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CIVIL ENGINEERING

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Contents

UNIT-I Strength of Material

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CHAPTER 1

BASIC AND INTRODUCTION

OBJECTIVE QUESTIONS

1. If a material has identical properties in all directions it is said to be.....
(a) Homogenous (b) Isotropic
(c) Elastic (d) Orthotropic
[RPSC Lecturer (Tech. Edu.) 2011]
OR
If a material has identical elastic properties in all directions it is said to be....
(a) Homogenous (b) Isotropic
(c) Elastic (d) Orthotropic
[RPSC – ACF – 2011]
OR
The material that has same properties in all directions is called
(a) Homogenous (b) Isotropic
(c) Elastic (d) Orthotropic
[PHED-JE (Diploma) 2014]
OR
The in material having same elastic properties all direction are called
(a) Ideal materials
(b) Isotropic materials
(c) Elastic materials
(d) Uniform materials
[RPSC ACF – 2018]

Ans. (b)
Let consider any point inside the bulk of a material. At that point, we apply a stimulus (or a load) in a direction. We get a certain response and that is what we call property of the material in that direction.
However, if we apply similar stimuli at all possible directions at that one point and get different results every time, we call that material anisotropic.
Now, if we get similar results by applying similar stimuli in all possible directions at that point, we call the material Isotropic. It is an idealized concept and no such material exists.
If we get similar results by applying similar stimuli in only 3 mutually perpendicular directions at that point alone, we call the material orthotropic.
A material is called homogeneous if it exhibits similar results (properties) in a single direction only but at every point throughout the bulk of the material. In other words, Homogeneous material is a material of uniform composition throughout that cannot be mechanically separated into different materials.
In other words,

Isotropic Material	Orthotropic material	Anisotropic material
Identical material properties in all directions at every given point. When a specific load is applied at any point of isotropic materials, it will exhibit the same strength, stress, strain, young's modulus, and hardness in the x, y, or z-axis direction.	If it has three different properties in three mutually perpendicular directions. They are a subset of anisotropic materials.	If it has different properties (such as Young's modulus) in each direction.
For an isotropic, homogeneous, and elastic material obeying Hook's law, the number of independent elastic constants is 2. *Examples:* metals, glasses.	There are 9 independent elastic constants required to define the stress-strain relationship for orthotropic material.	There are 21 independen t elastic constants required to define the stress-strain relationship for an anisotropic material. *Examples:* wood and composites.

2. The bulk modulus of K, modulus of elasticity E and Poisson's ratio is 1/m then which of the following is true

(a) $E = 3K\left(1-\frac{2}{m}\right)$ (b) $E = 3K\left(1-\frac{1}{m}\right)$

(c) $E = 3K\left(1+\frac{2}{m}\right)$ (d) $E = 3K\left(1+\frac{1}{m}\right)$

[RPSC – AEN – 2018]

OR

The relation between modulus of elasticity E, bulk modulus K, Poisson's ratio 1/m is.

(a) E = 3K(1 – 2/m) (b) E = 2K(1 – 3/m)

(c) K = 3E(1 – 2/m) (d) K = 2E(1 – 3/m)

[RPSC – AEN – 2013]

OR

The relationship between modulus of elasticity (E) and Bulk Modulus (K) and Poisson's ratio m is

(a) E = 3k(1 – 2m) (b) E = 3k(1 + 2m)

(c) E = 3k(1 – m) (d) E = 3k(1 + m)

[PHED-JE (Diploma) 2014]

OR

The relation between modulus of elasticity E, bulk modulus K, Posson's ratio 1/m is:

(a) E = 3K (1 – 2/m)

(b) E = 2K (1 – 3/m)

(c) K = 3E (1 – 2/m)

(d) K = 2E (1 – 3/m)

[RSMSSB – JE (Degree) – 2020]

Ans. (a)

The relationship between Young's Modulus (E), shear modulus (G), Bulk modulus of elasticity (K) and Poisson's ratio (μ)

$$E = 2G (1 + \mu)$$

$$E = 3K (1 - 2\mu)$$

$$E = 9KG/(3K + G)$$

$$\mu = (3K - 2G)/(6K + 2G)$$

3. The poisson's ratio is defined as

(a) $\frac{\text{Axial Stress}}{\text{Lateral Stress}}$ (b) $\frac{\text{Lateral Strain}}{\text{Axial Strain}}$

(c) $\frac{\text{Lateral Stress}}{\text{Axial Stress}}$ (d) $\frac{\text{Axial Strain}}{\text{Lateral Strain}}$

[RCDF - Assistant Manager (Civil) – 2021]

Ans. (b)

The ratio of lateral strain to the longitudinal strain is a constant for a given material when the material is stressed within the elastic limit. This ratio is known as Poisson's ratio (μ).

4. The shear modulus of most materials with respect to the modulus of elasticity is

(a) Equal to half (b) Less than half

(c) More than half (d) None of these

[RIICO-ASE (Civil)–2015]

Ans. (b)

$$G = \frac{E}{2(1+\mu)}$$

Where,

G = Shear modulus of the material,

E = Modulus of elasticity of the material, and

μ = Poisson's ratio of the material

For realistic material, Modulus of elasticity is always at least double (when μ = 0) than the shear modulus.

5. When a bar is cooled to –5°C, it will develop

(a) No stress (b) Shear stress

(c) Tensile stress (d) Compressive stress

[RIICO - ASE (Civil) – 2015]

Ans. (c)

Thermal stress: When a bar or beam is subjected to a change of temperature and its deformation is prevented, the stress induced in the bar is called thermal stress.

In other words if the material is constrained (i.e. body is not allowed to expand or contract freely), change in length due to rise or fall of temperature is prevented, the stresses induced in the body is known as thermal stress.

Remember:

- When the temperature of the bar is raised, and the bar is not free to expand, the bar tries to expand and exerts axial pressure on wall. At the same time wall puts equal and opposite pressure on the bar which will develop compressive stress in the bar.
- If there is a drop in the temperature of the bar, the bar will try to contract, exerting pull on the wall. At the same time the wall offers equal and opposite reaction exerting pull on the bar which will develop tensile stress in the bar.
- Increase in temperature leads to Compressive stress
- Decrease in temperature leads to Tensile stress

6. The poisson's ratio for steel varies for

(a) 0.23 to 0.27

(b) 0.25 to 0.33

(c) 0.31 to 0.34

(d) 0.32 to 0.42

[RIICO – ASE (Civil) – 2015]

Ans. (b)

Poisson's ratio is the ratio of transverse strain to longitudinal strain

μ = –lateral strain/longitudinal strain

Most materials have Poisson's ratio values ranging between 0.0 and 0.5 (mostly 0.33).

A perfectly incompressible material has a value of 0.5.

- **Stainless steel :** 0.30 – 0.31
- **Steel :** 0.25 – 0.33
- **Cast iron :** 0.21 – 0.26
- **Cork : 0**.0
- **Rubber :** 0.5

7. The ratio of change in volume to the original volume is called

(a) Linear strain

(b) Linear stress

(c) Volumetric strain

(d) Poisson's ratio

[RIICO – ASE (Civil) – 2015]

Ans. (c)

$$\text{Strain} = \frac{\text{Change in Dimension}}{\text{Original Dimension}}$$

There are three types of strain

- Volumetric strain
- Longitudinal strain
- Shear strain

Whenever there is stress applied on an object from all the sides or some sides then there will be a change in its volume (δv) and if its original volume is v then according to the definition of strain volumetric strain = $\delta v/v$. *i.e.*

$$\text{Volumetric strain} = \frac{\text{change in volume}}{\text{original volume}}$$

8. A beam supported on more than two supports is called

(a) Simply supported beam

(b) Fixed beam

(c) Overhang beam

(d) Continuous beam

[RIICO – ASE (Civil) – 2015]

Ans. (d)

A beam supported on more than two supports is known as a continuous beam.

The intermediate supports are always subjected to bending moment which is negative (Hogging case)

If end supports are simply supported, the bending moment at end supports will be zero

If end supports are fixed, the bending moment at end supports will not be zero.

Continuous beams are those that rest over three or more supports.

When a beam is resting on the supports at both the ends is called simply supported beam.

When a beam is fixed between the two supports is called fixed beam.

When a beam whose end portion is extended beyond the supports is called over hanging beam.

