POSTAL Book Package 2023

Mechanical Engineering

Objective Practice Sets

Strength of Materials

Contents

MADE EASY Publications

1 CHAPTER
Properties of Materials

MCQ and NAT Questions

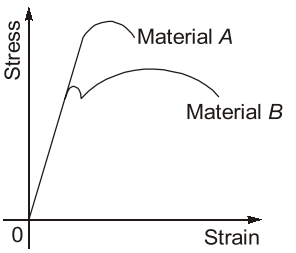
Q.1 In a tensile test, near the elastic limit zone
(a) tensile stress increases at a faster rate
(b) tensile stress decreases at a faster rate
(c) tensile stress increases in linear proportion to the strain
(d) tensile stress decreases in linear proportion to the strain

Q.2 Consider the following statements:
1. Mild steel is more elastic than rubber.
2. Young's modulus of a material is used to represent the elasticity of the material.
3. Greater the Young's modulus, greater the elasticity.

Which of the above statement(s) is/are correct?
(a) Only 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.3 Which of the following properties is more sensitive to increase in strain rate?
(a) Yield strength
(b) Elastic limit
(c) Proportional limit
(d) Tensile strength

Q.4 The stress-strain diagram for two materials *A* and *B* is shown below:



The following statements are made based on this diagram:
I. Material *A* is more brittle than material *B*.
II. The ultimate strength of material *B* is more than that of *A*.

With reference to the above statements, which of the following applies?
(a) Both the statements are false
(b) Both the statements are true
(c) I is true but II is false
(d) I is false but II is true

Q.5 As soon as the external forces causing deformation in a perfectly elastic body, are withdrawn, the elastic deformation disappears
(a) only partially
(b) completely over a prolonged period of time
(c) completely and instantaneously
(d) completely after an initial period of rest

Q.6 Consider the following statements regarding tensile test diagrams for carbon steels with varying carbon contents:
As the carbon content increases
1. the ultimate strength of steel decreases.
2. the elongation before fracture increases.
3. the ductility of the metal decreases.
4. the ultimate strength of steel increases.

Which of the statements above are correct?
(a) 3 and 4 (b) 1 and 3
(c) 1, 2 and 3 (d) 1 and 2

Q.7 Which one of the following favours brittle fracture in a ductile material?
(a) Elevated temperature
(b) Slow rate of straining
(c) Presence of notch
(d) Circular cross-section

Q.8 When the strain in a material increases with time under sustained constant stress, the phenomenon is known as
(a) Strain hardening
(b) Hysteresis
(c) Creep
(d) Visco-clasticity

Select the correct answer using the codes given below.

(a) 1-2-3-4 (b) 1-2-4-3
(c) 2-1-4-3 (d) 3-1-2-4

Q.32 The following observation refer to two metal specimens 'A' and 'B' of the same size subjected to uni-axial tension test upto failure.

1. The elastic strain energy of A is more than that of B.
2. Area under stress strain curve of A is less than that of B.
3. The yield strength of A is more than that of B.
4. The percentage elongation of A and B at elastic limit are equal.

Which of the following statements is true in this regard?

(a) Specimen A is more ductile than specimen B.
(b) Specimen B is more ductile than specimen A.
(c) The ductility of two specimens are equal.
(d) The data is insufficient to compare the ductilities of the two specimens.

Q.33 A steel bar of length 3 m has yield stress 250 MPa and the slope of linear part of stress-strain curve is 190 GPa. The bar is loaded axially until it elongates 6 mm and then the load is removed. What is the residual strain in bar?

(a) 0.002 (b) 0.00131
(c) 0.00069 (d) None of these

Q.34 The initial diameter of a cylindrical test specimen is 30 mm. During plastic deformation stage, it shows a diameter of 27 mm. Assuming the specimen is ductile material. The true longitudinal strain is_____ (Answer up to two decimal place)

Q.35 Consider the following statements regarding tension test of a specimen:

1. Gauge length for specimen is $5.65\sqrt{A}$, where A is cross-sectional area of specimen.
2. True rupture stress is much more than nominal rupture stress in specimen.
3. For steel specimen, proportionality limit is more than elastic limit.
4. Steel specimen breaks at ultimate stress.

Which of the above statements are CORRECT?

