Lecture # 2.2

Engineering Materials Properties

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Mechanical properties of common engineering materials

The important properties from design point of view are:

(a) Elasticity
(b) Plasticity
(c) Hardness
(d) Ductility
(e) Malleability
(f) Brittleness
(g) Resilience
(h) Toughness
(i) Creep

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(a) Elasticity

This is the property of a material to regain its original shape after deformation when the external forces are removed.

All materials are plastic to some extent, but the degree varies,

for example, both mild steel and rubber are elastic materials, but steel is more elastic than rubber.

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(b) Plasticity

This is associated with the permanent deformation of material when the stress level exceeds the yield point.

Under plastic conditions materials ideally deform without any increase in stress.

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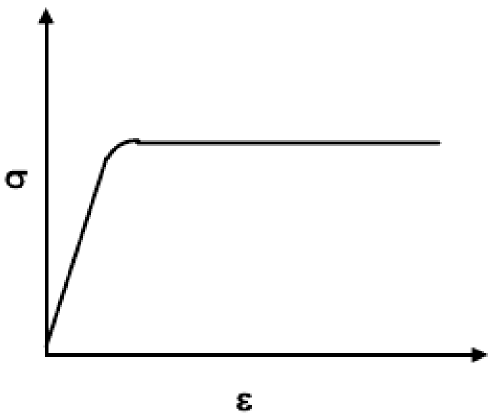
A typical stress strain diagram for an elastic-perfectly plastic material is shown in the figure.



Mises-Henky criterion gives a

good starting point for plasticity analysis.

The criterion is given as

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 = 2\sigma_y^2,$$

where σ_1, σ_2, σ_3 and σ_y are the three principal stresses at a point for any given loading and the stress at the tensile yield point, respectively.

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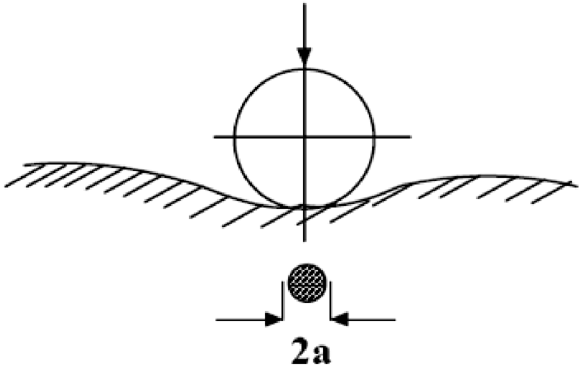
A typical example of plastic flow is the indentation test where a spherical ball is pressed in a semi-infinite body where 2a is the indentation diameter.



In a simplified model we may write that

if $\frac{P}{\pi a^2} > p_m$ plastic flow occurs

where, p_m is the flow pressure. This is also shown in figure.

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(c) Hardness

Property of the material that enables it to resist permanent deformation, penetration, indentation etc.

Size of indentations by various types of indenters are the measure of hardness

e.g. Brinnel hardness test,

Rockwell hardness test,

Vickers hardness (diamond pyramid) test.

These tests give hardness numbers which are related to yield pressure (MPa).

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(d) Ductility

This is the property of the material that enables it to be drawn out or elongated to an appreciable extent before rupture occurs.

The percentage elongation or percentage reduction in area before rupture of a test specimen is the measure of ductility.

Normally if percentage elongation exceeds 15% the material is ductile and

if it is less than 5% the material is brittle.

Lead, copper, aluminium, mild steel

are typical ductile materials.

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(e) Malleability

It is a special case of ductility where it can be rolled into thin sheets but it is not necessary to be so strong.

Lead,

Soft steel,

Wrought iron,

Copper and

Aluminium are some materials in order of diminishing malleability.

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(f) Brittleness

This is opposite to ductility.

Brittle materials show little deformation before fracture and failure occur suddenly without any warning.

Normally if the elongation is less than 5% the material is considered to be brittle.

E.g. cast iron, glass, ceramics

are typical brittle materials.

(g) Resilience

This is the property of the material that enables it to resist shock and impact by storing energy.

The measure of resilience is the strain energy absorbed per unit volume.

For a rod of length L subjected to tensile load P, a linear load-deflection plot is shown in figure.

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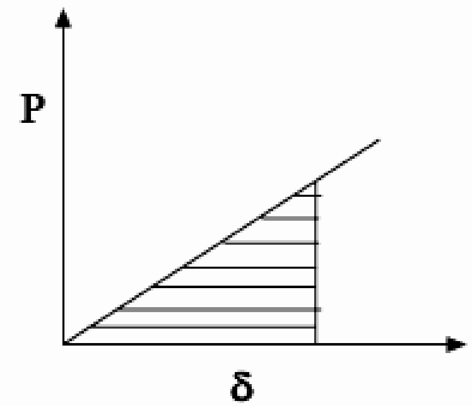
Strain energy (energy stored) $= \frac{1}{2} P\delta L = \frac{1}{2}\frac{P}{A}\frac{\delta L}{L} AL = \frac{1}{2}\sigma\varepsilon V$

Strain energy/unit volume $= \frac{1}{2}\sigma\varepsilon$



A linear load-deflection plot.

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(h) Toughness

This is the property which enables a material to be twisted, bent or stretched under impact load or high stress before rupture.

It may be considered to be the ability of the material to absorb energy in the plastic zone.

The measure of toughness is the amount of energy absorbed after being stressed upto the point of fracture.

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(i) Creep

When a member is subjected to a constant load over a long period of time it undergoes a slow permanent deformation, and this is termed as "creep".

This is dependent on temperature.

Usually at elevated temperatures creep is high.

References

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