

UNIT – III TORSION

1. Define Torsion?

A shaft is said to be in torsion, when equal and opposite torques are applied at the two ends of shaft. The shaft is subjected to a twisting moment. This causes the shear stresses and shear strains in the material of the shaft.

2. What are the assumptions made in torsion equation.

Torsion is based on the following assumptions:

- The material of the shaft is uniform throughout.
- The twist along the shaft is uniform.
- The shaft is uniform circular section throughout.
- Cross-sections of the shaft, which are plane before twist, remain plane after twist.
- All radii which are straight before twist remain straight after twist.
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3. Define polar modulus

Polar modulus is defined as the ratio of the polar moment of inertia to the radius of the shaft.

4. Write down the expression for power transmitted by a shaft.

$$\text{Power (Watts)} = \frac{2\pi NT_{\text{mean}}}{60} \quad \text{Where,}$$

N = Speed of the shaft, rpm

T = Mean Torque transmitted, Nm.

5. Write the polar modulus for solid shaft and hollow shaft.

$$Z_p = \frac{\pi D^3}{16} \quad \text{where } D = \text{Diameter of solid shaft}$$

$$Z_p = \frac{\pi [D_o^4 - D_i^4]}{16 D_o} \quad \text{where, } D_o = \text{Outer Diameter of hollow shaft}$$

$D_i = \text{Inner diameter of Hollow shaft}$

6. Why hollow circular shafts are preferred when compared to solid circular shafts?

For the same power transmission and Material, the weight of hollow shafts are less compared to solid shaft.

7. Write torsional equation

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{l} \quad \text{where,}$$

T = Torque Transmitted, Nm

J = Polar Moment of Inertia, m⁴

r = Radius of shaft, m

G = Modulus of rigidity, N/m²

θ = Angle of Twist, Radians, l = Length of Shaft, m

8. Write down the expression for torque transmitted by hollow shaft.

$$\text{Torque transmitted by a hollow shaft} - T = \frac{\pi}{16} \tau \left[\frac{D_o^4 - D_i^4}{D_o} \right]$$

Where D_o = Outer Diameter of hollow shaft

D_i = Inner diameter of Hollow shaft

T = Shear stress induced in the outer surface of the shaft

9. Write down the equation for maximum shear stress of a solid circular section in diameter D when subjected to torque T in a solid shaft.

The maximum shear stress induced at the outer surface of the solid shaft.

$$\tau = \frac{\pi}{16} \tau D^3$$

10. Define torsional rigidity

Torsional rigidity or stiffness of the shaft is defined as the product of modulus of rigidity (C) and polar moment of inertia of the shaft (J).

$$\text{Torsional rigidity} = C \times J.$$

11. What is composite shaft?

A shaft made up of two or more different materials and behaving as a single shaft is known as composite shaft.

12. What is a spring? Name two important types of spring.

Springs are elastic bodies which absorb energy due to resilience. The absorbed energy may be released as and when required. The two important types of springs are

1. Laminated or leaf springs
2. Helical springs

13. State any two functions of springs.

1. It will absorb energy when it is loaded and releases the absorbed energy as and when required
2. It will act as cushion

14. Define helical springs specify the type of helical springs

Helical springs are the thick spring wires coiled in to a helix
The two types of helical springs are

- (i) Close coiled helical springs
- (ii) Open coiled helical springs.

15. What is solid length of a spring?

The solid length of spring means the distance between the coils when the coils are touching each other. There is no gap between the coils. The solid length is given by

Solid length = Number of coils x Diameter of the wire = $n \times d$

16. Define spring rate (stiffness).

The stiffness of the spring is defined as the load per unit deflection.

$$S = \frac{W}{\delta}$$

Where W = Load and δ = Deflection

17. Define pitch of the spring.

The distance between to consecutive coils is known as pitch of the spring.

18. What is spring index (C)?

The term Spring index in relation to springs it means the ratio of the mean diameter of the spring to the diameter of the wire. The preferred index range is 4 to 12.

19. What is free length of spring?

This is the length over all of the spring in the fully unloaded position (free position).