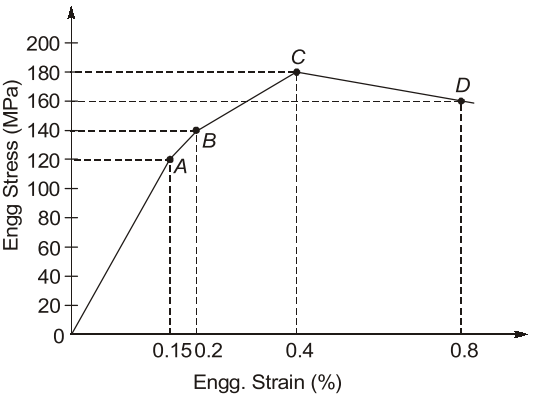
(a) 1 and 2 (b) 1 and 3
(c) 2, 3 and 4 (d) 3 and 4

Multiple Select Questions (MSQ)

Q.36 Consider the following statements with reference to ductile materials and choose the correct statement(s) :

(a) Large deformation is possible before absolute failure by rupture takes place.
(b) In ductile material, elastic deformation is more predominant than plastic one.
(c) Drawn permanently with great changes of shape without rupture.
(d) It can be beaten or rolled into plates.

Q.37 A hypothetical engineering stress-strain curve is shown in figure below :



$A \rightarrow$ Elastic Limit; $B \rightarrow$ Yield Point
$C \rightarrow$ UTS Point; $D \rightarrow$ Fracture Point

With reference to the information given above, the correct statements is(are) :

(a) The resilience of the material is 0.09 MJ/m^3.
(b) The resilience of the material is 0.140 MJ/m^3.
(c) The toughness of the material is 1.14 MJ/m^3.
(d) The toughness of the material is 0.46 MJ/m^3.

Q.38 Which of the following statements is(are) correct?

(a) The greatest strain energy stored in a body is called proof resilience.
(b) The quantity of strain energy stored in a body when strained upto elastic limit is called proof resilience.
(c) The least energy stored in a body is called proof resilience.
(d) Ability to absorb mechanical energy upto failure is called toughness.

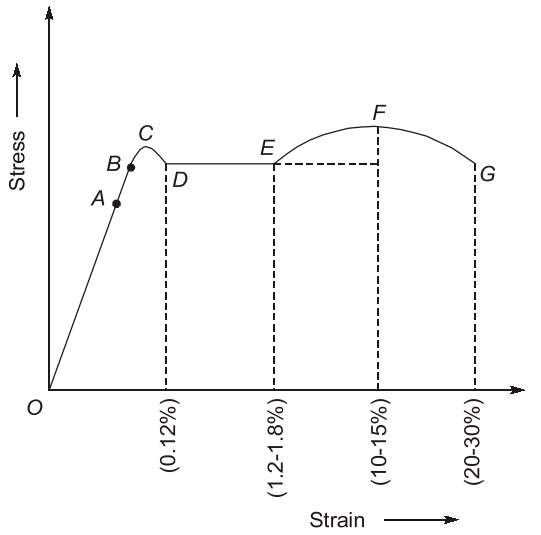
■■■■

Answers Properties of Materials

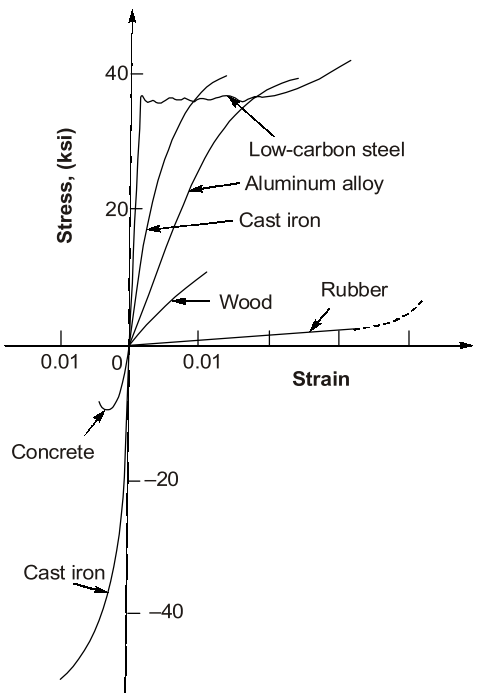
1. (c)	2. (d)	3. (b)	4. (c)	5. (c)	6. (a)	7. (c)	8. (c)	9. (c)	10. (c)
11. (d)	12. (c)	13. (b)	14. (d)	15. (15707.96)		16. (c)	17. (0.85)	18. (d)	19. (a)
20. (d)	21. (a)	22. (d)	23. (b)	24. (b)	25. (c)	26. (b)	27. (a)	28. (b)	29. (b)
30. (b)	31. (b)	32. (b)	33. (c)	34. 0.21	35. (a)	36. (a, c)	37. (a, c)	38. (a, b, d)	

