Rocket faring mandrel

Disadvantages and Limitations of Composite Materials

- Properties of many important composites are anisotropic - the properties differ depending on the direction in which they are measured – this may be an advantage or a disadvantage
- Many of the polymer-based composites are subject to attack by chemicals or solvents, just as the polymers themselves are susceptible to attack
- Composite materials are generally expensive
- Manufacturing methods for shaping composite materials are often slow and costly

- **CONCRETE**

  Concrete is a composite material in which a binding material mixed in water on solidification binds the inert particles of well graded fine and coarse aggregates.

  Cement and lime are generally used as binding materials, whereas sand cinder is used as fine aggregates and crushed stones, gravel, broken bricks, clinkers are used as coarse aggregates.

CONCRETE

Freshly prepared concrete till it has not yet set is called *wet or green concrete.* After it has thoroughly set and fully hardened it is called *set concrete* or just concrete.

TYPES OF CONCRETE AND ITS USES

Concrete are classified into different types:

1. According to binding material used in concrete.
2. According to design of concrete.
3. According to purpose of concrete.

TYPES OF CONCRETE AND ITS USES

CLASSIFICATION ACCORDING TO BINDING MATERIAL:

According to binding material used concrete are classified into two types.

(1) Cement concrete (2) lime concrete.

CEMENT CONCRETE

The concrete consisting of cement, sand and coarse aggregates mixed in a suitable proportions in addition to water is called cement concrete. In this type of concrete cement is used as a binding material, sand as fine aggregates and gravel, crushed stones as coarse aggregates.

In cement concrete useful proportions of its ingredients are

1 part cement:1-8 part sand:2-16 parts coarse aggregates.

USES

cement concrete is commonly used in buildings and other important engineering works where strength and durability is of prime importance.

LIME CONCRETE

The concrete consisting of lime, fine aggregates, and coarse aggregates mixed in a suitable proportions with water is called lime concrete.

In this type of concrete hydraulic lime is generally used as a binding material, sand and cinder are used as fine aggregates and broken bricks, gravel can be used as coarse aggregates.

PLACING OF LIME CONCRETE :

Placing of concrete shall be completed within three hours of adding water in case of concrete is prepared with hydraulic lime.

Concrete should be well cured for a period of atleast 10 days.

USES:

Lime concrete is generally used for the sake of economy in foundation works, under floors, over roof and where cement is not cheaply and easily available in required quantity.

TYPES OF CONCRETE AND ITS USES

CLASSIFICATION ACCORDING TO DESIGN OF CONCRETE

(1) Plain cement concrete.

(2) Reinforced cement concrete(RCC).

(3) Pre-stressed cement concrete(PCC).

PLAIN CEMENT CONCRETE

The cement concrete in which no reinforcement is provided is called plain cement concrete or mass cement concrete.

This type of concrete is strong in taking compressive stresses but weak in taking tensile stresses.

USES:

Plain cement concrete is commonly used in for foundation work and flooring of buildings.

REINFORCED CEMENT CONCRETE(RCC)

The cement concrete in which reinforcement is embedded for taking tensile stress is called reinforced cement concrete.

In this type of concrete the steel reinforcement is to be used generally in the form of round bars,6mm to 32mm dia. This concrete is equally strong in taking tensile, compressive and shear stresses. Usual proportions of ingredients in a reinforced concrete are 1part of cement:1-2parts of sand:2-4parts of crushed stones or gravel.

USES: RCC is commonly used for construction of slabs, beams, columns, foundation, precast concrete.

REINFORCED CEMENT CONCRETE(RCC)

REINFORCED CEMENT CONCRETE(RCC)

