CE34 – MECHANICS OF SOLIDS

UNIT –1

STRESS STRAIN AND DEFORMATION OF SOLIDS, STATES OF STRESS

1. Define stress.

When an external force acts on a body, it undergoes deformation. At the same time the body resists deformation. The magnitude of the resisting force is numerically equal to the applied force. This internal resisting force per unit area is called stress.

Stress = Force/Area

When a body is subjected to an external force, there is some change of dimension in the body. Numerically the strain is equal to the ratio of change in length to the original length of the body.= P/A unit is N/mm^2

2. Define strain

δ Strain = Change in length/Original length

$e = \delta L/L$

3. State Hooke's law.

It states that when a material is loaded, within its elastic limit, the stress is directly proportional to the strain.

Stress α Strain

$\sigma \alpha e$

$\sigma = Ee$

$E = \sigma/e$ unit is N/mm^2

Where,

E - Young's modulus

σ - Stress

e - Strain

4. Define shear stress and shear strain.

The two equal and opposite force act tangentially on any cross sectional plane of the body tending to slide one part of the body over the other part. The stress induced is called shear stress and the corresponding strain is known as shear strain.

5. Define Poisson's ratio.

When a body is stressed, within its elastic limit, the ratio of lateral strain to the longitudinal strain is constant for a given material.

Poisson' ratio (μ or 1/m) = Lateral strain /Longitudinal strain

6. State the relationship between Young's Modulus and Modulus of Rigidity.

$$E = 2G (1+1/m)$$

Where,

E - Young's Modulus

K - Bulk Modulus

1/m - Poisson's ratio

7. Define strain energy

Whenever a body is strained, some amount of energy is absorbed in the body. The energy which is absorbed in the body due to straining effect is known as strain energy.

8. Give the relationship between Bulk Modulus and Young's Modulus.

$$E = 3K (1-2/m)$$

Where,

E - Young's Modulus

K - Bulk Modulus

1/m - Poisson's ratio

9. What is compound bar?

A composite bar composed of two or more different materials joined together such that system is elongated or compressed in a single unit.

10. Define- elastic limit

Some external force is acting on the body, the body tends to deformation. If the force is released from the body its regain to the original position. This is called elastic limit

11. Define – Young's modulus

The ratio of stress and strain is constant with in the elastic limit.

12. Define Bulk-modulus

The ratio of direct stress to volumetric strain.

13. Define- lateral strain

When a body is subjected to axial load P. The length of the body is increased. The axial deformation of the length of the body is called lateral strain.

14. What is principle of super position?

The resultant deformation of the body is equal to the algebric sum of the deformation of the individual section. Such principle is called as principle of super position

15. Define- Rigidity modulus

The shear stress is directly proportional to shear strain.

16. State principle plane.

The planes, which have no shear stress, are known as principal planes. These planes carry only normal stresses.

17. Define principle stresses and principle plane.

Principle stress: The magnitude of normal stress, acting on a principal plane is known as principal stresses.

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

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

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

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

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

20. List the methods to find the stresses in oblique plane?

1. Analytical method
2. Graphical method

21. Define- longitudinal strain

The strain right angle to the direction of the applied load is called lateral strain.

UNIT II

ANALYSIS OF PLANE TRUSS, THIN CYLINDERS / SHELL

1. What is mean by perfect frame?

If a frame is composed of such members, which are just sufficient to keep the frame in equilibrium, when the frame is supporting the external load, then the frame is know as perfect frame.

2. What are the different types of frames?

The different types of frame are:

- Perfect frame
- Imperfect frame.

3. What is mean by Imperfect frame?

A frame in which number of members and number of joints are not given by $n = 2j – 3$ is know as imperfect frame. This means that number of members in an

imperfect frame will be either more or less than (2j – 3).

4. What is mean by deficient frame?

If the number of member in a frame are less than (2j -3), then the frame is know as deficient frame

5. What is mean by redundant frame?

If the number of member in a frame are more than (2j -3), then the frame is know as deficient frame

6. What are the assumptions made in finding out the forces in a frame?

The assumptions made in finding out the forces in a frame are:

The frame is a perfect frame

The frame carries load at the joints All the members are pin-joined.

7. What are the reactions of supports of a frame?

The frame are generally supported

- on a roller support or
- On a hinged support.

