POSTAL BOOK PACKAGE 2024

CONTENTS

CIVIL ENGINEERING

Objective Practice Sets

Strength of Materials

1 CHAPTER

Properties of Materials

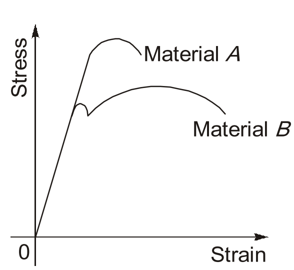
Q.1 In a tensile test, near the elastic limit zone
(a) tensile stress increases at a faster rate
(b) tensile stress decreases at a faster rate
(c) tensile stress increases in linear proportion to the strain
(d) tensile stress decreases in linear proportion to the strain

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Q.5 As soon as the external forces causing deformation in a perfectly elastic body, are withdrawn, the elastic deformation disappears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

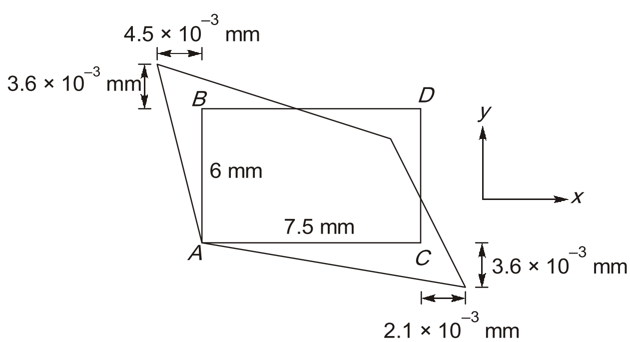
Q.7 Which one of the following favours brittle fracture in a ductile material?
(a) Elevated temperature
(b) Slow rate of straining
(c) Presence of notch
(d) Circular cross-section

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-elasticity

Q.9 Consider the following statements:
1. Strain-softening region in stress strain curve is also known as post ultimate stress.
2. Logarithmic strain given as $\bar{\varepsilon} = \ln\left(\frac{L_f}{L_0}\right)$ is same as true strain.
3. Value of elastic modulus is a definite property of a material.

Which of the above statements is(are) INCORRECT?
(a) 1 and 3 (b) 2 only
(c) 1 only (d) None of these

Q.10 An initially rectangular element of a material is deformed as shown in figure. The shear strain for the element (γ_{xy}), will be

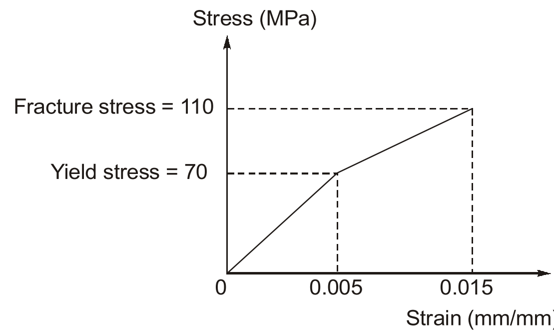


(a) 1370×10^{-6} (b) 1500×10^{-6}
(c) 1230×10^{-6} (d) 900×10^{-6}

Q.11 Due to change in temperature, the deformation in cuboid element is
(a) same in perpendicular directions only
(b) different in perpendicular directions
(c) same in all directions
(d) different in all directions

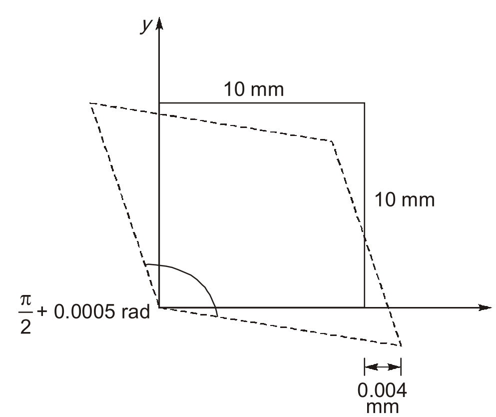
Q.12 If $\in$ is engineering strain in a tensile specimen. The value of true strain ($\in_t$) is given as
(a) $\in$ (b) $e^{\in} - 1$
(c) $ln(1 + \in)$ (d) $\left(\frac{1-\in}{6}\right)$

Q.13 The stress stain behaviour of a material is as shown in figure below. Its modulus of resilience and toughness in Nm/m^3 are respectively:



