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ESE 2019

Preliminary Examination

Detailed Solutions of

Civil Engineering

(Set-A)

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Expected Cutof of ESE 2019 Prelims					Actual Cutof of ESE 2018 Prelims				
Branch	Gen	OBC	SC	ST	Branch	Gen	OBC	SC	ST
CE	180-190	170-180	150-160	150-160	CE	207	194	169	188
ME	190-200	180-190	160-170	160-170	ME	256	255	220	223
EE	230-240	220-230	190-200	190-200	EE	230	218	190	191
E&T	210-220	200-210	170-180	170-180	E&T	213	206	173	155

Civil Engineering Paper Analysis
ESE 2019 Prelims Exam

Sl.	Subjects	Number of Questions
1	Building Materials and Construction	13
2	Strength of Materials	17
3	Structural Analysis	9
4	Steel Structures	12
5	RCC	13
6	Construction Planning and Management	12
7	Fluid + Hydraulic Machine + OCF	12
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UPSC ESE/IES Prelims 2019 : Civil Engineering analysis and expected cutoff by MADE EASY faculty

https://youtu.be/IHyKkywcrTA

1. Which of the following statements are wholly correct regarding broken-brick aggregate usable in concretes?

1. Broken-brick aggregate is obtained by crushing waste bricks; and it has a density varying between 1000 kg/m^3 - 1200 kg/m^3.
2. Such aggregate is usable in concrete for foundation in light buildings, floorings and walkways.
3. Such aggregate may also be used in light-weight reinforced concrete floors.

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (d)

End of Solution

2. In handling air-entraining admixtures the beneficial amount of entrained air depends upon certain factors like

1. Type and quantity of air-entraining agent.
2. Water-cement ratio of the mix.
3. Strength of aggregates.
4. Extent of compaction of concrete.

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 1, 3 and 4 only (d) 1, 2, 3 and 4

Ans. (b)

Air-entraining admixtures has dependency on

- Quantity of air-entraining admixture (dose of admixture)
- $\frac{w}{c}$ ratio
- Compaction requirement of concrete.

End of Solution

3. Which one of the following statements is not correct with respect to fry ash?

(a) As part replacement of cement in the range of 15% - 30%, fly ash reduces the strength in the initial period, but once the Pozzolanic process sets in, higher strength can be obtained.
(b) Fly ash as a part replacement of sand has a beneficial effect on strength even at early age.
(c) Fly ash as a part replacement of sand is economical.
(d) A simultaneous replacement of cement and fine aggregates enables the strength at a specified age to be equalled depending upon the water content.

Ans. (b)

End of Solution

4. Which one of the following statements is not correct with respect to the properties of cement?
(a) Highly reactive Pozzolanas enhance the early age strength of the composite cement.
(b) Pozzolanic activity refines pore structure which decreases electrolytic resistance of concrete.
(c) The expansion due to alkali-silica reaction can be controlled by replacement of as high as 60% of OPC with high-calcium Pozzolana.
(d) Such high amounts of replacement cements result in higher accelerated carbonation depths compared to pure use of OPC only.

Ans. (a)

End of Solution

5. Hydration of which compound is responsible for increase in strength of cement in later age?
(a) Tri-calcium Aluminate (C_3A)
(b) Tetra-calcium Aluminoferrite (C_4AF)
(c) Tri-calcium Silicate (C_3S)
(d) Di-calcium Silicate (C_2S)

Ans. (d)
Dicalcium silicate (C_2S) is responsible for later gain of strength i.e., after 28 days it is the only compound that contributes in strength.

End of Solution

6. The creep strain of cement attains its terminal value by
(a) 1 year
(b) 2 years
(c) 5 years
(d) 6 months

Ans. (c)
The creep strain of cement attains its terminal value by 5 yrs.
- Creep strain is due to continuous sustained load for long term; where initially it increases, then starts reducing.

End of Solution

7. Which of the following methods will help in reducing segregation in concrete?
1. Not using vibrator to spread the concrete.
2. Reducing the continued vibration.
3. Improving the cohesion of a lean dry mix through addition of a further small quantity of water.

(a) 1, 2 and 3
(b) 1 and 2 only
(c) 1 and 3 only
(d) 2 and 3 only

Ans. (d)

End of Solution

8. On an average, in a 125 mm slump, the concrete may lose about (in first one hour)

(a) 15 mm of slump (b) 25 mm of slump

(c) 40 mm of slump (d) 50 mm of slump

Ans. (d)

The slump loss is negligible in the first half hour (due to small volume of hydration products), and on an average, a 120 mm slump concrete may lose about 50 mm in the first one hour.

End of Solution

9. Permeability in concrete is studied towards providing for, or guarding against, which of the following features?

1. The penetration by materials in solution may adversely affect the durability of concrete; moreover, aggressive liquids 'attack' the concrete.
2. In case of reinforced concrete, ingress of moisture and air will result in corrosion of steel leading to an increase in volume of steel, resulting in cracking and spalling of the concrete cover.
3. The moisture penetration depends on permeability and if the concrete can become saturated with water it is less vulnerable to frost action.

(a) 1, 2 and 3 (b) 1 and 2 only

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

Ans. (b)

Moisture penetration depends on permeability but when concrete is saturated with water, then chances of frost action will be more.

End of Solution

10. Poisson's ratio of concrete μ can be determined using the formula

(a) $\left(\frac{V}{2nL}\right) = \frac{(1-\mu)}{(1-2\mu)(1+\mu)}$ (b) $\left(\frac{V}{2nL}\right) = \frac{(1+\mu)}{(1-2\mu)(1+\mu)}$

(c) $\left(\frac{V^2}{2nL}\right) = \frac{(1-\mu)}{(1-2\mu)(1+\mu)}$ (d) $\left(\frac{V^2}{2nL}\right) = \frac{(1-\mu^2)}{(1-2\mu)(1+\mu)}$

where V is pulse velocity, in mm/s,

n is resonant frequency of longitudinal vibration, in Hz,

L is distance between transducers, in mm

Ans. (*)

A per IS 13311 (Part 1): 1992

The dynamic Poisson's ratio may be obtained from measurements on concrete test beams of the velocity (v) alongwith length (L) of the beam and the fundamental resonant frequency (n) of the beam in longitudinal mode of vibration is related as

$$\frac{v^2}{(2nl)^2} = \frac{1-\mu}{(1-2\mu)(1+\mu)}$$

End of Solution

11. Which one of the following methods/techniques will be used for placing of concrete in dewatered "Caissons or Coffer' dams?

(a) Tremie method
(b) Placing in bags
(c) Prepacked concrete
(d) In-the-dry practice

Ans. (d)

Placing of concrete in dewatered "Caissons or Coffer' Dams follows normal in "Dry practice".

[Reference 12.4.1; concrete technology by Gambhir]

End of Solution

12. The minimum cement content (kg/m^3) for a pre-specified strength of concrete (using standard notations) premised on 'free water-cement ratio' will be as

(a) $1-\frac{C}{1000S_C}-\frac{W}{1000}$

(b) $\frac{\text{Water Content}}{\text{Water Cement Ratio}}$

(c) Water Content × Water Cement Ratio

(d) $\frac{100F}{C+F}$

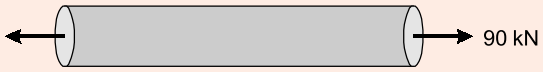
Ans. (b)

End of Solution

13. A bar specimen of 36 mm diameter is subjected to a pull of 90 kN during a tension test. The extension on a gauge length of 200 mm is measured to be 0.089 mm and the change in diameter to be 0.0046 mm. The Poisson's ratio will be

(a) 0.287
(b) 0.265
(c) 0.253
(d) 0.241

Ans. (a)



d = 36 mm

L = 200 mm, ΔL = 0.089 mm

Δd = 0.0046 mm

$$\mu = \frac{\Delta d/d}{\Delta L/L} = \frac{0.0046/36}{0.089/200}$$

$$\mu = 0.287$$

End of Solution

14. A steel rod 15 m long is at a temperature of 15°C. The values of $\alpha = 12 \times 10^{-6}$/°C and $E = 200$ GN/m^2 are adopted. When the temperature is raised to 65°C, what is the free expansion of the length; and if this expansion of the rod is fully prevented, what is the temperature stress produced?

(a) 5 mm and 120 MN/m^2 (b) 9 mm and 120 MN/m^2

(c) 5 mm and 150 MN/m^2 (d) 9 mm and 150 MN/m^2

Ans. (b)

$$\Delta L = L\,\alpha\,\Delta T$$
$$= (15 \times 10^3)\,(12 \times 10^{-6})\,(65 - 15)$$
$$= 9 \text{ mm}$$
$$\sigma = E\,\alpha\,\Delta T$$
$$= (200 \times 10^3 \times 12 \times 10^{-6} \times 50)$$
$$= 120 \text{ MN/m}^2$$

End of Solution

15. A bar of uniform rectangular section of area A is subjected to an axial tensile load P; its Young's modulus is E and its Poisson's ratio is $\frac{1}{m}$. Its volumetric strain ϵ_v is

(a) $\frac{P}{AE}\left(1+\frac{3}{m}\right)$ (b) $\frac{P}{AE}\left(1+\frac{2}{m}\right)$

(c) $\frac{P}{AE}\left(1-\frac{2}{m}\right)$ (d) $\frac{P}{AE}\left(1-\frac{2}{2m}\right)$

Ans. (c)

$$\epsilon_V = \frac{\sigma_x + \sigma_y + \sigma_z}{E}(1-2\mu) \qquad \left(\because \mu = \frac{1}{m}\right)$$

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

$$\sigma_y = \sigma_z = 0$$

$$\epsilon_V = \frac{P}{AE}\left(1-\frac{2}{m}\right)$$

End of Solution

16. The normal stresses on two mutually perpendicular planes are 140 N/mm^2 (Tensile) and 70 N/mm^2 (Tensile). If the maximum shear stress is 45 N/mm^2, the shear stress on these planes will be nearly

(a) 20.9 N/mm^2 (b) 24.6 N/mm^2

(c) 28.3 N/mm^2 (d) 32.0 N/mm^2

Ans. (c)

$\sigma_x = 140$

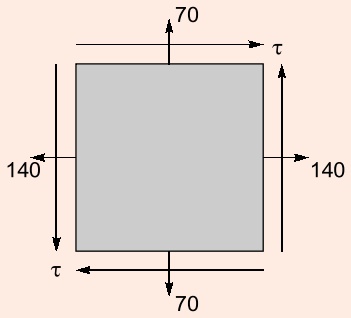
$\sigma_y = 70$

$\sigma_{xy} = \tau$

$$\tau_{max} = 45 = \frac{1}{2}\sqrt{(\sigma_y - \sigma_x)^2 + 4\tau_{xy}^2}$$

$$45 = \frac{1}{2}\sqrt{(70-140)^2 + 4\tau^2}$$

$\tau = 28.28$ MPa



End of Solution

17. The normal stresses on the two mutually perpendicular planes at a point are 120 MPa (Tensile) and 60 MPa (Tensile). If the shear stress across these planes is 30 MPa, the principal stresses will be nearly

(a) 124 MPa (Tensile) and 24 MPa (Compressive)

(b) 132 MPa (Tensile) and 24 MPa (Compressive)

(c) 124 MPa (Tensile) and 48 MPa (Tensile)

(d) 132 MPa (Tensile) and 48 MPa (Tensile)

Ans. (d)

$\sigma_x = 120$ MPa

$\sigma_y = 60$ MPa

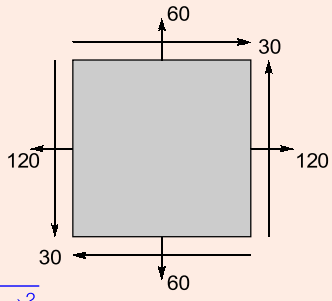
$\tau_{xy} = 30$ MPa

$$\sigma_{P_1}/\sigma_{P_2} = \frac{\sigma_x + \sigma_y}{2} \pm \frac{1}{2}\sqrt{(\sigma_y - \sigma_x)^2 + 4\tau_{xy}^2}$$

$$= \frac{120+60}{2} \pm \frac{1}{2}\sqrt{(60-120)^2 + 4(30)^2}$$

$\sigma_{P1} = 132.43$ MPa

$\sigma_{P2} = 47.58$ MPa

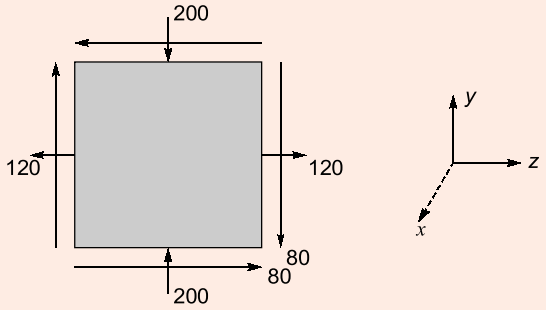


End of Solution

18. At a point in a material, the stresses acting on two planes at right angles to each other are: σ_z = 120 MPa and σ_y = –200 MPa and τ_{zy} = –80 MPa. The maximum shear stress on the element will be nearly

(a) 142 MPa (b) 155 MPa
(c) 167 MPa (d) 179 MPa

Ans. (d)