9. The greatest amount of strain energy per unit volume that a material can absorb up to its elastic limit is: –

(a) Toughness Index (b) Proof resilience

(c) Resilience (d) Potential energy

[RPSC – VP – ITI – 2012]

Ans. (*)

As we know that:

Strain energy absorbed by the material up to elastic limit is called resilience.

Strain energy absorbed per unit volume by the material up to elastic limit is called modulus of resilience.

Maximum strain energy that can be absorbed by the spring up to the elastic limit without creating a permanent distortion is called proof resilience.

10. The value of Poisson's ration of the materials lie between:

(a) 1 and 2 (b) 0 and 1/2

(c) 0 and 1 (d) 2 and 3

[RPSC – VP – ITI – 2012]

OR

The value of Poisson's ratios of the materials lie between

(a) 1 and 2 (b) 0 and 1/2

(c) 0 and 1 (d) 2 and 3

[RSMSSB – JE(Degree) – 2020]

Ans. (b)

Poisson's Ratio: Simon Poisson pointed out that within the elastic limit, lateral strain is directly proportional to the longitudinal strain. The ratio of the lateral strain to the longitudinal strain in a stretched wire is called Poisson's ratio.

Here lateral strain the strain perpendicular to the applied force and its is given as ($\Delta R/R$)

μ = (–laterial strain)/(longitudinal strain)

Here negative sign shows that as length of wire increases, the radius of wire will decrease.

The normal value of μ lies between – 1 and + 1/2. Whereas practical value of μ lies between 0 to + 1/2 and just like strain Poisson's ratio is also Dimensionless.

Note: For a rigid body, the value of Poisson's ratio is zero. A zero Poisson's ratio means that there is no transverse deformation resulting from an axial strain. Most materials have Poisson's ratio values ranging between 0.0 and 0.5.

A perfectly incompressible material deformed elastically at small strains would have a Poisson's ratio of exactly 0.5. Most steels and rigid polymers when used within their design limits (before yield) exhibit values of about 0.3, increasing to 0.5 for post – yield deformation which occurs largely at constant volume. Rubber has a Poisson ratio of nearly 0.5. Cork's Poisson ratio is close to 0, showing very little lateral expansion when compressed.

11. A rectangular bar having cross section A, length L, modulus of elasticity E and Poisson's ratio 1/m, is subjected to axial pull of P. The volumetric strain will be given by

(a) $\frac{PL}{AE}\left(1-\frac{2}{m}\right)$ (b) $\frac{P}{AE}\left(1-\frac{2}{m}\right)$

(c) $\frac{PL}{AE}\left(1-\frac{1}{m}\right)$ (d) $\frac{P}{AE}\left(1-\frac{1}{m}\right)$

[RPSC – VP – ITI – 2012]

Ans. (a)

Volumetric strain = change in volume/original volume

$$\in_v = (\sigma_x + \sigma_y + \sigma_z)(1 - 2\mu)/E$$

For uniaxial tensile load (P),

$$\in_v = \frac{P}{AE}(1-2\mu)$$

12. The value of stress up to which a member regains its original shape or size after load removal is called

(a) Elastic limit (b) Proportional limit

(c) Yield stress (d) Plastic limit

[RPSC – VP – ITI – 2012]

Ans. (a)

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

13. The ratio of young's modulus of high tensile steel to that of mild steel is about

(a) 0.5 (b) 1.0
(c) 1.5 (d) 2.0

[WRD-JE-Degree – 2013]

Ans. (b)

Young's modulus for all steel are same.

Irrespective of grade of steel, modulus of elasticity, density and poisson's ratio of steel remains the same.

Some common mechanical properties of structural steel:

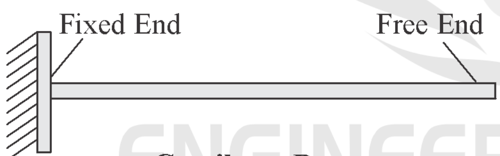
- **Modulus of elasticity** $= 2 \times 10^5$ N/mm^2
- Coefficient of thermal expansion $= 12 \times 10^{-6}$/°C
- **Density** = 7850 kg/m^3
- **Poisson's ratio:** $\mu = 0.3$ (elasticrange)
  $\mu = 0.5$ (plasticrange)

14. A Cantilever beam is one which is supported with

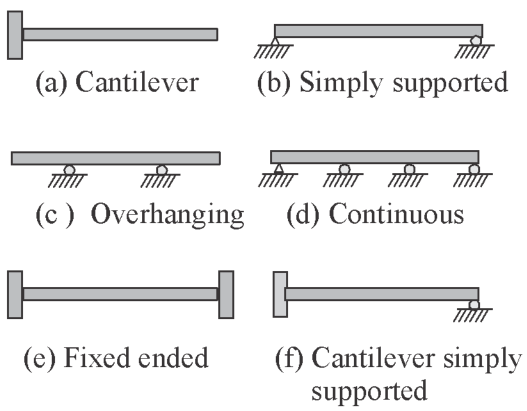
(a) One end hinged and other on roller
(b) One end fixed and other on roller
(c) Both ends on rollers
(d) One end fixed and other free

[WRD-JE (Diploma) – 2013]

Ans. (d)



Cantilever Beam



15. The percentage elongation of a material from a direct tensile test indicates

(a) Ductility (b) Strength
(c) Yield stress (d) Ultimate strength

[WRD-JE (Diploma) – 2013]

Ans. (a)

Ductility is the property of the material that enables it to be drawn out or elongated to an appreciable extent before rupture occurs. Ductility is the ability of a metal to exhibit large deformation or plastic response when being subjected to tensile force.

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.

16. Toughness is

(a) ability to absorb energy during plastic deformation
(b) higher ultimate strength
(c) stress at yield
(d) strain energy at yield

[WRD-JE (Diploma) – 2013]

Ans. (a)

Toughness is the ability of a material to absorb energy in plastic deformation till the point of fracture. Toughness is indicated by the total area under the stress-strain curve up to the fracture point.

17. The ratio of shear modulus to the modulus of elasticity when poisons ratio is 0.25, will be

(a) 3 (b) 2
(c) 1.4 (d) 0.4

[WRD-JE (Diploma) – 2013]

Ans. (d)

As we knows that, $E = 2G(1 + \mu)$

Where, E = Modulus of elasticity
G = Modulus of rigidity
μ = Poisons ratio

Given: Poisson's ratio, $\mu = 0.25$

The ratio of modulus of rigidity to modulus of elasticity

$$= G/E = \frac{1}{2(1+\mu)} = 0.4$$

18. Determine the Poission ratio of a material for which Young's modulus is 1.2×10^5 N/mm^2 and modulus of rigidity is 4.8×10^4 N/mm^2

(a) 0 (b) 0.5

(c) 1 (d) 0.25

[RPSC ACF – 2018]

Ans. (d)

As we know that:

$$E = 2G(1+\mu)$$
$$1.2 \times 10^5 = 2 \times 4.8 \times 10^4 (1+\mu)$$
$$\mu = 0.25$$

19. A bar of 30 mm diameter is subjected to a pull of 60 kN; the measured tension on gauge length of 200 mm is 0.1 mm and change in diameter is 0.004 mm. Calculate Young's modulus

(a) 1.432×10^5 N/mm^2

(b) 1.697×10^5 N/mm^2

(c) 1.0×10^5 N/mm^2

(d) 2×10^5 N/mm^2

[RPSC ACF – 2018]

Ans. (b)

Given: Diameter, d = 30 mm

Pull, p = 60 kN = 60×10^3 N

Length, L = 200 mm

Change in Length, δL = 0.1 mm

Change in Diameter, δd = 0.004 mm

Young's modulus,

$$E = \frac{\text{Tensile stress } (\sigma)}{\text{Tensile strain (e)}}$$

$$E = \frac{60 \times 10^3}{\frac{\pi}{4} \times 30^2 \times 5 \times 10^{-4}}$$

$$E = 1.698 \times 10^5 \text{ N/mm}^2$$

20. A tapering bar (diameters of end sections are d_1 and d_2) and a bar of uniform cross-section 'd' has the same length and are subjected to same axial pull. Both the bars will have the same extension if 'd' is equal to

(a) $\frac{d_1 + d_2}{2}$ (b) $\sqrt{d_1 d_2}$

(c) $\sqrt{\frac{d_1 d_2}{2}}$ (d) $\sqrt{\frac{d_1 + d_2}{2}}$

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

Ans. (b)

For a tapering bar (diameters of end sections are d_1 and d_2)

$$\text{Elongation of taper bar} = \frac{4PL}{E\pi d_1 d_2}$$

For a bar of uniform cross-section 'd' Elongation

$$= \frac{4PL}{E\pi d^2}$$

Both the bars will have the same extension, so on comparing above two, will get

$$d = \sqrt{d_1 d_2}$$

21. Bar of steel 20 mm in diameter was subjected to a tensile load. The measured extension on a 100 mm gauge length was 1 mm and the change in diameter was 0.05 mm. What is the value of Poisson's ratio?

