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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 6

Section A : Design of Steel Structure + Surveying and Geology

Section B : Solid Mechanics - 1

Section C : Geo-Technical & Foundation Engineering-2 + Environmental Engineering-2

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

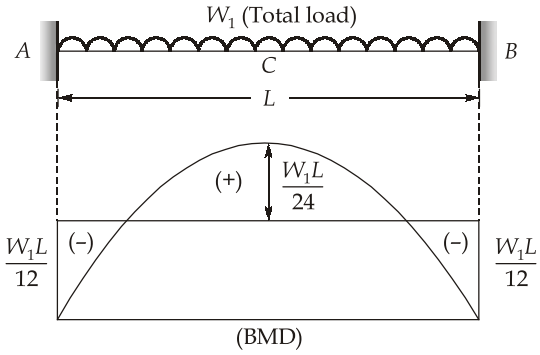
DETAILED EXPLANATIONS

Section A : Design of Steel Structure + Surveying and Geology

1. (c)

A riveted joint can never be as strong as the original plates because the process of making a rivet hole inherently removes material from the plate, creating a "weakest link" that is less strong than the solid material itself.

2. (c)



$\because$ BM at A > BM at C

$\therefore$ First plastic hinges will develop at A and B simultaneously.

Hence, $$M_p = \frac{W_1 L}{12}$$

$\Rightarrow$ $$W_1 = \frac{12\, M_P}{L}$$

3. (b)

Number of possible plastic hinges, n = 5 (at A, B, C, D, E)

Degree of static indeterminacy, $D_S = R_e - 3 = 5 - 3 = 2$

Number of possible independent mechanisms

$$N = n - D_S = 5 - 2 = 3$$

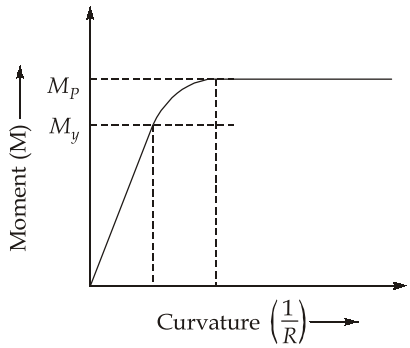
4. (b)

Refer IS 800 : 2007 (*Cl* 10.5.5)

The clear spacing between the effective lengths of intermittent fillet weld shall not exceed 12 and 16 times the thickness of thinner plate joined, for compression and tension joints respectively, and in no case be more than 200 mm.

5. (c)

Moment and curvature relationship



From the graph it is clear that at the location of plastic hinge developed in a structure, curvature is infinite

6. (a)

As per IS 800 : 2007 (Cl 6.3.3)

The rupture strength of an angle connected through one leg is affected by shear lag. The design strength, T_{dn}, as governed by rupture at net section is given by:

$$T_{dn} = 0.9\, A_{nc} f_u/\gamma_{m1} + \beta A_{go}\, f_y/\gamma_{m0}$$

where

$$\beta = 1.4 - 0.076\,(w/t)\,(f/f_u)\,(b_s/L_c) \le (f_u\gamma_{m0}/f_y\gamma_{m1})$$
$$\ge 0.7$$

7. (b)

As per IS 800 : 2007 (Cl 10.5.10.1)

Fillet welds when subjected to a combination of normal stress and shear stress, the equivalent stress (f_e) shall satisfy the following:

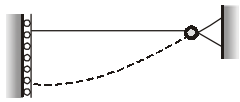
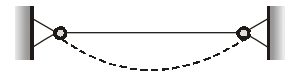
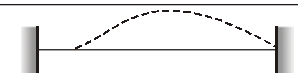
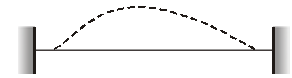
$$f_e = \sqrt{f_a^2 + 3q^2} \le \frac{f_u}{\sqrt{3}\gamma_{mw}}$$

Where

f_a = Normal stresses, compression or tension, due to axial force or bending moment

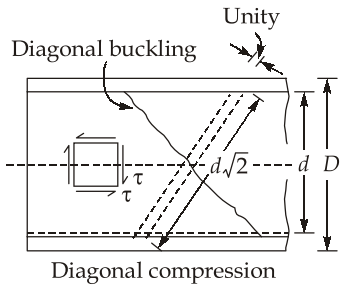
q = Shear stress due to shear force or tension

8. (d)