Explanations Properties of Materials

1. (c)



2. (d)



4. (c)

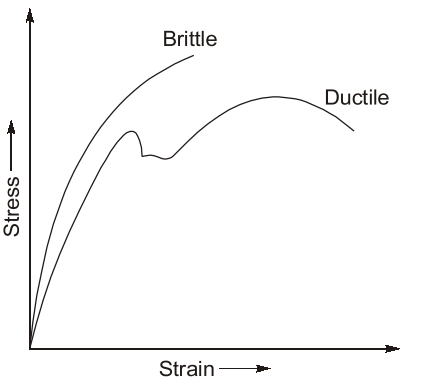
Since strain in material *B* is more, hence it is more ductile than material *A* i.e., material *A* is more brittle than material *B*. Hence **statement I is true**. Material *A* can reach upto higher stress level hence ultimate strength of material *A* is more than that of material *B*. Hence **statement II is false**.

5. (c)

For perfectly elastic body, ideal deformation takes place. Ideal deformation means that the deformation takes place instantaneously upon application of force and disappears completely and instantaneously on the removal of force.

6. (a)

With increase of carbon content brittleness of material increases and therefore elongation before fracture becomes less or ductility decreases. There will be increase in ultimate strength.



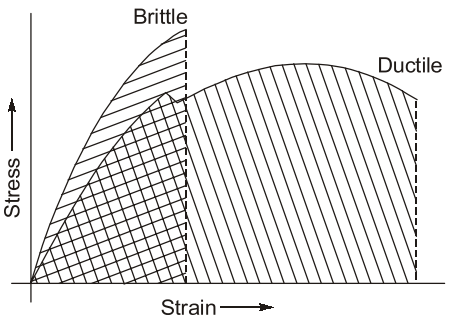
7. (c)

- When an elastic body of ductile material with a local geometrical irregularity such as on oil hole, a keyway or a notch is stressed, usually there is a localised variation in the stress state in the immediate neighbourhood of the irregularity.

- The peak stress level at the irregularity may be several times higher than the nominal stress levels in the bulk of the body.
- Under these circumstances the irregularity is said to cause a stress concentration. This leads to brittle fracture in the material.
- Also, the lower the temperature for a given steel, the greater the possibility that brittle fracture will occur.

Key Points:

- **Fracture :** The separation of a material into two or more pieces under the action of stress.
- Whether a material undergoes ductile fracture or a brittle fracture, it depends on the ability of the material to undergo plastic deformation before the fracture.



- **Brittle Fracture :** It is the sudden and rapid cracking of material under stress.
  - The material does not exhibits (or very little) evidence of ductility or plastic deformation.
  - It is often caused by low temperatures. If the steel temperature is at or below its brittle-to-ductile transition temperature, it will be susceptible to brittle fracture.
- **Ductile Fracture :** It is characterized by extensive plastic deformation or necking.
  - There is absorption of massive amounts of energy before fracture, unlike brittle fracture.

8. (c)

(i) **Strain Hardening :** When a material is strained beyond the yield point, it experiences plastic deformation. And when it is unloaded and then loaded again, an increasing stress is required to produce additional plastic deformation and the material becomes apparently more stronger and more difficult to deform.

Hence, strain hardening is the process of making a metal harder and stronger through plastic deformation. It also reduces ductility, thereby increases the chances of a brittle failure.

(ii) **Hysteresis :** During loading and unloading of a material, strain does not follow the same path. It is because some of the energy is absorbed by the material and is not returned back on unloading. Hence, hysteresis curve is the curve showing the loading and unloading path of a material. And, hysteresis loss, which is equal to the area under the hysteresis curve, represents the energy absorbed by the material.

(iii) **Creep:** It is the gradual increase in plastic strain in a material, with time, at sustained loading.

(iv) **Visco-Elasticity :**

- It is the property of materials that exhibit both viscous as well as elastic characteristics while undergoing deformation.
- Viscous materials resist strain linearly with time when a stress is applied. Elastic materials strain when stretched and immediately return to their original state when the stress is removed.
- Visco-elastic materials have elements of both of these properties and thus, exhibit time-dependent strain.
- Some properties of Visco-elastic materials are :
  - For cyclic loading, hysteresis occurs.
  - For constant stress, creep occurs.
  - For constant strain, stress relaxation takes place.

9. (c)

Strain-softening region in stress strain curve is also known as post ultimate stress.

