Conventional materials:

1) Polymers → Light weight, low cost but low strength and moduli

2) Ceramics → Strong, stiff but brittle

3) Metals → Intermediate strength & moduli but heavy

Engineering components require a mixture of these properties. Therefore, we use composites. → A 'man made' multiphase material

Applications:

1) mud + straws Plaster / Bricks

2) Carbon / epoxy Composite crutch:

- Stronger & quieter, weighs 50% less
- Asthetically more pleasing

3) Carbon fibres used in turbine blade
   ↳ lighter than glass fibres

Components of composites:

1) Matrix — Continous

2) Reinforcement — discontinous (fibre)

3) Interface

Classification:

1) Polymer matrix composite:

GRFP: Glass reinforced fibre plastic
CRFP: Carbon reinforced fibre plastic

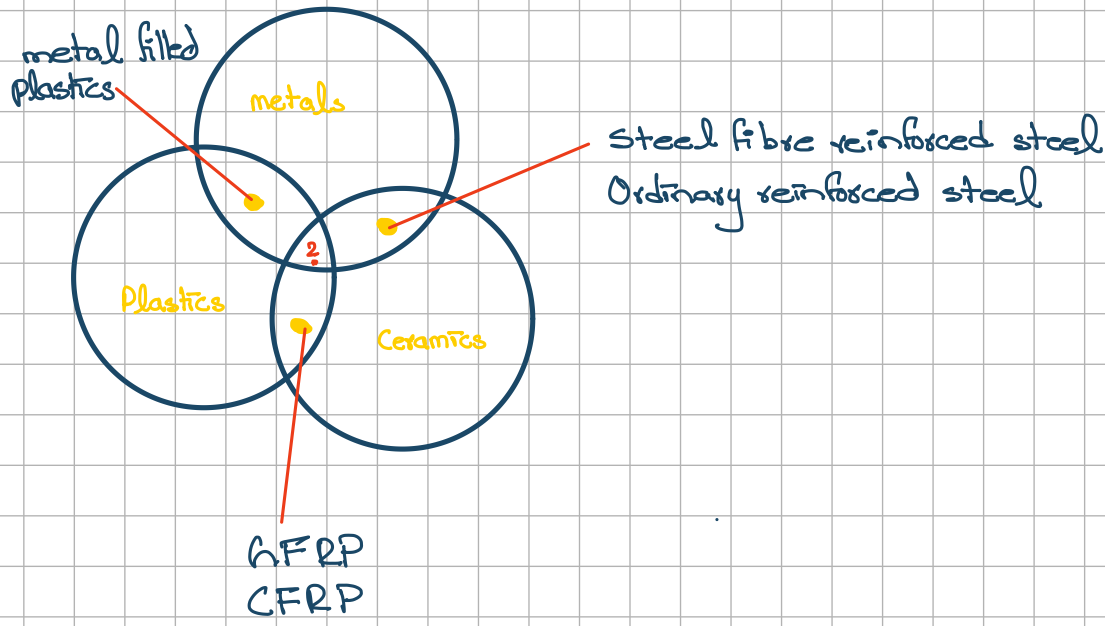
2) Metal matrix composites:

- Al — Al_2O_3 → Reinforcement

Al ↓ matrix

3. Ceramic matrix composite:

- $Al_2O_3 - SiC$

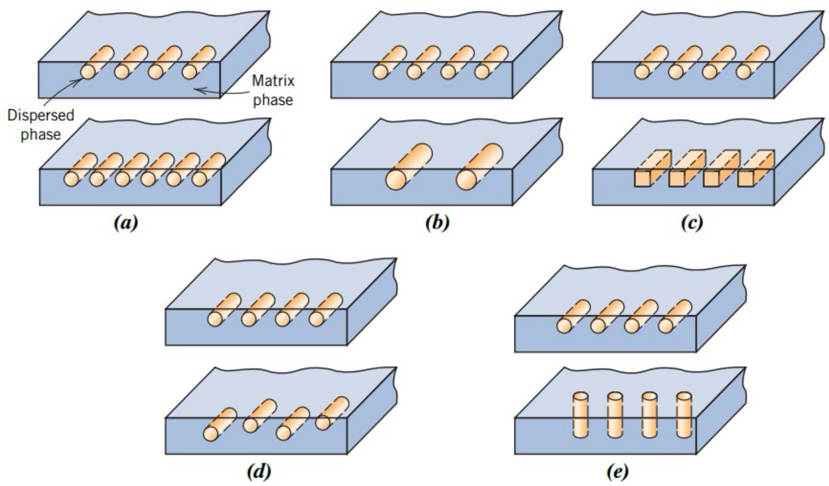


Classification based on reinforcement phase:

Composites

- particle reinforced
  - Large particles
  - Dispersion strengthened
- fibre reinforced
  - Continous (alligned)
  - discontinous (short)
    - Alligned
    - Random
- structural
  - Laminates
  - Sandwich panels
- Nano

Geometry:



Properties of composites:

- ↳ Depends on properties of fibre
- ↳ Load transfer from matrix to fibre

Critical length:
Minimum length where there is maximum load transfer from matrix to fibre.