σ_z = 120 MPa
σ_y = – 200 MPa

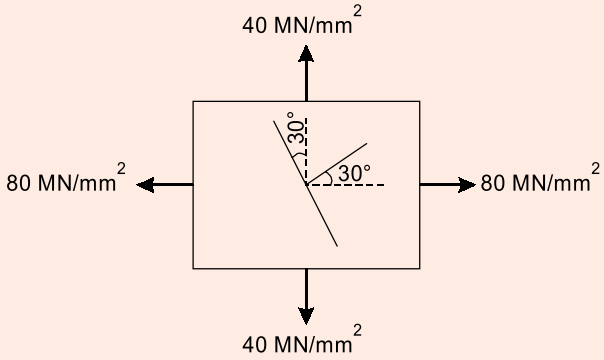
$$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_y - \sigma_z)^2 + 4\tau_{yz}^2}$$

$$= \frac{1}{2}\sqrt{(-200-120)^2 + 4(-80)^2}$$

τ_{max} = 178.88 MPa

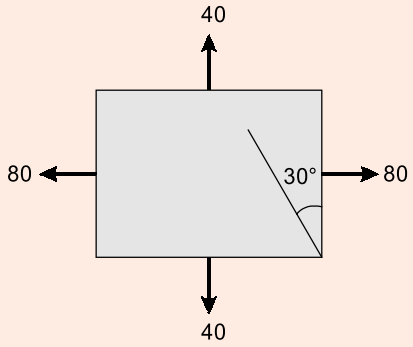
End of Solution

19. The principal stresses in the wall of a container are 40 MN/mm^2 and 80 MN/mm^2. The normal makes an angle of 30° with a direction of maximum principal stress. The resultant stresses (in magnitude) in the plane will be nearly



(a) 84 MN/mm^2 (b) 72 MN/mm^2
(c) 64 MN/mm^2 (d) 58 MN/mm^2

Ans. (b)



$$\theta = 30°$$

$$\sigma_x' = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta + 2\tau_{xy} \cos\theta\sin\theta$$

$$= 80 \cos^2 30° + 40 \sin^2 30°$$

$$\sigma_{x'} = 60 + 10 = 70 \text{ MPa}$$

$$\tau_{x'y'} = (\sigma_y - \sigma_x) \cos\theta \sin\theta + \tau_{xy}(\cos^2\theta - \sin^2\theta)$$

$$= (40 - 80) \cos 30° \sin 30°$$

$$= -17.32 \text{ MPa}$$

$$\sigma_{res} = \sqrt{\sigma_{x'}^2 + \tau_{x'y'}^2} = \sqrt{(70)^2 + (-17.32)^2}$$

$$\sigma_{res} = 72.11 \text{ MPa}$$

End of Solution

20. The change in shearing force between two points on the beam is equal to the area of
(a) Loading diagram between the two points
(b) Shear force diagram between the two points
(c) Bending moment diagram between the two points
(d) M/EI diagram between the two points

Ans. (a)

$$L = \frac{dV}{dx}$$

$$\int_1^2 dV = \int_1^2 L dx$$

$$V_2 - V_1 = \text{Area of loading diameter between point 1 and 2}$$

End of Solution

21. Which one of the following statements specifies shear flow?
(a) Flow of shear force along the beam
(b) It is the product of the shear stress at any level and the corresponding width b (of the section)
(c) Unbalanced force on any side of given section divided by area of section
(d) The deformation at any level due to sudden variation in shear stress

Ans. (b)

Shear stress, $\tau = \dfrac{SA\bar{y}}{Ib}$

Shear flow, $\tau.b = \dfrac{SA\bar{y}}{I}$

End of Solution

22. Which one of the following statements is correct for the rotating shafts transmitting power?
(a) Lower the frequency of shaft lower will be the torque
(b) Higher the frequency of shaft lower will be the torque
(c) Frequency of the shaft does not influence the torque
(d) Higher the frequency of shaft higher will be the torque

Ans. (b)

Power = torque × W (W = angular frequency)

If power constant
$\uparrow W \rightarrow \downarrow$Torque

End of Solution

23. The maximum shear stress induced in a solid circular shaft of diameter 15 cm, when the shaft transmits 150 kW power at 180 rpm will be
(a) 16 N/mm^2 (b) 14 N/mm^2
(c) 12 N/mm^2 (d) 10 N/mm^2

Ans. (c)

$$\text{Power} = T \times W$$

$$150 \times 10^3 = T \times \frac{2\pi 180}{60}$$

$$T = 7957.74 \text{ N-m}$$

$$\tau_{max} = \frac{16T}{\pi D^3} = \frac{16 \times \left(7957.74 \times 10^3\right)}{\pi (150)^3}$$

$$\tau_{max} = 12 \text{ MPa}$$

End of Solution

24. A closely coiled helical spring made of 10 mm diameter steel wire has 15 coils of 100 mm mean diameter. The spring is subjected to an axial load of 100 N. For a modulus of rigidity of 8.16 × 10^4 N/mm^2, the stiffness of the spring will be nearly
(a) 5.9 N/mm (b) 6.8 N/mm
(c) 7.7 N/mm (d) 8.8 N/mm

Ans. (b)

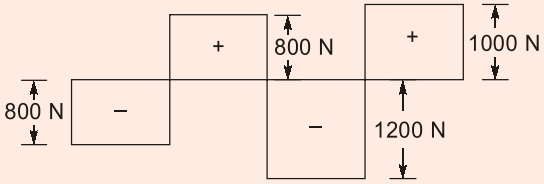
$d = 10$ mm, $n = 15$, $D = 100$ mm, $P = 100$ N, $G = 8.16 \times 10^4$ N/mm^2

$$K = \frac{Gd^4}{64R^3n}$$

$$K = \frac{\left(8.16\times10^4\right)\left(10^4\right)}{64(50)^3(15)} = 6.8 \text{ N/mm}$$

End of Solution

25. The shear-force diagram of a beam is shown in the figure

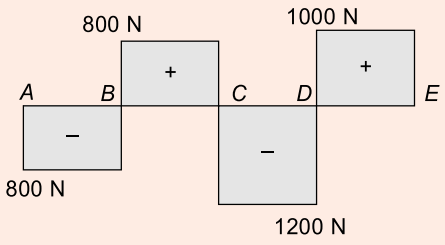


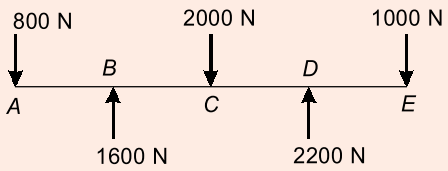
The total of the vertically downward loads on the beam is

(a) 2600 N (b) 3000 N

(c) 3400 N (d) 3800 N

Ans. (d)





Total vertically downward force

$= 800 + 2000 + 1000 = 3800$ N

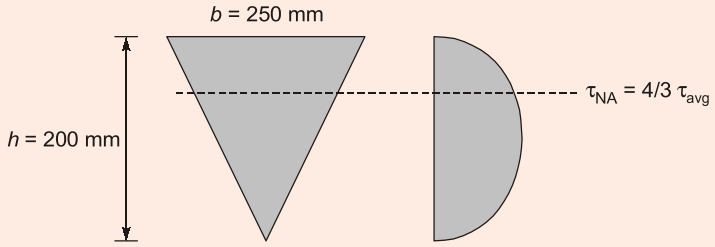
End of Solution

26. A beam of triangular cross-section is subjected to a shear force of 50 kN. The base width of the section is 250 mm and the height is 200 mm. The beam is placed with its base horizontal. The shear stress at neutral axis will be nearly

(a) 2.2 N/mm^2 (b) 2.7 N/mm^2

(c) 3.2 N/mm^2 (d) 3.7 N/mm^2

Ans. (b)



$$\tau_{NA} = \frac{4}{3}\frac{V}{\text{Area}} = \frac{4}{3}\frac{\left(50\times10^3\right)}{\left(\frac{1}{2}\times250\times200\right)}$$

$$\tau_{NA} = 2.66 \text{ MPa} = 2.7 \text{ MPa}$$

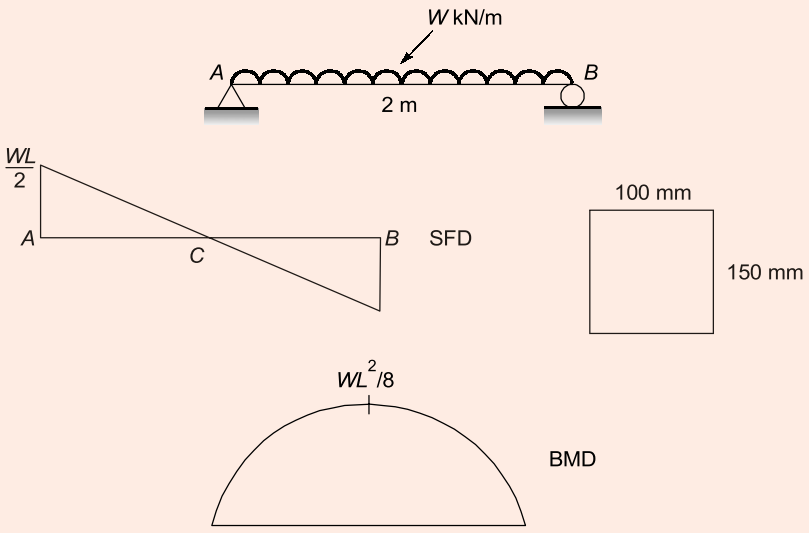
End of Solution

27. A timber beam, 100 mm wide and 150 mm deep, supports a UDL over a span of 2 m. If the safe stresses are not to exceed 28 MPa in bending and 2 MPa in shear, the maximum load that the beam can support is

(a) 16 kN/m (b) 20 kN/m

(c) 24 kN/m (d) 28 kN/m

Ans. (b)



$$\sigma = \frac{My}{I} = \frac{(WL^2/8)\times(150/2)}{\frac{100(150)^3}{12}} = 28$$

$$W = 21 \text{ kN/m}$$

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

$$2 = \frac{3}{2}\left(\frac{WL/2}{150\times100}\right)$$

$$W = 20 \text{ kN/m}$$

So maximum safe load will be 20 kN/m.

End of Solution

28. A 1.5 m long column has a circular cross-section of 50 mm diameter. Consider Rankine's formula with values of f_c = 560 N/mm^2, $\alpha = \frac{1}{1600}$ for pinned ends and factor of safety of 3. If one end of the column is fixed and the other end is free, the safe load will be

(a) 9948 N (b) 9906 N
(c) 9864 N (d) 9822 N

Ans. (b)

$$P_{Rankine} = \frac{\sigma_c A}{1+\alpha\left(\frac{l_e}{k}\right)^2} \qquad \left[K^2 = \frac{I}{A};\ l_e = 2L\right]$$

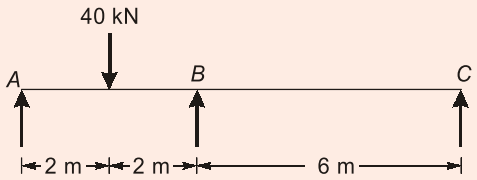
$$= \frac{(560)\frac{\pi}{4}(50)^2}{1+\left[\frac{1}{1600}\times\frac{\left(2\times1.5\times10^3\right)^2}{\frac{\pi}{64}(50)^4}\frac{\pi}{4}(50)^2\right]}$$

$$= 29718 \text{ N}$$

$$\text{So, safe load} = \frac{29718}{3} = 9906 \text{ N}$$

End of Solution

29. A continuous beam with uniform flexural rigidity is shown in the figure

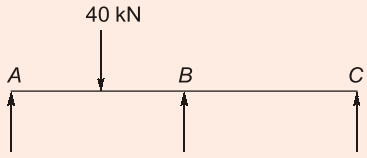


The moment at B is

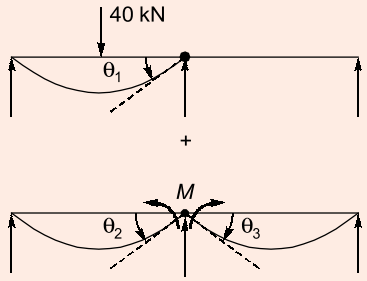
(a) 18 kNm (b) 16 kNm

(c) 14 kNm (d) 12 kNm

Ans. (d)



Considering BM_B as redundant



$$\theta_1 + \theta_2 + \theta_3 = 0$$

$$\Rightarrow \quad \frac{PL^2}{16EI} + \frac{ML}{3EI} + \frac{ML}{3EI} = 0$$

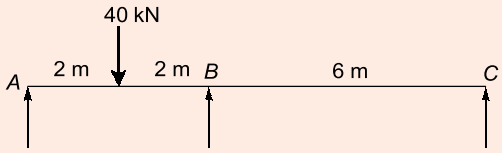
$$\Rightarrow \quad \frac{P \times 4^2}{16} + \frac{M \times 4}{3} + \frac{M \times 6}{3} = 0$$

$$\Rightarrow \quad \frac{P \times 3}{10} = -M$$

$$\Rightarrow \quad M = -12 \text{ kNm}$$

Negative sign represents hogging bending moment.

Alternate Method



1. Distribution factor

Joint	Member	Relative stiffness (K)	ΣK	Distribution factor (DF) = $\frac{K}{\Sigma K}$
B	BA	$\frac{3}{4}\times\frac{I}{4}=\frac{3I}{16}=\frac{9I}{48}$	$\frac{15I}{48}$	0.6
	BC	$\frac{3}{4}\times\frac{I}{6}=\frac{3I}{24}=\frac{6I}{48}$		0.4

2. End moment distribution

Joint	A	B		C
DF	1	0.6	0.4	1
Fixed end moment (FEM)	– 20	+ 20	0	0
Release A	+20			
Carryover moment (COM)		+10		
Net FEM	0	+30	0	0
Balancing B		–18	–12	
Final end moment	0	+12	–12	0

Moment at B = 12 kNm

End of Solution

30. The maximum shear stress across a circular section is

(a) $\left(\frac{4}{3}\right)$ Average shear stress (b) $\left(\frac{3}{2}\right)$ Average shear stress

(c) $\left(\frac{5}{4}\right)$ Average shear stress (d) $\left(\frac{9}{5}\right)$ Average shear stress

Ans. (a)

End of Solution

31. Which of the following statements are correct in respect of temperature effect on a load-carrying three-hinged arch?

1. No stresses are produced in a three-hinged arch due to temperature change alone.
2. There is a decrease in horizontal thrust due to rise in temperature.
3. There is an increase in horizontal thrust due to rise in temperature.