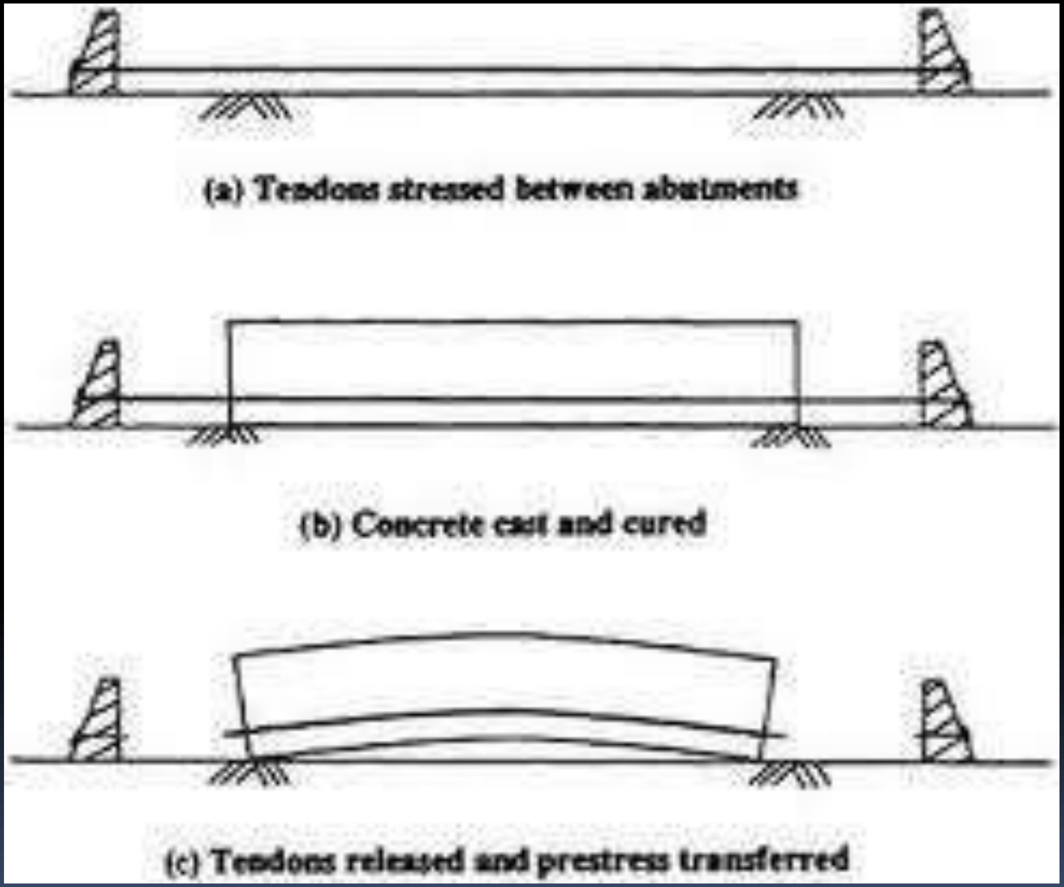
PRE-STRESSED CEMENT CONCRETE (PCC)

The cement concrete in which high compressive stresses are artificially induced before their actual use is called pre-stresses cement concrete.

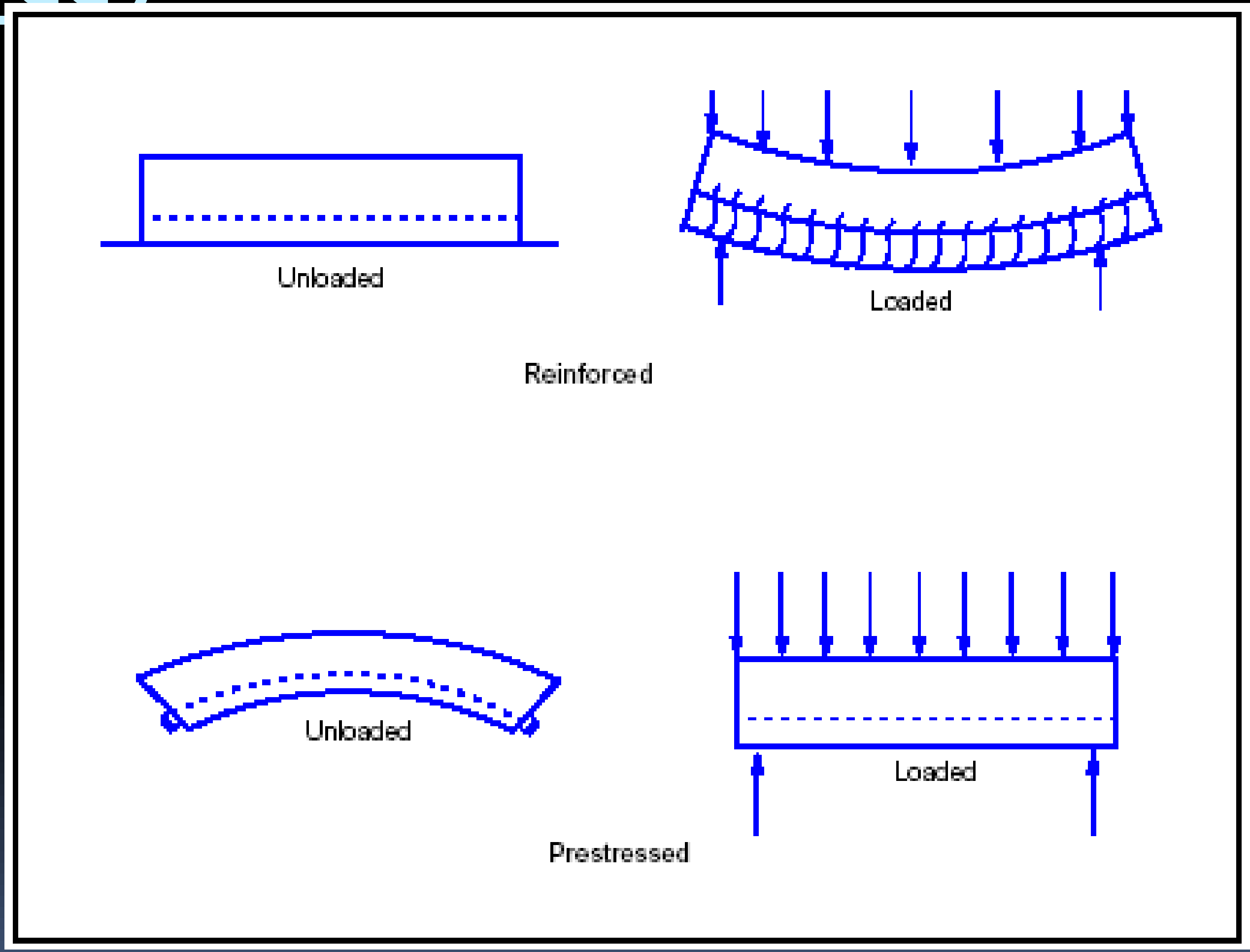
in this type of cement concrete, the high compressive stresses are induced by pre-tensioning the reinforcement before placing the concrete, and the reinforcement is released when final setting of the concrete take place.