8. How will you Analysis of a frame?

Analysis of a frame consists of

Determinations of the reactions at the supports and

Determination of the forces in the members of the frame

9. What are the methods for Analysis the frame?

Methods of joints, Methods of sections, and Graphical method.

10. How method of joints applied to Trusses carrying Horizontal loads.

If a truss carries horizontal loads (with or without vertical loads) hinged at one end supported on roller at the other end, the support reaction at the roller support end will be normal. Whereas the support reaction at the hinged end will consist of (i)

horizontal reaction and (ii) vertical reaction

11. How method of joints applied to Trusses carrying inclined loads.

If a truss carries inclined loads hinged at one end supported on roller at the other end, the support reaction at the roller support end will be normal. Whereas the support reaction at the hinged end will consist of (i) horizontal reaction and (ii) vertical reaction

12. What is mean by compressive and tensile force?

The forces in the member will be compressive if the member pushes the joint to which it is connected whereas the force in the member will be tensile if the member pulls the joint to which it is connected.

13. How will you determine the forces in a member by method of joints?

While determining forces in a member by methods of joints, the joint should be selected in such a way that at any time there are only two members, in which the forces are unknown.

14. Define thin cylinder?

If the thickness of the wall of the cylinder vessel is less than 1/15 to 1/20 of its internal diameter, the cylinder vessel is known as thin cylinder.

15. What are types of stress in a thin cylindrical vessel subjected to internal pressure?

These stresses are tensile and are know as

Circumferential stress (or hoop stress) and Longitudinal stress.

16. What is mean by Circumferential stress (or hoop stress) and Longitudinal stress?

The stress acting along the circumference of the cylinder is called circumferential stress (or hoop stress) whereas the stress acting along the length of

the cylinder is known as longitudinal stress.

17. What are the formula for finding circumferential stress and longitudinal stress?

Circumferential stress (f) is given by as $f = p \times d / 2t \times \eta_l$ and the

longitudinal stress (f) is given by $f_2 = p \times d / 2t \times \eta_c$

18. What are maximum shear stresses at any point in a cylinder?

Maximum shear stresses at any point in a cylinder, subjected to internal

fluid pressure is given by $f_1 - f_2 / 2 = pd / 8t$

19. What are the formula for finding circumferential strain and longitudinal strain?

The circumferential strain and longitudinal strain are given by

$e_1 = pd / 2tE (1- 1/2m)$, e_2 $pd / 2tE (1/2 – 1/m)$.

20. What are the formula for finding change in diameter, change in length and change volume of a cylindrical shell subjected to internal fluid pressure p?

$\delta d = pd^2 / 2tE (1 – 1/2m)$, $\delta L = pdL / 2tE (1/2 – 1/m)$,

$\delta V = pd / 2tE (5/2 – 2/m) \times$ volume,

21. What are the formula for finding principal stresses of a thin cylindrical shell subjected to internal fluid pressure p and a torque?

Major Principal Stress $= f_1 + f_2 / 2 + \sqrt{\{(f_1 - f_2 /2)^2 + f_s^2}$

Minor Principal Stress $= f_1 + f_2 / 2 - \sqrt{\{(f_1 - f_2 /2)^2 + f_s^2}$

Maximum shear stress = ½ [Major Principal Stress - Minor Principal

Stress]

Where f_1 = Circumferential stress,

f_2 =Longitudinal stress,

f_s =shear stress due to torque.

UNIT III

TRANSVERSE LOADING ON BEAMS

1. Define beam?

BEAM is a structural member which is supported along the length and subjected to external loads acting transversely (i.e) perpendicular to the center line of the beam.

2. What is mean by transverse loading on beam?

If a load is acting on the beam which perpendicular to the central line of it then it is called transverse loading.

3. What is Cantilever beam?

A beam one end free and the other end is fixed is called cantilever beam.

4. What is simply supported beam?

A beam supported or resting free on the support at its both ends.

5. What is mean by over hanging beam?

If one or both of the end portions are extended beyond the support then it is called over hanging beam.

6. What is mean by concentrated loads?

A load which is acting at a point is called point load.

7. What is uniformly distributed load.

If a load which is spread over a beam in such a manner that rate of loading ‘w’ is uniform through out the length then it is called as udl.

8. Define point of contra flexure? In which beam it occurs?

Point at which BM changes to zero is point of contra flexure. It occurs in overhanging beam.

9. What is mean by positive or sagging BM?

BM is said to positive if moment on left side of beam is clockwise or right side of the beam is counter clockwise.