21. What are the differences between closed coil & open coil helical springs?

Closed coil	Open coil
The wire is coiled so close that the plane containing each turn is nearly at right angle to the axis of helix	The spring wire is coiled in such away that, there is a large gap between the two consecutive turns and takes compression load also.
The helix angle is less than 10°	The helix angle is greater than 10°
Due to loading, spring will elongate	Due to loading, spring will contract

22. What is the use of wahl's factor?

- The wahl's factor is used to account the stress due to direct shear and curvature stress of spring.
- It is used to calculate shear stress induced in a helical spring by considering shear stress due to twisting.

23. What kind of stress is introduced when an axial load acts on a closed coil spring?

Shear stress is introduced when an axial load acts on a closed coil spring. In addition direct shear stress due to load is introduced. Stress due to curvature of the wire is also introduced.

24. What are the assumptions made in a closed coil helical spring subjected to axial load?

The assumptions are

1. An element of an axially loaded helical spring, behaves essentially as a straight bar in pure tension.
 2. The planes perpendicular to the bar axis do not warp or distort during deformation.
25. List out the uses of helical springs.
Automobiles and railway carriages
Shock absorbers
Reciprocating mechanisms and clock springs.

UNIT – IV DEFLECTION IN BEAMS

1. What are the methods for finding out the slope and deflection at a section?

- (i) Double Integration Method
- (ii) Moment Area method
- (iii) Macaulay's method
- (iv) Conjugate beam method

2. State Mohr's theorems.

- (i) The change of slope between any two points is equal to the net area of the B.M Diagram between these points divided by EI
- (ii) The total deflection between any two points is equal to the moment area of B.M Diagram between the two points about the last point divided by EI.

3. What is the relation between slope and deflection?

If y = deflection
Slope = dy/dx

4. State the equation for bending moment and shear force.

$$BM = EI \frac{d^2y}{dx^2}$$
$$SF = EI \frac{d^3y}{dx^3}$$

5. Give expression for determining slope at the supports of a simply supported beam carrying a point load at the centre.

$$\theta_a = \theta_b = \frac{WL^2}{16 EI}$$

6. Give expression for determining deflection of a simply supported beam carrying a point load at the centre.

$$y_c = - \frac{WL^3}{48 EI}$$

7. Give expression for determining slope and deflection of a simply supported beam carrying a UDL over the entire span.

$$\theta_a = \theta_b = \frac{WL^2}{24EI}$$

$$y_c = \frac{5}{384} \frac{WL^2}{EI}$$

8. What are the steps to be followed in determining slopes and deflections at any point of a beam using Macaulay's method?

- (i) Brackets are to be integrated as a whole.
- (ii) Constants of integrations are written after the first term
- (iii) The section, for which B M equation is to be written, should be taken in the last part of the beam.

9. What is the condition for maximum deflection in a beam.?

For maximum deflection, the slope dy/dx must be equal to Zero.

10. State the expression for determining slope in area moment method.

$$\theta_b = \frac{\text{Area of BMD}}{EI}$$

11. State the expression for determining deflection in area moment method.

$$y = \frac{AX}{EI}$$

12. What is a column?

A vertical member of a structure, which is subjected to axial compressive load and is fixed at both of its ends is known as a column.

13. What is a strut?

Strut is a member of a structure which is not vertical or whose one or both of its ends are hinged or pin jointed.

14. Specify how the long and short column will fail?

All short columns fail due to crushing where as long column will fail due to buckling or crushing.

15. What is buckling load?

The load at which the column just buckles is known as buckling load or critical load or crippling load.

16. Give the expressions for a column by Euler's formula for different end conditions.

$$P = \frac{\pi^2 EI}{l^2} \quad \text{When both ends are hinged}$$

$$P = \frac{\pi^2 EI}{4l^2} \quad \text{When one end is fixed and other end is free}$$

$$P = \frac{4\pi^2 EI}{l^2} \quad \text{When both ends are fixed}$$

$$P = \frac{2\pi^2 EI}{l^2} \quad \text{When one end is fixed and other end is hinged.}$$

17. What is effective length of a column?

The effective length of a given column with given end conditions is the length of an equivalent column of the same material and cross section with hinged ends, and having the value of crippling load equal to that of the given column.

18. What is slenderness ratio?

Slenderness ratio is the ratio of the effective length of the column to the least radius of gyration.

$$\text{Mathematically, Slenderness ratio} = \frac{L_e}{k}$$

19. State the limitation of Euler's formula.

If the slenderness ratio is small, the crippling stress will be high. But for the column material, the crippling stress cannot be greater than the crushing stress. Hence when the slenderness ratio is less than a certain limit, Euler's formula gives a value of crippling stress greater than the crushing stress. In this limiting case, we can find the value of l/k for which crippling load equal to crushing stress.