Effective lengths of prismatic compression members					
Boundary Conditions				Schematic Representation	Effective length (KL)
At One End		At the Other End			
Translation	Rotation	Translation	Rotation		
Restrained	Restrained	Free	Free		2.0 L
Free	Restrained	Restrained	Free		2.0 L
Restrained	Free	Restrained	Free		1.0 L
Restrained	Restrained	Free	Restrained		1.2 L
Restrained	Restrained	Restrained	Free		0.8 L
Restrained	Restrained	Restrained	Restrained		0.65 L

9. (b)

Diagonal buckling



$$\text{Effective length} = \frac{d\sqrt{2}}{2} = \frac{d}{\sqrt{2}}$$

$$\text{Minimum radius of gyration} = \frac{t_w}{\sqrt{12}}$$

$$\text{Slenderness ratio, } \lambda = \frac{d/\sqrt{2}}{t_w/\sqrt{12}} = \frac{d\sqrt{6}}{t_w} = 2.45\frac{d}{t_w}$$

10. (a)

Points of maximum bending moment usually correspond to points of zero shear, where intermediate stiffeners (for shear buckling) are not theoretically required. Bearing stiffeners are provided at points of concentrated loads and reactions (supports), which are locations of high shear and bearing stress, not necessarily maximum bending moment.

11. (b)

S = spacing of the trusses
t = cost of the trusses/unit area
p = cost of the purlins/unit area
r = cost of the roof coverings/unit urea
x = overall cost of the roof system/unit area

The cost of the truss is inversely proportional to the spacing of trusses,

$$t \propto \frac{1}{S}$$

$$\Rightarrow \quad t = \frac{c_1}{S}$$

The cost of the purlins is directly proportional to the square of spacing of trusses.

$$p \propto S^2$$

$$p = c_2 S^2$$

The cost of roof coverings is directly proportional to the spacing of trusses,

$$r \propto S$$

$$\Rightarrow \quad r = c_3 S$$

Thus, overall cost, $x = t + p + r$

$$\Rightarrow \quad x = \frac{c_1}{S} + c_2 S^2 + c_3 S$$

For the overall cost to be minimum,

$$\frac{dx}{dS} = 0 = -\frac{c_1}{S^2} + 2c_2 S + c_3$$

$$\Rightarrow \quad -\frac{c_1}{S^2} + 2c_2 S + c_3 = 0$$

$$\Rightarrow \quad -\frac{c_1}{S} + 2c_2 S^2 + c_3 S = 0$$

$$\Rightarrow \quad -t + 2p + r = 0$$

$$\Rightarrow \quad t = 2p + r$$

12. (d)

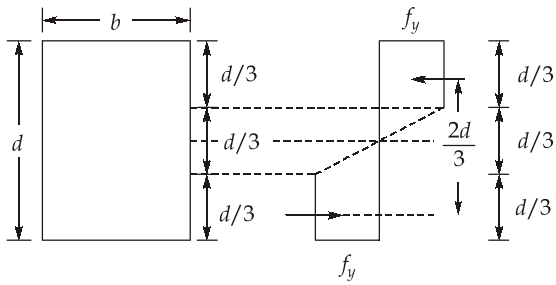
- Purlins placed at intermediate points: This causes bending because the load is applied between the truss joints and not directly at them as assumed in ideal truss theory.
- Rigidity of the joints: Real-world joints (welded/bolted) are rigid, not perfect 'pins', so they resist rotation and introduce bending moments.
- Eccentricity of the bolt line and centroid of the member section: When the force applied doesn't pass exactly through the center of the member, it creates a moment (torque) that causes bending.

13. (c)

As per IS 800 : 2007, Clause 10.3.3.3, the design shear capacity of bolts carrying shear through packing plate in excess of 6 mm shall be decreased by a factor of (β_{pk}) where,

$$\beta_{pk} = 1 - 0.0125\, t_{pk}$$
$$= 1 - 0.0125 \times 10 = 0.875$$

14. (b)



$$M = M_1 + M_2$$

$$\Rightarrow \quad M = f_y \times \frac{b\left(\frac{d}{3}\right)^2}{6} + \left(f_y \times \frac{d}{3} \times b\right) \times \frac{2d}{3}$$

$$\Rightarrow \quad M = f_y \times \frac{bd^2}{54} + \frac{2 f_y bd^2}{9}$$

$$\Rightarrow \quad M = \frac{13}{54} f_y bd^2$$

15. (c)

Refer IS 800 : 2007 (*Cl* 7.6)

The slenderness ratio of lacing bar shall not exceed 145.

