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ESE 2026 : Prelims Exam

CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 8

Section A : CPM PERT + Hydrology & Water Resource Engineering [All Topics]

Section B : Design of Steel Structure-1 + Surveying and Geology-1 [Part Syllabus]

Section C : Solid Mechanics-2 [Part Syllabus]

1.	(d)	16.	(c)	31.	(a)	46.	(b)	61.	(b)
2.	(a)	17.	(a)	32.	(c)	47.	(c)	62.	(a)
3.	(b)	18.	(b)	33.	(c)	48.	(b)	63.	(b)
4.	(a)	19.	(a)	34.	(a)	49.	(b)	64.	(d)
5.	(c)	20.	(b)	35.	(c)	50.	(c)	65.	(b)
6.	(b)	21.	(c)	36.	(c)	51.	(d)	66.	(a)
7.	(b)	22.	(a)	37.	(a)	52.	(c)	67.	(c)
8.	(a)	23.	(d)	38.	(a)	53.	(c)	68.	(a)
9.	(d)	24.	(c)	39.	(c)	54.	(d)	69.	(b)
10.	(c)	25.	(d)	40.	(c)	55.	(c)	70.	(d)
11.	(d)	26.	(d)	41.	(b)	56.	(a)	71.	(c)
12.	(b)	27.	(c)	42.	(c)	57.	(a)	72.	(d)
13.	(a)	28.	(b)	43.	(b)	58.	(a)	73.	(d)
14.	(d)	29.	(c)	44.	(d)	59.	(b)	74.	(b)
15.	(c)	30.	(c)	45.	(a)	60.	(a)	75.	(b)

DETAILED EXPLANATIONS

Section A : CPM PERT + Hydrology & Water Resource Engineering

1. (d)

The following are the primary objectives of the accident prevention programme:

1. **Safety of personnel**
   - To reduce the human lives sacrificed.
   - To prevent needless pain and sufferings to its employees.
2. **Safety of materials and equipment**
   - To avoid loss of or damage to equipment.
3. **Safety of structure**
   - To provide minimum cost of construction of structure or demolition of structure.
   - To increase the quality of output and reduce wastage.
4. **Management considerations**
   - To eliminate the cost of workmen's compensation insurance.
   - To avoid loss of time because of accidents.
   - To maintain the temporary and permanent morale of employees.

2. (a)

The capitalised value of property is the amount, the interest on which at the highest prevailing rate would be equal to the net income out of the property.

3. (b)

Ripple Effect occurs when the client forces acceleration of one activity, which then disturbs the sequence of the remaining work.

4. (a)

$$\sigma_{total} = \sqrt{\text{variance}_{total}}$$

$$\Rightarrow \quad \sigma_{total} = \sqrt{9+9+9+3^2+3^2} = 3\sqrt{5} \text{ days}$$

5. (c)

6. (b)

$$\text{Total working hours} = 80 \times 48 \times 40$$

$$\text{Frequency of injury} = \frac{12}{80 \times 48 \times 40} \times 100000 = 7.81 \simeq 8$$

7. (b)

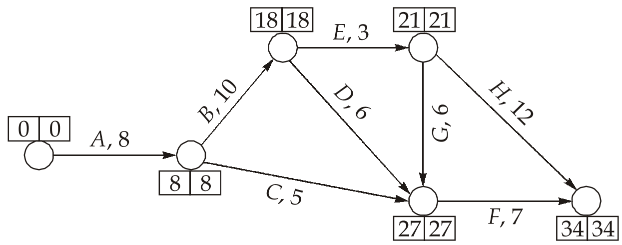
$$\text{Limit of economic haul} = \text{Free haul distance} + \frac{\text{Excavation cost}}{\text{Overhaul cost}}$$

$$\Rightarrow \quad LEH = 500 + \frac{8}{0.80} \times 30 = 800 \text{ m}$$

8. (a)

Milestone charts are a modification of bar charts. The interdependencies of activities is not shown in milestone charts.