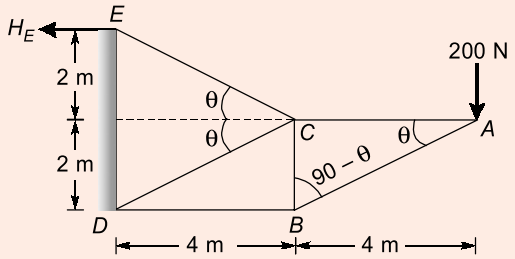
(a) 1 and 2 only (b) 1 and 3 only

(c) 2 only (d) 3 only

Ans. (a)

End of Solution

32. Consider the frame as shown in the figure

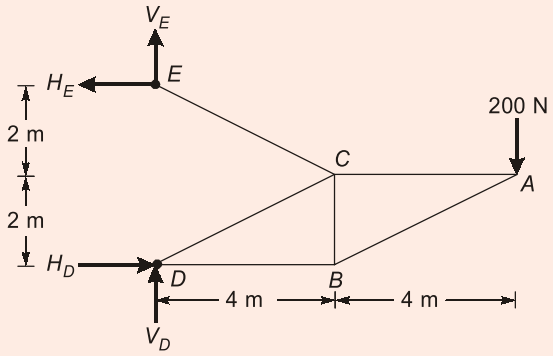


The magnitude of the horizontal support reaction at E is

(a) 400 kN (b) 300 kN

(c) 250 kN (d) 200 kN

Ans. (a)



$$\Sigma M_D = 0$$

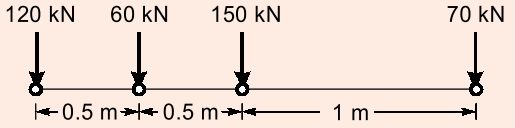
$$\Rightarrow \quad 200 \times 8 - H_E \times 4 = 0$$

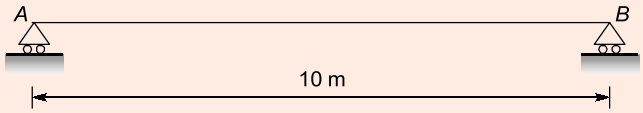
$$\Rightarrow \quad H_E = 400 \text{ N}$$

Note: Answer should be 400 N as per the given figure.

End of Solution

33. The load system in the figure moves from left to right on a girder of span 10 m





The maximum bending moment for the girder is nearly

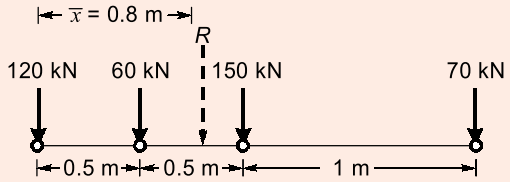
(a) 820 kNm (b) 847 kNm

(c) 874 kNm (d) 890 kNm

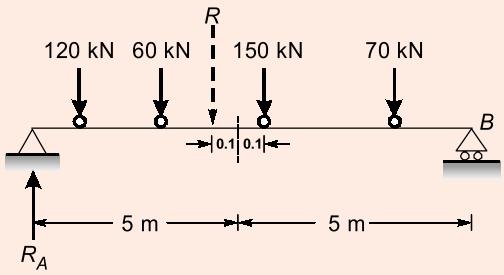
Ans. (d)

$$R = 120 + 60 + 150 + 70 = 400 \text{ kN}$$

$$\bar{x} = \frac{60 \times 0.5 + 150 \times 1 + 70 \times 2}{400} = 0.8 \text{ m}$$



Maximum bending moment is below 150 kN



$$R_A = \frac{R(5+0.1)}{10} = \frac{400 \times 5.1}{10} = 204 \text{ kN}$$

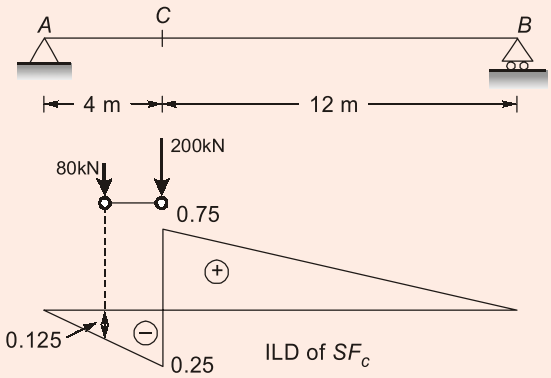
$$BM_{max} = R_A (5 + 0.1) - 120 \times 1 - 60 \times 0.5$$
$$= 204 \times 5.1 - 120 - 30$$
$$= 890.4 \text{ kNm}$$

End of Solution

34. Two wheel loads 80 kN and 200 kN respectively spaced 2 m apart, move on a girder of span 16 m. Any wheel load can lead the other. The maximum negative shear force at a section 4 m from the left end will be

(a) –50 kN (b) –60 kN
(c) –70 kN (d) –80 kN

Ans. (b)



$$SF_{max} = 80 (-0.125) + 200 (-0.25)$$
$$= -60 \text{ kN}$$

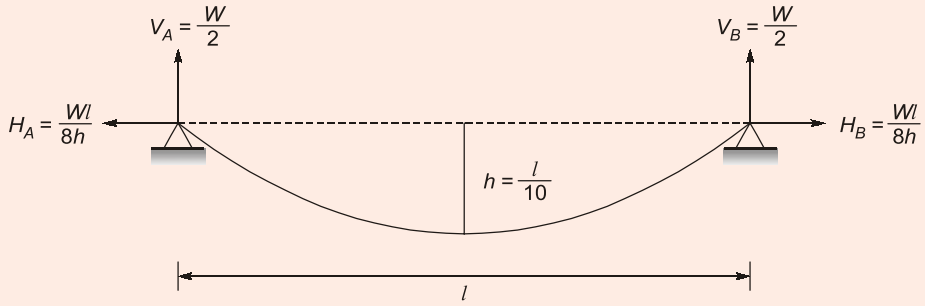
End of Solution

35. The maximum possible span for a cable supported at the ends at the same level (assuming it to be in a parabolic profile) allowing a central dip of $\frac{1}{10}$ of the span with permissible stress of 150 N/mm^2 (where the steel weighs 78000 N/m^3) will be nearly

(a) 1270 m (b) 1330 m

(c) 1388 m (d) 1450 m

Ans. (c)



Since only self weight of cable need to be considered so exact length of cable should be used for calculation.

Considering maximum span = l

then, length of cable = $L = l\left[1+\frac{8}{3}\left(\frac{h}{l}\right)^2\right]$

$$\Rightarrow \quad L = l\left[1+\frac{8}{3}\left(\frac{l/10}{l}\right)^2\right] = \frac{308}{300}l$$

Let cross-sectional area of cable = Amm^2

Total weight of cable = $W = \frac{A}{1000^2}\times 78000 \times \frac{308}{300} l = 0.08008\, Al$

Now, Vertical reaction = $V_A = \frac{W}{2}$

Horizontal reaction = $\frac{Wl}{8h} = \frac{W\times l}{8\times \frac{l}{10}} = \frac{5W}{4}$

Since, Maximum stress = $\frac{T_{max}}{A}$

$$\Rightarrow \quad \sigma_{max} = \frac{\sqrt{V_A^2 + H_A^2}}{A} = \frac{\sqrt{\left(\frac{W}{2}\right)^2 + \left(\frac{5W}{4}\right)^2}}{A}$$

$$\Rightarrow \quad \sigma_{max} = \frac{1.35W}{A} = \frac{1.35\times 0.08008\, Al}{A}$$

$$\Rightarrow \quad 150 = 1.35 \times 0.08008 \times l$$

$$l = 1387.5 \text{ m}$$

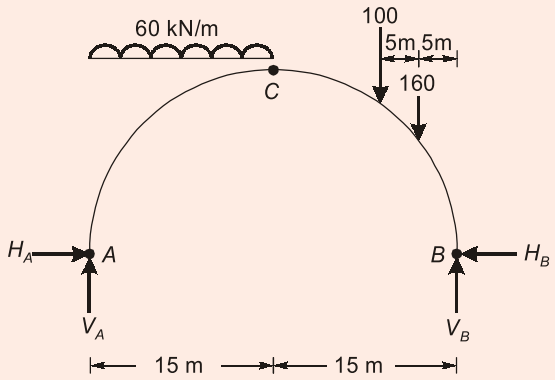
End of Solution

36. A three-hinged arch has a span of 30 m and a rise of 10 m. The arch carries UDL of 60 kN/m on the left half of its span. It also carries two concentrated loads of 160 kN and 100 kN at 5 m and 10 m from the right end. The horizontal thrust will be nearly

(a) 446 kN (b) 436 kN

(c) 428 kN (d) 418 kN

Ans. (c)



$\Rightarrow \quad V_A \times 30 - 60 \times 15 \times 22.5 - 100 \times 10 - 160 \times 5 = 0$

$\Rightarrow \quad V_A = 735 \text{ kN}$

$M_C = 0$ (LHS)

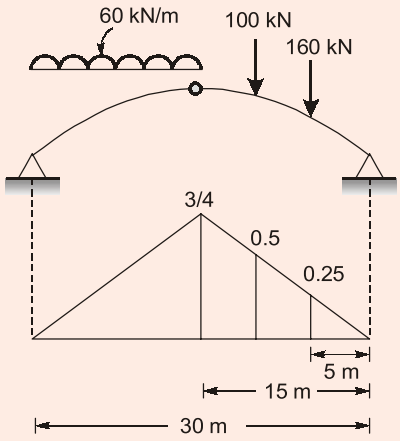
$\Rightarrow \quad V_A \times 15 - 60 \times 15 \times 7.5 - H_A \times 10 = 0$

$\Rightarrow \quad 735 \times 15 - 60 \times 15 \times 7.5 - H_A \times 10 = 0$

$\Rightarrow \quad H = 427.5 \text{ kN}$

$\simeq 428 \text{ kN}$

Alternate solution:



$$\frac{L}{4h} = \frac{30\text{m}}{4\times 10\text{m}} = \frac{3}{4}$$

$$H = 60\times\left(\frac{1}{2}\times 15\times\frac{3}{4}\right) + (100\times 0.5) + (160\times 0.25)$$

$= 337.5 + 50 + 40 = 427.5 \text{ kN}$

End of Solution

37. An unstable vibratory motion due to combined bending and torsion which occurs in flexible plate like structures is called

(a) Galloping
(b) Ovalling
(c) Flutter
(d) Oscillation

Ans. (c)

End of Solution

38. A propped cantilever beam of span l and constant plastic moment capacity M_P carries a concentrated load at mid-span. The load at collapse will be

(a) $\frac{2M_P}{l}$
(b) $\frac{4M_P}{l}$
(c) $\frac{6M_P}{l}$
(d) $\frac{8M_P}{l}$

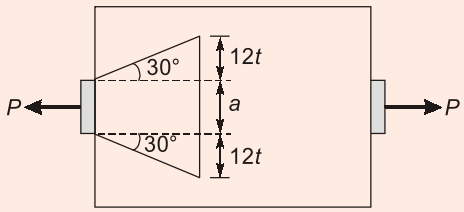
Ans. (c)

End of Solution

39. A steel plate is subjected to tension. The tensile force is applied over a width 'a' whereas the gross width of the plate is 'b'. The dispersion of the force from the point of application is at about 30° with the axis and extends to a maximum width of 12 times the thickness t of the plate. The effective width which comes into action will be

(a) $2a + 12t$
(b) $a + 12t$
(c) $a + 24t$
(d) $2a + 24t$

Ans. (c)



Effective width, $b_f = a + 2 \times 12t = a + 24t$

End of Solution

40. A wind brace is to be provided between two columns spaced at 5 m, at an inclination of 30° with the horizontal, to resist a tension of 320 kN developed by a wind force. The effective area required will be nearly (considering 150 N/m^2 as a relevant factor).

(a) 1670 mm^2
(b) 1640 mm^2
(c) 1600 mm^2
(d) 1570 mm^2

Ans. (*)

End of Solution

41. A beam column for a non-sway column in a building frame is subjected to a factored axial load of 500 kN, factored moment at bottom of column of 45 kNm. For ISHB 200, the values are A = 4750 mm^2, γ_y = 45.1, h = 200 mm, b = 200 mm, b_f = 9 mm and the effective length is 0.8 L. Its buckling load will be

(a) 910 kN (b) 930 kN
(c) 950 kN (d) 980 kN

Ans. (c)

Buckling load or effective axial load 'P_e' as suggested by Yura is given by

$$P_e = P + \frac{2M}{d} = 500 + \frac{2 \times 45}{0.2\ \text{m}} = 950\ \text{kN}$$

(d = depth of beam section = 200 mm = 0.2 m)

End of Solution

42. Which of the following assumptions are correct for ideal beam behaviour?

1. The compression flange of the beam is restrained from moving laterally.
2. The tension flange of the beam is restrained from moving laterally.
3. Any form of local buckling is prevented.

(a) 2 and 3 only (b) 1 and 3 only
(c) 1 only (d) 3 only

Ans. (b)

End of Solution

43. In which one of the following industrial roofing contexts, is the loading carried by the combination of pure flexure and flexure due to shear induced by the relative deformation between the ends of the top and bottom chord members?