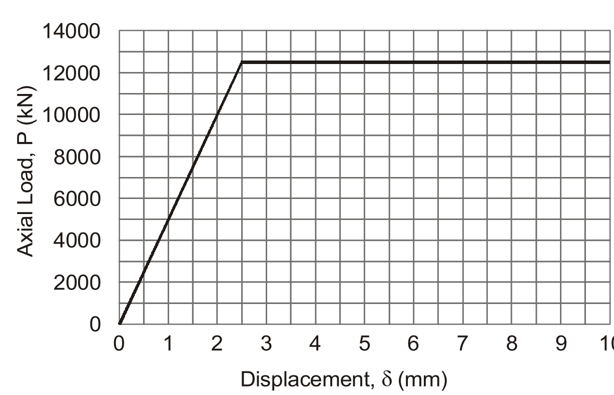
(a) 20×10^4 and 107.5×10^4
(b) 17.5×10^4 and 107.5×10^4
(c) 17.5×10^4 and 120×10^4
(d) 35×10^4 and 140×10^4

Q.14 In a material under a state of plane strain, a 10×10 mm square centered at a point gets deformed as shown in the figure.



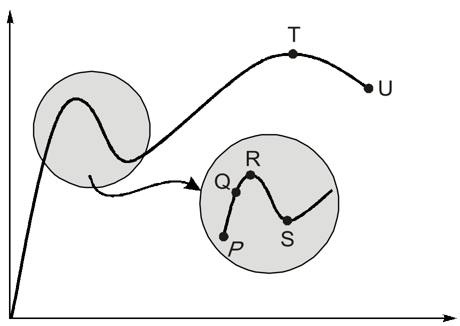
If the shear strain γ_{xy} at this point is expressed as 0.001 k (in rad), the value of k is
(a) 0.50 (b) 0.25
(c) –0.25 (d) –0.50

Q.15 A 2 m long, axially loaded mild steel rod of 8 mm diameter exhibits the load-displacement (P-δ) behavior as shown in the figure.



Assume the yield stress of steel as 250 MPa. The complementary strain energy (in N-mm) stored in the bar up to its linear elastic behaviour will be ___________.

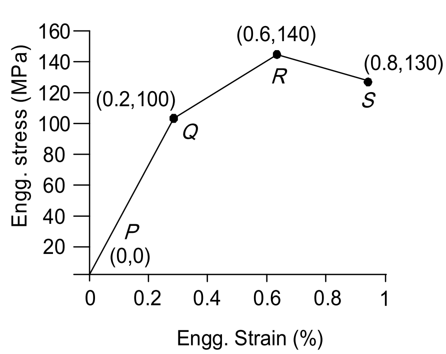
Q.16 The stress-strain curve for mild steel is shown in figure given below. Choose the correct option referring to both figure and table.



Point on the graph	Description of the point
P.	1. Upper yield point
Q.	2. Ultimate tensile strength
R.	3. Proportionality limit
S.	4. Elastic limit
T.	5. Lower yield point
U.	6. Failure

(a) P–1, Q–2, R–3, S–4, T–5, U–6
(b) P–3, Q–1, R–4, S–2, T–6, U–5
(c) P–3, Q–4, R–1, S–5, T–2, U–6
(d) P–4, Q–1, R–5, S–2, T–3, U–6

Q.17 A hypothetical engineering stress-strain curve shown in the figure has three straight lines *PQ*, *QR*, *RS* with coordinates *P*(0, 0), *Q*(0.2, 100), *R*(0.6, 140) and *S*(0.8, 130). *Q* is the yield point, *R* is the UTS point and *S* the fracture point.



The toughness of the material (in MJ/m^3) is_______.

Q.18 Which of the following are incorrect statements?
1. Linear elastic range in compression in larger as compared to that in tension for most brittle materials.
2. The brittle fracture is performed by separation and is not accompanied by noticeable plastic deformation.