9. (d)



Critical path : $A - B - E - G - F$

Critical duration : 34 days

10. (c)

$$\text{Bank measure volume of one cycle} = \frac{3.90}{1.30} = 3 \text{ m}^3$$

$$\text{Actual time working per hour} = 45 \times 60 \text{ seconds}$$

$$\text{Number of cycles in one hour} = \frac{45 \times 60}{30} = 90 \text{ cycles per hr}$$

$$\therefore \quad \text{Output of showel} = \text{Bank measure volume} \times \text{cycles per hour}$$

$$= 3 \times 90 = 270 \text{ m}^3/\text{hr}$$

11. (d)

Wheel-tractor bulldozers generally have higher speeds than crawler-mounted bulldozers.

12. (b)

CPM and Gantt charts mainly highlight the execution stage of a project because this is the phase where most of the scheduled work is actually carried out and where a major share of the project expenditure typically occurs.

Modern project management, however, places greater strategic importance on the initial or planning phases.

These early stages are where the business justification is developed, alternative approaches are evaluated, major risks are examined, and the overall feasibility of the project is determined. Since most value-adding decisions are made at this point, the initial phase has the highest ability to influence the final outcome, even if it involves comparatively less cost.

13. (a)

Blaney-Criddle equation,

$$C_u = \sum \frac{kp(4.61t + 81)}{100} \text{cm/month}$$

$$\Rightarrow \quad C_u = \frac{0.7 \times 9 \times (4.61 \times 20 + 81)}{100}$$

$$\Rightarrow \quad C_u = 10.9116 \text{ cm/month}$$

$$\Rightarrow \quad C_u = \frac{10.9116}{30} \times 10 \text{ mm/day}$$

$$\Rightarrow \quad C_u = 3.64 \text{ mm/day}$$

14. (d)

Situations like backwater effects causing flow reversal, flood waves produced by dam failure, and unusually high or maximum flood events involve rapidly varying and complex flow behaviour. In these cases, hydrologic routing becomes inadequate, and hydraulic routing based on the Saint Venant's continuity and momentum equations is necessary.

15. (c)

A floodway is a natural or man-made channel into which a part of flood can be diverted during high stages.

16. (c)

Only Saint-Venant method uses the full dynamic equations (continuity and momentum equations), hence it is hydraulic routing.

17. (a)

Potential evaporation represents the amount of water that would evaporate if water were freely available, while actual evaporation is controlled by factors such as temperature and wind. Evaporation also increases when the difference between saturated and actual vapour pressure increased, as described by Dalton's law. The Penman method estimates potential evapotranspiration by combining the effects of available energy and wind transfer.

18. (b)

The value of C_R recommended for use in Ryve's equation are:

- C_R = 6.8 for areas within 80 km from the east coast.
- C_R = 8.5 for area which are 80-160 km from the east coast.
- C_R = 10.2 for limited areas near hills.

Ryves' equation,

$$Q_p = C_R A^{2/3}$$

$$\Rightarrow \quad Q_p = 6.8 \times (64)^{2/3}$$

$$\Rightarrow \quad Q_p = 6.8 \times 16 = 108.8 \text{ m}^3/\text{s}$$

19. (a)

Anticyclones are characterized by high atmospheric pressure and a calm central region. Winds around an anticyclone circulate clockwise in the northern hemisphere. Extratropical cyclones form outside the tropical belt and are associated with frontal systems. The areal extent of an extratropical cyclone is typically larger than that of a tropical cyclone.

20. (b)

Pluviometer, Ombrometer, and Hyetometer are all used to designate a rain gauge.

21. (c)

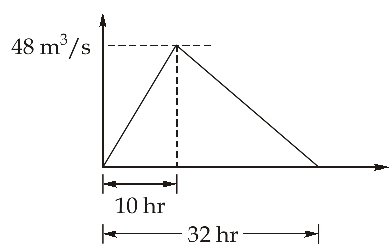
We know, $$Q_p = \frac{kiA}{36}$$

$$\Rightarrow \quad Q_p = \frac{0.5 \times 3.6 \times 60}{36} = 3 \text{ m}^3/\text{s}$$

22. (a)

Urbanisation increases the volume of surface runoff.