(a) Vierendeel girders (b) Scissors girders
(c) Lenticular girders (d) Mansard girders

Ans. (a)

End of Solution

44. Bearing stiffeners are provided

(a) At the ends of plate girders
(b) At the ends of plate girder and on both faces of the web
(c) At the ends of plate girder and only on one face of the web
(d) At the points of concentrated loads, to protect the web from the direct compressive loads

Ans. (d)

End of Solution

45. If the cost of purlins/unit area is p and the cost of roof covering/unit area is r, then cost of trusses/unit area l for an economical spacing of the roof trusses will be

(a) $p + r$ (b) $2p + r$

(c) $p + 2r$ (d) $2p + 2r$

Ans. (b)

End of Solution

46. A welded plate girder of span 25 m is laterally restrained throughout its length. It has to carry a load of 80 kN/m over the whole span besides its weight. If $K = 200$ and $f_y = 250$ MPa, the thickness of web will be nearly

(a) 10 mm (b) 14 mm

(c) 16 mm (d) 20 mm

Ans. (a)

Economical depth of plate girder is given by

$$d = 3\sqrt{\frac{MK}{f_y}}$$

M = Maximum bending moment $= \frac{wl^2}{8} = \frac{80 \times 25^2}{8} = 6250$ kNm

$k = 200 \left(= \frac{d}{t_w}\right)$

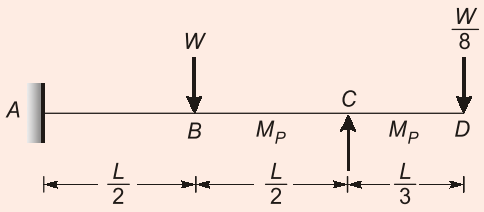
$$d = 3\sqrt{\frac{6250 \times 10^6 \times 200}{250}} = 1710 \text{ mm}$$

Thickness of web, $t_w = \frac{d}{k} = \frac{1710}{200} = 8.55$ mm

So, provide, $t_w = 10$ mm

End of Solution

47. A propped cantilever ABCD is loaded as shown in figure. If its is of uniform cross-section, the collapse load of the beam will be nearly



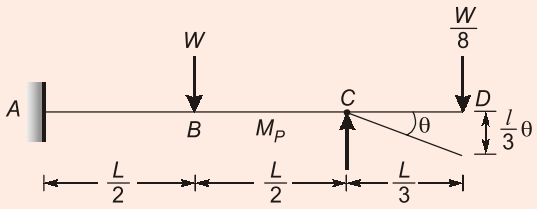
(a) $6.5\frac{M_P}{L}$ (b) $5.6\frac{M_P}{L}$

(c) $4.7\frac{M_P}{L}$ (d) $3.8\frac{M_P}{L}$

Ans. (a)

Ist Possibility

Plastic hinge at C alone

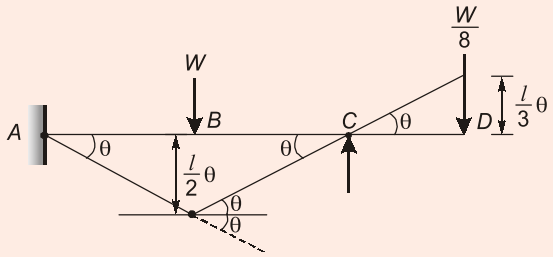


$$\Rightarrow \quad \frac{w}{8}\times\left(\frac{l}{3}\times\theta\right) = M_P\theta$$

$$\Rightarrow \quad W_u = \frac{24M_P}{l} \qquad \ldots(i)$$

II[nd] Possibility

Plastic hinges at A and B



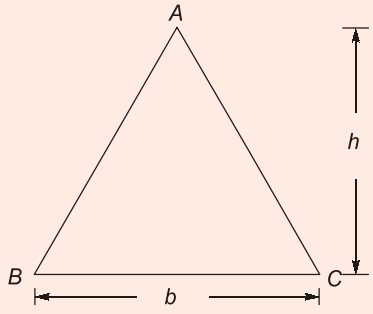
$$\Rightarrow \quad w\times\left(\frac{l}{2}\times\theta\right) - \frac{w}{8}\times\left(\frac{l}{3}\times\theta\right) = M_P(\theta) + M_P(\theta+\theta)$$

$$\Rightarrow \quad w_u = \frac{6.5M_P}{l}$$

So, true collapse load = $w_u = 6.5\ M_P/l$

End of Solution

48. Consider a triangular section with base b and height h as shown in the figure.



The shape factor will be nearly

(a) 2.3 (b) 3.2

(c) 4.1 (d) 5.0

Ans. (a)

End of Solution

49. Fatigue in RCC beams will not be a problem if the number of cycles is less than
(a) 20000 (b) 25000
(c) 30000 (d) 35000

Ans. (*)

End of Solution

50. The desired characteristic strength of a mix is 20 N/mm^2. The standard deviation is 4 N/mm^2 for 150 mm size of concrete cubes; and K = 1.645. The average strength of the cubes will be nearly
(a) 38.2 N/mm^2 (b) 32.4 N/mm^2
(c) 26.6 N/mm^2 (d) 22.8 N/mm^2

Ans. (c)

Average strength of 4 cubes for quality control at site

$$f_{av} = f_{ck} + 0.825\sigma$$
$$= 20 + 0.825 \times 4.0$$
$$= 23.30 \text{ N/mm}^2$$ (Not matching with any answer)

Average strength of cubes at the time of design mix

$$= f_{ck} + 1.645 \times \sigma$$
$$= 20 + 1.645 \times 4$$
$$= 26.58 \text{ N/mm2}$$
$$\simeq 26.6 \text{ N/mm}^2 \text{ (say)}$$

End of Solution

51. A circular column is subjected to an un-factored load of 1600 kN. The effective length of the column is 3.5 m, the concrete is M25, and the value of $\rho_g = \frac{A_{SC}}{A_g}$ = 2% for Fe415 steel. The design diameter of the column will be nearly
(a) 446 mm (b) 432 mm
(c) 424 mm (d) 410 mm

Ans. (a)

$$P_u = 1.5 \times 1600 = 2400 \text{ kN}$$

Considerably,

$$P_u = 0.40\ f_{ck} \cdot A_c + 0.67\ f_y \cdot A_{sc}$$

$$2400 \times 10^3 = 0.40 \times 25 \times \left[\frac{\pi}{4}(D)^2 - A_{sc}\right] + 0.67 \times 415 \times A_{sc}$$

$$2400000 = 0.40 \times 25 \times 0.98 \times \frac{\pi}{4} D^2 + 0.67 \times 415 \times 0.02 \times \frac{\pi}{4}(D)^2$$

$$D = 446 \text{ mm}$$

Check:

(a) $e_{min} = \left(\frac{L_0}{500} + \frac{D}{30}\right)$ [Assuming $L_0 = L_{eff}$]

$= \left(\frac{3500}{500} + \frac{446}{30}\right) = 21.86$ mm

$0.05 \times D = 0.05 \times 446 = 23.30$

$e_{min} < 0.05D$ (OK)

(b) $SR = \frac{3500}{446} = 7.84$ Short column (OK)

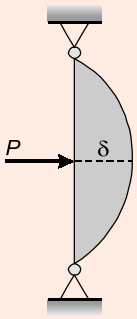
End of Solution

52. A strut is made of a circular bar, 5 m long and pin-jointed at both ends. When freely supported the bar gives a mid-span deflection of 10 mm under a load of 80 N at the centre. The critical load will be

(a) 8485 N (b) 8340 N

(c) 8225 N (d) 8110 N

Ans. (c)



$\delta = \frac{PL^3}{48EI} = 10$ mm

$P_{cr} = \frac{\pi^2 EI}{L_e^2}$ $(L_e = L)$

$P_{cr} = \frac{\pi^2}{(5\times10^3)^2} \times \frac{(80)(5\times10^3)^3}{48\times10}$

$P_{cr} = 8224.67$

$P_{cr} = 8225$ N

End of Solution

53. The recommended imposed load on staircase in residential buildings as per IS 875 is

(a) 5.0 kN/m^2 (b) 3.0 kN/m^2

(c) 1.5 kN/m^2 (d) 1.3 kN/m^2

Ans. (b)

3.0 kN/m^2 For residential building on staircase

(As per Table - 1/P-7/ IS 875/ P-2

End of Solution

54. A 230 mm brick masonry wall is to be provided with a reinforced concrete footing on site having soil with safe bearing capacity of 120 kN/m^2, unit weight of 17.5 kN/m^3 and angle of shearing resistance of 30°. The depth of footing will be nearly

(a) 0.8 m (b) 0.7 m

(c) 0.6 m (d) 0.5 m

Ans. (a)

$$\text{Minimum depth of footing} = \frac{P}{\gamma}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2$$

$$= \frac{125}{17.5}\times\left(\frac{1}{3}\right)^2 = 0.794\ \text{m}$$

$$\simeq 0.80\ \text{m (say)}$$

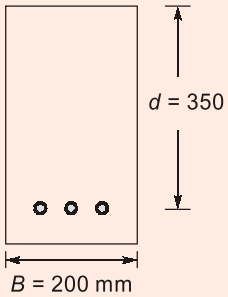
End of Solution

55. A rectangular beam 200 mm wide has an effective depth of 350 mm. It is subjected to a bending moment of 24,000 Nm. The permissible stresses are c = 5 N/mm^2, t = 140 N/mm^2; and m is 18. The required area of tensile reinforcement will be

(a) 688 mm^2 (b) 778 mm^2

(c) 864 mm^2 (d) 954 mm^2

Ans. (b)



Bending moment = 24 kN-m

c = 5 N/mm^2

t = 140 N/mm^2

$$K = \frac{mc}{t+mc} = \frac{18\times 5}{140+18\times 5} = 0.39$$

$$j = \left(1 - \frac{K}{3}\right) = 0.87$$

$$Q = \frac{1}{2} c \cdot j \cdot K = \frac{1}{2} \times 5 \times 0.87 \times 0.39 = 0.85$$

$$MR_{bal} = 0.85 \times 200 \times 350^2$$
$$= 20.83 \text{ kN-m}$$

Over reinforced section is required as BM > MR_{bal}

For over reinforced section,

$$x_a > x_c$$
$$c_a = \sigma_{cbc}$$
$$t_a < \sigma_{st}$$

Equating

$$\text{BM} = B \cdot x_a \cdot \frac{c_a}{2} \cdot \left(d - \frac{x_a}{3}\right)$$

$$24 \times 10^6 = 200 \times x_a \times \frac{5}{2} \times \left(350 - \frac{x_a}{3}\right)$$

$$48000 = 350 x_a - \frac{x_a^2}{3}$$

$$\frac{x_a^2}{3} - 350 x_a + 48000 = 0$$

$$x_a = 162.2 \text{ mm}$$
$$c_a = 5 \text{ N/mm}^2$$

$$\frac{c_a}{x_a} = \frac{t_a / m}{d - x_a}$$

$$t_a = \frac{c_a \times m \times (d - x_a)}{x_a}$$

$$= \frac{5 \times 18 \times (350 - 162.2)}{162.2} = 104.2 \text{ N/mm}^2$$

$$A_{st} = \frac{BM}{t_a \left(d - \frac{x_a}{3}\right)}$$

$$= \frac{24 \times 10^6}{104.2 \times \left(350 - \frac{162.2}{3}\right)} = 778 \text{ mm}^2$$

End of Solution

56. Which of the following statements are correct with reference to ensuring minimum shrinkage of prestressed concrete?

1. The water-cement ratio and proportion of cement paste should be kept minimum to reduce shrinkage.
2. Aggregates of larger size, well graded for minimum void, need a smaller amount of cement paste, and attendant shrinkage will be smaller.
3. Harder and denser aggregates of low water absorptions and high modulus of elasticity will exhibit small shrinkage.

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

End of Solution

57. During earthquakes, the corner and edge columns may be subjected to

(a) Uniaxial bending
(b) Biaxial bending
(c) Combined biaxial bending and torsion
(d) Combined biaxial bending and tension

Ans. (c)

End of Solution

58. The minimum number of bars required in a rectangular column for an earthquake resistance design, is

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

Ans. (a)

End of Solution

59. The permissible or allowable compressive stress f_{ac} of brick masonry does ***not*** depend on

(a) Type and strength of bricks (b) Efflorescence of bricks
(c) Strength of mortar (d) Slenderness ratio

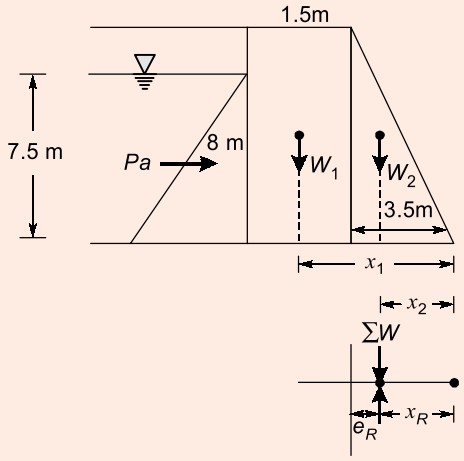
Ans. (b)

End of Solution

60. A masonry dam 8 m high, 1.5 m wide at the top and 5 m wide at the base retains water to a depth of 7.5 m, the water face of the dam being vertical. If the weight of water is 9.81 kN/m^3, weight of masonry is 22 kN/m^3, the maximum intensity of stress developed at the base will be nearly

(a) 196 kN/m^2 (b) 182 kN/m^2
(c) 160 kN/m^2 (d) 148 kN/m^2

Ans. (b)



$$W_1 = 1.5 \times 8.0 \times 1.0 \times 22 = 264 \text{ kN}$$

$$x_1 = 5.0 - \frac{1.5}{2} = 4.25 \text{ m}$$

$$W_2 = \frac{1}{2} \times 3.5 \times 8.0 \times 22 = 308 \text{ kN}$$

$$x_2 = 3.5 \times \frac{2}{3} = 2.3333 \text{ m}$$

$$P_a = \frac{1}{2} \times \gamma \cdot H^2 = \frac{1}{2} \times 9.81 \times 7.5^2 = 275.91 \text{ kN}$$

$$h = \frac{1}{3} \times 7.5 = 2.50 \text{ m}$$

$$\Sigma W \cdot x_R = W_1 x_1 + W_2 x_2 - P_a h$$

$$x_R = \frac{(264 \times 4.25 + 308 \times 2.33333) - 275.91 \times 2.50}{264 + 308}$$

$$= 2.012 \text{ m}$$

$$e_R = \frac{5}{2} - 2.012 = 0.488 \text{ m}$$

$$\text{Maximum pressure} = \frac{\Sigma W}{A}\left(1 + \frac{6e_R}{B}\right)$$

$$= \frac{(264 + 308)}{5.0 \times 1.0}\left(1 + \frac{6 \times 0.488}{5.0}\right) = 181.39 \text{ kN/m}^2$$