10. What is mean by negative or hogging BM?

BM is said to negative if moment on left side of beam is counterclockwise or right side of the beam is clockwise.

11. Define shear force and bending moment?

SF at any cross section is defined as algebraic sum of all the forces acting either side of beam.

BM at any cross section is defined as algebraic sum of the moments of all the forces which are placed either side from that point.

12. When will bending moment is maximum?

BM will be maximum when shear force change its sign.

13. What is maximum bending moment in a simply supported beam of span 'L' subjected to UDL of 'w' over entire span?

Max BM $=wL^2/8$

14. In a simply supported beam how will you locate point of maximum bending moment?

The bending moment is max. When SF is zero. Write SF equation at that point and equating to zero we can find out the distances 'x' from one end .then find maximum bending moment at that point by taking all moment on right or left hand side of beam.

15. What is shear force?

The algebric sum of the vertical forces at any section of the beam to the left or right of the section is called shear force.

16. What is shear force and bending moment diagram?

It shows the variation of the shear force and bending moment along the length of the beam.

17. What are the types of beams?

1. Cantilever beam

2. Simply supported beam

3. Fixed beam

4. Continuous beam

5. over hanging beam

18. What are the types of loads?

1. Concentrated load or point load

2. Uniform distributed load

3. Uniform varying load

19. In which point the bending moment is maximum?

When the shear force change of sign or the shear force is zero

20. Write the assumption in the theory of simple bending?

- The material of the beam is homogeneous and isotropic.
- The beam material is stressed within the elastic limit and thus obey hooke'slaw.
- The transverse section which was plane before bending remains plains after bending also.
- Each layer of the beam is free to expand or contract independently about the layer, above or below.
- The value of E is the same in both compression and tension.

21. Write the theory of simple bending equation?

$M/ I = F/Y = E/R$

M - Maximum bending moment

I - Moment of inertia

F - Maximum stress induced

Y - Distance from the neutral axis

E - Young's modulus

R - Constant.

UNIT –IV

DEFLECTION OF BEAMS AND SHEAR STRESSES

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

The important methods used for finding out the slope and deflection at a section in a loaded beam are

- 1. Double integration method
- 2. Moment area method
- 3. Macaulay's method

The first two methods are suitable for a single load, where as the last one is suitable for several loads.

2. Why moment area method is more useful, when compared with double integration?

Moment area method is more useful, as compared with double integration method because many problems which do not have a simple mathematical solution can be simplified by the ending moment area method.

3. Explain the Theorem for conjugate beam method?

Theorem I : "The slope at any section of a loaded beam, relative to the original axis of the beam is equal to the shear in the conjugate beam at the corresponding section"

Theorem II: "The deflection at any given section of a loaded beam, relative to the

original position is equal to the Bending moment at the corresponding section of the conjugate beam”

4. Define method of Singularity functions?

In Macaulay’s method a single equation is formed for all loading on a beam, the equation is constructed in such away that the constant of Integration apply to all portions of the beam. This method is also called method of singularity functions.

5. What are the points to be worth for conjugate beam method?

1. This method can be directly used for simply supported Beam

2. In this method for cantilevers and fixed beams, artificial constraints need to be supplied to the conjugate beam so that it is supported in a manner consistent with the constraints of the real beam.

6. What are the different sections in which the shear stress distribution is to be obtained?

- Rectangular section
- Circular section
- I- section
- T- section
- Miscellaneous section

7. What do you mean by shear stress in beams?

The stress produced in a beam, which is subjected to shear forces is know as stresses.

8. What is the shear stress distribution rectangular section?

The shear stress distribution rectangular section is parabolic and is given by

$q = F/2I [d^2/4 – y^2]$

d = Depth of the beam

y = Distance of the fiber from NA

9. What is the shear stress distribution Circular section?

$q = F/3I [R^2 - y^2]$

10. State the main assumptions while deriving the general formula for shear stresses

The material is homogeneous, isotropic and elastic

The modulus of elasticity in tension and compression are same.

The shear stress is constant along the beam width

The presence of shear stress does not affect the distribution of bending stress.