23. (d)



From hydrograph,

$$\frac{1}{2} \times 32 \times 3600 \times 48 = A \times 10^6 \times \frac{1}{100}$$

$$\Rightarrow \quad A = 276.48 \text{ km}^2$$

Equilibrium discharge of S-curve is,

$$Q_S = \frac{2.78A}{D}$$

$$\Rightarrow \quad Q_S = \frac{2.78 \times 276.48}{4} \simeq 192 \text{ m}^3/\text{s}$$

24. (c)

Lack of aeration is an effect of water logging in a field.

25. (d)

Rocky Stage: The river flows through steep, hard mountainous terrain with very high velocity. The channel is narrow and deep, and erosion is dominant, forming gorges and valleys.

Boulder Stage: As the slope reduces, the river enters a zone where the bed contains boulders and coarse soil. Velocity decreases, and the river becomes wider compared to the rocky stage.

Trough/Alluvial Stage: Flowing through plains, the river has a gentle slope and moderate-to-low velocity. The channel becomes wide, meandering develops, and the bed is made of alluvial soil.

Delta Stage: Near the sea, very low velocity causes heavy silt deposition. The river splits into distributaries, forming a delta, and the course becomes poorly defined.

26. (d)

- An ogee spillway is mostly suitable for concrete gravity dams, especially when the spillway is located within the dam body in the same valley.
- A chute spillway consists of a steeply sloping open channel, placed along a dam abutment or through a flank or a saddle.
- A chute spillway is adopted when a separate spillway is needed away from the main valley.

27. (c)

Points to be considered while selecting the site for diversion head works:

1. The site on the river should be straight and narrow.
2. The riverbank should be stable and well-defined.
3. The valley land should not be submerged when the weir or barrage is constructed.
4. The elevation of the site should be much higher than the area to be irrigated.
5. The site should be easily accessible by roads or railways.
6. The material of construction should be available in the vicinity of the site.
7. The site should not be far away from the command area of the project, to avoid transmission loss.

28. (b)

Spurs: Spurs are temporary, permeable structures provided on the curve of a river to protect the bank from erosion. They project from the riverbank toward the bed at angles of 60° to 75°, with their length depending on the river's width and sharpness of the curve. Their main function is to break the flow velocity and create a water pocket on the upstream side, where sediment deposits and helps in reclaiming land along the bank.

Groynes: Groynes serve the same basic function as spurs but are permanent, impervious structures constructed on river bends to protect the bank from erosion. They extend from the bank towards the riverbed at angles of 60° to 75°, and sometimes are built perpendicular to the bank. Made with stone pitching or concrete blocks, the length of a groyne depends on the river's width and nature, and they are used where long-term erosion control is necessary.

29. (c)

Non-modular Outlets: These outlets discharge water depending on the difference of water levels between the distributary and the watercourse. Because of this dependence, the discharge varies widely.

Semi-modular or Flexible Outlets: These outlets discharge water independent of the watercourse level, but the discharge depends on the distributary water level as long as a minimum working head is available. Examples include open sluice, venturi flume, and orifice semi-module.

Modular or Rigid Outlets: These outlets give a constant discharge irrespective of fluctuations in the water levels of both the distributary and the watercourse. Gibb's module is a common example.

30. (c)

31. (a)

Duty for Kharif,

$$D_k = \frac{8.64 \times (2 \times 7)}{0.56} = 216 \text{ hectares/cumec}$$

$\therefore$ Discharge required for Kharif, $Q_k = \dfrac{3240}{216} = 15$ cumec

Duty for Rabi,

$$D_R = \frac{8.64 \times (4 \times 7)}{0.42} = 576 \text{ hectares/cumec}$$

$\therefore$ Discharge required for Rabi, $Q_R = \dfrac{2880}{576} = 5$ cumec

$\therefore$ Required design discharge $= \text{Max}\{Q_k, Q_R\}$

$= 15$ cumec

32. (c)

Consumptive use efficiency,

$$\eta_{cu} = \frac{\text{Consumptive use} \times 100}{\text{Amount of water depleted from root zone}}$$

$$\Rightarrow \quad \eta_{cu} = \frac{560}{880} \times 100$$

$$\Rightarrow \quad \eta_{cu} = 63.6\%$$

33. (c)

Any canal is designed for a maximum discharge but actually, maximum discharge is not always required in the canal. The ratio of the average discharge over a specific period to the maximum discharge is called capacity factor.