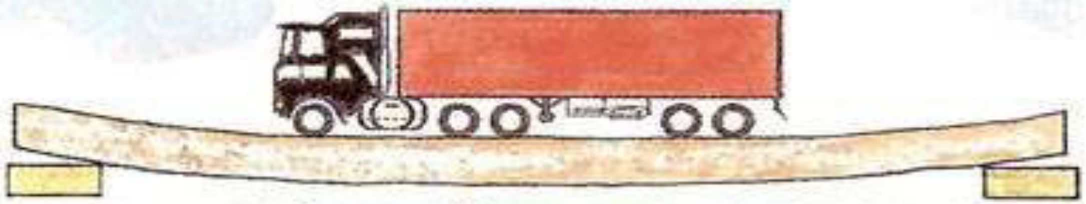
Uses : This concrete can take up high tensile and compressive stresses without development of cracks. The quantity of reinforcement can be considerably reduced by using this concrete.

PRE-STRESSED CEMENT CONCRETE (PCC)

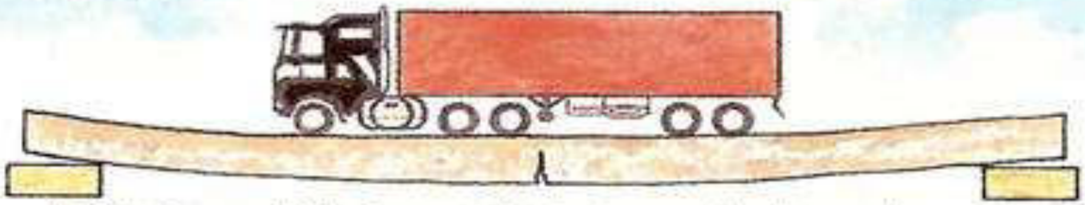


PRE-STRESSED CEMENT CONCRETE (PCC)

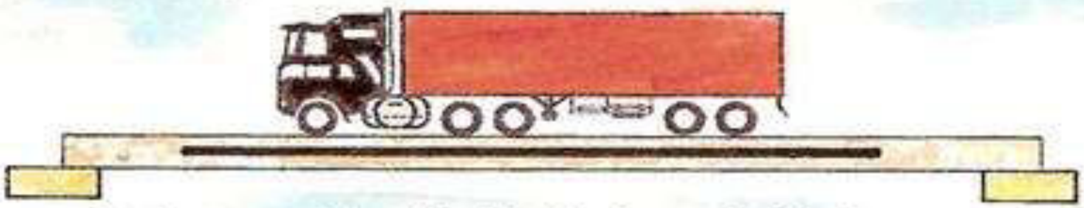




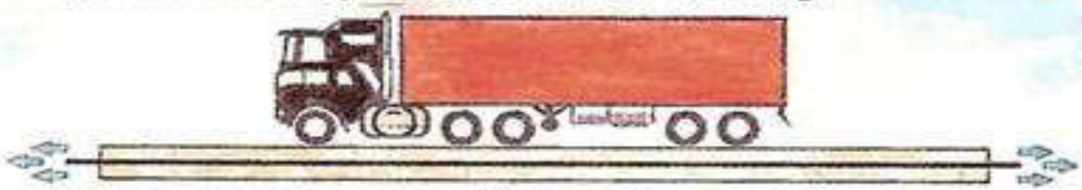
▲ A concrete beam will begin to bend when heavily loaded.



▲ The base of the beam starts to crack where the concrete is pulled apart.



▲ Placing a steel rod inside the beam holds the concrete together and stops the beam from cracking.



▲ Stretching the rod and then releasing it to squeeze the concrete makes the beam very strong.

TYPES OF CONCRETE AND ITS USES

CLASSIFICATION ACCORDING TO PURPOSE

According to purpose concrete is classified into following types.

a. Vacuum concrete:

The cement concrete from which entrained air and excess water is removed after placing it, by suction with the help of vacuum pump is called vacuum concrete.