16. (c)

A. Riveted joint - 2. Strap: In a lap joint, a strap is often used to connect the edges of the plates that are riveted together.

B. Welded joint - 4. Fillet: A fillet is a common type of weld used to join two surfaces at an angle.

C. Bolted joint - 3. Lock washer: A lock washer is used in a bolted joint to prevent the nut from vibrating loose.

D. Knuckle joint - 1. Pin: A knuckle joint uses a pin to connect the two rod ends, allowing for relative axial movement.

17. (b)

$$P_{weld} = f_w A_{eff} = f_w (l_{eff} \times t_t)$$

$$\Rightarrow \quad P_{weld} = 110\,(100 + 100 + 50) \times 0.7 \times 6 \text{ N}$$

$$\Rightarrow \quad P_{weld} = 115.5 \text{ kN}$$

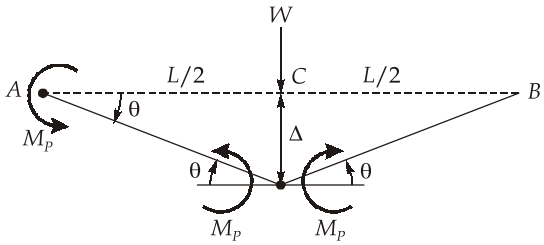
Now, $\quad P_{plate} = f_{plate} A_{plate} = 150 \times (50 \times 8)$ N

$$\Rightarrow \quad P_{plate} = 60 \text{ kN}$$

$\therefore$ Permissible load, $\quad P = \text{Min } \{115.5 \text{ kN}, 60 \text{ kN}\}$

$$\Rightarrow \quad P = 60 \text{ kN}$$

18. (a)



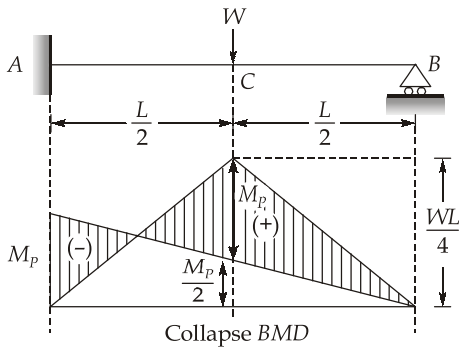
External workdone = Internal workdone

$$\Rightarrow \quad W\Delta = M_P\theta + M_P(\theta + \theta)$$

$$\Rightarrow \quad W\left(\frac{L}{2}\theta\right) = 3M_P\theta$$

$$\Rightarrow \quad W = \frac{6M_P}{L}$$

Alternatively



From BMD at the stage of collapse

$$\frac{WL}{4} = M_P + \frac{M_P}{2} = \frac{3M_P}{2}$$

$$\Rightarrow \quad W = \frac{6M_P}{2}$$

19. (c)

Effective length of column

$$l_{eff} = KL$$

where, K = Constant which depends on the end conditions of column.

20. (d)

As per IS 800 : 2007, slenderness ratio of tension members is restricted to 400 to fulfill stiffness requirements associated with self weight.

21. (b)

Equinoctial Colure is a great circle passing through the celestial poles and the vernal equinox.

22. (c)

$$\text{Displacement} = \text{Radial distance} \times \frac{h}{(H - h_a)}$$

$$= 50 \times \frac{80}{(3000 - 500)} = 1.6 \text{ mm}$$

23. (d)

- The weight of the arithmetic mean of n equally weighted observations is equal to n times the weight of one observation.
- The weight of the weighted arithmetic mean is equal to the sum of the individual weights.
- The weight of the algebraic sum (or difference) of two or more quantities is equal to the reciprocal of the sum of the reciprocals of the individual weights.
- When an observation is multiplied by a constant k, the new weight becomes the old weight divided by the square of that constant.
- When an observation is divided by a constant k, the new weight becomes the old weight multiplied by the square of that constant.
- When each term of an equation is multiplied by a constant k, the weight of the entire equation is then multiplied by k^2.
- When signs of all terms are changed or a constant is added/subtracted, the weight remains unchanged.

24. (a)

In tacheometric survey,

$$\text{Horizontal distance, } D = \frac{f}{i}s + (f + d)$$

$$\Rightarrow \quad 60 = \frac{0.20}{i}(1.845 - 1.345) + (0.20 + 0.10)$$

$$\Rightarrow \quad 60 = \frac{0.20}{i}(0.500) + (0.30)$$

$$\Rightarrow \quad i = 1.675 \times 10^{-3} \text{ m} = 1.675 \text{ mm}$$

25. (a)

The size of a theodolite is defined by the diameter of the horizontal circle which varies from 8 to 25 cm.