34. (a)

As flow strength starts increasing from a very low discharge in an alluvial channel, the first bed form to appear is ripples. This stage occurs before the development of larger structures such as dunes, transition beds, or antidunes, which require higher flow strengths.

35. **(c)**

Total roughness in a movable-bed channel includes both grain roughness and form roughness.

36. **(c)**

An off-taking channel tends to draw excessive quantity of sediment due to the combined effects of the following:

1. Due to their smaller velocities, lower layers of water are more easily diverted into the off-taking channels in comparison to the upper layers of water.
2. Sediment concentration is generally near the bed.
3. Sediment concentration near the banks is usually higher.

37. **(a)**

An earthquake may impart either upstream or downstream acceleration. When the reservoir is full, this force would produce the worst results if it is additive to the hydrostatic water pressure. It happens when the force is acting towards the downstream i.e. when upstream earthquake acceleration towards the reservoir is produced.

38. **(a)**

When the catchment has large storage like reservoir, lake, low areas, etc. then the storage gets delayed and buffers the runoff. Thus, the outflow does not increase proportionally with rainfall and hence, the hydrograph distorts. UH theory is applicable for catchment areas between 200 ha and 5000 km^2.

Section B : Design of Steel Structure-1 + Surveying and Geology-1

39. **(c)**

Block shear strength (T_{db}) is minimum of T_{db_1} and T_{db_2}

$$T_{db} = \min\{T_{db_1}, T_{db_2}\}$$

Where,

T_{db_1} = fracture strength of the shear surface and yield strength of the tension surface

$$T_{db_1} = \frac{0.9 f_u}{\sqrt{3}\,\gamma_{m_1}}(A_{vn}) + \frac{f_y}{\gamma_{m_o}}(A_{tg})$$

and T_{db_2} = fracture strength of the tension plane and the yield strength of the shear plane

$$T_{db_2} = \frac{f_y}{\sqrt{3}\gamma_{mo}}(A_{vg}) + \frac{0.9 f_u}{\gamma_{m_1}}(A_{tn})$$

40. (c)

Refer IS 800 : 2007 (Cl 3.8)

- For a tension member in which a reversal of direct stress occurs due to loads other than wind or seismic forces (like general live loads), the maximum slenderness ratio permitted is 180. This stricter limit ensures greater stability and limits deformation under more regular loading conditions.
- For a member normally acting as a tie in a roof truss or bracing system but subjected to possible reversal of stresses resulting from the action of wind or earthquake forces, the maximum slenderness ratio permitted is 350. This higher limit is allowed because these compressive forces are typically transient, short-duration events, and slightly larger deformations might be acceptable under such extreme, occasional conditions without compromising overall structural integrity.

41. (b)

In the case of single angle connected through one leg, the net effective sectional area shall be taken as

$$A_{net} = A_1 + kA_2$$

where

$$A_1 = \text{Area of connected leg} = \frac{A}{2}$$

$$A_2 = \text{Area of unconnected leg} = \frac{A}{2}$$

$$k = \frac{3A_1}{3A_1 + A_2} = \frac{\frac{3A}{2}}{\frac{3A}{2} + \frac{A}{2}} = \frac{3}{4}$$

$$\therefore \quad A_{net} = \frac{A}{2} + \frac{3}{4} \times \frac{A}{2} = 0.875\,A$$

$$\therefore \quad \text{Percentage reduction is effective area} = \left(\frac{A - 0.875A}{A}\right) \times 100 = 12.5\%$$

42. (c)

- Lacings should typically form a mirror image (shadow pattern) on opposite faces to prevent twisting moments.
- A well-designed lacing system generally offers better efficiency and rigidity compared to a battened system due to smaller shear deformation effects.