End of Solution

61. A front-end loader on a given job moves a load of 1.5 m^3 of loose soil in one cycle consisting of loading-lifting-travelling-unloading-return trip-and-ready for next loading. If each cycle time is 1.2 minutes, the actual output will be

(a) 75 m^3/hour
(b) 70 m^3/hour
(c) 65 m^3/hour
(d) 60 m^3/hour

Ans. (a)

$$\text{Cycle time} = \frac{1.2}{60}\text{hr}$$

$$\therefore \quad \text{Output} = \frac{1.5}{\frac{1.2}{60}} = 75\ \text{m}^3/\text{hr}$$

End of Solution

62. Which of the following techniques belong to 'Project Time Plan'?

1. Critical path method
2. Precedence network analysis
3. Line of balance technique
4. Linear programme chart

(a) 1, 2 and 3 only
(b) 1, 2 and 4 only
(c) 3 and 4 only
(d) 1, 2 3 and 4

Ans. (d)

End of Solution

63. A construction equipment has an initial cost of ₹ 2,00,000 and salvage value of ₹ 50,000 at the end of an economic life of 5 years. The rate of straight-line depreciation and total depreciation will be

(a) 0.1 and ₹ 1,50,000
(b) 0.2 and ₹ 1,50,000
(c) 0.1 and ₹ 1,00,000
(d) 0.2 and ₹ 1,00,000

Ans. (b)

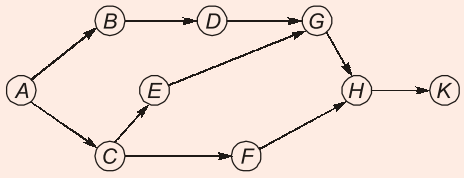
$$\text{Total Depreciation} = C_i - C_s = 200000 - 50000 = 1,50,000$$

$$\text{Depreciation in 5 years} = \frac{C_i - C_s}{n} = \frac{150000}{5} = 30,000$$

$$\therefore \quad \text{rate of depreciation} = \frac{30000}{150000} = 0.2$$

End of Solution

64. Consider the following assembly with different operations:



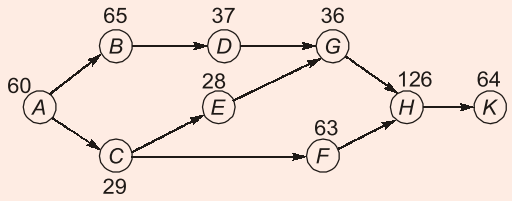
Operation	Standard time, minutes
A	60
B	65
C	29
D	37
E	28
F	63
G	36
H	126
K	64

There are 250 working days in a year to produce 4000 units in a year. The minimum number of work stations required will be

(a) 13 (b) 12

(c) 11 (d) 10

Ans. (a)



Total project duration = 60 + 65 + 37 + 36 + 126 + 64 = 388 min

Time required for 4000 units in a year = 388 × 4000 min = 1552000 min

Assuming the working hour as 8 hrs in a day

Time available in a year = 250 × 60 min = 120000 mm

$\therefore$ no. of work stations required = $\frac{1552000}{120000} = 12.9 \simeq 13$

End of Solution

65. Flattening and smoothing the road surface by scrapping is called

(a) Compaction (b) Consolidation

(c) Grading (d) Ditch digging

Ans. (c)

End of Solution

66. The amount of time by which the start of the activity may be delayed without interfering with the start of any succeeding activity is called

(a) Activity float (b) Free float

(c) Total float (d) Interfering float

Ans. (b)

End of Solution

67. A crew consisting of two carpenters and one helper can fix 10 m^2 of a slab form work in 8 hours and the hourly labour rate of a carpenter is ₹ 85 and for a helper is ₹ 69.50. An average hourly rate per worker of the crew will be nearly

(a) ₹ 90 (b) ₹ 80

(c) ₹ 70 (d) ₹ 60

Ans. (b)

$$\text{rate of carpenter} = 85\frac{₹}{\text{hr.}} \times 8 \times 2 = 1360\ ₹$$

$$\text{rate of helper} = 69.50 \times 8 = 556\ ₹$$

$$\therefore \quad \text{Average hourly rate} = \frac{1360 + 556}{24} = 79.83 \simeq 80\ ₹$$

End of Solution

68. A project with the production cost of ₹ 100 crores, has 20,000 man-months as direct labour, of which 60% is non-productive time. The labour cost as estimated while tendering is 20% of project cost. If 15% of the wastage resulting from non-productive time is eliminated by using improved methods, the resulting saving in labour cost will be

(a) 14.5% (b) 18.5%

(c) 22.5% (d) 26.5%

Ans. (c)

Labour cost = 20% of ₹ 100 cr

= ₹ 20 cr ₹ 8 cr (productive cost)

₹ 12 cr (Non productive cost)

Cost saving = 15% of ₹ 12 cr = ₹ 1.8 cr

$$\Rightarrow \quad \%\ \text{Cost saving} = \frac{₹\ 1.8\ \text{cr}}{₹\ 8\ \text{cr}} \times 100 = 22.5\%$$

End of Solution

69. Consider the following data:

Work is carried out by a contractor employing labour with 25% overtime per day

Working for 5 days a week

Contractor peak manpower is 40 per day

Build-up period is 20%

Rundown period is 10%

Total effort in standard man days is 1200

The duration of work by Trapezoidal manpower distribution pattern will be

(a) 5.5 weeks (b) 6.5 weeks

(c) 7.5 weeks (d) 8.5 weeks

Ans. (a)

According to trapezoidal distribution

$$\text{Activity duration, } d = \frac{\text{Total man days}}{0.85P}$$

$$\Rightarrow \qquad d = \frac{1200}{0.85 \times 40} = 35.3 \text{ days}$$

Considering 25% overtime and 5 days a week.

$$\text{No. of weeks} = \frac{35.3}{1.25 \times 5} = 5.5 \text{ weeks}$$

End of Solution

70. A systematic measurement and evaluation of the way in which an organization manages its health and safety programme against a series of specific and attainable standards is called

(a) Safety inspection (b) Safety audit
(c) Safety plan (d) Safety committee

Ans. (b)

End of Solution

71. On a construction project, the contractor, on an average, employed 100 workers with 50 hours working per week. The project lasted for 35 weeks and, during this period, 14 disabling injuries occurred. The injury-frequency rate will be (based on one lakh of man hours worked)

(a) 5 (b) 5
(c) 7 (d) 8

Ans. (d)

$$\text{Total working hour} = 50 \times 35 \times 100 = 175000 \text{ hr}$$

$$\text{frequency of injury} = \frac{14}{175000} \times 100000 = 8$$

End of Solution

72. The graphical representations wherein long duration jobs are broken down to key segmental elements, wherein events are shown in chronological order without attention to logical sequencing, and wherein interdependencies between the events is not highlighted, is referred to as

(a) CPM (b) Milestone chart
(c) GANTT chart (d) PERT

Ans. (b)

End of Solution

73. A ship weighs 127 MN. On filling the ship's boats on one side with water weighing 600 kN with the mean distance of the boats from the centre line of the ship being 10 m, the angle of displacement of the plumb line is 2°16′. The metacentric height will be nearly (Take sin 2°16′ = 0.04, cos 2°16′ = 0.9992 and tan 2°16′ = 0.04)

(a) 1.73 m (b) 1.42 m
(c) 1.18 m (d) 0.87 m

Ans. (c)

According to experimental method of determination of metacentric height

$$GM = \frac{wx}{W\tan\theta}$$

where, w = 600 kW, W = 127 MN = 127 × 10^3 kN, $\theta = 2°16''$, x = 10 m

$$GM = \frac{600\times10}{127\times10^3\tan2°16''} = \frac{6000}{127\times10^3\times0.04} = 1.18 \text{ m}$$

End of Solution

74. For frictionless adiabatic flow of compressive fluid, the Bernoulli's equation with usual notations is

(a) $\frac{k}{k-1}\frac{p_1}{w_1}+\frac{v_1^2}{2g}+z_1 = \frac{k}{k-1}\frac{p_2}{w_2}+\frac{v_2^2}{2g}+z_2+h_L$

(b) $\frac{k}{k-1}\frac{p_1}{w_1}+\frac{v_1^2}{2g}+z_1 = \frac{k}{k-1}\frac{p_2}{w_2}+\frac{v_2^2}{2g}+z_2$

(c) $\frac{p_1}{w_1}+\frac{v_1^2}{2g}+z_1+H_m = \frac{p_2}{w_2}+\frac{v_2^2}{2g}+z_2$

(d) $\frac{k}{k-1}\frac{p_1}{w_1}+\frac{v_1^2}{2g}+z_1+H_m = \frac{p_2}{w_2}+\frac{v_2^2}{2g}+z_2+h_L$

Ans. (b)

As we know that, $\int\frac{dP}{\rho g}+\frac{V^2}{2g}+z = \text{constant}$ ...(i)

For a compressible flow, undergoing an adiabatic process

$$\frac{P}{\rho^k} = c \text{ (constant)}$$

$$dP = K \cdot C \cdot \rho^{k-1} \cdot d\rho$$

By equation (i)

$$\int\frac{K.C.\rho^{k-1}.d\rho}{\rho g}+\frac{V^2}{2g}+z = \text{constant}$$

$$\frac{KC}{g}\int\rho^{k-2}\,d\rho+\frac{V^2}{2g}+z = \text{constant}$$

$$\frac{K.C.\rho^{k-1}}{g(k-1)}+\frac{V^2}{2g}+z = \text{constant}$$

$$\frac{K.C.\rho^{k-1}}{g(k-1)}.\frac{\rho}{\rho}+\frac{V^2}{2g}+z = \text{constant}$$

$$\frac{K}{K-1}.\frac{C.\rho^k}{\rho.g}+\frac{V^2}{2g}+z = \text{constant} \qquad (\because P = C.\rho^k)$$

$$\frac{K}{K-1}.\frac{p}{\rho.g}+\frac{V^2}{2g}+z = \text{constant}$$

End of Solution

75. The phenomenon of generation of lift by rotating an object placed in a free stream is known as

(a) Coanda effect
(b) Magnus effect
(c) Scale effect
(d) Buoyancy effect

Ans. (b)

End of Solution

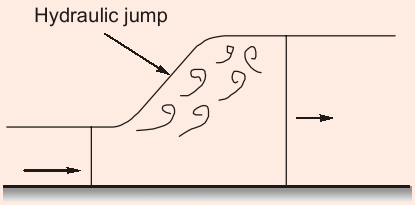
76. Which of the following assumptions is/are made in the analysis of hydraulic jump?

1. It is assumed that before and after jump formation the flow is essentially two-dimensional and that the pressure distribution is hydrostatic.
2. The length of the jump is small so that the losses due to friction on the channel floor are small and hence neglected.
3. The channel floor is horizontal or the slope is so gentle that the weight component of the water mass comprising the jump is very high.

(a) 1 only
(b) 2 only
(c) 3 only
(d) 1, 2 and 3

Ans. (b)

Before and after the jump formation, the flow is essentially one dimensional.



The channel floor is horizontal or the slope is so gentle that the weight component of the water mass comprising the jump is negligibly small.

End of Solution

77. Water is to be pumped out of a deep well under a total head of 95 m. A number of identical pumps of design speed 1000 rpm and specific speed 900 rpm with a rated capacity of 150 *l*/s are available. The number of pumps required will be

(a) 1
(b) 3
(c) 5
(d) 7

Ans. (b)

H_{total} = 95 m, N = 1000 rpm, N_S = 900, Q = 150 L/s

$$N_S = \frac{N\sqrt{Q}}{H_m^{3/4}}$$

$$900 = \frac{1000\sqrt{150}}{H_m^{3/4}}$$

$$H_m = 32.49 \text{ m}$$

$$\text{No. of pumps} = \frac{H_{total}}{H_m} = \frac{95}{32.49} = 2.92 \simeq 3$$

End of Solution

78. Consider the following data from a test on Pelton wheel?
Head at the base of the nozzle = 32 m
Discharge of the nozzle = 0.18 m^3/s
Area of the jet = 7500 mm^2
Power available at the shaft = 44 kW
Mechanical efficiency = 94%
The power lost in the nozzle will be nearly
(a) 3.9 kW (b) 4.7 kW
(c) 3.5 kW (d) 2.3 kW

Ans. (b)

Power at the base of nozzle = $\dot{m}.g.H$

$= \rho.Q.\ g.\ H$

$= (10)^3\ (0.18)\ (9.81)\ (32) = 56.51$ kW

$$V_1 = \frac{Q}{a} = \frac{0.18}{7500\times10^{-6}}$$

Power at the exit of nozzle = $\frac{1}{2}\dot{m}V_1^2$

$$= \frac{1}{2}\rho Q V_1^2$$

$$= \frac{1}{2}\left(10^3\right)(0.18)(24)^2$$

$= 51.84$ kW

$= 24$ m/s

Power lost in the nozzle = 56.51 – 51.84 = 4.67 $\simeq$ 4.7 kW

End of Solution

79. A certain hydropower plant utilizes the flow as it occurs, without any provision for storage. It is premised that a defined minimum dry weather flow is available. Such a plant is classified as
(a) Diverted-flow plant (b) Pooled storage plant
(c) Base-load plant (d) Run-of-river plant

Ans. (d)

End of Solution

80. Two turbo-generators, each of capacity 25,000 kW, have been installed at a hydel power station. The load on the hydel plant varies from 15,000 kW to 40,000 kW. The total installed plant capacity and the load factor are nearly
(a) 40,000 kW and 68.8% (b) 50,000 kW and 68.8%
(c) 40,000 kW and 62.3% (d) 50,000 kW and 62.3%

Ans. (b)

$$\text{Load factor} = \frac{\text{Average load over a certain period}}{\text{Peak load during that period}}$$

$$= \frac{\frac{15{,}000+40{,}000}{2}}{40{,}000}$$

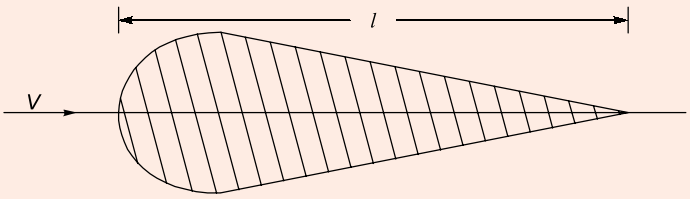
$$= 0.6875$$

i.e. 68.75%

Since two turbo-generators, each of capacity 25,000 kW have bean installed. So total installed plant capacity = 2 × 25,000 = 50,000 kW.