11. Define: Shear stress distribution

The variation of shear stress along the depth of the beam is called shear stress distribution

12. What is the ratio of maximum shear stress to the average shear stress for the rectangular section?

Q_{max} is 1.5 times the Q_{avg}

13. What is the ratio of maximum shear stress to the average shear stress in the case of solid circular section?

Q_{max} is 4/3 times the Q_{avg}

14. What is the shear stress distribution value of Flange portion of the I-section?

q= f/2I * (D2/4 - y)

D-depth

y- Distance from neutral axis

15. What is the value of maximum of minimum shear stress in a rectangular cross section?

Qmax=3/2 * F/ (bd)

16. What is the shear stress distribution for I-section?

The shear stress distribution I-section is parabolic, but at the junction of web and flange, the shear stress changes abruptly. It changes from

$F/8I [D^2 - d^2]$ to $B/b \times F/8I [D^2 - d^2]$

where D = over all depth of the section

d = Depth of the web

b = Thickness of web

B = Over all width of the section.

17. How will you obtained shear stress distribution for unsymmetrical section?

The shear stress distribution for Unsymmetrical sections is obtained after calculating the position of N A.

18. Where the shear stress is max for Triangular section?

In the case of triangular section, the shear stress is not max at N A. The shear stress is max at a height of h/2

19. Where shear stress distribution diagram draw for composite section?

The shear stress distribution diagram for a composite section, should be drawn by calculating the shear stress at important points.

UNIT –V

TORSION AND SPRINGS

1. Define Torsion

When a pair of forces of equal magnitude but opposite directions acting on body, it tends to twist the body. It is known as twisting moment or torsion moment or simply as torque.

Torque is equal to the product of the force applied and the distance between the

point of application of the force and the axis of the shaft.

2. What are the assumptions made in Torsion equation

- The material of the shaft is homogeneous, perfectly elastic and obeys Hooke's law.
- Twist is uniform along the length of the shaft
- The stress does not exceed the limit of proportionality
- The shaft circular in section remains circular after loading
- Strain and deformations are small.

3. Define polar modulus

It is the ratio between polar moment of inertia and radius of the shaft.

4. Write the polar modulus for solid shaft and circular shaft.

£ = polar moment of inertia = J/R

$J = \pi D^4/32$

5. Why hollow circular shafts are preferred when compared to solid circular

shafts?

- The torque transmitted by the hollow shaft is greater than the solid shaft.
- For same material, length and given torque, the weight of the hollow shaft will be less compared to solid shaft.

6. Write torsional equation

$T/J=C\theta/L=q/R$

T-Torque

J- Polar moment of inertia

C-Modulus of rigidity

L- Length

q- Shear stress

R- Radius

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

$P=2\pi NT/60$

N-speed in rpm

T-torque

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

$T= (\pi/16)*Fs*((D4-d4)/d4$

T-torque

q- Shear stress

D-outer diameter

D- Inner diameter

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.

$T=\pi/16 * Fs*D3$

T-torque

q Shear stress

D diameter

10. Define torsional rigidity

Product of rigidity modulus and polar moment of inertia is called torsional rigidity

11. What is composite shaft?

Some times a shaft is made up of composite section i.e. one type of shaft is sleeved over other types of shaft. At the time of sleeving, the two shafts are joined together, that the composite shaft behaves like a single shaft.

12. What is a spring?

A spring is an elastic member, which deflects, or distorts under the action of load

and regains its original shape after the load is removed.

13. State any two functions of springs.

1. To measure forces in spring balance, meters and engine indicators.
2. To store energy.

14. What are the various types of springs?

- Helical springs
- Spiral springs
- Leaf springs
- **Disc spring or Belleville springs**

15. Classify the helical springs.

1. Close – coiled or tension helical spring.
2. Open –coiled or compression helical spring.

16. What is spring index (C)?

The ratio of mean or pitch diameter to the diameter of wire for the spring is called the spring index.

17. What is solid length?

The length of a spring under the maximum compression is called its solid length. It is the product of total number of coils and the diameter of wire.

$L_s = n_t \times d$

Where, n_t = total number of coils.

18. Define spring rate (stiffness).

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

$$K = W/y$$

Where W -load

Y – Deflection

19. Define pitch.

Pitch of the spring is defined as the axial distance between the adjacent coils in uncompressed state.

20. Define helical springs.

The helical springs are made up of a wire coiled in the form of a helix and are primarily intended for compressive or tensile load.

Part -B

1. A rectangular block of material is subjected to a tensile stress of 110 N/mm2 on one plane and a tensile stress of 47 N/mm2 on the plane at right angle to the former. Each of the above stress is accompanied by a shear stress of 63 N/mm2 Find (i) The direction and magnitude of each of the principal stress (ii) Magnitude of greatest shear stress.