In this concrete the excess water which is added to increase workability but not required for the hydration of cement of concrete is removed by forming vacuum chamber

VACCUM CONCRETE

b. Air entrained concrete

The concrete prepared by mixing aluminum in it is called air entrained ,cellular or aerated concrete. In this concrete bubbles of hydrogen gas are liberated which forms cell and make the concrete cellular.

USES: This concrete is used for lining walls and roofs for heat and sound insulation purpose.

c. Light weight concrete

The concrete prepared by using coke breeze, cinder or slag as coarse aggregate is called light weight concrete. The concrete is light in weight and posses heat insulating properties.

USES

This concrete is used in making precast structural units for partition and wall lining.

DESCRIPTION OF WORK	GRADE OF CONCRETE
Concrete in columns, beams	1:1:2
Water retaining structures, Piles, precast work or dense Concrete.	1:1.5:3
RCC beams, slabs, columns	1:2:4
Foundations for buildings, Mass reinforced works.	1:3:6
For mass concrete work.	1:4:8

WATER CEMENT RATIO

- In the preparation of concrete the water cement ratio is very important
- For normal construction the water cement ratio is usually 0.5
- Adding to much water will reduce the strength of concrete and can cause seggregation.

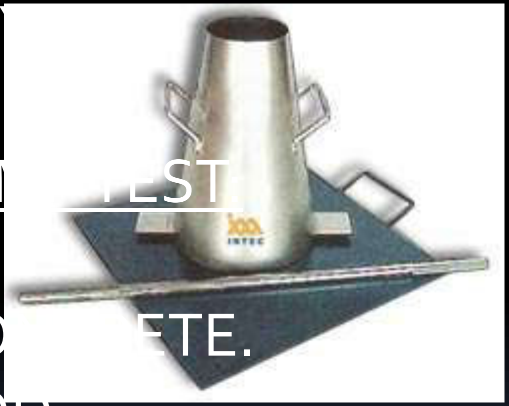
WATER CEMENT RATIO

- For different ratio of concrete the amount of water for 50kg of cement is

Concrete ratio	Water quantity
1:3:6	34 liter
1:2:4	30 liter
1:1.5:3	27 liter
1:1:2	25 liter

SLUMP TEST

SLUMP TEST IS A TEST CONDUCTING BEFORE CONCRETE TO BE USED FOR CASTING. THE PURPOSE OF SLUMP TEST IS TO DETERMINE THE WATER CONTENT IN CONCRETE AND ITS WORKABILIT



EQUIPMENT FOR SLU EST

1. BASE PLATE.
2. TROWEL TO MIX CO ETE.
3. STEEL TAMPING RO .
4. SLUMP CONE.
5. RULER.

SLUMP TEST

STEP 1:

Fill cone 1/3 full by volume and rod 25 times with 5/8-inch diameter x 24-inch-long hemispherical tip steel tamping rod. (This is a specification requirement which will produce nonstandard results unless followed exactly.) Distribute rodding evenly over the entire cross section of the sample.

SLUMP TEST

STEP 2:

Fill cone 2/3 full by volume. Rod this layer 25 times with rod penetrating into, but not through first layer. Distribute rodding evenly over the entire cross section of the layer.

SLUMP TEST

STEP 3:

Remove the excess concrete
from the top of the cone, using tamping rod
as a screed. Clean overflow from base of
cone.7 Immediately lift cone vertically with
slow, even motion. Do not jar the concrete or
tilt the cone during this process. Invert the
withdrawn cone, and place next to, but not
touching the slumped concrete. (Perform in
5-10 seconds with no lateral or torsional
motion.)

SLUMP TEST

STEP 4:

Lay a straight edge across the top of the slump cone. Measure the amount of slump in inches from the bottom of the straight edge to the top of the slumped concrete at a point over the original center of the base. The slump operation shall be completed in a maximum elapsed time of 21/2 minutes. Discard concrete. DO NOT use in any other tests.

Slump value for different concrete

- Mass concrete and road work 2.5 to 5cm
- Ordinary beams and slabs 5 to 10cm
- Columns and retaining walls 7.5 to 12.5cm

WORKABILITY OF CONCRETE

- It is the amount of work required to place concrete and to compact it thoroughly.
- Workability of concrete increases with the addition of water but it reduces the strength that's why it is not a desirable way of increasing the workability.
- Use of aggregates which are round and have smooth surfaces increases the workability.