End of Solution

81. An airfoil is a streamlined body as shown in the figure below. Because of the streamlining of the body, the separation occurs only at the extreme rear of the body, resulting in



(a) A very high pressure drag
(b) A small wake and consequently small pressure drag
(c) A moderate pressure drag
(d) No pressure drag

Ans. (b)

End of Solution

82. A plate 0.025 mm distant from a fixed plate moves at 60 cm/s and requires a force of 0.2 kgf/m^2 to maintain this speed. The dynamic viscosity of the fluid between the plates will be nearly

(a) 9.2×10^{-10} kgfs/cm^2 (b) 8.3×10^{-10} kgfs/cm^2
(c) 7.4×10^{-10} kgfs/cm^2 (d) 6.5×10^{-10} kgfs/cm^2

Ans. (b)

$$\frac{F}{A} = 0.2 \text{ kgf/m}^2 = \frac{0.2}{10^4} \text{ kgf/cm}^2$$

We know that

$$\tau = \mu.\frac{V}{H}$$

$$\frac{F}{A} = \mu.\frac{V}{H}$$

$$\frac{0.2}{10^4} = \mu\frac{(60)}{0.025\times10^{-1}}$$

$$\mu = 8.3 \times 10^{-10}\ \text{kgfs/cm}^2$$

End of Solution

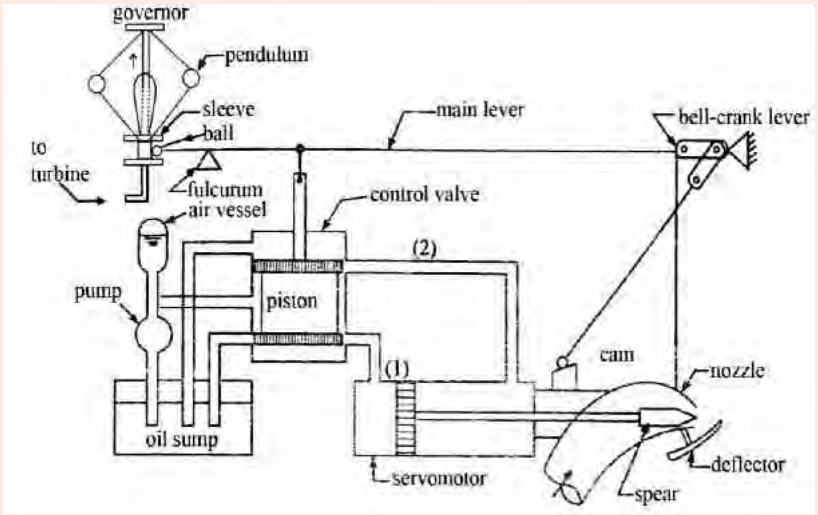
83. Which of the following are component parts for an oil pressure governor in modern turbines?

1. Servomotor, known as relay cylinder
2. Oil sump
3. Oil pump which is driven by belt connected to turbine main shaft
4. Draft tube

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 1, 3 and 4 only (d) 2, 3 and 4 only

Ans. (a)

Draft tube is not a part of governor.



The components parts for an oil pressure governor in modern turbine are as following:

1. Servomotor also know as relay cylinder.
2. Relay valve also known as control valve or distribution valve.
3. Actuator or pendulum which is belt driven from the turbine main shaft.
4. Oil sump.
5. Oil pump which is driven by belt connected to turbine main shaft.
6. A system of oil supply pipes connecting the oil sump with the relay valve and the relay valve with the servomotor.

End of Solution

84. A double-acting reciprocating pump having piston area 0.1 m^2 has a stroke 0.30 m long. The pump is discharging 2.4 m^2 of water per minute at 45 rpm through a height of 10 m. The slip of the pump and power required to drive the pump will be nearly

(a) 0.005 m^3/s and 4.8 kW (b) 0.003 m^3/s and 4.8 kW

(c) 0.005 m^3/s and 4.4 kW (d) 0.003 m^3/s and 4.4 kW

Ans. (c)

$$\text{Piston area } (A) = 0.1 \text{ m}^2$$

$$\text{Stroke } (L) = 0.3 \text{ m}$$

$$Q_{actual} = \frac{2.4}{60} \text{m}^3/\text{s}$$

$$N = 45 \text{ rpm}$$

$$H = h_s + h_d = 10 \text{ m}$$

$$Q_{theo} = \frac{2ALN}{60} \text{ m}^3/\text{s}$$

$$= \frac{2(0.1)(0.3)(45)}{60} \text{ m}^3/\text{s}$$

$$= \frac{2.7}{60} \text{ m}^3/\text{s}$$

$$\text{Slip} = Q_{Theo} - Q_{Act}$$

$$= \frac{2.7}{60} - \frac{2.4}{60} = 0.005 \text{ m}^3/\text{s}$$

$$\text{Power required} = \dot{m}.g.H = \rho.Q_{theo}.g.H$$

$$= \left(10^3\right)\left(\frac{2.7}{60}\right)(9.81)(10) = 4.41 \text{ kW}$$

End of Solution

85. In intensity-duration analysis by Sherman, the intensity of rainfall i is represented as

(a) $\dfrac{b^n}{(t+a)}$ (b) $\dfrac{a^n}{(t+b)^n}$

(c) $\dfrac{(a+t)^n}{b}$ (d) $\dfrac{a}{(t+b)^n}$

where t is time and a, b, n are constants for the area.

Ans. (d)

End of Solution

86. Which one of the following points should be kept in mind while selecting the site for a rain gauge station?

(a) The site where a rain gauge is set up should be close to a meteorological observatory.
(b) The rain gauge should be on the top. of a hill.
(c) A fence, if erected to protect the rain gauge from cattle etc. should be located within twice the height of the fence.
(d) The distance between the rain gauge and the nearest object should be at least twice the height of the object.

Ans. (d)

End of Solution

87. Which of the following statements relates to a retarding reservoir?

1. There are no gates at the outlets and hence the possibility of human error in reservoir operation is eliminated.
2. The high cost of gate installation and also its operation is saved.
3. An automatic regulation may cause coincidence of flood crest farther downstream where two or more channels taking off from retarding reservoirs join together.

(a) 1, 2 and 3 (b) 1 and 2 only
(c) 1 and 3 only (d) 2 and 3 only

Ans. (a)

Flood control reservoirs are adopted to prevent loss of life and valuable property due to floods. There are two types of single purpose flood control reservoirs, namely:

(i) Retarding reservoirs
(ii) Detention basins

(i) Retarding reservoirs: A retarding reservoir is the one in which the spillway and outlets are not controlled by gates or valves but instead, they moderate the flood peak by passing discharge downstream, depending upon reservoir elevation.

Advantages: (a) There are no gates at the outlets and hence the possibility of human error in reservoir operation is eliminated. (b) The cost of expensive gate installation and operation is saved.

Disadvantages: A serious disadvantage of retarding reservoir is that automatic regulation may cause coincidence of flood crest farther downstream where two or more channels taking off from retarding reservoirs join together.

Note: The most ideal location of such reservoirs is immediately above a city or above the area to be protected from flood furiosity.

End of Solution

88. The coefficient of transmissibility T for a confined aquifer can be determined by a pumping-out test together with other relevant observations. The applicable formula is (where Q = discharge, and ΔS = Difference in drawdowns in two wells)

(a) $\dfrac{Q}{2.72\Delta S}$ (b) $\dfrac{Q}{1.72\sqrt{\Delta S}}$

(c) $\dfrac{Q}{2.72}\Delta S$ (d) $\dfrac{Q}{2.72}\sqrt{\Delta S}$

Ans. (a)

Discharge from confined aquifer using Thiem's theory

$$Q = \frac{2\pi kH(s_1 - s_2)}{2.303 \log_{10}(r_2/r_1)}$$

Assuming, $r_2 = 10\, r_1$

$$Q = \frac{2\pi T\Delta S}{2.303 \log_{10} 10} = \frac{2\pi T\Delta S}{2.303}$$

$$T = \frac{Q}{\frac{2.303\Delta S}{2\pi}}$$

$\Rightarrow$ $$T = \frac{Q}{2.72\Delta S}$$

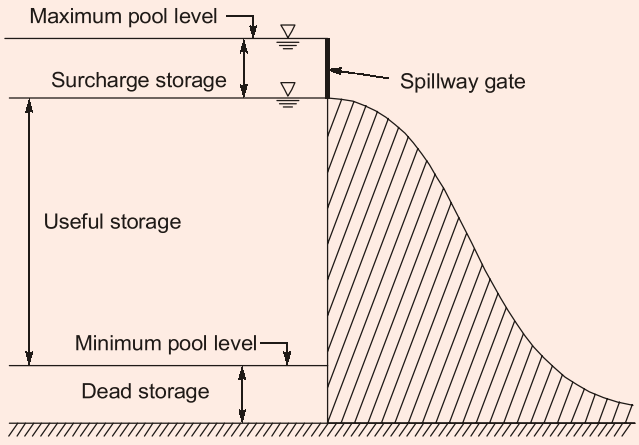
End of Solution

89. The volume of water below the minimum pool level in a reservoir is known as

(a) Useful storage (b) Surcharge storage

(c) Dead storage (d) Bank storage

Ans. (c)



End of Solution

90. Depending upon the source from which the water is drawn, flow irrigation can be sub-divided into

1. River canal irrigation
2. Reservoir or tank irrigation
3. Combined storage and lift irrigation
4. Combined storage and diversion irrigations

Which of the above designations are relevant?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 1, 3 and 4 only (d) 2, 3 and 4 only

Ans. (b)

Flow irrigation is that type of irrigation in which the supply of irrigation water available is at such a level that it is conveyed on to the land by gravity flow. Examples are river canal irrigation reservoir or tank irrigation, combined storage and diversion irrigation under gravity flow.

End of Solution

91. Consider the following data

Root zone depth = 2 m
Existing water content = 5%
Dry density of soil = 15 kN/m^3
Water applied to the soil = 500 m^3
Water loss due to evaporation and deep percolation = 10%
Area of plot = 1000 m^2
The field capacity of the soil will be nearly

(a) 16.8% (b) 17.7%
(c) 18.8% (d) 19.7%

Ans. (d)

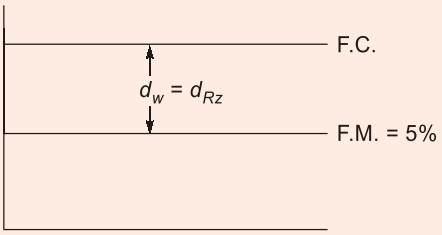
Depth of water added into the soil after removing 10% losses = $\frac{(500 \times 0.9)\text{m}^3}{1000\ \text{m}^2} = 0.45$ m

$$d_w = \frac{\gamma_d}{\gamma_w} \times d \times (F.C. - \text{Existing moisture})$$

F.C. = 0.14715 + 0.05
= 0.19715
or, F.C. $\simeq$ 19.715%

Note : If γ_w = 10 kN/m^3 is taken, then it can be solved without calculator and answer will be F.C. = 20% = 19.7%

Alternatively,



$d_w = d_{Rz}$ = Depth of water getting stored in the R.Z. to ↑ M.C. upto F.C.

$$d_{Rz} = \frac{V_{Rz}}{\text{Area}} = \text{Volume getting stored in the R.Z.}$$

$$V_{Rz} = V_F = \text{Losses}$$

$$V_{Rz} = 500 - \frac{10}{100} \times 50 = 450 \text{ m}^3$$

$$d_{Rz} = d_w = \frac{V_{Rz}}{\text{Area}} = \frac{450}{1000} = 0.45 \text{ m}$$

Using,

$$d_w = \frac{\gamma_d}{\gamma_w} \times d \times \left(\frac{F.C.}{100} - \frac{E.M.}{100} \right)$$

$$\Rightarrow \quad 0.45 = \frac{15}{9.81} \times 2 \times \left(\frac{F.C.}{100} - \frac{5}{100} \right)$$

$$F.C. = 19.71\%$$

End of Solution

92. Consider the following data for irrigation water

	Concentration	Milli-equivalents per litre
1	Na^+	24
2	Ca^{++}	3.6
3	Mg^{++}	2

The Sodium-Absorption Ratio (SAR) is nearly

(a) 13.1 (b) 14.3

(c) 15.5 (d) 16.7

Ans. (b)

$$SAR = \frac{\left[Na^+\right]}{\sqrt{\frac{\left[Ca^{2+}\right] + \left[Mg^{2+}\right]}{2}}} = \frac{24}{\sqrt{\frac{3.6 + 2}{2}}}$$

$$= \frac{24}{\sqrt{2.8}} = \frac{24}{1.673} = 14.35$$

End of Solution

93. Consider the following statements with respect to weir under discussion:

1. Its design corresponds to soft sandy foundation.
2. The difference in weir crest and downstream river bed may not exceed 3 m.
3. When water passes over it, the longitudinal location of the formation of a hydraulic jump is variable.