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.19 Which of the following pairs is not correctly matched?
(a) Visco-elastic: Small plastic zone
(b) Orthotropic material: Different properties in their perpendicular directions
(c) Strain hardening material: Stiffening effect at some stage
(d) Isotropic material: Same physical property in all direction at a point

Q.20 Assuming a force of 18 kN is applied to a round metal test specimen with diameter of 9.6 mm. The original length of test specimen is 400 mm. Determine the engineering stress and strain at 401.5 mm

(a) σ = 280 MPa, ε = 0.0037
(b) σ = 350 MPa, ε = 0.018
(c) σ = 200 MPa, ε = 0.002
(b) σ = 249 MPa, ε = 0.0037

Q.21 Which of the following pairs are correctly matched?
1. Resilience ... Resistance to deformation
2. Malleability ... Deformation under compressive load
3. Creep ... Progressive deformation
4. Plasticity.... Permanent deformation

Select the correct option using the codes below:
(a) 2, 3 and 4 (b) 1, 2 and 3
(c) 1, 3 and 4 (d) 3 and 4

Q.22 Fatigue test is carried out for
(a) Stresses varying between two limits of equal value, but of opposite sign
(b) Stresses varying between two limits of unequal value but of opposite sign
(c) Stresses varying between two limits of unequal value but of same sign
(d) All are the correct

Q.23 When plastic deformation occurs, then volume of a ductile specimen is essentially constant. If the initial radius of the specimen is $\frac{d_0}{2}$, then what will be the true strain when radius is $\frac{d}{2}$?

(a) $\varepsilon_t = 2\ln\left(\frac{d}{d_0}\right)$ (b) $\varepsilon_t = 2\ln\left(\frac{d_0}{d}\right)$

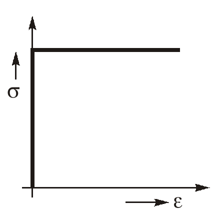
(c) $\varepsilon_t = \frac{1}{2}\ln\left(\frac{d_0}{d}\right)$ (d) $\varepsilon_t = \frac{1}{2}\ln\left(\frac{d}{d_0}\right)$

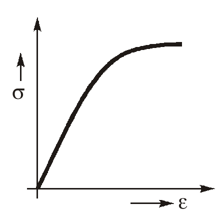
Q.24 Steel has its yield strength of 400 N/mm^2 and modulus of elasticity of 2×10^5 MPa. Assuming the material to obey Hooke's law up to yielding, what is its proof resilience?

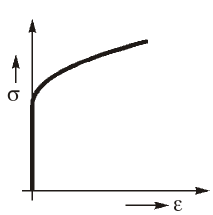
(a) 0.8 N/mm^2 (b) 0.4 N/mm^2

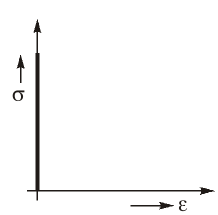
(c) 0.6 N/mm^2 (d) 0.7 N/mm^2

Q.25 Which of the following curve represent correct rigid plastic material considering strain hardening effects?

(a)


(b)


(c)


(d)


Directions: Each of the next items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)

(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)

(c) Statement (I) is true; but Statement (II) is false

(d) Statement (I) is false; but Statement (II) is true

Q.26 Statement (I): Strain is a fundamental behaviour of the material, while stress is a derived concept.

Statement (II): Strain does not have a unit while stress has a unit.

Q.27 Statement (I): The ultimate load of a structure made of ductile material, subjected to reversible repeating loads and plastic deformation, is lowered with each reversal of load.

Statement (II): When subjected to repeated reversal of loads and plastic deformation, the structure made of a ductile material accumulates residual strains.

Q.28 Statement (I): When a material is subjected to repeated tensile stress within elastic range, it is found that the material deteriorates and fractures after many but finite number of repeated application of stress.

Statement (II): The critical stress below which fluctuating stresses cannot cause a fatigue failure is termed as 'endurance limit'.

Q.29 Statement (I): For a given mean stress, there is a limiting value of stress below which failure will not take place for infinite number of cycles, known as endurance limit.

Statement (II): When a structure is subjected to fluctuating stresses, the fracture occurs at value of stress much lower than that in case of static loading.

Q.30 In mild steel specimens subjected to tensile test cycle, the elastic limit in tension is raised and the elastic limit in compression is lowered. This is called

(a) Annealing effect (b) Bauschinger effect

(c) Strain rate effect (d) Fatigue effect

Q.31 What is the correct sequence of the following material in the decreasing order of their modulus of elasticity?

(1) Steel (2) Cast iron

(3) Aluminium (4) Brass

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 untill 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?