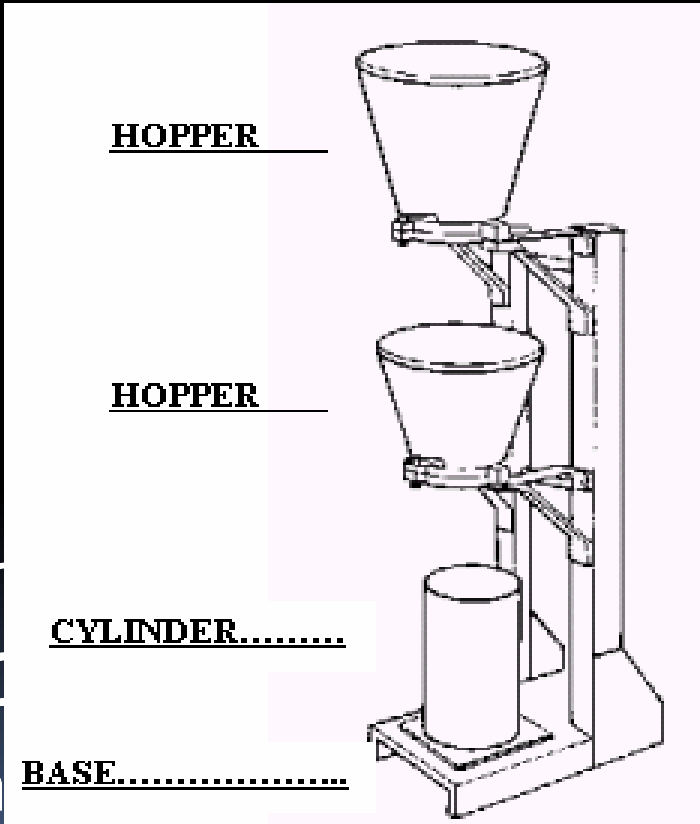
WORKABILITY OF CONCRETE

- Workability could also be improved by adding air entraining agent such as vinsol resin or Darex.
- Use of *Lisapole* liquid at 30 cubic centimeter per bag of cement improves not only the workability but also the water tightness of concrete.
- Workability of concrete is better determine by compaction factor test.

COMPACTION FACTOR TEST

COMPACTION FACTOR TEST

- The apparatus use for compaction factor test consist of two hoppers ***A*** and ***B*** and a cylinder ***C.***
- The hoppers are provided with hinged bottom. There is a clear distance between hopper ***A*** and ***B*** and cylinder ***C.*** the diameter of cylinder ***C*** is 15cm and is of 30cm heigh



COMPACTION FACTOR TEST

- Cement concrete to be tested is placed in the hopper ***A*** and its bottom released. The concrete falling in hopper ***B*** achieves some compaction.
- The bottom of hopper ***B*** is now released so that concrete now falls in cylinder ***C.*** surplus concrete is removed from the top of cylinder. Concrete in the cylinder is now weighed. Let this weight be W_1.
- After cleaning the cylinder it is refilled with concrete in layers of 5cm each. Every layer of concrete is thoroughly compacted with an iron rod. Concrete in the cylinder is weighted again. Let this weight be W_2 .

COMPACTION FACTOR TEST

- The ratio of the two weights is known as compaction factor.

  Compaction Factor= W_1/W_2

- A compaction factor of 0.85 represents a mix of poor workability, 0.92 represents medium and 0.95 represents good workability.

PLACING OF CONCRETE

- After mixing of concrete it should be placed within 30min of adding of water.
- It should be quickly transported to the place of lying by means of iron pans manually, in wheel barrows, by pumping or by cranes.
- In placing, concrete should be laid in thin layers. Each layer being thoroughly consolidated, before the next one is laid.

PLACING OF CONCRETE

- Concrete should not be dropped from a height as it would cause segregation of aggregates.
- In case concrete has more of water or it has been laid in thick layers then on compaction water and fine particles of cement comes at the top forming a layer of weak substance known as ***laintance***

COMPACTION OF CONCRETE

- Compaction of concrete is very important in developing qualities like strength, durability, imperviousness by making the concrete dense and free from voids.
- In case of RCC compaction is done by pinning with an iron rod or even with trowel blade.
- Excess temping should be avoided as otherwise water, cement and finer particles would come to the surface and results in non uniform concreting.

COMPACTION OF CONCRETE

- In case of important and big works, compaction of concrete is done with vibrator.
- Use of vibrator is best and the most efficient way of compacting concrete. It gives very dense concrete.
- Care should be taken not to make excessive use of vibrators otherwise the concrete becomes non homogeneous

CURING OF CONCRETE

- The process of keeping concrete wet to enable it to attain full strength is known as ***curing.***
- The objective of curing is to prevent loss of moisture from concrete due to evaporation or because of any other reasons.
- Curing should be done for a period of three weeks but not less then 10 days.

CURING OF CONCRETE

- To do curing, any one of the following method can be used.

i. The surface of concrete is coated with a layer of bitumen or similar other waterproofing compound which gets into the pores of concrete and prevent loss of water from concrete.

ii. Concrete surface is covered with waterproof paper or with a layer of wet sand. It could also be covered with gunny bags.