This weir is of the type

(a) Vertical drop weir
(b) Masonry or concrete sloping weir
(c) Dry stone slope weir
(d) Parabolic weir

Ans. (b)

Weirs constructed of masonry or concrete with sloping glacis are usually used now a days and their design in based upon modern concepts of sub-surface flow (Khosla's theory). Sheet piles of sufficient lengths are driven at the ends of upstream and downstream floor. The hydraulic jump is formed on the downstream sloping glacis so as to dissipate the energy of the flowing water.

This type of weir is exclusively used on permeable foundations (sandy soil). These are provided with a low crest with the differences in weir crest and d/s river not exceeding 3 m usually.

End of Solution

94. Consider the following data while designing an expansion transition for a canal by Mitra's method:

Length of flume = 16 m
Width of thorat = 9 m
Width of canal = 15 m

If B_x is the width at any distance x from the flumed section, the values of B_x at x = 8 m and at x = 16 m are nearly

(a) 10.8 m and 15 m
(b) 11.3 m and 15 m
(c) 10.8 m and 13 m
(d) 11.3 m and 13 m

Ans. (b)

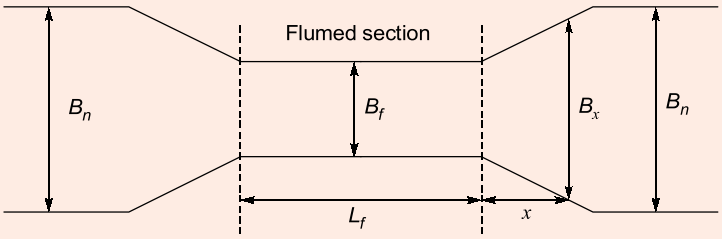
B_x is given by

$$B_x = \frac{B_n \times B_f \times L_f}{B_n L_f - x(B_n - B_f)}$$

B_n - normal width of canal
B_f - width of throat of canal
L - length of flume = 16 m

$$B_x(x = 8\text{m}) = \frac{15 \times 9 \times 16}{15 \times 16 - 8 \times (15 - 9)} = 11.25 \text{ m}$$

$$B_x(x = 16\text{m}) = \frac{15 \times 9 \times 16}{15 \times 16 - 16 \times (15 - 9)} = 15 \text{ m}$$



End of Solution

95. Consider the following data for a drain:
L = 50 m, a = 10 m, b = 10.3 m and $k = 1 \times 10^{-5}$ m/s
If the drains carry 1% of average annual rainfall in 24 hrs, the average annual rainfall for which this system has been designed will be
(a) 78 cm (b) 84 cm
(c) 90 cm (d) 96 cm

Ans. (*)
As per the standard notations:
$a \rightarrow$ distance between impervious strata from the centre of the drain
$b \rightarrow$ maximum height of drained water level above the impervious floor
$l \rightarrow$ length of the drain
$s \rightarrow$ centre to centre spacing between the drain
The question cannot be solved since spacing 's' is not given.

Note: If in place of L = 50m, it would have been s = 50m, then it would be solved like this:

$$s = \frac{4k}{q}(b^2 - a^2)$$

$$50 = \frac{4 \times 10^{-5} \times (10.3^2 - 10^2)}{q}$$

$$\therefore \quad q = 4.872 \times 10^{-6} \text{ m}^2/\text{s}$$

$$q = \frac{\frac{1}{100} \times \bar{p} \times (s \times 1)}{8.64 \times 10^4}$$

where, $\bar{p} \rightarrow$ annual average rainfall

$$\bar{p} = 0.841 \text{ m} \simeq 84 \text{ cm}$$

End of Solution

96. The purpose of constructing a 'Groyne' is to
(a) Expand a river channel to improve its depth
(b) Encourage meandering
(c) Train the flow along a certain course
(d) Reduce the silting in the river bed

Ans. (c)
Groynes are the structures constructed transverse to the river flow and extend from the bank into river upto a limit
They perform one or more of following functions depending on their type:
1. Training the river along the desired course to reduce the concentration of flow at a point of attack.
2. Creating a low flow for silting up in the vicinity.
3. Protecting the bank by keeping the flow away from it.

In general, all the types of groynes train the flow along a certain course.

End of Solution

97. Which one of the following compounds of nitrogen, when in excessive amounts in water, contributes to the illness known as infant methemoglobinemia.
(a) Ammoniacal nitrogen
(b) Albuminoid nitrogen
(c) Nitrite
(d) Nitrate

Ans. (d)
Nitrate in water in excess of 45 mg/*l* cause methemoglobinemia, as there are certain types of enzymes found in the intestine of infants which reduces nitrate into nitrite that has very high affinity for hemoglobin hence combines with it and leads to deficiency of O_2 and causes methemoglobinemia.

End of Solution

98. Consider the following data regarding a theoretical profile of a dam:
Permissible value of compressible stress σ = 350 tonnes/m^2
Specific gravity of concrete, s = 2.4
Uplift coefficient, c = 0.6 m
The value of γ = 1
The height of base width will be nearly
(a) 125 m and 63 m
(b) 175 m and 63 m
(c) 125 m and 93 m
(d) 175 m and 93 m

Ans. (c)
Critical or limiting height of dam,

$$H_{lim} = \frac{F}{\gamma_w (G_c - C + 1)} = \frac{350 \text{ tonnes/m}^2}{1(2.4 - 0.6 + 1)} = 125 \text{ m}$$

Base width, $$B_{min} = \frac{H_{lim}}{\sqrt{G_c - C}} = \frac{125}{\sqrt{2.4 - 0.6}} = \frac{125}{\sqrt{1.8}} = 93.14 \text{ m} \simeq 93 \text{ m}$$

End of Solution

99. Chlorine usage in the treatment of 25,000 m^3/day of water has been 9 kg/day. The residual chlorine after 10 minutes contact is 0.2 mg/l. The chlorine demand of water would be nearly

(a) 0.28 mg/l (b) 0.22 mg/l
(c) 0.16 mg/l (d) 0.12 mg/l

Ans. (c)

$$\text{Chlorine usage} = 9 \text{ kg/d}$$
$$Q_0 = 25000 \text{ m}^3\text{/d}$$
$$\text{Chlorine usage} = \frac{9\times10^6}{25000\times10^3} = 0.36 \text{ mg/}l$$
$$\text{Chlorine usages} = \text{chlorine demand} + \text{residual chlorine}$$
$$0.36 = \text{chlorine demand} + 0.2$$
$$\text{Chlorine demand} = 0.36 - 0.2 = 0.16 \text{ mg/}l$$

End of Solution

100. The demand of water is 150 litres/head/day in a city of one lakh population. The factor of safety is taken as 1.5, detention time as 4 h and overflow rate as 20,000 litres/day/m^2. The area of 3 m deep plain sedimentation tank as per surface loading considerations will be

(a) 1025 m^2 (b) 1075 m^2
(c) 1125 m^2 (d) 1175 m^2

Ans. (c)

$$\text{Design discharge} = 1.5 \times 150 \times 10^5 = 2.25 \times 10^7 \text{ } l\text{/d}$$
$$\text{Overflow rate} = 20000 \text{ } l\text{/d/m}^2$$
$$\text{Surface area} = \frac{Q_0}{OFR} = \frac{2.25\times10^7}{2\times10^4} = 1125 \text{ m}^2$$

or
$$\text{Volume} = Q_0 \times t_d = 2.25\times10^7 \times \frac{4}{24} = 3.75 \times 10^6 \text{ } l$$
$$\text{Surface area} = \frac{V}{H} = \frac{3.7\times10^6\times10^{-3}}{3} = 1250 \text{ m}^2$$

As per loading consideration $S_A = 1125$ m^2

End of Solution

101. The rain intensity over 54 hectares of land is 50 mm/h, 30% of area consists of roof surfaces with runoff rate as 0.9. 30% is open field with runoff rate of 0.2 and remaining 40% is road network with runoff rat 0.4. The storm water flow will be nearly,

(a) 2.6 m^3/s (b) 3.7 m^3/s
(c) 4.8 m^3/s (d) 4.9 m^3/s

Ans. (b)

Given data: $A = 54 \times 10^4\ m^2$

$i = 50$ mm/hr

$$k_{eq} = \frac{k_1A_1 + k_2A_2 + k_3A_3}{A_1 + A_2 + A_3} = \frac{(0.3A \times 0.9) + (0.3A \times 0.2) + (0.4A \times 0.4)}{0.3A + 0.3A + 0.4A}$$

$$= 0.27 + 0.06 + 0.16$$

$$= 0.49$$

$\therefore$ Discharge, $Q = KiA$

$$= \frac{0.49 \times 50 \times 10^{-3} \times 54 \times 10^4}{3600\ \text{sec}}\ m^3 = 3.675 \simeq 3.7\ m^3/\text{sec}$$

End of Solution

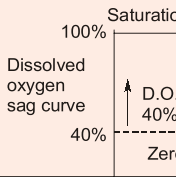
102. Critical dissolved oxygen (D.O.) deficit occurs in which one of the following zones of pollution of 'oxygen sag curve' in case of self-purification of natural stream?

(a) Zone of recovery
(b) Zone of active decomposition
(c) Zone of degradation
(d) Zone of clear water

Ans. (b)

Critical dissolved oxygen (DO) deficit occurs in zone of active decomposition

Table: Showing zone of pollution along a river stream

	Zones of pollution				
	Clear water	Zone of degradation	Zone of active decomposition	Zone of recovery	Zone of clearer water
					
Physical Indices	Clear, water, no bottom sludge, no colour	Floating solids; bottom sludge present, colour getting turbid	Darker and greyish colour, evolution of gases like CH_4, CO_2, H_2S etc. lot of sludge coming to the surface forming an ugly scum layer at top	Turbid with bottom sludge	Clear water with no bottom sludge
Fish presence	Ordinary fish like game, pan, food & forage etc. present.	Tolerant fishes like carp, buffalo, gary, etc. present	No fish present	Tolerant fish like carp, buffalo, etc. are present	Ordinary fish like game, pan, food, and forage, etc. present
Bottom Animals					
Algae & Protozoa etc. called plankton					

Here,
Zone-I : Zone of degradation
Zone-II : Zone of active decomposition
Zone-III : Zone of recovery
Zone-IV : Zone of clear water

End of Solution

103. The MLSS concentration in an aeration tank is 2000 mg/*l* and the sludge volume after 30 minutes of settling in a 1000 m*l* graduated cylinder is 176 m*l*. The value of sludge density index (SDI) will be nearly

(a) 3.34 g/m*l* (b) 2.22 g/m*l*
(c) 1.14 g/m*l* (d) 0.26 g/m*l*

Ans. **(c)**

$$SVI = \frac{V_s}{X_s} \times 10^3 \text{ (ml/gm)}$$

V_s = volume of solids settled in 30 min = 175 m*l*
X_s = concentration of solids = 2000 mg/*l*

$$SVI = \frac{175}{2000} \times 10^3 = 87.5 \text{ (ml/gm)}$$

$$SDI = \frac{100}{SVI} = \frac{100}{87.5} = 1.14 \text{ (g/l)}$$

End of Solution

104. Which one of the following gases is the principal by-product of anaerobic decomposition of the organic content in waste water?

(a) Carbon monoxide (b) Ammonia
(c) Hydrogen sulphide (d) Methane

Ans. **(d)**

During anaerobic decomposition of organic content in waste water major gases produced are CH_4 (65-70%) and CO_2 (30%).

End of Solution

105. Consider the following statements with reference to be mixing of industrial waste water with domestic waste water:

1. The industrial waste water can be mixed with domestic water when it has higher BOD.
2. The industrial waste water can be mixed with domestic water when the pH value of industrial waste water in highly alkaline.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (d)

As per **IS: 3306 1974** maximum permissible limits for industrial effluent discharges for BOD and pH into public sewers is 350 mg/*l* and 5.5 – 9 respectively. Hence both options are correct.

End of Solution

106. The waste water from a factory having a pH of 10, contains KOH only. For waste water discharge is 80 m^3/day. The total quantity of KOH per day will be nearly

(a) 4.5 kg/day (b) 5.4 kg/day
(c) 6.3 kg/day (d) 7.2 kg/day

Ans. (*)

pH = 10, pH + pOH = 14, pOH = 14 – 10 = 4

$-\log_{10}[OH] = 4 \Rightarrow [OH^-] = 10^{-4}$ moles/*l*

$K^+ + OH = KOH$

1 mole of OH^- ion forms 1 moles of KOH

Moles of KOH formed = 10^{-4} moles/*l*

Total quantity of KOH formed = $10^{-4} \times 80 \times 10^3 \times 56 \times 10^{-3}$

= 0.448 kg/d = 0.45 kg/d

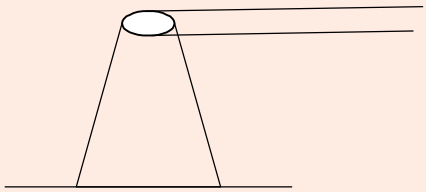
End of Solution

107. Fanning type of plume behaviour takes place when

(a) Super-adiabatic lapse rate prevails with light to moderate wind speed
(b) Extreme inversion conditions exist in the presence of light wind
(c) There exists a strong super-adiabatic lapse rate above a surface of inversion
(d) Plume is caught between two inversion layers

Ans. (b)

Fanning plume is formed under extreme inversion condition when pollutants are heavier than surrounding air, hence are not able to rise vertically up. It is formed during light turbulence and extremely stable atmosphere below the stack.