- load transfer (Tensile stress) is zero at fibre ends and maximum at the centre

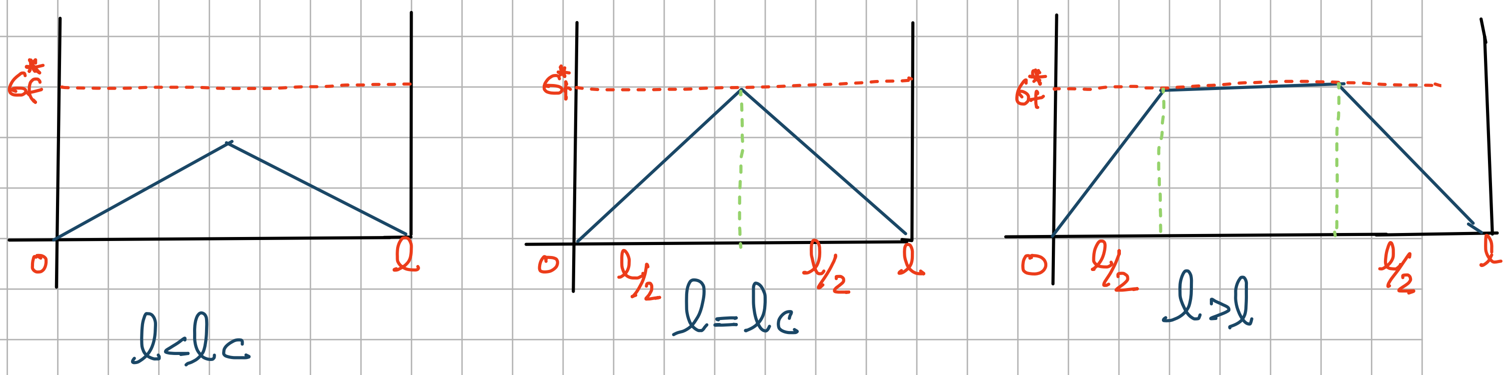
$l < l_c$ — poor performance

$l = l_c$

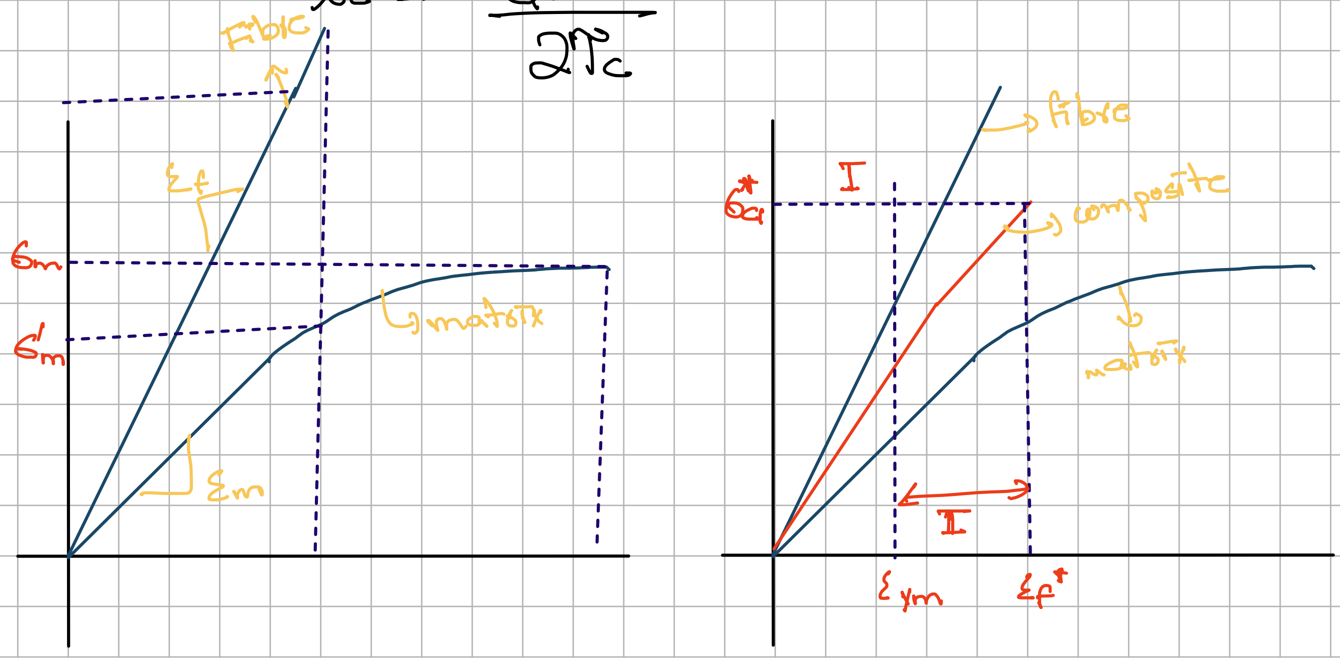
$l > l_c$ — Better performance

For continous $l >> 15 l_c$

For short fibres $l < 15 l_c$



$$l_c = \frac{\sigma_f d}{2\tau_c}$$



Rule of mixtures:

↳ To determine properties of composites by Volume fraction of Matrix & fibre

$$E_c = E_m V_m + E_f V_f \rightarrow \text{longitudinal}$$

$$E_c = \frac{E_m E_f}{E_f V_m + E_m V_f} \rightarrow \text{Transverse } / \perp \text{ to longitudinal}$$

$$F_c = F_m + F_f$$

$$\sigma_c A_c = \sigma_m A_m + \sigma_f A_f$$

$$\sigma_c = \sigma_m \frac{A_m}{A_c} + \sigma_f \frac{A_f}{A_c}$$

$$\sigma_c = \sigma_m V_m + \sigma_f V_f$$

As $\varepsilon_c = \varepsilon_m = \varepsilon_f$

$$\frac{\sigma_c}{\varepsilon_c} = \frac{\sigma_m}{\varepsilon_m} V_m + \frac{\sigma_f}{\varepsilon_f} V_f$$

$$E_c = E_m V_m + E_f V_f$$

$$E_c = E_f V_f + E_m (1 - V_f)$$

Ratio of load carried to fibre

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m}$$