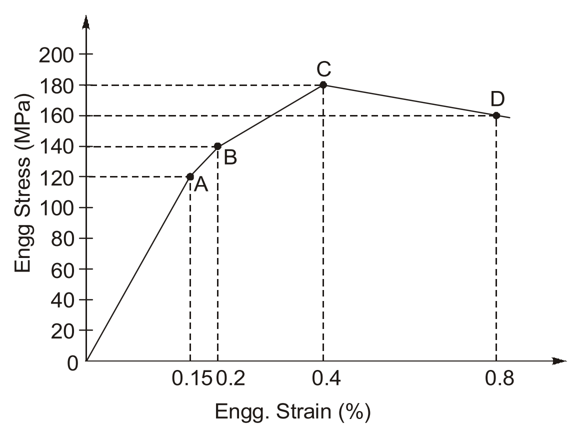
(a) 1 and 2 (b) 1 and 3
(c) 2, 3 and 4 (d) 3 and 4

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 → Elastic Limit; B → Yield Point
C → UTS Point; D → Fracture Point

With reference to the information given above, the correct statement(s) 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 statement(s) 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.

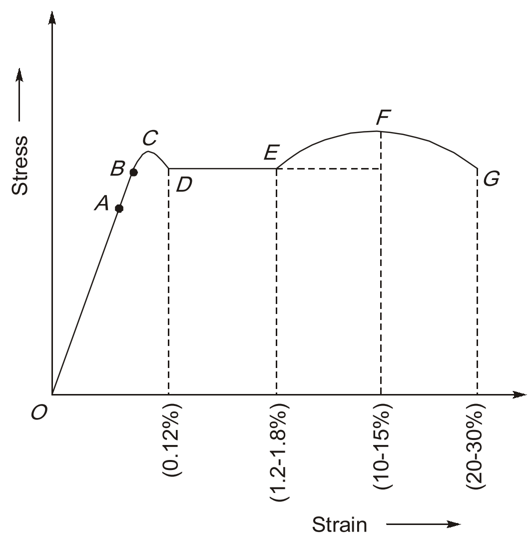
■■■■

Answers Properties of Materials

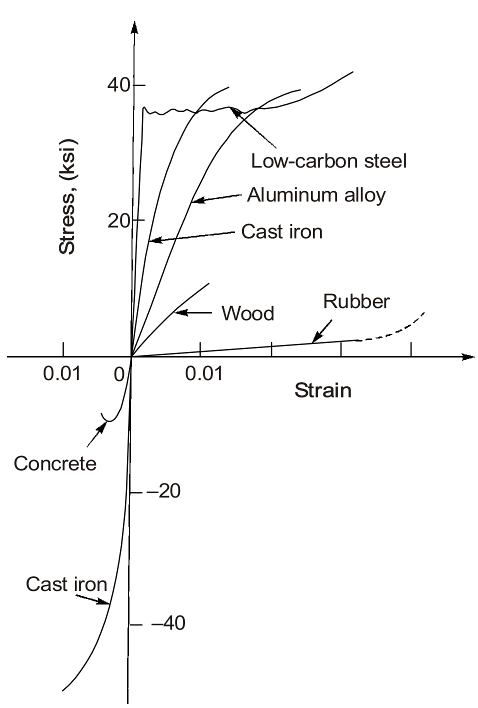
1. (c)	2. (d)	3. (b)	4. (c)	5. (c)	6. (a)	7. (c)	8. (c)	9. (c)	10. (c)
11. (d)	12. (c)	13. (b)	14. (d)	15. 15707.96		16. (c)	17. 0.85	18. (d)	19. (a)
20. (d)	21. (a)	22. (d)	23. (b)	24. (b)	25. (c)	26. (b)	27. (a)	28. (b)	29. (b)
30. (b)	31. (b)	32. (b)	33. (c)	34. 0.21	35. (a)	36. (a, c)		37. (a, c)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

Explanations Properties of Materials

1. (c)



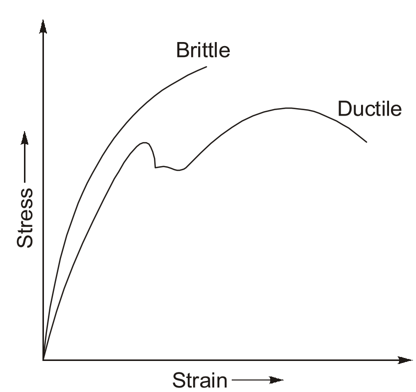
2. (d)



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.