(a) 4.0 (b) 1.0

(c) 0.25 (d) 0.50

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

Ans. (c)

We know

$$\mu = -\frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

$$\text{Lateral strain} = \frac{\text{Change in diameter}}{\text{Original diameter}}$$

$$\text{Longitudinal strain} = \frac{\text{Change in length}}{\text{Original length}}$$

Given,

Diameter of bar = 20 mm,

Length of bar = 100 mm

Elongation = 1 mm

Decrease in diameter = 0.05 mm

Lateral strain = – 0.05/20

Longitudinal strain = 1/100

So, $$\mu = -\frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

$$\mu = 0.25$$

22. Bar of area 500 mm^2 is 4 meter long and carries a tensile load of 100 kN. Determine the strain energy stored in the bar.

[Take E = 2 × 10^5 N/mm^2]

(a) 100 Nm (b) 200 Nm

(c) 1000 Nm (d) 500 Nm

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

Ans. (b)

Given:

$$P = 100 \text{ kN} = 100000 \text{ N}$$
$$L = 4\text{m} = 4000 \text{ mm}$$
$$A = 500 \text{ mm}^2$$
$$E = 2 \times 10^5 \text{ N/mm}^2$$

Axial Deformation (δ) of the Bar:

The deformation of a bar with known geometry and subjected to an axial load can be determined by the equation of the form,

$$\delta_1 = PL/AE,$$

Where

AE = Axial rigidity and

L = Length of member

$$\delta_1 = \frac{100000 \times 4000}{500 \times 200000}$$
$$= \frac{1000}{250} = 4 \text{ mm}$$

So, Strain Energy = 0.5 × Load × δL

= 0.5 × 100000 × 0.004

= 200 Nm

23. The modulus of rigidity for a material is 4 × 10^4 N/mm^2. For the axially loaded material, if the value of Poisson's ratio is 0.25, calculate the modulus of elasticity (in N/mm^2).

(a) 1 × 10^5 (b) 2 × 10^5

(c) 1 × 10^4 (d) 5 × 10^4

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

Ans. (a)

The relationship between elastic modulus, modulus of rigidity and Poisson's ratio is given by

$$E = 2G(1 + \mu)$$
$$= 2 \times 4 \times 10^4(1 + 0.25)$$
$$= 1 \times 10^5 \text{ N/mm}^2$$

24. Which of the following is not matched correctly?

Material property	Defination
1. Ductility	a measure of the degree of plastic deformation
2. Stiffness	a property of material to resist plastic deformation
3. Malleability	material can be flattened into sheets
4. Flexibility	a property of material which permit considerable bending.

[RPSC Lecturer (Tech. Edu.) P – II – 2020]

Ans. (b)

Stiffness

- It is a mechanical property.
- The stiffness is the resistance of a material to elastic deformation or deflection.
- In stiffness, a material which suffers light deformation under load has a high degree of stiffness.
- The stiffness of a structure is important in many engineering applications, so the modulus of elasticity is often one of the primary properties when selecting a material.

Ductility

- The ductility is a property of a material which enables it to be drawn out into a thin wire.
- Mild steel, copper, aluminium are the good examples of a ductile material.

Malleability

- The malleability is a property of a material which permits it to be hammered or rolled into sheets of other sizes and shapes.
- Aluminium, copper, tin, lead etc are examples of malleable metals.

25. Which of the following metals is not ductile?

(a) Cast iron (b) Wrought iron

(c) Aluminium (d) Mild steel

[RPSC Lecturer (Tech. Edu.) P – II – 2020]

Ans. *(a)*

Ductility is the ability of a material to undergo plastic deformation, with the increase in carbon content the ductility decrease.

Mild Steel: Mild steel is ductile. Ductility of mild steel is more than that of cast iron and less than that of wrought iron.

Cast – Iron: Cast – iron is not ductile.

Wrought Iron: Wrought iron is ductile. Ductility of wrought iron is more than mild steel and cast – iron.

26. If a composite bar of steel and copper is heated, the copper bar will be under.......

(a) Tension (b) Compression
(c) Shear (d) Torsion

[RPSC Lecturer (Tech. Edu.) 2011]

OR

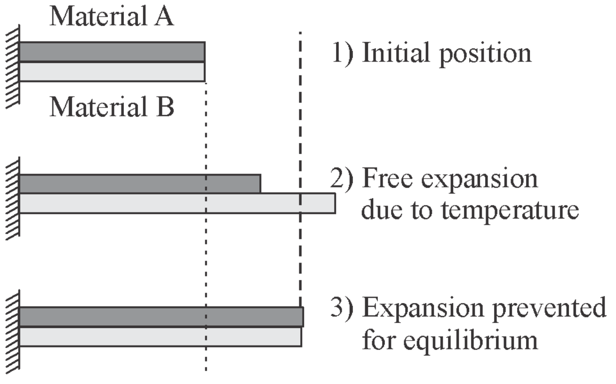
If a composite bar of steel and copper is heated, the copper bar will be under.......

(a) Tension (b) Compression
(c) Shear (d) Torsion

[RPSC – ACF – 2011]

Ans. *(b)*

A composite bar may be defined as a bar made up of two or more materials joined in such a manner that both are equally extended or contracted. Since coefficient of thermal expansion of copper is more than that of steel ($\alpha_c > \alpha_s$) hence copper bar will expend more but as both the bars are connected rigidly with each other so their final length will be same (the strain produced is the same) This results compression in copper bar and tension in steel bar. Thermal expansion is the tendency of matter to change its shape, area, and volume in response to a change in temperature.



27. Poisson's ratio is involving.......

(a) Elastic Modulli (b) Stresses
(c) Strains (d) None of these

[RPSC – ACF – 2011]

Ans. *(c)*

Poisson's ratio is given by

$$\mu = -\left(\frac{\text{Lateral Strain}}{\text{Longitudinal Strain}}\right)$$

Hence, strains are involved in Poisson's ratio.

28. According to Robert Hooke, stress is directly proportional to strain within

(a) Yield point (b) Elastic limit
(c) Proportional limit (d) Ultimate stress

[RPSC Lecturer (Tech. Edu.) 2014]

OR

Every material obeys the Hooks law within its

(a) Elastic limit
(b) Plastic limit
(c) Limit of proportionality
(d) None of the above

[RPSC Lecturer (Tech. Edu.) 2011]

OR

Every material obeys the Hook's law within its

(a) Elastic limit
(b) Plastic limit
(c) Limit of proportionality
(d) None of the above

[RPSC – ACF – 2011]

Ans. *(c)*

Every material obeys the Hooke's Law within limit of proportionality.

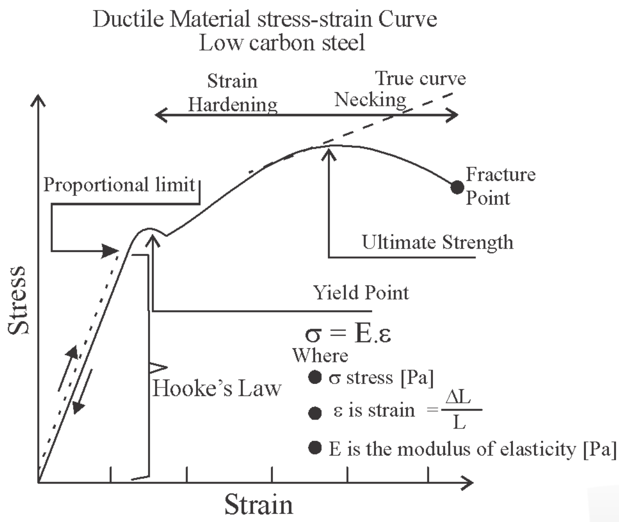
Up to limit of proportionality, axial stress is propositional to longitudinal strain according to Hooke's law.