CURING OF CONCRETE

CURING OF CONCRETE

CURING OF CONCRETE

CURING OF CONCRETE

QUALITIES OF GOOD CONCRETE

- ***STRENGTH:*** The concrete should be able to withstand the stresses that it is subjected to. It is quite strong in compression but weak in tension.
- ***DURABILITY:*** It should be durable enough to resist the effect of weathering agents.
- ***DENSITY:*** the concrete should be well compacted so that there are no voids or hollows left. It should weigh 3000 kg/cu.m

QUALITIES OF GOOD CONCRETE

- ***WATERTIGHTNESS:*** when used for construction of water retaining structures such as dams, elevated tanks and water reservoirs then this property of concrete becomes very important. Otherwise the moisture inside the RCC would corrode steel and leakage would start resulting in the ultimate failure of the structure.

QUALITIES OF GOOD CONCRETE

- ***WORKABILITY:*** It should be easily workable.
- ***RESISTANCE TO WEAR AND TEAR:*** when used in floors and in the construction of roads the concrete should be able to withstand abrasive forces.

FIBER REINFORCED PLASTICS

What is a Polymer Composite-FRP

FRP: also referred to as a *fiber-reinforced polymer* is a composite material made of a ***polymer matrix and some reinforcing materials (eg. Fibers, particles)***

The reinforcing_materials are also referred to as dispersed phase

Process definition

- A polymer is generally manufactured by
  - Step-growth polymerization
  - Addition polymerization.

- When combined with various agents to enhance or in any way alter the material properties of polymers the result is referred to as a plastic.

Composite plastics refer to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties

Classification

- Fiber reinforced
- Particle reinforced
- Structural

Fiber reinforced

- Fibre reinforced plastics are a category of composite plastics that specifically use fibre materials to ***mechanically enhance the strength and elasticity*** of plastics

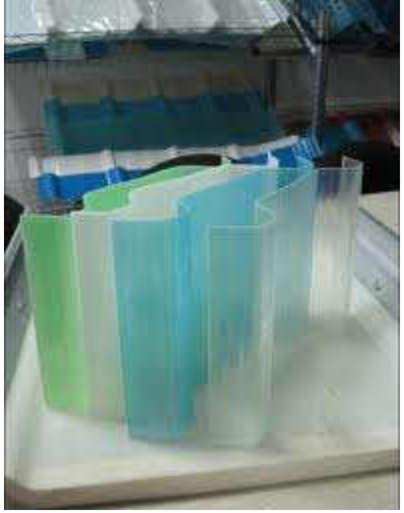
The original plastic material without fibre reinforcement is known as the ***matrix***. The matrix is a ***tough but relatively weak*** plastic that is reinforced by stronger stiffer reinforcing filaments or fibres

Factors affecting Properties of FRP

mechanical properties of both the fibre and matrix

their volume relative to one another

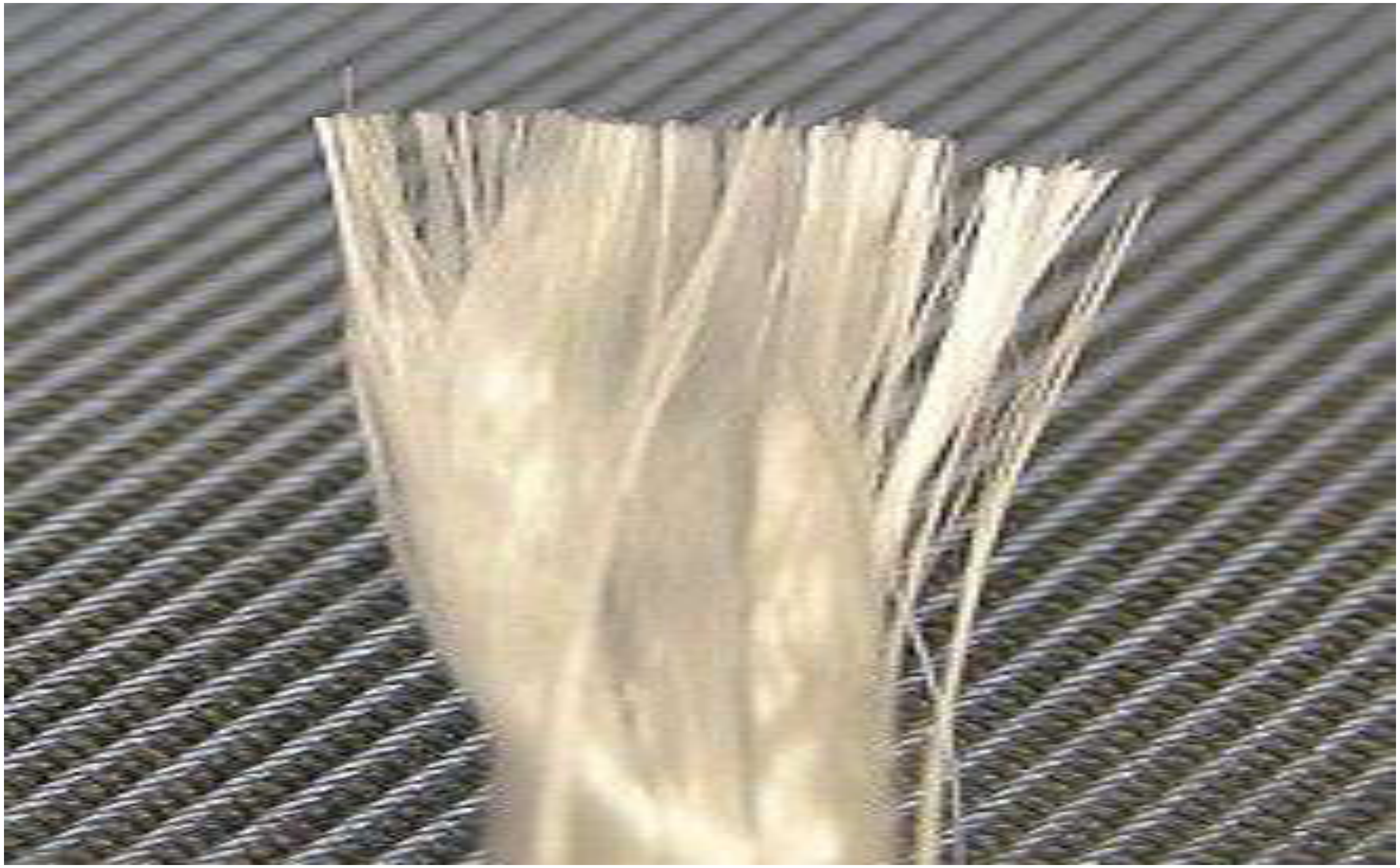
fibre length and orientation within the matrix