43. (b)

As per IS 800 : 2007, *Cl* 10.5.1.2, minimum length of lap shall not be less than four times the thickness of thinner part being jointed or 40 mm, whichever is more.

$$\therefore \quad \text{Length of lap} = \text{maximum}\begin{cases} 4 \times 12 = 48 \text{ mm} \\ 40 \text{ mm} \end{cases}$$

$$\therefore \quad \text{Minimum length of lap} = 48 \text{ mm}$$

44. (d)

$$\text{Strength of weld} = \frac{f_u}{\sqrt{3}\gamma_{m_1}}\left(A_{eff}\right)$$

$$\Rightarrow \quad \text{Strength of weld} = \frac{410}{\sqrt{3}\times 1.25}\left(KS\, l_{eff}\right)$$

$$= 0.65\times 8\times 250\times\frac{410}{\sqrt{3}\times 1.25}N \qquad \{\because \text{ For } \theta = 95°, k = 0.65\}$$

$$= 246.18 \text{ kN}$$

45. (a)

The forces on either side balance each other so force in bolts is due to moment only. The moment on the rivets is,

$$M = P \times 100 + P \times 100 = 200\,P$$

Maximum distance of any rivet from centroid (r)

$$r = \sqrt{(50)^2 + (50)^2} = 50\sqrt{2} \text{ mm}$$

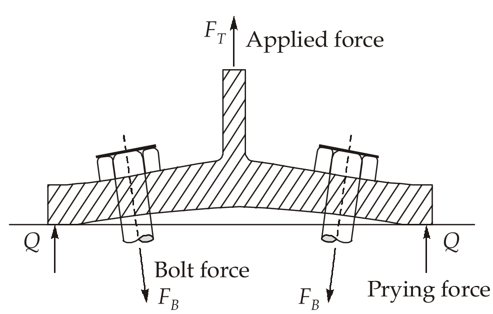
∴ Maximum force in the bolt

$$F_{max} = \frac{Mr_{max}}{\Sigma r^2} = \frac{Mr}{4r^2} = \frac{M}{4r}$$

$$\Rightarrow \quad F_{max} = \frac{200P}{4\times 50\sqrt{2}} = \frac{P}{\sqrt{2}}$$

46. (b)

Prying force is an additional tensile force induced in a bolt when the connected plates or components deform (flex or bend) under an applied tensile load.



47. (c)

As per IS 800 : 2007 (Cl 7.6.6.1)

Lacing systems in built-up columns must be designed to resist a minimum transverse shear force, which is conventionally taken as 2.5% of the total axial load on the column.

$$V_t = 2.5\% \text{ of } 800 \text{ kN}$$

$$\Rightarrow \quad V_t = \frac{2.5\times 800}{100} = 20 \text{ kN}$$

48. (b)

49. (b)

Horizontal distance, $D = \frac{f}{i}s + C$

If δD = error in distance

and δi = error in stadia interval

then, $\delta D = -s\frac{f}{i^2}\delta i$

$\Rightarrow \delta D = -s\frac{f}{i} \times \frac{1}{i}\delta i$

Given, $\frac{f}{i} = 100$

$\Rightarrow i = \frac{f}{100} = \frac{30}{100} = 0.3 \text{ cm}$

$\therefore \delta D = -s \times 100 \times \frac{1}{0.3} \times 0.003$

$\Rightarrow \delta D = -s$

50. (c)

$$\alpha = \frac{l}{R} \text{ radians} = \frac{l}{R} \times 206265 \text{ seconds}$$

$\Rightarrow 25 = \frac{2.5/1000}{R} \times 206265$

$\Rightarrow R = \frac{2.5}{25 \times 1000} \times 206265$

$\Rightarrow R = 20.63 \text{ m}$

51. (d)

The height of instrumen method is more rapid, less tedious and simpler, but the check on the intermediate sights is not available, so these mistakes pass unnoticed. It is more suitable in cases where several readings are required to be taken from a single station, such as construction work, profile levelling, etc.

52. (c)

53. (c)

Secular variation appears to be of periodic character and follows a sine-curve pattern. It swings like a pendulum. Its period is approximately 250 years.