20. Specify the expression for Rankine's formula.

$$\frac{1}{P} = \frac{1}{P_c} + \frac{1}{P_E}$$

P = Crippling load by Rankine's formula

P_c = Crushing load

P_E = Crippling load by Euler's formula

UNIT – V Analysis of Stresses in Two Dimensions

1. When will you call a cylinder as thin cylinder?
A cylinder is called as a thin cylinder when the ratio of wall thickness to the diameter of cylinder is less than 1/20
2. In a cylinder will the radial stress vary over thickness of wall?
No, in the cylinders radial stress developed in its wall is assumed to be constant since the wall thickness is very small as compared to the diameter of the cylinder.
3. What is the ratio of circumferential stress to longitudinal stress of a thin cylinder?

$$\text{The ratio of } \frac{\sigma_c}{\sigma_a} = 2$$

4. What is the maximum principal stress in a thin cylindrical?
The maximum principal stress in a thin cylinder is circumferential stress.

$$\tau_{\max} = \frac{\sigma_c - \sigma_a}{2} = \frac{p d}{8 t}$$

5. What is the maximum shear stress in a thin cylinder? Circumferential strains,

$$\tau_{\max} = \frac{\sigma_c - \sigma_a}{2} = \frac{p d}{8 t}$$

6. For a thin cylinder, write down the equation for strain along the circumferential direction.

$$\text{Circumferential strain, } e_c = \frac{\delta d}{d} = \frac{p d}{2 t E} \left(1 - \frac{1}{2 m} \right)$$

7. For a thin cylinder, write down the equation for strain along the longitudinal direction

$$\text{longitudinal strain, } e_c = \frac{p d}{2 t E} \left(\frac{1}{2} - \frac{1}{m} \right)$$

8. Write the expression for hoop stress in thin cylinder due to internal pressure P.

$$\text{Hoop stress, } \sigma_c = \frac{p d}{2 t}$$

9. Write the expression for longitudinal stress in thin cylinder due to internal pressure P.

$$\text{longitudinal stress, } \sigma_a = \frac{p d}{4 t}$$

10. For a thin cylinder, write down the expression for volumetric strain.

$$\text{volumetric strain, } e_v = 2e_c + e_a \text{ or } e_v = \frac{pd}{2tE} \left(\frac{5}{2} - \frac{2}{m} \right)$$

11. What is the circumferential stress in a thin spherical shell subjected to internal pressure 'P'?

$$\text{circumferential stress, } \sigma_c = \frac{pd}{4t}$$

12. Write the volumetric strain in a thin spherical shell subjected to internal pressure 'P'?

$$\text{volumetric strain, } e_v = 3 \times e_c = \frac{3pd}{4tE} \left(1 - \frac{1}{m} \right)$$

13. Write the circumferential strain in thin spherical shell.

$$\text{circumferential strain, } e_c = \frac{pd}{4tE} \left(1 - \frac{1}{m} \right)$$

14. In a thin cylindrical shell if hoop strain is 0.2×10^{-3} and longitudinal strain is 0.005×10^{-3} , find out volumetric strain.

$$\begin{aligned} \text{Volumetric strain, } e_v &= 2e_c + e_a \\ &= 0.2 \times 10^{-3} + 0.005 \times 10^{-3} \\ e_v &= 0.25 \times 10^{-3} \end{aligned}$$

15. Different between thin cylinder and thick cylinder.

Thin cylinder	Thick cylinder
1. Ratio of wall thickness to the diameter of cylinder is less than $1/20$.	1. Ratio of wall thickness to the dia., of cylinder is more than $1/20$.
2. Circumferential stress is assumed to be constant throughout the all thickness.	2. circumferential stress varies from inner to outer wall thickness

16. Distinguish between cylindrical shell and spherical shell.

cylindrical shell	spherical shell
1. Circumferential stress is twice the longitudinal stress.	1. Only hoop stress presents.
2. It withstands low pressure than spherical shell for the same diameter.	2. It withstands more pressure than cylindrical shell for the same diameter.