26. (b)

A plumbing fork is a hairpin-shaped brass frame having two arms of equal length which is used to ensure that the vertical axis of the instrument passes through the station point.

27. (c)

$$\text{Assumed scale} = \frac{1\,cm}{10\,m}$$

$$\text{Actual scale} = \frac{1\,cm}{12\,m}$$

$\therefore$ 10 m distance measured on ground by assumed scale is 1 cm on map.

$\therefore$ 350 m distance on ground = 35 cm on map

$\therefore$ Actual distance on ground = $35 \times 12 = 420$ m

28. (c)

In the trilateration technique of triangulation, no angular measurement is made. The three sides of the triangles are measured precisely using the electromagnetic distance measuring equipment. This technique is useful when angular measurement is difficult or impossible due to any reason.

29. (c)

The reduced bearing of a line is the angle made by the line with the north or south direction between 0° to 90°.

30. (b)

- **Disconformity:** Erosional surface between parallel sedimentary beds.
- **Angular unconformity:** Younger beds overlie tilted/folded, eroded older beds.
- **Nonconformity:** Sedimentary rocks overlying older igneous/metamorphic units.

31. (b)

A cumulative error is that which occurs in the same direction and tends to accumulate while a compensating error may occur in either direction and hence tends to compensate.

32. (d)

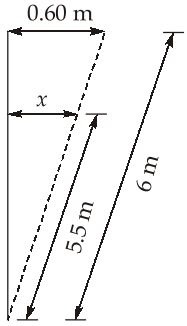
$$\text{Horizontal equivalent} = \text{Contour interval} \times \text{Gradient}$$

$$\Rightarrow \quad e = 10 \times 25 = 250 \text{ m}$$

33. (a)

Differential GPS (DGPS) is an enhanced form of GPS designed to improve positional accuracy. It works on the principle that positioning errors are nearly the same within a local area. A fixed reference station with known coordinates continuously computes the difference between its known position and the position calculated by the GPS. These differential corrections are then transmitted to other GPS receivers in the area, allowing them to correct their own positions in real time. As a result, DGPS can achieve accuracy within a few meters, making it highly useful for navigation and precise surveying applications.

34. (b)



Deviation of staff at 5.5 m,

$$x = \frac{5.5}{6} \times 0.6$$

$$\Rightarrow \quad x = 0.55 \text{ m}$$

$$\text{Correct staff reading} = \sqrt{5.5^2 - 0.55^2}$$

$$= \sqrt{30} \text{ m}$$

35. (c)

When the staff is held too near to the level, the graduations on the staff will not be clearly visible through the telescope. This problem is overcome by moving a piece of paper along the staff graduations and noting the readings when the line of collimation bisects the edge of the paper.

36. (c)

The following are the properties of a spherical triangle:

1. Any angle is less than two right angles or π.
2. The sum of the three angles is less than six right angles or 3π and greater than two right angles or π.
3. The sum of any two sides is greater than the third side.
4. If the sum of any two sides is equal to two right angles or π, then the sum of the angles opposite to them is equal to two right angles or π.
5. The smaller angle is opposite to the smaller side and vice versa.

Note: In spherical triangles, sides are measured in angular units, such as degrees or radians, not linear units like meters or kilometers. This is because a side of a spherical triangle is an arc of a great circle, and its length is defined by the angle it subtends at the center of the sphere.

37. (d)

38. (c)

The line whose difference between fore and back bearing deviates least from 180° is assumed to be free from local attraction and used as a reference for applying corrections.

Section B : Solid Mechanics - 1

39. (c)

Given: $E = 120\ \text{kN/mm}^2$

$G = 50\ \text{kN/mm}^2$

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

$\Rightarrow \quad 120 = 2 \times 50 (1+\mu)$

$\Rightarrow \quad \mu = 0.20$

40. (a)

Given: $\sigma_1 = 20\ \text{MPa}$

$\sigma_2 = -80\ \text{MPa}$

$$\because \quad \sigma_1/\sigma_2 = \frac{\sigma_x+\sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$\therefore \quad \sigma_1 + \sigma_2 = \sigma_x + \sigma_y$