Commonly used fibres

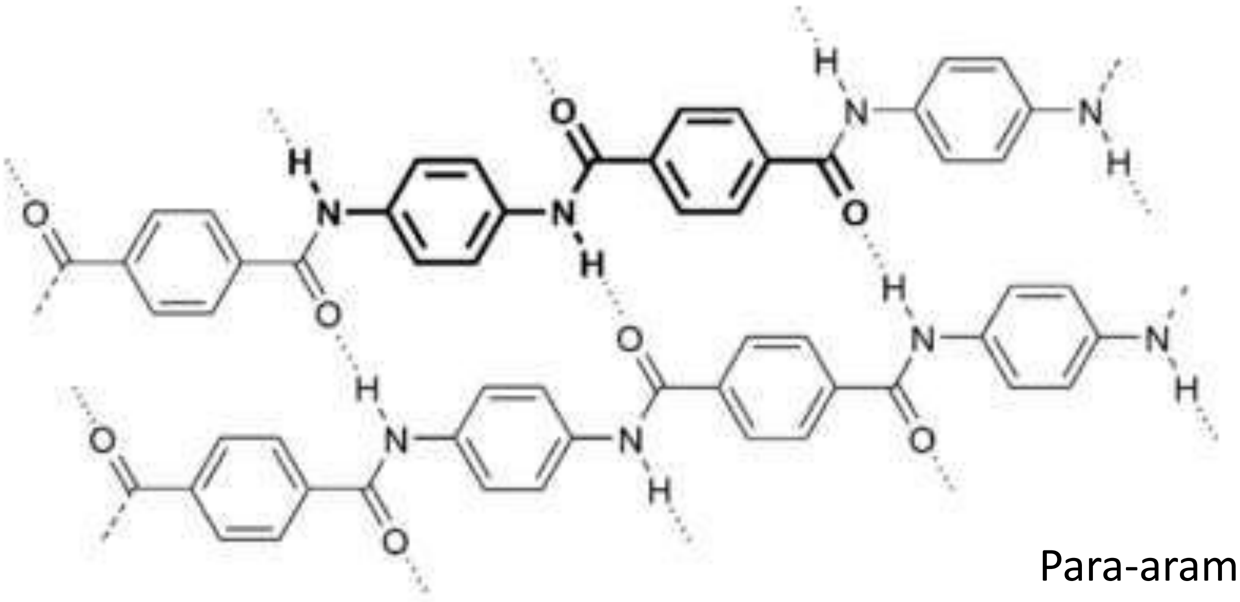


GLASS	•**Insulating material** •to form a **very strong and light** FRP composite material called glass-reinforced plastic (GRP), **popularly known as "*fiberglass*"** •**not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle.**



CARBON	•fibers about 5–10 µm in diameter and composed mostly of carbon atoms •carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber •The crystal alignment gives the fiber high strength-to-volume ratio (makes it strong for its size). •high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion

ARAMID	class of <u>heat-resistant and strong</u> synthetic fibers. They are used in aerospace and military applications, for ballistic rated body armor fabric and ballistic composites eg Kevlar , nomex