17. Write the equation for the change in diameter and length of a thin cylinder shell, when subjected to an internal pressure.

$$\text{Change in diameter, } \delta d = \frac{p d^2}{2 t E} \left(1 - \frac{1}{2 m} \right)$$

$$\text{Change in length, } \delta l = \frac{p d l}{2 t E} \left(\frac{1}{2} - \frac{1}{m} \right)$$

18. What is the effect of riveting a thin cylindrical shell?

Riveting reduces the area offering the resistance. Due to this, the circumferential and longitudinal stresses are more. It reduces the pressure carrying capacity of the shell.

19. What do you understand by term wire winding of thin cylinder?

In order to increase the tensile strength of a thin cylinder to withstand high internal pressure without excessive increase in wall thickness, they are some times pre-stressed by winding with a steel wire under tension.

20. Define principal stresses and principal plane.

Principal stress: The magnitudes of normal stress, acting on a principal planes are known as principal stresses.

Principal planes: The planes which have no shear stress are known as principal planes.

21. Give the expression for maximum shear stress in a two dimensional stress system.

$$\text{Maximum shear stress, } (P_t)_{\max} = \frac{1}{2} \sqrt{(\sigma_1 - \sigma_2)^2 + 4 q^2}$$

22. What is the radius of Mohr's circle?

Radius of Mohr's circle is equal to the maximum shear stress.

23. A bar of cross sectional area 600 mm^2 is subjected to a tensile load of 50 kN applied at each end. Determine the normal stress on a plane inclined at 30° to the direction of loading.

$$A = 600 \text{ mm}^2$$

$$\text{Load, } p = 50 \text{ kN}$$

$$\theta = 30^\circ$$

$$\text{Stress, } \sigma = \frac{\text{Load}}{\text{Area}} = \frac{50 \times 10^3}{600} = 83.33 \text{ N/mm}^2$$

$$\text{Normal stress, } \sigma_n = p \cos^2 \theta = 83.33 \times \cos^2 30^\circ = 62.5 \text{ N/mm}^2$$

24. Give the expression for stresses on an inclined plane when it is subjected to a axial pull.

$$\text{Normal stress, } \sigma_n = p \cos^2 \theta$$

$$\text{Shear stress, } \sigma_t = p/2 \sin 2\theta$$

$$\text{Resultant stress, } \sigma_{\text{res}} = \sqrt{\sigma_n^2 + \sigma_t^2}$$

25. What is the use of Mohr's circle?

To find out the normal, tangential, resultant stresses and principal stress and their planes.

26. What are the planes along which the greatest shear stresses occur?
Greatest shear stress occurs at the planes which is inclined at 45° to its normal
27. Write the expression for a normal stress on an inclined plane in a block which is subjected to two mutually perpendicular normal stresses and shear stresses?

$$\text{Normal stress, } \sigma_n = \left(\frac{\sigma_1 + \sigma_2}{2} \right) + \left(\frac{\sigma_1 - \sigma_2}{2} \right) \cos 2\theta + q \sin 2\theta$$

28. At a point in strained material is subjected to a compressive stress of 100 N/mm^2 and shear stress of 60 N/mm^2 . determine graphically or otherwise the principal stresses.

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

$$q = 60 \text{ N/mm}^2$$

$$\begin{aligned} \text{Major Principal Stress, } \sigma_{n1} &= \frac{\sigma}{2} + \frac{1}{2} \sqrt{(\sigma^2 + 4q^2)} \\ &= \frac{-100}{2} + \frac{1}{2} \sqrt{100^2 + 4 \times 60^2} \\ \sigma_{n1} &= 28.1 \text{ N/mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Minor Principal Stress, } \sigma_{n2} &= \frac{\sigma}{2} - \frac{1}{2} \sqrt{(\sigma^2 + 4q^2)} \\ &= \frac{-100}{2} - \frac{1}{2} \sqrt{100^2 + 4 \times 60^2} \\ \sigma_{n2} &= -128.1 \text{ N/mm}^2 \text{ (compressive)} \end{aligned}$$

29. In case of equal like principal stresses, what is the diameter of the Mohr's circle?
Zero.

30. What is the value of maximum shear stress when the principal stresses are σ_1 compression and σ_2 tension?

$$\text{Maximum shear stress, } (\sigma_t)_{\max} = \frac{-\sigma_1 - \sigma_2}{2}$$