$\Rightarrow \quad \sigma_x + \sigma_y = -60 \qquad ...(i)$

$$\because \quad \tau_{max} = \frac{\sigma_1-\sigma_2}{2}$$

$$\Rightarrow \quad \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2} = \frac{20-(-80)}{2}$$

$$\Rightarrow \quad \left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + 30^2 = 2500$$

$\Rightarrow \quad \sigma_x - \sigma_y = 80 \qquad ...(ii)$

From equations (i) and (ii)

$2\sigma_x = 20$

$\Rightarrow \quad \sigma_x = 10\ \text{MPa (tensile)}$

and $\sigma_y = -70\ \text{MPa (compressive)}$

41. (a)

- The center of Mohr's circle is at

$$\left(\frac{\sigma_x+\sigma_y}{2}, 0\right) \text{ or } \left(\frac{\sigma_1+\sigma_2}{2}, 0\right)$$

This represents the average normal stress on two planes which are mutually perpendicular.

- The radius of Mohr's circle is

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

This represents the maximum shear stress. (τ_{max})

- On Mohr's circle, the angle is doubled that is the angle between two points on the circle is 2θ, where θ is the actual rotation of the plane in the physical element.

42. (c)

Given: $W = wL$

$\Sigma F_y = 0 \Rightarrow R_A + R_B = W + W + wL$

$\Rightarrow R_A + R_B = 3\,wL$ ...(i)

$\because$ Beam and loading are symmetrical.

$\therefore R_A = R_B$

From equation (i), $R_A = R_B = \frac{3}{2}wL$

Taking moments about mid point of span AB,

$$M_c = W\left(\frac{L}{2}+a\right) + w\left(\frac{L}{2}\right)\left(\frac{L}{4}\right) - R_B\frac{L}{2}$$

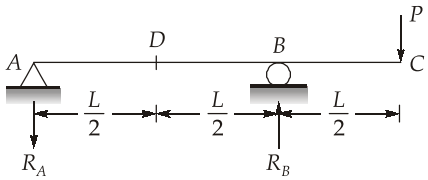
$$\Rightarrow 0 = wL\left(\frac{L}{2}+a\right) + \frac{wL^2}{8} - \frac{3}{2}wL\times\frac{L}{2} = \frac{L}{2}+a+\frac{L}{8}-\frac{3L}{4}$$

$$\Rightarrow a = \frac{L}{8}$$

43. (a)

If a material is not equally elastic in all directions, it is anisotropic, but that does not imply homogeneity.

44. (c)



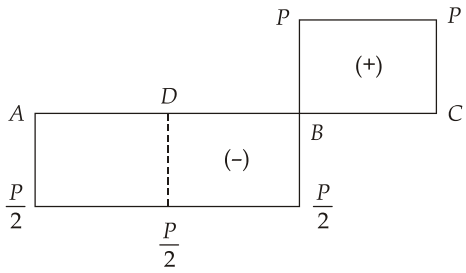
$\Sigma F_y = 0,$

$\Rightarrow R_B - R_A = P$

Taking moments about point A,

$$R_B \times L = P\times\frac{3L}{2}$$

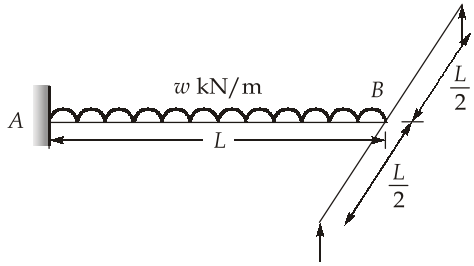
$$\Rightarrow R_B = \frac{3P}{2} \quad \text{and} \quad R_A = \frac{P}{2}$$



SFD

$\therefore$ Shear force at $D = \frac{P}{2}$

45. (d)



Let the reaction at point B be R,

$\therefore$ Deflection at B in cantilever beam = Deflection at B in simply supported beam.

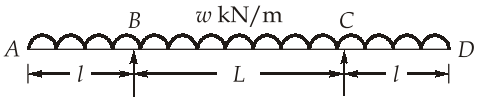
$$\frac{wL^4}{8EI} - \frac{RL^3}{3EI} = \frac{RL^3}{48EI}$$

$$\Rightarrow \quad \frac{wL}{8} = R\left(\frac{1}{48} + \frac{1}{3}\right)$$

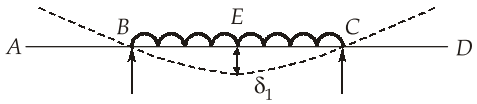
$$\Rightarrow \quad \frac{wL}{8} = R \times \frac{17}{48}$$

$$\Rightarrow \quad R = \frac{6}{17}wL$$

46. (c)