Mathematically,

$$\sigma \propto \varepsilon_{Longitudinal}$$

$$\sigma = E\varepsilon_{Longitudinal}$$

Where, E = Young's modulus



29. Modulus of rigidity is defined as the ratio of

(a) Longitudinal stress to longitudinal strain
(b) shear stress to shear strain
(c) Stress to strain
(d) Stress to volumetric strain

[RPSC – AEN – 2013]

Ans. (b)

According Hooke's low, shear stress is proportional to shear strain up to proportional limit.

Mathematically,

Shear stress (τ) $\propto$ shear strain (γ)

$\Rightarrow \quad \tau = G \times \gamma$

$\Rightarrow \quad G = \frac{\tau}{\gamma}$

Where, G = Modulus of rigidity or shear modulus.

Note: Line equation,

$y = mx$

where, m = slope of the line

Similarly, $\tau = G\gamma$

G = slope of shear stress – shear strain curve up to propositional limit.

30. The stress developed in a bar which is not free to expand due to increase in temperature, is given as

(a) $P = \alpha tE$ (b) $P = \alpha/tE$
(c) $P = t/\alpha E$ (d) $P = E/\alpha t$

Where α is the coefficient of thermal expansion and t = temperature increased.

[RPSC – AEN – 2013]

Ans. (a)

Stress which is induced in a body due to a change in the temperature is known as thermal stress and the corresponding strain is called thermal strain. Thermal stress induces in a body when the temperature of the body is raised or lowered and the body is not allowed to expand or contract freely. No stress will be induced in a body when it is allowed to expand or contract freely. The thermal stress can be expressed as $\sigma = \alpha tE$.

31. The phenomenon of decreased resistance of material due to reversal of stress is called

(a) Creep (b) Fatigue
(c) Resilience (d) Plasticity

[RPSC – AEN – 2018]

Ans. (b)

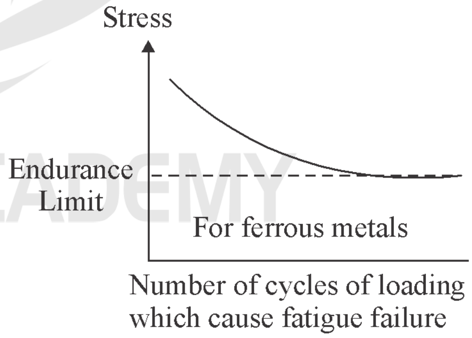
In materials science, fatigue is the weakening of a material caused by cyclic loading (reversal of stress) that results in progressive and localized structural damage and the growth of cracks.

32. The stress at which a material fractures under large number of reversals of stress is called :

(a) Creep (b) Ultimate strength
(c) Endurance limit (d) Residual stress

[RPSC-AEN - GWD – 2014]

Ans. (c)



The stress below which a material does not fractures under large number of reversals of stress is called endurance limit. Endurance limit is also known as Fatigue limit.

Creep is a property by virtue of which a material undergoes additional deformation (over and above elastic deformation) with passes of time under sustained loading within elastic limit.

56. A sample of a metal is tested in tension, and it is found that there is a strain of 0.0080 at a corresponding stress of 450 N/mm^2. On the removal of the load a permanent strain of 0.0015 is found to be present. 'The value of modulus of elasticity for the metal

(a) 1.44×10^5 N/mm^2

(b) 1.77×10^5 N/mm^2

(c) 0.692×10^5 N/mm^2

(d) 0.30×10^5 N/mm^2

[RPSC – VP – ITI – 2018]

Ans. (c)

As we know that,

$$\text{Modulus of elasticity} = \frac{\text{Elastic stress}}{\text{Elastic strain}}$$

$$\text{Modulus of Elasticity} = \frac{450}{(0.0080 - 0.0015)}$$

$$= 0.692 \times 10^5 \text{ N/mm}^2$$

57. Two solid bars are made up of two different materials. Both the bars have equal cross-sectional area and are subjected to the same amount of pull force. If the bars have elongation per unit length in the ratio of 3 : 5, then the ratio of modulus of elasticity of the two materials will be:

(a) 9 : 25 (b) 1 : 2

(c) 5 : 3 (d) 2 : 1

[RIICO-ASE (Civil) – 2021]

Ans. (c)

Hooke's law: As per Hooke's law, stress is proportional to strain

i.e. $\sigma \propto \in$ or, $\sigma = \in \times E$

For Hooke's law to be valid:

(a) The material should be homogenous.

(b) The material should be isotropic.

(c) The material should behave in a linearly elastic manner.

Thus for a plane bar with Area 'A', Length 'L' and Modulus of Elasticity 'E',

$$\sigma = \frac{P}{A}$$

and $\in = \delta L/L$

As per Hooke's law, $\sigma = \in \times E$

$$P/A = \frac{\delta L}{L} \times E$$

$$\delta L = \frac{PL}{AE}$$

Given, Two bars of unit length, *i.e.* $L_1 = L_2$

Elongation ratio is 3 : 5, *i.e.* $\delta L_1 : \delta L_2 = 3 : 5$

Both subjected to same tensile load, *i.e.* $P_1 = P_2$

Both have the same size, *i.e.* $A_1 = A_2$

Elongation of the first bar:

$$\delta L_1 = \frac{P_1 L_1}{A_1 E_1}$$

Elongation of the second bar:

$$\delta L_2 = \frac{P_2 L_2}{A_2 E_2}$$

Taking ratio, $\dfrac{\delta L_1}{\delta L_2} = \dfrac{E_2}{E_1}$

$$\therefore \quad \frac{E_1}{E_2} = \frac{5}{3}$$

Hence, the ratio of modulus of elasticity of the two materials will be 5 : 3.

58. If a tie bar 50 mm x 8 mm is to carry a load of 80 kN, then the gauge length is:

(a) 150 mm (b) 113 mm

(c) 83 mm (d) 57 mm

[JMRC-JE – 2021]

Ans. (b)

In a tension test on a bar, gauge length means the length over which extension is measured.

$$GL = 5.65\sqrt{A}$$

Where, A = Initial cross-sectional area before loading

Gauge length is independent of the length of a bar, material of bar, and shape of cross-section.

Calculation: $A = 50 \times 8 = 400$

$$GL = 5.65\sqrt{A}$$

$$= 5.65\sqrt{400} = 113 \text{ mm}$$

CHAPTER 2

SFD AND BMD

OBJECTIVE QUESTIONS

1. Maximum bending moment in a beam occurs where
(a) Shear force is maximum.
(b) Shear force is minimum
(c) Deflection is zero
(d) Shear force changes sign
[RPSC – VP – ITI – 2018]
OR
Maximum bending moment in a beam occurs where....
(a) Deflection is zero
(b) Shear force is maximum
(c) Shear force is minimum
(d) Shear force changes sign
[RPSC Lecturer (Tech. Edu.) 2011]
OR
The maximum bending moment in a beam occurs where....
(a) Deflection is zero
(b) Shear force is maximum
(c) Shear force is minimum
(d) Shear force changes sign
[PHED-JE (Degree) 2014]

Ans. (d)

As we know that,

The relation between shear force (V) and loading rate (w) is:

$$dV/dx = -w$$

It means a positive slope of the shear force diagram represents an upward loading rate.

The relation between shear force (V) and bending moment (M) is:

$$dM/dx = V$$

It means the slope of a bending moment diagram will represent the magnitude of shear force at that section. Maximum bending moment in a beam occurs where shear force changes sign

The point of contraflexure (PoC) occurs where bending is zero and at the point of change between positive and negative (or between compression and tension). In a beam that is flexing (or bending), the point where there is zero bending moment is called the point of contraflexure.