Para-aramid structure

Silicon , aluminium oxide and metal wires are also used as reinforcing material

Silicon fibreglass sheating

The polymer is usually

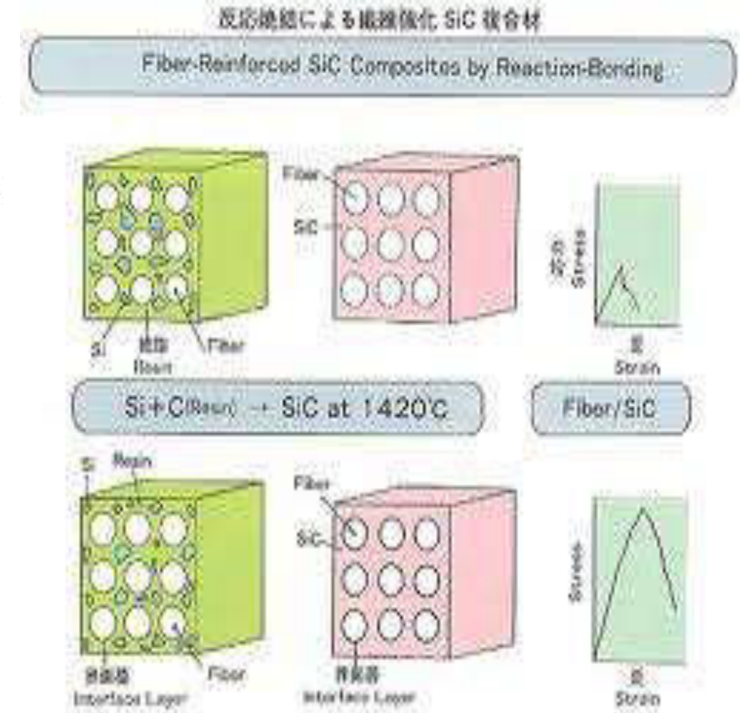
- Epoxy vinyl ester
- polyester
- thermosetting plastic
- phenol formaldehyde resins

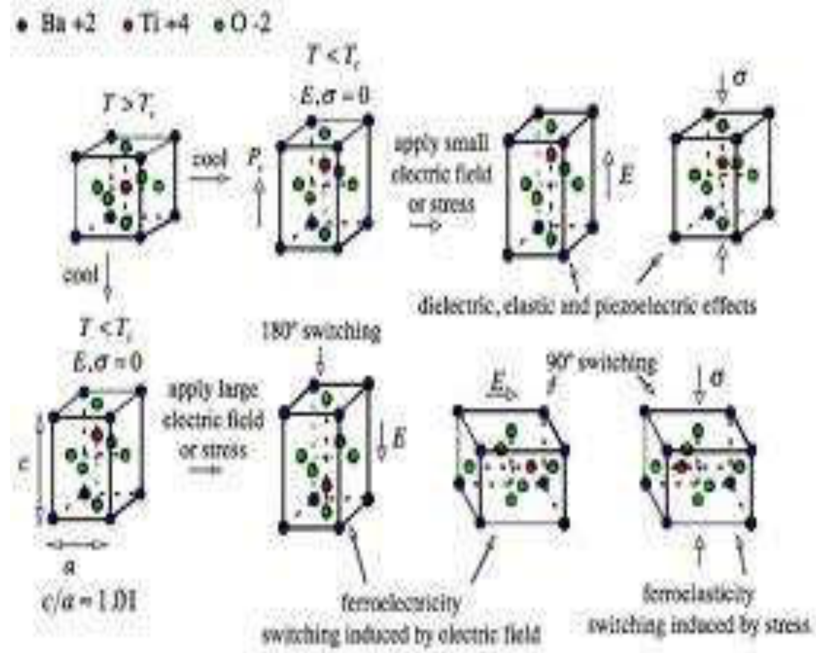
The reason the fiber was discussed in more detail is because they are what actually differentiate the FRP from its parent polymer

Particle reinforced

The most important feature is the equidistibution of paticles in all direction

The strength of the bonding at matrix-particle interface dictates the mechanical properties of composite





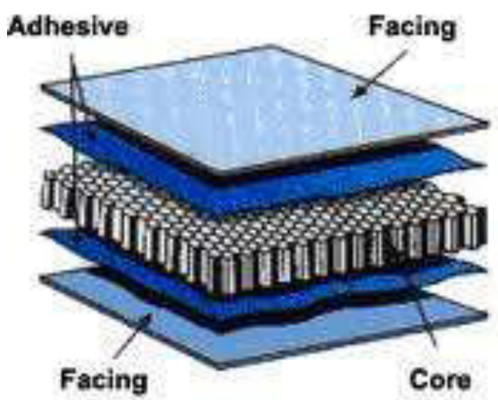
Structural Composites

LAMINAR

- Consists of sheets or panels
- Proper orientation
- Cemented together with resin
- High strength in multiple directions
- Eg: plywood

SANDWICHED

- Two strong planes with a less dense layer in the middle called core



PROPERTIES

- Low coefficient of expansion
- High dimensional stability
- High tensile strength
- High heat stability
- Better abrasion and wear resistance
- Better toughness and impact strength

APPLICATIONS

- Aerospace
- Missile tech
- Automotives
- High speed machinery
- Equipment parts
- Coolers
- Office cabins
- Room insulations