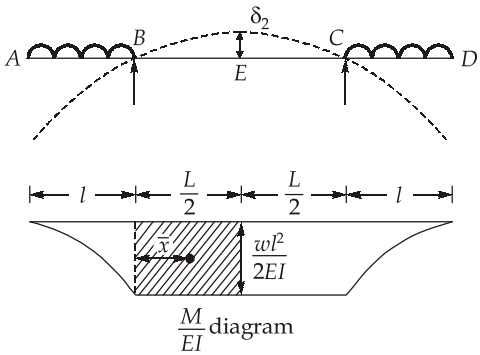
Considering *UDL* only on midspan *BC*,



We know for such loading,

$$\delta_1 = \frac{5}{384}\frac{wL^4}{EI}$$

Considering *UDL* only on overhangs *AB* and *CD*,



Here, $\bar{x} = \frac{L}{4}$

Shaded area $= \frac{wl^2}{2EI} \times \frac{L}{2}$

$\therefore \quad \delta_2 = A\bar{x} = \frac{wl^2}{2EI} \times \frac{L}{2} \times \frac{L}{4}$

For no deflection at mid point,

$\Rightarrow \quad \frac{5}{384}\frac{wL^4}{EI} = \frac{wl^2}{2EI} \times \frac{L^2}{8}$

$\Rightarrow \quad \frac{5L^2}{384} = \frac{l^2}{16}$

$\Rightarrow \quad \frac{l^2}{L^2} = \frac{5}{24}$

$\Rightarrow \quad \frac{l}{L} = \sqrt{\frac{5}{24}}$

47. (a)

When the ribbon is wound around the drum, the radius of curvature is constant. Therefore, bending moment induced is constant.

$M = \frac{EI}{R}$ (from bending equation, $\frac{E}{R} = \frac{M}{I}$)

Now, strain energy, $U = \frac{M^2L}{2EI}$

$\Rightarrow \quad U = \left(\frac{EI}{R}\right)^2 \frac{L}{2EI} = \frac{EIL}{2R^2}$

$\Rightarrow \quad U = \frac{2 \times 10^5 \times \left(\frac{8 \times 0.9^3}{12}\right) \times \pi \times 800}{2 \times 400^2}$

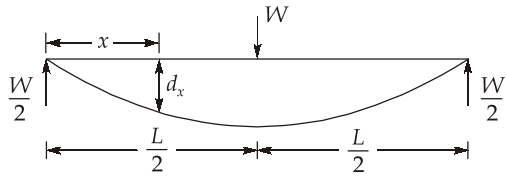
$\Rightarrow \quad U = 243\,\pi$ N-mm

Strain energy stored per unit length,

$U' = \frac{243\pi \times 1000}{\pi \times 800}$

$\Rightarrow \quad U' = 303.75$ N-mm/m

48. (b)



$$Z_x = \frac{bd_x^2}{6}$$

$$M_x = f Z_x = \frac{f\, bd_x^2}{6}$$

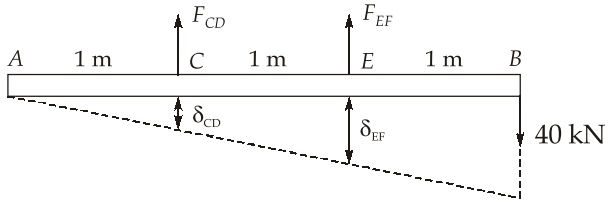
Also, $$M_x = \frac{Wx}{2}$$

$\Rightarrow$ $$d_x^2 = \frac{3Wx}{fb}$$

$$d_x = \sqrt{\frac{3Wx}{fb}} = C\sqrt{x}$$

where, $$C = \sqrt{\frac{3W}{fb}}$$

49. (a)



From similarity of triangles, $$\frac{\delta_{CD}}{1} = \frac{\delta_{EF}}{2}$$

$\Rightarrow$ $$\delta_{EF} = 2\delta_{CD}$$

$\Rightarrow$ $$\frac{F_{EF} \times L}{A_{EF} \times E_s} = \frac{2 \times F_{CD} \times L}{A_{CD} \times E_s}$$