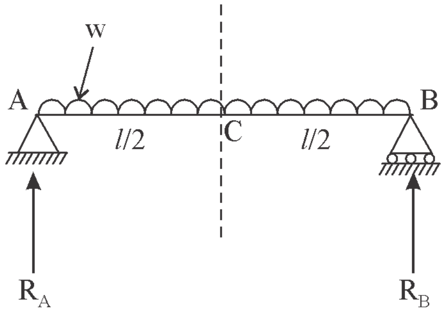
2. The rate of change of shear force is
(a) Bending moment (b) Deflection
(c) Slope (d) Loading
[PHED-JE (Degree) 2014]

Ans. (d)

$$dV/dx = -w$$

3. In a simply supported beam carrying a udl (w) along full span (L), the maximum bending moment at center would be
(a) $wL^2/4$ (b) $wL^2/8$
(c) $wL^2/12$ (d) $wL^2/16$
[PHED-JE (Diploma) 2014]

Ans. (b)



$\circlearrowright \Sigma M_A = 0$

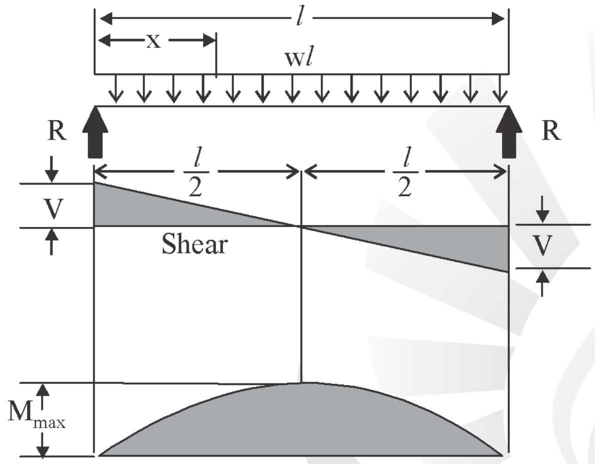
$$R_B \times l - w \times l \times \frac{l}{2} = 0$$

$$R_B = \frac{wl}{2}$$

Bending moment at C

$$= \frac{wl}{2} \times \frac{l}{2} - \frac{wl}{2} \times \frac{l}{4}$$

$$= \frac{wl^2}{8}$$



4. The diagram showing the variation of axial load along the span is called

(a) Shear force Diagram

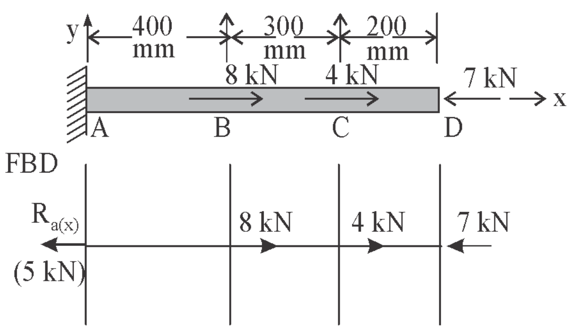
(b) Bending moment diagram

(c) Thrust diagram

(d) Influence Line Diagram

[PHED-JE (Diploma) 2014]

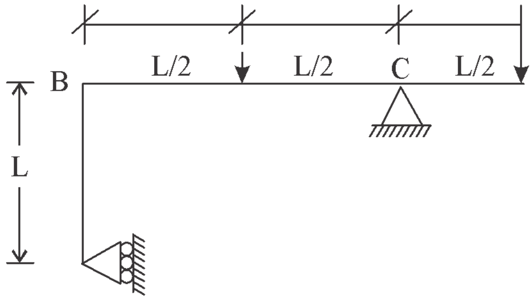
Ans. (c)



The diagram showing the variation of axial load along the span is called thrust diagram.

5. A frame ABCD is supported by a roller and a hinge as shown in Figure:

The reaction at the roller end A is given by



(a) P (b) 2P

(c) $\frac{P}{2}$ (d) Zero

[RCDF – Assistant Manager (Civil) – 2021]

Ans. (d)

The loads are symmetrical with respect to point C.

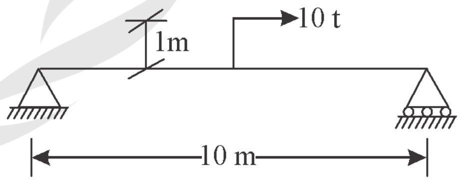
There will not be any horizontal force on A.

Theoretically, if we take moment about C.

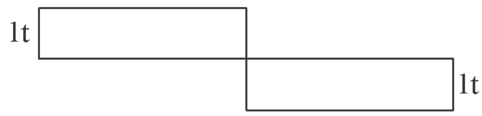
$$H_A \times L \times \frac{PL}{2} = \frac{PL}{2}$$

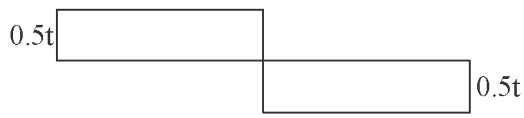
$$\therefore \quad H_A = 0$$

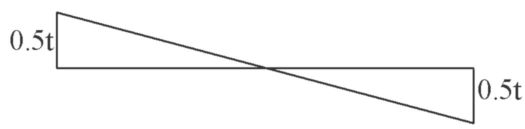
6. The shear force diagram (SFD) for the beam shown in figure is



(a) 

(b) 

(c) 

(d) 

[RCDF – Assistant Manager (Civil) – 2021]

Ans. (a)

Moment are not contribute to the shear force effect.

At the centre of beam act a moment is

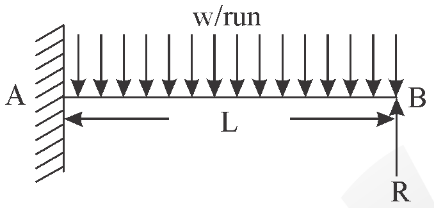
$$10 \times 1 = 10 \text{ kNm}$$

$$R_b \times 10 = 10$$

$$R_b = 1$$

Thus, R_a also equals for equating the R_b effect because of there is no other loads.

7. For the propped cantilever beam shown in figure, the reaction R at B will be



(a) $\frac{Wl}{2}$ (b) $\frac{Wl}{4}$

(c) $\frac{5}{8}Wl$ (d) $\frac{3}{8}Wl$

[RCDF – Assistant Manager (Civil) – 2021]

Ans. (d)

From the figure, the deflection at the free end is equal. That means Deflection due to propped reaction R = Deflection due to UDL of w/l

$$\Rightarrow \quad \frac{Rl^3}{3EI} = \frac{wl^4}{8EI}$$

$$R = \frac{3wl}{8}$$

8. In a beam where shear forces changes sign, the bending moment will be

(a) Zero (b) Minimum

(c) Maximum (d) Infinity

[RIICO – ASE (Civil) – 2015]

Ans. (c)

Let w be load intensity, V be the shear force and M be the bending moment.

$$w = dV/dx$$

$$V = dM/dx$$

For finding the maximum value of Bending Moment:

$$dM/dx = 0$$

$$\Rightarrow \quad V = 0$$

Bending moment is maximum where shear force is zero or its sign changes (positive to negative or vice – versa).

9. The slope of the bending moment diagram of any section of a loaded beam is

(a) Torsion at the section.

(b) Maximum shear force of the beam.

(c) Shear force at that section.

(d) Maximum bending moment of the beam.

[RPSC – VP – ITI – 2012]

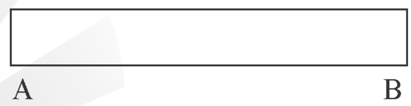
Ans. (c)

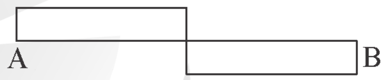
We know that,

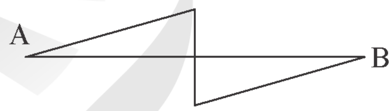
$$(SF)_{xx} = \frac{d(BM)_{x-x}}{dx}$$

Hence, the slope of the bending moment diagram at any section of a loaded beam is equal to shear force (SF) at that section.

10. Shape to the Force Diagram for a simply supported beam (AB) subjected to point load W at the centre of span shall be

(a)


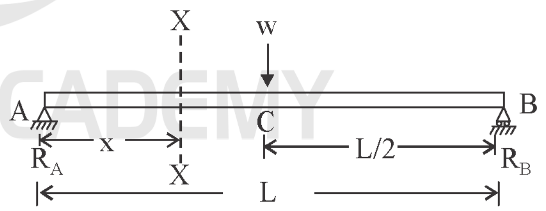
(b)


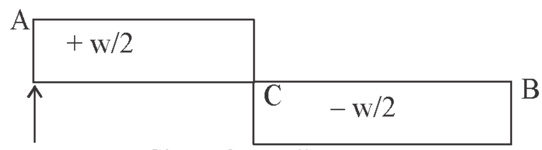
(c)


(d)

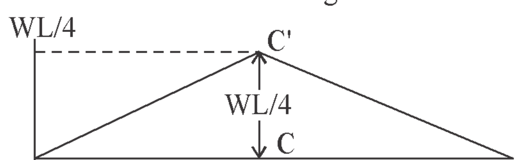

[RPSC – VP – ITI – 2012]

Ans. (b)





Shear force diagram



Bending moment Diagram

42. The maximum bending moment caused by three equal loads (each W/3) spaced apart at equal intervals of L/3 on a simply supported beam is

(a) 3WL/20 (b) WL/6

(c) 5WL/36 (d) WL/8

[RSMSSB – JE(Diploma) – 2020]

Ans. (c*)

The maximum bending moment will be at mid of span as per the arrangement of loads.