54. (d)

Correction for pull,

$$C_P = \frac{(P - P_o)L}{AE}$$

$$\Rightarrow \quad C_P = \frac{(15 - 10)30}{0.05 \times 2 \times 10^6} = 0.0015 \text{ m (positive)}$$

Correction for sag,

$$C_S = \frac{W^2 L}{24 P^2}$$

$$\Rightarrow \quad C_S = \frac{1.2^2 \times 30}{24 \times 15^2} = 0.008 \text{ (negative)}$$

Total correction,

$$C = C_P - C_S$$

$$\Rightarrow \quad C = 0.0015 - 0.008 = -0.0065 \text{ m}$$

55. (c)

A pantograph is an instrument used for reproducing, enlarging or reducing the maps. It is based on the principle of similar triangles.

56. (a)

The difference between *FB* and *BB* is related to local attraction, not declination. Declination affects both *FB* and *BB* equally and does not cause their difference to deviate from 180°.

57. (a)

Present area of 81 cm^2 is equivalent to,

$$A' = \left(\frac{12}{10.8}\right)^2 \times 81 = 100 \text{ cm}^2$$

Scale of the plan was 1 cm = 20 m

$\Rightarrow$ 1 cm^2 = 400 m^2

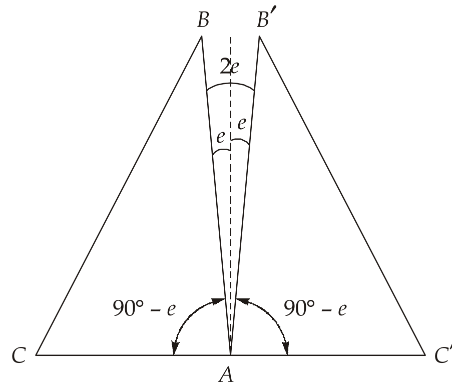
$\therefore$ Original area = 100 × 400 = 40000 m^2

58. (a)

59. (b)

The sextant is based on the principle that when a ray of light is reflected successively from two mirrors, the angle between first and last directions of ray is twice the angle between the planes of the two mirrors. So the angle indicated on the arc is only half of the real angular separation between the objects.

60. (a)



By reversing the instrument or part of it, the error becomes apparent. The magnitude of apparent error is double the true error because the reversion simply places the error as much to one side as it was to the opposite side before reversion.

Section C : Solid Mechanics-2

61. (b)

Minimum principal stress is given by

$$\sigma_{min} = \left(\frac{\sigma_x + \sigma_y}{2}\right) - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$\because$ $$\sigma_{min} = 0$$

$\therefore$ $$\frac{\sigma_x + \sigma_y}{2} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Squaring both sides

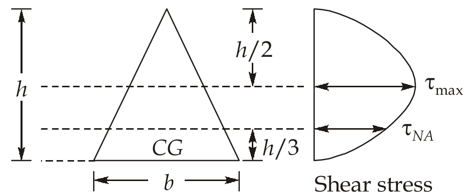
$\Rightarrow$ $$(\sigma_x + \sigma_y)^2 = (\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2$$

$\Rightarrow$ $$2\sigma_x\sigma_y = -2\sigma_x\sigma_y + 4\tau_{xy}^2$$

$\Rightarrow$ $$\tau_{xy}^2 = \sigma_x\sigma_y$$

$\Rightarrow$ $$\tau_{xy} = \sqrt{\sigma_x\sigma_y}$$

62. (a)



Shear stress distribution

Average shear stress, $$\tau_{avg} = \frac{V}{A}$$

Shear stress at NA, $$\tau_{NA} = \frac{4}{3}\tau_{avg} = \frac{4}{3}\left(\frac{V}{A}\right)$$

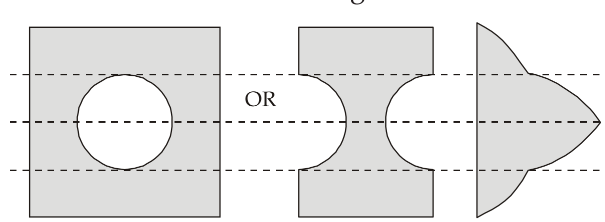
Maximum shear stress, $$\tau_{max} = \frac{3}{2}\tau_{avg} = \frac{3}{2}\left(\frac{V}{A}\right)$$