$\Rightarrow$ $$F_{EF} = 2F_{CD} \quad \text{...(i)}$$

$$\Sigma M_A = 0$$

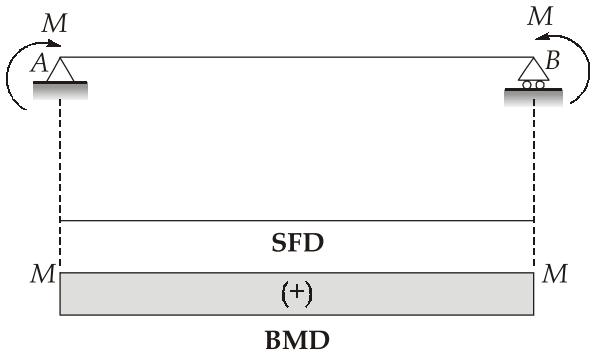
$\Rightarrow$ $$F_{CD} \times 1 + F_{EF} \times 2 = 40 \times 3$$

$\Rightarrow$ $$F_{CD} + 2 \times (2F_{CD}) = 120$$

$\Rightarrow$ $$5F_{CD} = 120$$

$\Rightarrow$ $$F_{CD} = 24 \text{ kN}$$

50. (a)



Since, bending moment is constant.

Also, cross-section is constant throughout the length.

From bending formula, $\frac{\sigma}{y} = \underbrace{\frac{M}{I} = \frac{E}{R}}$

$\Rightarrow \quad R = \frac{EI}{M}$

$\Rightarrow \quad R = \text{Constant}$

Hence, deflection curve will be in the shape of a circular arc.

51. (c)

Free contraction, $\Delta L = L\alpha\Delta T$

$\Rightarrow \quad \Delta L = 500 \times 12 \times 10^{-6} \times (65 - 30)$

$\Rightarrow \quad \Delta L = 0.21 \text{ cm}$

$\because$ Ends yield by 0.12 cm,

$\therefore$ Strain resisted, $\in = \frac{\Delta L'}{L} = \frac{(0.21 - 0.12)}{500} = \frac{0.09}{500}$

$\therefore$ Stress induced, $\sigma_T = \in \times E$

$$\sigma_T = \frac{0.09}{500} \times 2 \times 10^5 = 36 \text{ N/mm}^2$$

Section C : Geo-technical & Foundation Engg - 2 + Environmental Engg - 2

52. (d)

- The bearing capacity of footings in sands varies with the size of footing hence the scale effect gives misleading results.
- Consolidation settlements in cohesive clays take years, but the plate load test is of short duration, making it insignificant for this case.
- As the test is conducted on either a square plate or a circular plate, its results are not recommended to be used for the designing of strip footings owing to shape effects.
- The load test results reflect the characteristics of the soil located only within a depth of about twice the width of the plate.

53. (b)

Skempton's equation:

$$q_{nu} = 5C\left(1+0.2\frac{b}{L}\right)\left(1+0.2\frac{D_f}{b}\right) \qquad \left[\because \quad \frac{D_f}{b} < 2.5\right]$$

$$\Rightarrow \quad q_{nu} = 5\times 90\left[1+0.2\left(\frac{2}{4}\right)\right]\left[1+0.2\left(\frac{1.2}{2}\right)\right]$$

$$\Rightarrow \quad q_{nu} = 450\ (1.1)\ (1.12)$$

$$q_{nu} = 554.4\ \text{kN/m}^2 \approx 554\ \text{kN/m}^2$$

54. (c)

Piston sampler is particularly useful in sampling saturated sands and other soft and wet soil. A rotary sampler is used in sampling from firm to hard cohesive soil, and particularly in rocks.

55. (c)

At the optimum spacing, pile group efficiency = 1

Width of block for 16 piles = $3S + D$

Pile group capacity for block failure = $A_S \times C$

$= 4\ L\ (3S + D) \times C$

Group capacity based on individual pile failure

$= n\ \alpha\ C\ A_S$

$= 16 \times 0.7 \times C\ \pi DL$

Since, pile group efficiency = 1,

$\therefore \quad 4L\ (3S + D)\ C = 16 \times 0.7 \times C\pi DL$

$\Rightarrow \quad S = 2.6\ D$

56. (b)

IS: 1892-1979 recommends that for a compact building site covering an area of about 0.4 hectare, one borehole or trial pit in the centre and one at each corner will be adequate. For smaller and less important buildings, one borehole or trial pit in the centre will be sufficient.

57. (c)

58. (b)

Reinforced earth is a combination of soils strong in shear and compression, and reinforcements like bamboo or PVC strong in tension.