Reaction forces at supports = W/2

Hence, bending moment at mid of span is

$$\frac{W}{2}\times\frac{L}{2}-\frac{W}{3}\times\frac{L}{3} = \frac{5WL}{36}$$

*We here by assumed symmetry in the loading arrangement, otherwise in asked question loading arrangement is not clearly mentioned.

43. The shear force and bending moment are related by

V = Shear force, M = Bending moment

I = Moment of Inertia, z = section modulus

(a) V = My/I (b) V = dM/dx

(c) V = $\int$Mdx (d) V = M/z

[RSMSSB – JE(Diploma) – 2020]

Ans. (b)

The relation between shear force (V) and loading rate (w) is: dV/dx = – w.

The relation between shear force (V) and bending moment (M) is: dM/dx = V

It means the slope of a bending moment diagram will represent the magnitude of shear force at that section.

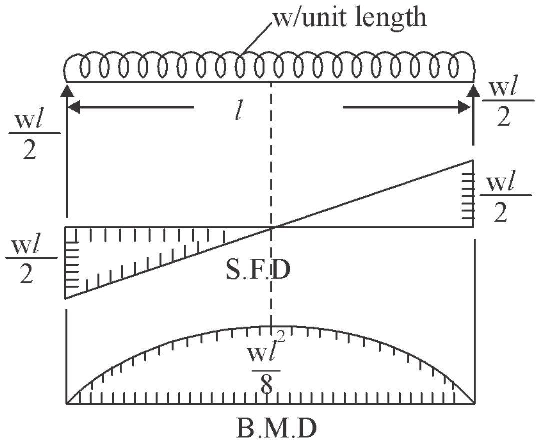
44. In a simply supported beam carrying UDL(W) along full span (L), the maximum bending moment at centre would be

(a) $WL^2/16$ (b) $WL^2/4$

(c) $WL^2/8$ (d) $WL^2/12$

[RSMSSB – JE(Diploma) – 2020]

Ans. (c)



The maximum bending moment for a simply supported beam with a uniformly distributed load W per unit length is

$$= \frac{WL}{2}\times\frac{L}{2}-\frac{WL}{2}\times\frac{L}{4}$$

$$= \frac{WL^2}{8}$$

45. A simply supported beam carrying a triangular load, varying gradually from zero at both ends to (W) per meter at center, the maximum shear force will be

(a) W/8 (b) W/2

(c) W/4 (d) W/6

[RSMSSB – JE(Diploma) – 2020]

Ans. (c)

Given that there is a triangular loading with max. at center. So, total downward force

= 0.5 × 1 × W

= 0.5 W

So, RXn force at both ends = total downward force

$R_a + R_b = 0.5$ W

As loading is symmetric. So, $R_a = R_b$

$2R_a = 0.5$ W

$R_a = 0.25$ W = W/4

which is the max. shear force at support end.

46. Asimply supported beam carries a uniformly distributed load of 8 kN/m over the whole span of 3 m. What will be the maximum bending moment of the beam?

(a) 8.34 kN-m (b) 9 kN-m

(c) 11.25 kN-m (d) 15.17 kN-m

[JMRC-JE – 2021]

Ans. (b)

When a simply supported beam of length L is subjected with UDL of w.

The maximum bending moment introduced in the beam is given by.

$$M_{max} = wl^2/8$$

Given: $w = 8$ kN/m ,

$L = 3$ m

Maximum BM is,

$$M_{max} = wl^2/8 \text{ N-m}$$

$$= 8 \times 328$$

$$= 9 \text{ kN-m,}$$

$\therefore$ Maximum Bending moment = 9 kN-m

CHAPTER 3

CG AND MOI

OBJECTIVE QUESTIONS

1. The unit of mass-moment of inertia is

(a) Kg – m^3 (b) Kg – m^2

(c) Kg – m (d) Kg – m^4

[WRD-JE (Diploma) – 2013]

Ans. (b)

The unit of mass moment of inertia is Kg – m^2.

$$I = MR^2$$

2. The moment of inertia of a rectangle of width b and depth d, about an axis XX passing through its centre of gravity and parallel to the ends, is given as

(a) $I_{xx} = 1/12\ db^3$ (b) $I_{xx} = 1/12\ bd^3$

(c) $I_{xx} = 1/64\ bd^3$ (d) $I_{xx} = 1/32\ db^3$

[RPSC – AEN – 2013]

OR

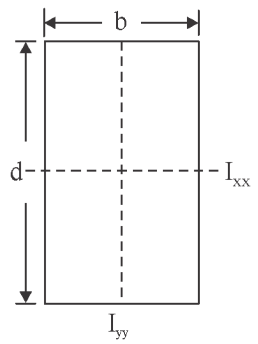
The moment of inertia of a rectangle of width b and depth d, about an axis xx passing through its centre of gravity and parallel to the ends, is given as

(a) $I_{xx} = db^3/24$ (b) $I_{xx} = bd^3/12$

(c) $I_{xx} = db^3/64$ (d) $I_{xx} = db^3/32$

[RSMSSB – JE(Degree) – 2020]

Ans. (b)



Moment of Inertia about x-axis

$$I_{xx} = \frac{bd^3}{12}$$

Moment of Inertia about y-axis

$$I_{yy} = \frac{db^3}{12}$$

3. Area moment of inertia of a circular section of diameter D is:

(a) $\pi D^3/32$ (b) $\pi D^4/32$

(c) $\pi D^3/64$ (d) $\pi D^4/64$

[WRD-JE (Diploma) – 2016]

Ans. (d)

M.O.I. about diameter is $\pi D^4/64$.

4. Moment of inertia of a rectangular flat (length, L and width, B) about its axis parallel to its length at a distance B/2 from its top face is:

(a) $\frac{BL^3}{6}$ (b) $\frac{LB^3}{6}$

(c) $\frac{LB^3}{12}$ (d) $\frac{BL^3}{12}$

[WRD-JE (Diploma) (TSP) – 2016]

Ans. (c)

Note that here the axis about which MOI has been asked, may be inside the section and may be outside the section. Here, 02 cases must be analyzed.

CHAPTER 4

BENDING STRESS

OBJECTIVE QUESTIONS

1. The section modules of a circular section about an axis through its C.G is

(a) $\pi d^3/16$ (b) $\pi d^3/32$
(c) $\pi d^3/64$ (d) $\pi d^3/192$

[WRD-JE (Diploma) – 2013]

OR

Section modulus of a circular section of diameter d is

(a) $\pi d^3/64$ (b) $\pi d^3/32$
(c) $\pi d^3/16$ (d) $\pi d^3/8$

[PHED-JE (Diploma) 2014]

Ans. (b)

Section modulus of a circular section

$$Z = \frac{I}{y_{max}}$$

$$= \frac{\frac{\pi}{64}d^4}{d/2} = \frac{\pi}{32}d^3$$

2. What is the correct unit of section modulus?

(a) Square centimeter
(b) Cubic centimeter
(c) Kilogram
(d) Centimeter

[RIICO Draftsman cum Tracer (Civil) – 2021]

Ans. (b)

Sectional Modulus (Z): It is the ratio of Moment of Inertia (I) of the beam cross-section about the neutral axis to the distance (ymax) of extreme fiber from the neutral axis. For a circular section, the section modulus:

$$Z = \frac{I}{y_{max}}$$

where

I = Moment of Inertia (cm^4)

y = Distance from the centroid to top or bottom edge (cm)

$\therefore$ the unit of the section modulus is cm^3.