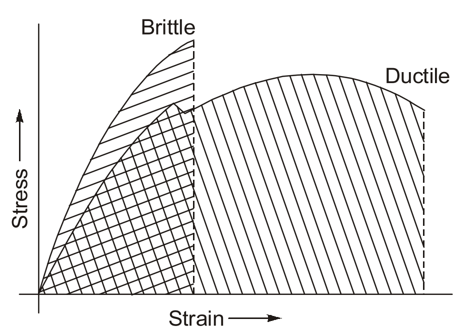
7. (c)
- When an elastic body of ductile material with a local geometrical irregularity such as on oil hole, a keyway or a notch is stressed, usually there

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

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

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

$$\epsilon_t = \ln(1+\epsilon)$$

13. (b)

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

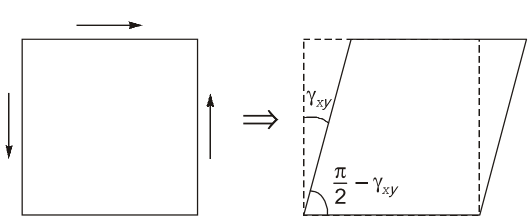
$$= 7.5\times10^{4}\ \text{Nm/m}^3$$

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

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

14. (d)

According to the sign convention,



+ve shear stress　　+ve shear strain

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

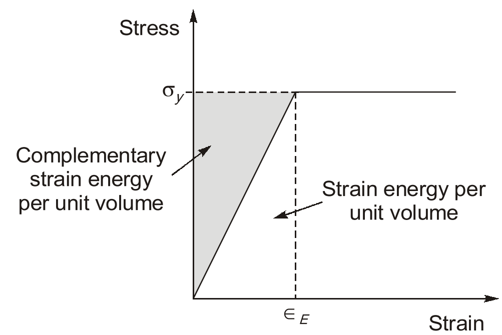
$$\therefore \quad \gamma_{xy} = -0.0005 \text{ rad}$$

$$= 0.001k$$

$$-0.0005 = 0.001k$$

$$\Rightarrow \quad k = -0.50$$

15. (15707.96)



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

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

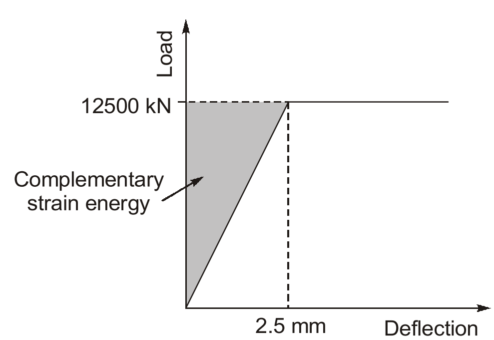
$$= \frac{1}{2}\times250\times1.25\times10^{-3}\times\frac{\pi}{4}\times8^2\times2000$$

$$= 15707.96 \text{ Nmm}$$

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:



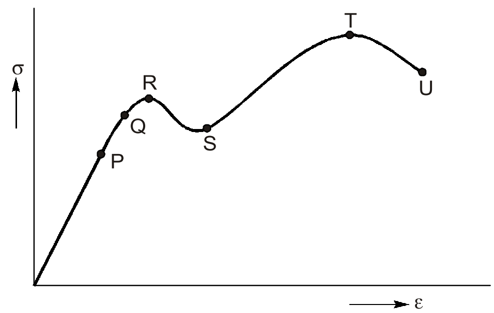
Complementary stain energy,

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

$$= 15625000 \text{ Nmm}$$

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)

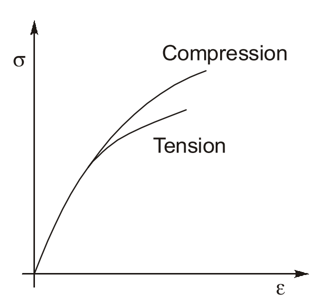
Toughness is area of curve upto *S* on strain axis

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

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

18. (d)

Brittle materials (in compression test): Brittle material in compression typically an initial linear region followed by a region in which the shortening increases at a higher rate than does the load for cast iron, the shape may be like this:



Brittle material in compression behave elastically upto certain load, and then fail suddenly by spiliting or by cracking in the way as shown in figure, thus brittle fracture is performed by separation and is not accompanied by noticeable plastic deformation.

19. (a)

Visco-elastic material exhibit a mixture of creep and elastic after effects at room temperature. Thus their behaviour is time dependent materials with different properties in different directions are called Anisotropic orthotropic material is a special case of an anisotropic material in three mutually perpendicular directions. However there are symmetric about any axis.