59. (a)

60. (a)

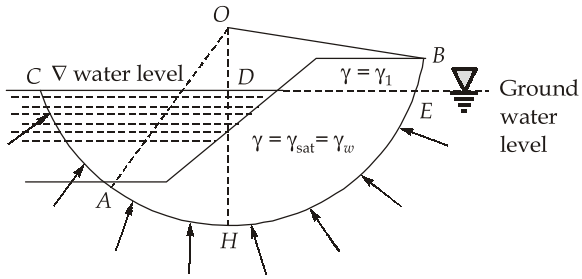
Load on the footing is vertical and purely axial.

61. (a)

In geotextiles, the reinforcing function is primarily based on the surface friction between the surface fill and the fabric, whereas in geogrids, it is achieved through the interlocking of the fill material into the apertures of the geogrids.

62. (d)

63. (a)



From the figure, it can be seen that the body of water in the half segment CDH balances that of the water contained in the other half segment DEH. The moments of the water pressure balance each other.

If the slope is fully submerged, submerged unit weight is used for the entire soil section, and the water resting on the slope acts as additional resistance. This increases the factor of safety for the slope.

64. (c)

When the C/N ratio is higher than optimum, then nitrogen is used up first and carbon is left over, leaving the digestion of organic matter incomplete. When the C/N ratio is lower than optimum, nitrogen is left in the digester, which combines with hydrogen and forms NH_3. This can kill or inhibit the growth of bacteria.

65. (d)

The UASB system does not require external mechanical mixing; the upflow velocity and gas production keep the sludge blanket in suspension.

66. (a)

Given:
$$\frac{F}{M} = 0.3 \text{ day}^{-1}$$
$$Q = 4200 \text{ m}^3/\text{day}$$
$$S_o = 180 \text{ mg}/l$$
$$X_t = 2800 \text{ mg}/l$$

We know,
$$\frac{F}{M} = \frac{QS_o}{VX_t}$$
$$\Rightarrow \quad 0.3 = \frac{4200 \times 180}{V \times 2800}$$
$$\Rightarrow \quad V = \frac{4200 \times 180}{0.3 \times 2800} = 900 \text{ m}^3$$

Hydraulic retention time,
$$HRT = \frac{V}{Q}$$
$$\Rightarrow \quad \text{HRT} = \frac{900}{4200} \times 24 = 5.14 \text{ hours}$$

67. (b)

Denitrification results in the formation of nitrogen gas bubbles, which lifts up the settled sludge, thereby deteriorating the quality of effluent sludge.

68. (c)

Elutriation is a unit operation in which a solid or a solid-liquid mixture is intimately mixed with a liquid for the purpose of transferring certain components to the liquid.

69. (d)

70. (d)

- It is based on the assumption that there is only one source of BOD when there may actually be several different point or non-point sources of BOD.
- Algal respiration in the absence of sunlight, nitrification processes that increase the oxygen demand and the presence of sludge deposits in pool areas can all increase stream's BOD. It doesn't account for them.
- In shallow streams, masses of microbial growth attached to the streambed may consume more dissolved oxygen.
- It assumes steady-state conditions all along a river reach and does not incorporate varying deoxygenation rate constants because of channel formation, obstacles, pools, etc.

71. (b)

Given: $Q = 150\ l/\text{capita/day}$

$C = 40000$

$A = 120\ ha$

$$\text{Quantity of sewage produced} = \frac{75}{100} \times 40000 \times 150$$

$$= 45 \times 10^5\ l/\text{day}$$

$$= 4500\ \text{m}^3/\text{day}$$

$$\text{Consuming capacity of soil} = \frac{\text{Quantity of sewage applied to land}}{\text{Total area of land}}$$

$$= \frac{4500}{120} = 37.5\ \text{m}^3/\text{ha/day}$$

72. (b)

Refractory organics are those organic substances that are not readily biodegradable and are resistant to biological oxidation processes, remaining after the BOD test but measured in COD.

73. (c)

Activated sludge process is suspended-growth biological treatment, and not sludge thickening.

74. (a)

$$\text{Sludge volume index} = \frac{\text{Volume of settled sludge}}{\text{MLSS present}}$$

$$\Rightarrow \quad SVI = \frac{150}{\frac{3000}{1000}} = 50 \text{ m}l/\text{g}$$

Sludge density index, $SDI = \frac{1}{SVI}$

$$\Rightarrow \quad SDI = \frac{1}{50} = 0.02 \text{ g/m}l$$

$$= 20 \text{ g}/l$$

75. (a)

■■■■