3. A composite bar is made of steel and aluminum strips each having 2 cm^2 area of cross section. The composite bar is subjected to load P. If the stress in aluminum is 10 N/mm^2 and $E_{steel} = 3E_{Aluminium}$, the value of load P is

(a) 4 kN (b) 6 kN
(c) 8 kN (d) 10 kN

[WRD-JE (Degree) – 2013]

Ans. (c)

Given, $A_{steel} = A_{aluminium} = 2\ cm^2$

$\sigma_{aluminium} = 10\ N/mm^2$

$E_{steel} = 3E_{Aluminium}$

For composite bar,

$$\Delta_{steel} = \Delta_{Aluminium}$$

$$\frac{\sigma_{steel} \times L}{E_{steel}} = \frac{\sigma_{aluminium} \times L}{E_{aluminium}}$$

Hence $\sigma_{steel} = 30\ N/mm^2$

$$P_{total} = P_{steel} + P_{aluminium}$$

$$= \sigma_{steel} \times A_{steel} + \sigma_{aluminium} \times A_{aluminium}$$

$$= 30 \times 200 + 10 \times 200$$

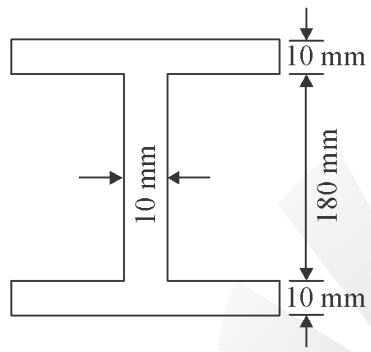
$$= 8\ kN$$

4. A beam of I-section of depth 200 mm is subjected to a bending moment M. The flange thickness is 10 mm. If the maximum stress induced in I section is 100 N/mm², the stress developed at the inner edge of the flange will be

(a) 95 N/mm² (b) 90 N/mm²
(c) 47.5 N/mm² (d) 45 N/mm²

[WRD-JE (Degree) – 2013]

Ans. (b)



$$\sigma \propto y$$

$$\frac{100}{\sigma} = \frac{100}{90}$$

$$\sigma = 90 \text{ N/mm}^2$$

5. A beam of uniform bending strength will have at every cross section

(a) Same deflection
(b) Same stiffness
(c) Same bending moment
(d) Same bending stress

[WRD-JE (Diploma) – 2013]

Ans. (d)

A beam of uniform bending strength will have same bending stress at every cross-section.

6. A beam of rectangular section 100 × 200 mm is subjected to a moment of 20 kN-m. The maximum bending stress is

(a) 30 N/mm²
(b) 56 N/mm²
(c) 10000 N/mm²
(d) 300 N/mm²

[WRD-JE (Diploma) – 2013]

Ans. (a)

Using bending formula,

$$\frac{E}{R} = \frac{M}{I} = \frac{f}{Y}$$

Given, M = 20 kN-m, b = 100 mm,

$$d = 200 \text{ mm}$$

$$I = (100 \times 200^3)/12$$

and $y = 100$ mm

$$f = \frac{20 \times 10^6 \times 12 \times 100}{100 \times 200^3}$$

$$= 30 \text{ N/mm}^2$$

7. The curvature (R) of beam is equal to

(a) EI/M (b) M/E
(c) M/EI (d) E/MI

[RPSC ACF – 2018]

Ans. (c)

The Bending equation states that:

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

Various terms in the above bending equation are:

σ = Bending stress
y = Distance from the neutral axis
M = Bending moment
I = Area moment of inertia
E = Modulus of elasticity
R = Radius of curvature

So, $R = \frac{1}{C} = \frac{EI}{M}$

$$\text{Curvature} = \frac{M}{EI}$$

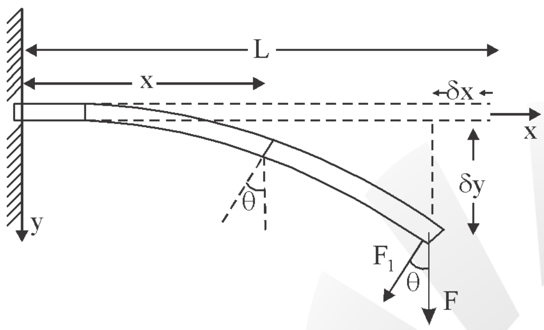
8. The maximum tensile stress in a cantilever beam with concentrated load acting downwards on the span is caused at

(a) Top fibre at mid span
(b) Bottom fibre at mid span
(c) Bottom fibre at support
(d) Top fibre at support

[RPSC-AEN - GWD – 2014]

Ans. (d)

When cantilever beam is loaded vertically downward, then all the fibres above Neutral axis got elongated and all fibres below neutral axis got contracted due to which tensile stress is induced in all fibres above Neutral axis and compressive stresses are induced in all fibres below the neutral axis. Therefore, the maximum compressive stress will be at bottom fibre, because that fibre has minimum section modulus.



9. In cantilever beam there is tensile stress

(a) Neutral axis

(b) Below neutral axis

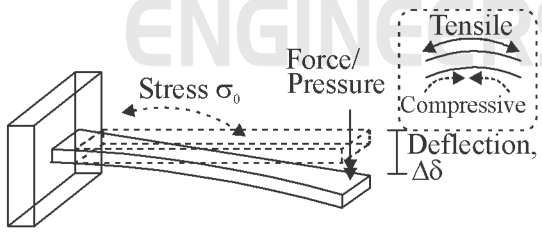
(c) Above neutral axis

(d) None of these

[RPSC ACF – 2018]

Ans. (c)

In a cantilever beam maximum compressive stress occurs at bottom most fiber and maximum tensile stress occurs at the top most fiber and zero at neutral axis hence the tensile stresses lies above the neutral axis.



10. The units of flexural stiffness are

(a) Radians per unit rotation

(b) Moment per unit rotation

(c) Force per unit deflection and rotation

(d) Extension per unit force

[RPSC ACF – 2018]

Ans. (b)

In a beam, the flexural rigidity is EI.

Where E is the young's modulus (in Pascal, Pa), I is the second moment of area (in m^4).

The SI unit of flexural rigidity is thus $Pa.m^4$ or Nm^4.

So, the Dimension is ML^3T^{-2}.

The Bending equation states that:

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

$$\text{Flexural stiffness} = \frac{\text{Flexural Rigidity}}{\text{Length}}$$

$$\text{Flexural stiffness} = \frac{EI}{L}$$

From the above equation,

$$\text{Flexural stiffness} = \frac{MR}{L}$$

Which can be denote as Moment per unit rotation.

11. The portion, which should be removed from top and bottom of a circular cross-section of diameter d in order to obtain maximum section modulus, is

(a) 0.01d (b) 0.1d

(c) 0.011d (d) 0.11d

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

Ans. (c)

A circular section can be made stronger by cutting off top and bottom corner. The maximum percentage increase in z will be 0.7 % when cut off portion (δ) = 0.011 d

12. In pure bending case, which of the following option is correct for fibre at neutral axis?

(a) Its length increases slightly,

(b) Its length increases substantially.

(c) Its length remains unchanged.

(d) Its length gets shortened.

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

CHAPTER 5

SHEAR STRESS

OBJECTIVE QUESTIONS

1. A Rectangular beam of width 150 mm and depth 300 mm is subjected to a transverse shear of 120 kN. The maximum shear stress in the section is

(a) 2.67 MPa

(b) 4 MPa

(c) 8 MPa

(d) 5.34 MPa

[PHED-JE (Degree) 2014]

Ans. (b)

Given, b = 150 mm

d = 300 mm

Shear force = 120 kN

Maximum shear stress

= 1.5 × average shear stress

= 1.5 × (120 × 1000)/(150 × 300)

= 4 MPa

2. Nature of distribution of horizontal shear stress in a rectangular beam section is

(a) Parabolic

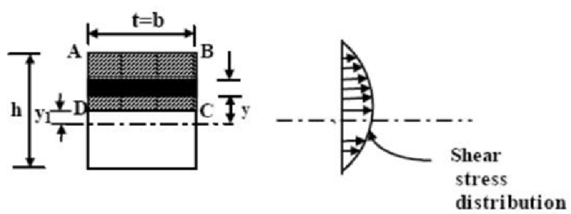
(b) Elliptic

(c) Hyperbolic

(d) Linear

[RCDF – Assistant Manager (Civil) – 2021]

Ans. (a)



3. The ratio of average shear stress to maximum shear stress in a prismatic beam of rectangular cross section is:

(a) 3/4 (b) 4/3

(c) 3/2 (d) 2/3

[WRD-JE (Degree) TSP – 2016]

Ans. (d)