63. (b)

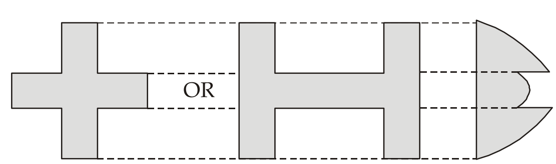
- The theory assumes the material behaves perfectly elastically until buckling occurs.
- Euler's theory assumes failure is purely due to elastic buckling in long columns, not material crushing or yielding.
- The theory explicitly assumes that the self-weight of the column is negligible compared to the applied axial load.
- A uniform cross-section ensures a constant moment of inertia along the column's axis for simplified mathematical modeling.

64. (d)

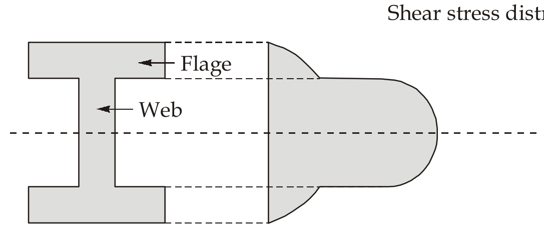
The shear stress distribution for the following cross-sections are as below:



Shear stress distribution



Shear stress distribution



Shear stress distribution

65. **(b)**

Given:

$$u = (-4x + 6y) \times 10^{-5} \text{ unit}$$
$$v = (-5x + 7y) \times 10^{-5} \text{ unit}$$

The shearing strain in xy plane is given by

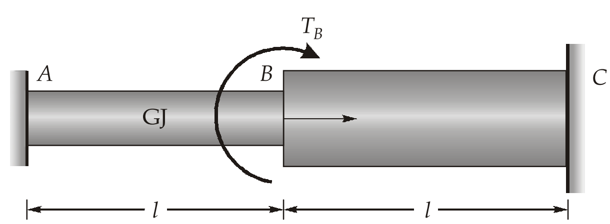
$$\phi_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} = 6 \times 10^{-5} + (-5 \times 10^{-6})$$

$$\Rightarrow \quad \phi_{xy} = 1 \times 10^{-5} \text{ unit}$$

66. **(a)**

- The fundamental definition of the shear center (also known as the center of twist) is the point where an applied transverse load will cause pure bending without inducing any torsion.
- For sections with one axis of symmetry, the shear flow distribution ensures that the shear center lies on that axis, simplifying its location. However, for most mono-symmetric open sections (like a channel or T-section), it does not coincide with the centroid.
- If a section has symmetry about two or more axes, the intersection of these axes is both the centroid and the shear center (e.g., I-beams, rectangular sections).
- The location of the shear center is solely a function of the geometry and shape of the cross-section and not the applied loading or material properties.

67. **(c)**



Angle of twist, $\quad \theta_{BA} = \theta_{BC} = 1$

Torque required to produce unit twist at B:

$$T_B = K_B\theta_B \qquad \text{...(i)}$$

where, $\quad K_B$ = Torsional stiffness at 'B'

$$\therefore \quad K_B = \sum\left(\frac{GJ}{l}\right) = \left(\frac{GJ}{l}\right)_{AB} + \left(\frac{GJ}{l}\right)_{BC}$$

$$\Rightarrow \quad K_B = \frac{GJ}{l} + \frac{GJ\left(\frac{3}{2}\right)^4}{l} \qquad \left[\because J_{BC} = \left(\frac{3}{2}\right)^4 J_{AB}\right]$$

$$\Rightarrow \quad K_B = \frac{GJ}{l}\left(1 + \frac{81}{16}\right)$$

$$\Rightarrow \quad K_B = \frac{97GJ}{16l}$$

From equation (i),

$$T_B = \frac{97GJ}{16l}$$

68. (a)

Given: $d = 4$ mm, $h = 10$, $D = 40$ mm

$P = 50$ N, $C = 80$ GPa $= 8 \times 10^4$ N/mm^2

Stiffness of closely coiled helical spring is given by

$$K = \frac{Cd^4}{64R^3n} = \frac{Cd^4}{8D^3n}$$

$$\Rightarrow \quad K = \frac{8\times10^4\times(4)^4}{8(40)^3\times10} = 4 \text{ N/mm}$$