20. (d)

Given, $P = 18\text{ kN} = 18000\text{ N}$

$$A_0 = \frac{\pi}{4}d^2 = \frac{\pi}{4}(9.6)^2 = 72.38\text{ mm}^2$$

$$l_0 = 400\text{ mm}$$

$$l'_0 = 401.5\text{ mm}$$

$$\sigma = \frac{P}{A_0} = \frac{18000}{72.38} = 249\text{ MPa}$$

$$\varepsilon = \frac{\Delta l}{l_0} = \frac{l'_0 - l_0}{l_0}$$

$$= \frac{401.5-400}{400} = 0.0037$$

21. (a)

Resilience: It is the property of a material to absorb energy when it is deformed elastically and then, upon unloading to have this energy recovered.

23. (b)

If the volume is constant,

L_0 = Initial length

L = Final length

$$\Rightarrow \quad \frac{\pi}{4}d^2L = \frac{\pi}{4}d_0^2L_0$$

$$\frac{L}{L_0} = \left(\frac{d_0}{d}\right)^2$$

True strain, $$\varepsilon_t = \int_{L_0}^{L}\frac{dL}{L} = \ln\frac{L}{L_0}$$

$$= \ln\left(\frac{d_0}{d}\right)^2 = 2\ln\left(\frac{d_0}{d}\right)$$

$$\varepsilon_t = 2\ln\left(\frac{d_0}{d}\right)$$

24. (b)

Proof resilience,

$$u_{max} = \frac{\sigma_y^2}{2E} = \frac{400^2}{2\times 2\times 10^5} = 0.4\text{ N/mm}^2$$

25. (c)

Option (a): Perfectly plastic (non-strain hardening)

Option (b): Elastic plastic material

Option (d): Rigid material

26. (b)

When a force is applied to a material, it deforms. The deformation can easily be measured. Hence, strain can be measured. Whereas, the force that was applied cannot be measured directly and hence, stress cannot be measured directly.

Therefore, although it appears that first a force is applied and then strains are developed in the body due to the applied forces.

But, due to the fact that strain can be measured directly and stress cannot be, strain is a fundamental behaviour of the material while stress is a derived concept.

27. (a)

Fatigue is the weakening of a material caused by repeatedly applied loads. It is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading.

Hence, on application of repeated reversal of loads and plastic deformation, material accumulates residual strains due to which ultimate load of the structure goes on lowering with each reversal of load.

28. (b)

- Statement (A), i.e., Assertion describes fatigue failure.
- **Fatigue limit** is the limiting value of stress at which failure occurs as number of cycles becomes very large.
- **Endurance limit** is the stress below which failure never occurs, even for an indefinitely large number of loading cycles.

29. (b)

Material can withstand infinte number of cycles at or below endurance limit.

The stress which can be withstood for specified number of cycles is called fatigue strength of material.

When mean stress is zero, the ratio of endurance limit stress (σ_e) and ultimate stress (σ_{ult}) is

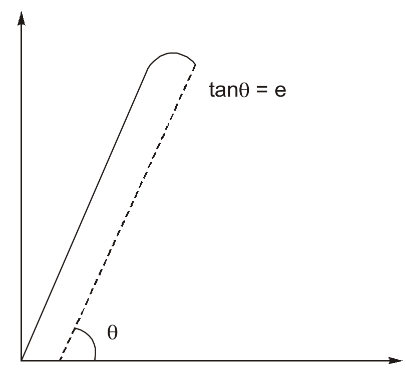
$$\frac{\sigma_e}{\sigma_{ult}} \simeq 0.4 \text{ (infinite life) for ferrous material}$$

$$\frac{\sigma_e}{\sigma_{ult}} \simeq 0.25 \text{ } (10^8 \text{ cycles}) \text{ for nonferrous materials.}$$

31. (b)

Material		Modulus of elasticity (E) (in GPa)
1.	Steel	200 - 220
2.	Cast iron	100 - 160
3.	Brass	80 - 90
4.	Aluminum	60 - 80

33. (c)



$$\text{Total strain} = \frac{6}{3000} = \frac{1}{500} = 0.002$$

$$\text{Elastic strain} = \frac{250}{190 \times 10^3} = 0.00131$$

$\therefore$ Residual strain = 0.002 – 0.00131 = 0.00069

34. 0.21 (0.15 to 0.25)

As the deformation is in plastic state, volume will remain constant

True strain,

$$\varepsilon_t = 2\ln\left(\frac{d_0}{d}\right) = 2\ln\left(\frac{30}{27}\right) = 0.21$$

36. (a, c)

- Stress-strain curve for ductile materials.