10. (c)

The shear strain is angle of distortion (change in angle of a corner of element) measured in radian.
For corner A,

$$\gamma_{xy} = \frac{3.6\times10^{-3}}{7.5} + \frac{4.5\times10^{-3}}{6} = 1230\times10^{-6}$$

12. (c)

True strain for finite increment of loading such that length changes from L_0 to L is given by

$$\in_t = \int_{l_0}^{L} \frac{dL}{L} = \ln\left(\frac{L}{L_0}\right)$$

$$\in_t = \ln\left(\frac{L_0+\delta}{L}\right) = \ln\left[1+\frac{\delta}{L_0}\right]$$

$$\in_t = \ln(1+\in)$$

13. (b)

$$\text{Resilience} = \frac{1}{2}\times70\times0.005\times10^6$$

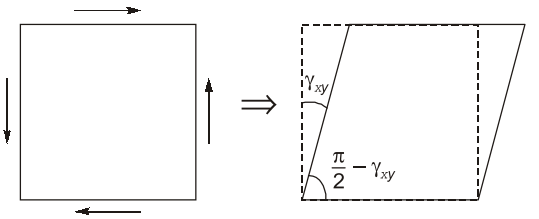
$$= 7.5\times10^4 \text{ Nm/m}^3$$

$$\text{Toughness} = 17.5\times10^4 + \left\{\frac{(70+110)}{2}\right\}\times0.01\times10^6$$

$$= 107.5\times10^4 \text{ Nm/m}^3$$

14. (d)

According to the sign convention,



In question since angle has been increase therefore shear strain should be negative.

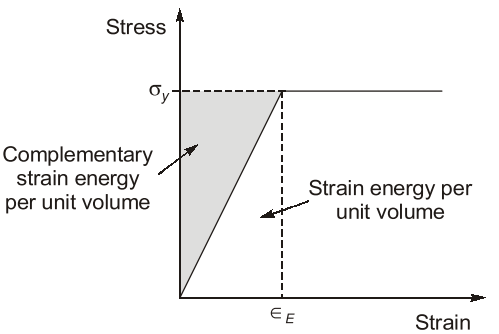
$\therefore \quad \gamma_{xy} = -0.0005$ rad

$= 0.001k$

$-0.0005 = 0.001k$

$\Rightarrow \quad k = -0.50$

15. (15707.96)



$$\text{Elastic strain, } \in_E = \frac{\Delta L}{L} = \frac{2.5}{2000} = 1.25\times10^{-2}$$

$$\therefore \text{Elastic strain energy} = \frac{1}{2}\sigma_y \in_E AL$$

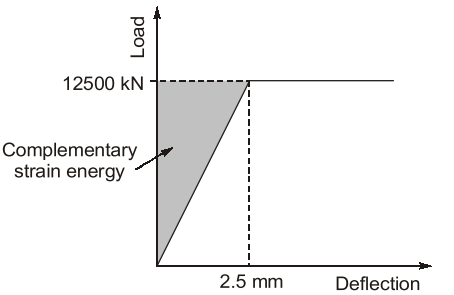
$$= \frac{1}{2}\times250\times1.25\times10^{-3}\times\frac{\pi}{4}\times8^2\times2000$$

$= 15707.96$ Nmm

Note: For linear elastic material both complementary energy and strain energy is same.

OR

By considering given graph in question, between Axial Load and Displacement the solution will be as follows:



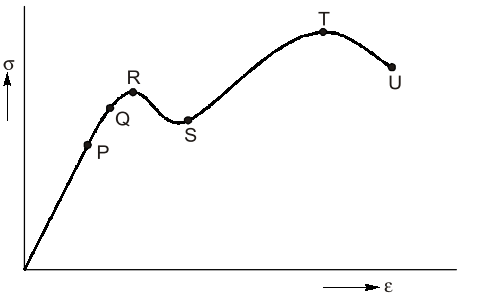
Complementary stain energy,

$$U = \frac{1}{2}P\delta = \frac{1}{2}\left(12500\times10^3\right)\times2.5$$

$= 15625000$ Nmm

It means there seems some error in the given data.

16. (c)



P : Proportional limit Q : Elastic limit

R : Upper Yield Point S : Lower Yield Point

T : Ultimate Tensile Strength

U : Failure/Rupture

17. (0.85)

Toughness is area of curve upto S on strain axis

$$\left[\frac{1}{2}\times\frac{0.2}{100}\times100\right] + \left\{\frac{[100+140]}{2}\times\frac{0.4}{100}\right\} + \left\{\frac{140+130}{2}\right\}\times\frac{0.2}{100}$$

$= 0.1 + 0.48 + 0.27 =$ **0.85 MJ/m³**