69. (b)

Shear stress, $\tau_s = \dfrac{F}{A_S}$

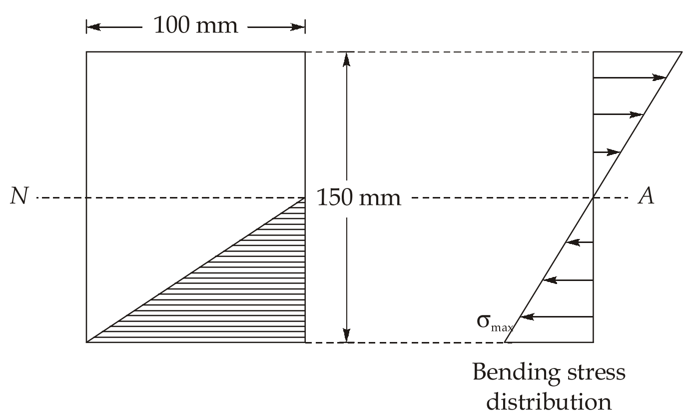
$\Rightarrow \quad F = \tau_s (\pi\, dt)$

$\Rightarrow \quad F = 250 \times \pi \times 30 \times 10$

$\Rightarrow \quad F = 75 \times 10^3\, \pi$ N

$\Rightarrow \quad F = 75\, \pi$ kN

70. (d)



Maximum bending stress.

$$\sigma_{max} = \frac{M}{I_{NA}}(y_{max}) = \frac{M}{Z}$$

$$\Rightarrow \quad \sigma_{max} = \frac{45\times10^6\times6}{100\times150^2}$$

$$\Rightarrow \quad \sigma_{max} = 120 \text{ N/mm}^2$$

71. (c)

Maximum shear stress due to applied loading.

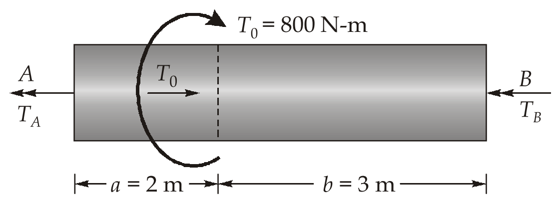
$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{60-10}{2} = 25 \text{ MPa}$$

Maximum shear stress in material at yield stress under uniaxial tension

$$\tau_y = \frac{f_y}{2} = \frac{180}{2} = 90 \text{ MPa}$$

$$\therefore \quad \text{Factor of safety} = \frac{\tau_y}{\tau_{max}} = \frac{90}{25} = 3.6$$

72. (d)



The fixing couple T_A and T_B at A and B respectively are given by

$$T_A = \frac{T_0 \times b}{a+b} = \frac{800 \times 3}{2+3} = 480 \text{ Nm}$$

and $$T_B = \frac{T_0 \times a}{a+b} = \frac{800 \times 2}{2+3} = 320 \text{ Nm}$$

73. (d)

For a non circular thin section,

$$\text{Shear stress, } \tau = \frac{T}{2tA_m}$$

where, $A_m = (300 \times 300) \text{ mm}^2, t = 6 \text{ mm}$

$$\therefore \quad \tau = \frac{27 \times 10^6}{2 \times 4 \times 300 \times 300} = 37.5 \text{ N/mm}^2$$

74. (b)

Effective length of column

$$L_{eff} = 2 \times 5 = 10 \text{ m} \quad (\because \text{ One end is fixed and other end is free})$$

Euler's buckling load

$$P_{cr} = \frac{\pi^2 EI_{min}}{L_{eff}^2} = \frac{\pi^2 \left(2 \times 10^5 \times \frac{300 \times 100^3}{12}\right)}{(10000)^2}$$

$$\Rightarrow \quad P_{cr} = 50000\,\pi^2 \text{ N}$$

$$P_{cr} = 50\,\pi^2 \text{ kN}$$

75. (b)

In fatigue failure, material fails below yield point without any warning.

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