2. At a point in a strained material, the principal stresses are100 N/mm2 (T) and 40 N/mm2 (C). Determine the resultant stress in magnitude and direction in a plane inclined at 600 to the axis of major principal stress. What is the maximum intensity of shear stress in the material at the point?

3. A thin cylindrical shell 3 m long has 1m internal diameter and 15 mm metal thickness. Calculate the circumferential and longitudinal stresses induced and also the change in the dimensions of the shell, if it is subjected to an internal pressure of 1.5 N/mm2 Take E = 2x105 N/mm2 and poison's ratio =0.3. Also calculate change in volume.

4. A closed cylindrical vessel made of steel plates 4 mm thick with plane ends, carries fluid under pressure of 3 N/mm2 The diameter of the cylinder is 25cm and length is

75 cm. Calculate the longitudinal and hoop stresses in the cylinder wall and determine the change in diameter, length and Volume of the cylinder. Take E = 2.1x105 N/mm2 and 1/m = 0.286.

5. Derive double integration method for cantilever beam concentrated load at free end.

6. Determine the diameter of a solid shaft which will transmit 300 KN at 250 rpm. The maximum shear stress should not exceed 30 N/mm2 and twist should not be more than 10 in a shaft length 2m. Take modulus of rigidity = 1x 105N/mm2.7. The stiffness of the closed coil helical spring at mean diameter 20 cm is made of 3cm diameter rod and has 16 turns. A weight of 3 KN is dropped on this spring. Find the height by which the weight should be dropped before striking the spring so that the spring may be compressed by 18 cm. Take C= 8x104 N/mm2.

8. A compound tube consist of steel tube 140mm internal diameter and 160mm external diameter and an outer brass tube 160mm internal diameter and 180mm external diameter. The two tubes are of same length. The compound tube carries an axial load of 900 KN. Find the stresses and the load carried by each tube and the amount it shortens. Length of each tube is 140mm. Take E for steel as 2 x 105 N/mm2.

9. A rectangle block of material is subjected to a tensile stress of 110 N/mm2 on one plane and a tensile stress of 47 N/mm2 on the plane at right angles to the former. Each of the above stress is accompanied by shear stress of 63 N/mm2. Find (i) the direction and magnitude of each of the principal stress (ii) magnitude of greatest shear stress.

10. . At a point in a strained material, the principal stresses are 100 N/mm2 (T) and 40 N/mm2 (C) Determine the direction and magnitude in a plane inclined at 600 to the axis of major principal stress. What is the maximum intensity of shear stress in the material at the point

11. It is required to design a closed coiled helical spring which shall deflect 1mm under an axial load of 100 N at a shear stress of 90 Mpa. The spring is to be made of

round wire having shear modulus of 0.8 x 105 Mpa. The mean diameter of the coil is 10 times that of the coil wire. Find the diameter and length of the wire.

12. A steel shaft ABCD having a total length of 2400 mm is contributed by three different sections as follows. The portion AB is hollow having outside and inside diameters 80 mm and 50 mm respectively, BC is solid and 80 mm diameter. CD is also solid and 70 mm diameter. If the angle of twist is same for each section, determine the length of each portion and the total angle of twist. Maximum permissible shear stress is 50 Mpa and shear modulus 0.82 x 105 MPa

13. Three planks of each 50 x200 mm timber are built up to a symmetrical I section for a beam. The maximum shear force over the beam is 4KN. Propose an alternate rectangular section of the same material so that the maximum shear stress developed is same in both sections. Assume then width of the section to be 2/3 of the depth.

14. A beam of uniform section 10 m long carries a udl of KN/m for the entire length and a concentrated load of 10 KN at right end. The beam is freely supported at the left end. Find the position of the second support so that the maximum bending moment in the beam is as minimum as possible. Also compute the maximum bending moment.

15. A rod 10mm diameter was subjected to an axial pull of 10KN. The change in diameter was found to be 0.003mm. Calculate the Poisson's ratio and the elasticity modulus. Given that N = 0.51×10^{5}MPa. Also calculate the bulk modulus.

16. A beam T – section is simply supported over a span of 8m and carries a UDL of 2 kN/m over the entire span. The T-section has a flange of 100mm x 20mm and a web of 100mmm x 20mm. Sketch the distribution of bending stress across the section

****