For rectangular section

$$\frac{\tau_{avg}}{\tau_{max}} = \frac{2}{3}$$

4. Ratio of the maximum shear intensity to average shear stress intensity for a rectangular section is:

(a) 3/2 (b) 4/3

(c) 5/2 (d) 2/3

[RPSC-VP – ITI – 2012]

OR

The ratio of maximum shear stress to average shear stress in the case of a rectangular section is

(a) 3/2 (b) 4/3

(c) 5/2 (d) 2/3

[WRD-JE (Diploma) – 2013]

OR

For a rectangular section, the ratio of the maximum and average shear stresses, is:

(a) 1.5 (b) 2.0

(c) 1.0 (d) 1.4

[RIICO Draftsman cum Tracer (Civil) – 2021]

Ans. (a)

Shear Stresses: Due to the shear forces the beam will be subjected to shear stresses. These shear stresses will be acting across transverse sections of the beam. These transverse shear stresses will produce complimentary horizontal shear stresses, which will be acting on longitudinal layers of the beam.

$$\tau_x = \frac{VAY}{IB}$$

Where,

V = Shear force (Due to change in bending moment)

A = Area above or below the section in the cross-section

Y = Distance from centroid of area from neutral axis

I = Moment of inertia of total cross-section about neutral axis

B = Width at the section

And for rectangular section, maximum shear stress occur at neutral axis i.e. y = 0

$$\tau_{max} = \frac{3V}{2Bd}$$

$$\tau_{max} = 1.5 \times \tau_{avg.}$$

5. In a simply supported beam, maximum shear stress in a triangular cross-section (altitude h) occurs at a distance:

(a) h/2 from bottom of beam

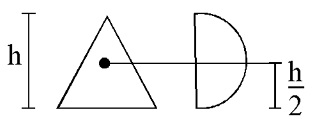
(b) h/3 from top of the beam

(c) h/6 from neutral axis

(d) h/5 from top the beam

[WRD-JE (Diploma) (TSP) – 2016]

Ans. (a)



$$\tau_{max} = \frac{3}{2}\tau_{avg}$$

6. A beam of triangular cross section is placed with its based horizontal. The maximum shear stress intensity in the section will be

(a) At the neutral axis

(b) At the base

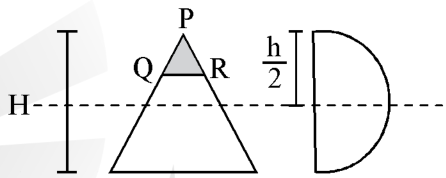
(c) Above the neutral axis

(d) Below the neutral axis

[RPSC ACF – 2018]

Ans. (c)

A beam of triangular cross section is placed with its based horizontal. The maximum shear stress intensity in the section will be above the neutral axis and which lies at H/2 distance from the base of beam. as we know that for triangular cross section, neutral axis lies at the distance of H/3 from the base of beam.



7. For a given shear force across a symmetrical I-section, the intensity of shear stress is maximum at the

(a) Junction of the flange and the web, but on the web

(b) Junction of the flange and the web, but on the flange

(c) Centroid of the section

(d) Extreme fibers

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

Ans. (c)

Flexural stress or Bending stress in a beam can be calculated by:

$$\sigma = M \times y/I$$

Shear stress in a beam can be calculated as:

$$\tau = \frac{(S \times A \times y)}{I \times B}$$

Where,

I = Moment of inertia about neutral axis

B = Width of the section considered

CHAPTER 6

TORSION

OBJECTIVE QUESTIONS

1. A shaft of diameter d is subjected to a torque T, the maximum shear stress is

(a) $32T/\pi d^2$ (b) $16T/\pi d^3$

(c) $16T/\pi d^2$ (d) $64T/\pi d^2$

[PHED JE (Diploma) 2014]

Ans. (b)

Maximum shear stress,

$$\tau = \frac{T}{j}\cdot r = \frac{T}{\frac{\pi}{32}d^4}\cdot\frac{d}{2}$$

$$T = \frac{16T}{\pi d^3}$$

2. The maximum shear stress produced in a shaft is 5 N/mm^2. The shaft is of 40 mm diameter. The value of twisting moment is

(a) 628 Nm

(b) 62.8 Nm

(c) 125.6 Nm

(d) 1256 Nm

[WRD-JE (Diploma) – 2013]

Ans. (b)

Use the following formula and get the value of T.

$$\tau_{max} = \frac{16T}{\pi d^3}$$

$$5 = \frac{16\times T}{\pi\times 40^3}$$

$$T = 62.8 \text{ Nm}$$

3. The most economical section for a column is

(a) I section

(b) Tubular section

(c) Solid round section

(d) Rectangular section

[WRD-JE (Diploma) – 2013]

Ans. (b)

The most economical section for a column is a tubular section.

4. Two shafts having the same length and material are joined in series. If the ratio of the diameter of the first shaft to that of the second shaft is 2, then the ratio of the angle of twist of the first shaft to that of the second shaft is

(a) 16 (b) 8

(c) 4 (d) 2

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

Ans. (a)

Torsion Equation:

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$$

$$\theta = \frac{TL}{GJ} = \frac{32TL}{G\pi D^4}$$

$$\theta \propto \frac{1}{D^4}$$

Calculation: $$\frac{\theta_2}{\theta_1} = \left(\frac{D_1}{D_2}\right)^4$$

$$\frac{\theta_2}{\theta_1} = (2)^4 = 16$$

Ratio will vary with D^4.

It can be either 16 : 1 or 1 : 16.

5. A circular shaft of 100 mm diameter has polar moment of inertia as 5.0×10^6 mm^4, If the shaft is subjected to a torque T = 10 kNm. What is the maximum tensile stress in N/mm^2?

(a) 100 (b) 200

(c) 50 (d) 1000

[RPSC Lecturer (Tech. Edu.) P – I – 2020]

Ans. (a)

The torsion equation is given by:

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$$

Where,

T is the torque applied

J = Polar moment of inertia

τ = Shear strength of the material

G = modulus of rigidity

τ = angular deflection of the shaft (in radians)

R = radius of the shaft, in case of the hollow shaft it is the outside radius.

Given,

$$d = 100 \text{ mm}$$

$$J = 5.0 \times 10^6 \text{ mm}^4$$

$$T = 10 \text{ kNm}$$

$$= 10 \times 10^6 \text{ Nmm}$$

So, $T/J = \tau/R$

$$\frac{10000000}{5.0\times10^6} = \frac{\tau}{50}$$

$$\tau = 100 \text{ N/mm}^2$$

6. Polar modulus of a section is a measure of strength of section in

(a) Bending (b) Shear

(c) Torsion (d) None of the above

[RPSC Lecturer (Tech. Edu.) 2011]

Ans. (c)

Polar modulus is defined as the ratio of the polar moment of inertia to the radius of the shaft. It is also called as torsional section modulus. It is denoted by Z_p. Polar section modulus of shaft is given by, Z_p = J/r.

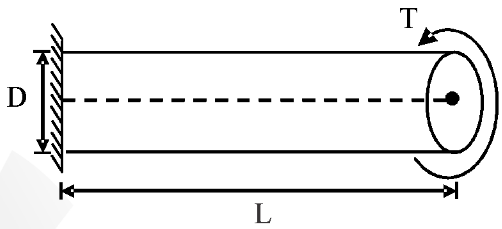
7. A solid circular shaft of diameter D and length L is fixed at one end and free at the other end. A torque T is applied at the free end. The shear modulus of the material is G, the angle of twist at the free end is

(a) 16 TL/πd^{4}G (b) 32 TL/πd^{4}G

(c) 64 TL/πd^{4}G (d) 128 TL/πd^{4}G

[RPSC Lecturer (Tech. Edu.) 2014]

Ans. (b)



By Torsion equation,

$$\frac{T}{J} = \frac{G\theta}{L}$$

$$\text{Angle of twist } (\theta) = \frac{TL}{GJ} = \frac{TL}{G\times\frac{\pi}{32}D^4}$$

$$\theta = \frac{32\,TL}{\pi D^4 G}$$

8. A shaft of length L having torsional rigidity GJ is subjected to a torque T. The corresponding stiffness shall be:

(a) TJ/L (b) GJ/L

(c) TG/L (d) TJ/GL

[WRD-JE (Degree) – 2016]

Ans. (b)

As we knows that, Torsional equation for the shaft is given by,

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$$

Torque per radian twist is known as torsional stiffness (k)

$$k = \frac{T}{\theta} = \frac{GJ}{L}$$