End of Solution

108. A thermal power plant burns coal at the rate of 8 t/h. The coal has sulphur content of 4.5%. The rate of emission of SO_2 Will be

(a) 180 g/s (b) 200 g/s
(c) 220 g/s (d) 240 g/s

Ans. (b)

$$\text{Coal burnt per sec} = \frac{8\times10^6}{60\times60} = 2222.22 \text{ gm/sec}$$

$$\text{Sulphur content} = \frac{4.5\times2222.22}{100} = 100 \text{ gm/sec}$$

Assuming entire sulphur is converted to SO_2

$$S + O_2 \rightarrow SO_2$$

1 mole of SO_2 is formed from 1 mole of S

64 gm of SO_2 is formed from 32 gm of S

$$SO_2 \text{ emission rate} = \frac{64}{32}\times100 = 200 \text{ gm/sec}$$

End of Solution

109. The property of clays by virtue of which they regain, if left alone for a time, a part of the strength lost due to remoulding at unaltered moisture content, is known as

(a) Thixotropy
(b) Sensitivity
(c) Consistency
(d) Activity

Ans. (a)

End of Solution

110. The plastic limit and liquid limit of a soil are 30% and 42% respectively. The percentage volume change from liquid limit to dry state is 35% of the dry volume. Similarly the percentage volume change from plastic limit to dry state is 22% of the dry volume. The shrinkage ratio will be nearly

(a) 4.2
(b) 3.1
(c) 2.2
(d) 1.1

Ans. (d)

Given data:

$w_P = 30\%$

$w_L = 42\%$

$V_L - V_d = 0.35\ V_d$

$V_P - V_d = 0.22\ V_d$

$V_L = 1.35\ V_d$

$V_P = 1.22\ V_d$

$$R = \frac{\left(\frac{V_1 - V_2}{V_d}\right)}{w_1 - w_2}\times100 = \frac{\frac{V_L - V_P}{V_d}}{w_L - w_P}\times100 = \frac{\left(\frac{1.35V_d - 1.22V_d}{V_d}\right)}{42-30}$$

$$R = \frac{0.13}{12}\times100 = 1.083 \simeq 1.1$$

End of Solution

111. The ratio of a given volume change in a soil, expressed as percentage of the dry volume, to the corresponding change in water content is called

(a) Specific gravity of soil solids (b) Mass-specific gravity of soils

(c) Shrinkage ratio of soils (d) Density ratio of soils

Ans. (c)

Shrinkage ratio $R = \dfrac{\dfrac{V_1 - V_2}{V_d}}{w_1 - w_2} \times 100$

End of Solution

112. A masonry is founded on pervious sand. A factor of safety of 4 is required against boiling. For the sand, n = 45% and G_s = 2.65. The maximum permissible upward hydraulic gradient will be nearly

(a) 0.18 (b) 0.23

(c) 0.28 (d) 0.33

Ans. (b)

$$n = 45\%$$
$$G_s = 2.65$$
$$\text{F.O.S} = 4$$
$$e = \frac{n}{1-n} = \frac{0.45}{1-0.45} = \frac{0.45}{0.55} = 0.818$$
$$\text{F.O.S} = \frac{i_c}{i}$$
$$\Rightarrow \quad i = \frac{i_c}{\text{F.O.S}} = \frac{\left(\dfrac{G-1}{1+e}\right)}{\text{F.O.S}}$$
$$i = \frac{\left(\dfrac{2.65-1}{1+0.818}\right)}{4} = \frac{0.9075}{4} = 0.22689 \simeq 0.23$$

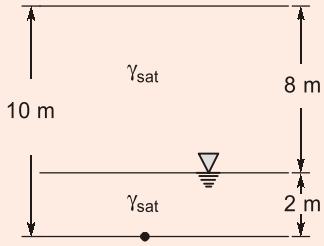
End of Solution

113. The representative liquid limit and plastic limit values of a saturated consolidate clay deposit are 60% and 30%, respectively. The saturated unit weight of the soil is 19 kN/m^3. The water table is at 8 m below ground level. Ata depth of 10 m from the ground surface, the undrained shear strength of the soil will be nearly

(a) 37.7 kN/m^2 (b) 33.5 kN/m^2

(c) 29.3 kN/m^2 (d) 25.1 kN/m^2

Ans. (a)



$$\bar{\sigma}_{n@base} = \sigma - u$$

$$\bar{\sigma}_n = 10\,\gamma_{sat} - 2\gamma_w$$

$$\bar{\sigma}_n = 10 \times 19 - 2 \times 9.81$$

$$= 190 - 19.62$$

$$= 170.38 \text{ kN/m}^2$$

$$\frac{c_u}{\bar{\sigma}_n} = 0.11 + 0.0037\, I_P\%$$

$$\frac{c_u}{170.38} = 0.11 + (0.0037 \times 30)$$

$$\frac{c_u}{170.38} = 0.221$$

$$c_u = 37.7 \text{ kN/m}^2$$

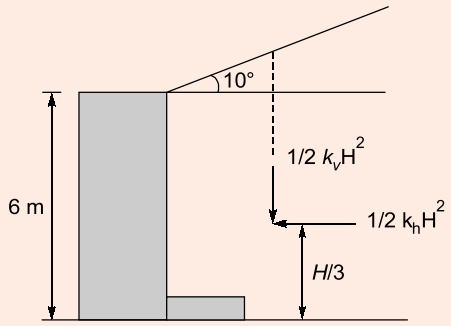
End of Solution

114. A 6 m high retaining wall with a vertical back has a backfill of silty sand with a slope of 10° for thw backfill. With values of K_H = 760 kg/m²/m and K_V = 100 kg/m²/m, the total active earth pressure will approximately be

(a) 128 kN/m (b) 134 kN/m

(c) 138 kN/m (d) 142 kN/m

Ans. (c)



K_H = 760 kg/m²/m

K_V = 100 kg/m²/m

By Peck Hensen and Thornburn method

$$P = \sqrt{\left(\frac{1}{2}K_V H^2\right)^2 + \left(\frac{1}{2}K_H H^2\right)^2}$$

$$P = \sqrt{\left(\frac{1}{2}\times 100\times 6^2\right)^2 + \left(\frac{1}{2}\times 760\times 6^2\right)^2}$$

$$= \sqrt{(1800)^2 + (13680)^2} = 13797.9 \text{ kg/m}$$

$$= 13797.9 \text{ kg/m} \times 9.81 = 135.357 \text{ kN/m}$$

By taking g = 10 m/s^2

$$P = 13797.9 \text{ kg/m} \times 10 = 137.979 \text{ kN/m}$$

End of Solution

115. The vertical stress at any point at a radial distance r and at depth z as determined by using Boussinesq's influence factor K_B and Westergaard's influence factor K_W would be almost same for $\left(\frac{r}{z}\right)$ ratios equal to or greater than

(a) 2.0 (b) 1.8
(c) 1.5 (d) 1.2

Ans. **(c)**

For $\frac{r}{z} = 1.5$

K_B and K_W would be almost same.

End of Solution

116. A strip footing 2 m in width, with its base at a depth of 1.5 m below ground surface, rests on a saturated clay soil with γ_{sat} = 20 kN/m^3, c_u = 40 kN/m^2, ϕ_u = 0, c' = 10 kN/m^3, and ϕ' = 20°. The natural water table is at 1 m depth below ground level. As per IS : 6403 – 1981, the ultimate bearing capacity of this footing will be (taking the relevant N_c as 5.14)

(a) 327 kN/m^2 (b) 285 kN/m^2
(c) 253 kN/m^2 (d) 231 kN/m^2

Ans. **(d)**

By assuming depth factor = 1
shape factor = 1
inclination factor = 1

$$q_{nu} = CN_C\,(s_c d_c i_c) + q(N_q - 1)\, s_q d_q i_q + 0.5\, B\gamma N_r (s_r d_r i_r)\, W$$

N_c = 5.14, N_q = 1, N_γ = 0

$$q_{nu} = CN_C = 5.14 \times 40$$

$$q_u = q_{nu} + \bar{\sigma} = 5.14\times 40 + (1\times\gamma + 0.5\gamma')$$

$$= 5.14 \times 40 + [1 \times 20 + 0.5 \times (20 - 10)] = 230.6$$

End of Solution

117. The settlement due to secondary compression is predominant in
(a) Granular soils (b) Inorganic clays
(c) Organics clays (d) Very fine sand and silts

Ans. **(c)**
Organic clays and highly plastic clays have secondary compression.

End of Solution

118. A raft foundation 10 m wide and 12 m long is to be constructed in a clayey soil having shear strength of 12 kN/m^2. Unit weight of soil is 16 kN/m^3. The ground surface carries a surcharge of 20 kN/m^2, the factor of safety is 1.2 and the value of N_c = 5.7. The safe depth of foundation will be nearly
(a) 8.2 m (b) 7.3 m
(c) 6.4 m (d) 5.5 m

Ans. **(d)**
Designing as a floating Raft
Applied load + over burden+ self weight = Weight soil excavated

$$= \frac{\left(1+0.3\frac{B}{L}\right)CN_C + \gamma D_f(1) - \gamma D_f + (\text{Overburden})}{F} = \gamma D_f$$

$$= \frac{\left(1+0.3\times\frac{10}{12}\right)\times 12\times 5.7 + 20}{1.2} = 16D_f$$

$$= \frac{105.5}{1.2} = 16D_f$$

$$D_f = 5.49 \text{ m}$$

End of Solution

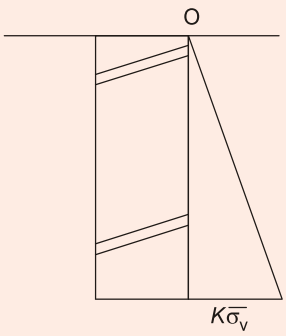
119. The skin frictional resistance of a pile driven in sand does not depend on
(a) Lateral earth pressure coefficient
(b) Angle of friction between pile and soil
(c) Pile material
(d) Total stress analysis

Ans. **(d)**
Skin frictional resistance of a pile driven in sand

$$Q_{sf} = q_s A_s = \left(\frac{1}{2}k\gamma L\tan\delta\right)A_s$$

In the presence of GWT,

$$Q_{sf} = \left(\frac{0+k\bar{\sigma}_v}{2}\right)\tan\delta A_s$$



For piles in granular soil, the design is based on an effective stress analysis. In clays, it is common to use a "total stress" analysis in which the load. Capacity is related to the undrained shear strength, C_u.

End of Solution

120. An excavation is made with a vertical face in a clay soil which has C_u = 50 kN/m^2, γ_t = 18 kN/m^3 and s_n = 0.261. The maximum depth of a stable excavation will be nearly

(a) 10.6 m (b) 12.4 m
(c) 14.2 m (d) 16.0 m

Ans. **(a)**

Taylor's stability number,

$$s_n = \frac{c}{\gamma H_c} = \frac{50}{18 \times H_c} = 0.261$$

$$H_c = 10.6428 \text{ m}$$

End of Solution

121. Reconnaissance survey for determining feasibility and estimation of scheme falls under the classification based on the

(a) Nature of the field survey (b) Object of surveying
(c) Instruments used (d) Method employed

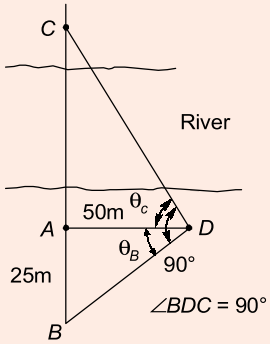
Ans. **(b)**

End of Solution

122. A survey line BAC crosses a river, A and C being on the near and distant banks respectively. Standing at D, a point 50 m measured perpendiculars to AB from A, the bearings of C and B are 320° and 230° respectively. AB being 25 m. The width of the river will be

(a) 80 m (b) 90 m
(c) 100 m (d) 110 m

Ans. (c)



From ΔABD

$$\tan\theta_B = \frac{25}{50} \Rightarrow \theta_B = 26°33'54''$$

$$\theta_C = (90 - \theta_B) = 90° - 26°33'54' = 63°26'6''$$

From ΔACD $\quad \tan\theta_C = \frac{AC}{AD}$

$$\Rightarrow \quad \tan 63°\ 26'6'' = \frac{AC}{50} \Rightarrow AC = 100\ \text{m}$$

Width of River = AC = 100 m

End of Solution

123. In plane surveying where a graduated staff is observed either with horizontal line of sight or inclined line of sight, the effect of refraction is to

(a) Increase the staff reading
(b) Decrease the staff reading
(c) Neither increase nor decrease the staff reading
(d) Duplicate the staff reading

Ans. (c)

Neither increase nor decrease the staff reading.

End of Solution

124. A sidereal day is the average time taken by

(a) The Earth to move around the Sun once
(b) The Moon to move around the Earth once
(c) The first point of Aries to cross the same meridian successively
(d) The Earth to move around its own axis once

Ans. (c)

The first point of Aries to cross the same meridian successively.

End of Solution

125. In triangulation, in order to control the accumulation of errors of length and azimuth subsidiary bases are selected. At certain stations, the astronomical observations for azimuth and longitude are also made. These stations are called

(a) Transportation stations (b) Bowditch stations

(c) Universe stations (d) Laplace stations

Ans. **(d)**

Laplace station

End of Solution

126. A vertical photograph is taken at an altitude of 1200 m 'above mean sea level' (a.m.s.*l*.) of a terrain lying at an elevation of 80 m a.m.s.*l*. The focal length of camera is 15 cm. The scale of the photograph will be nearly

(a) 1 : 8376 (b) 1 : 7467

(c) 1 : 6558 (d) 1 : 5649

Ans. **(b)**

H = 1200 m, h = 80 m, f = 15 cm

$$\text{Scale} = \frac{f}{H-h} = \frac{15\times10^{-2}}{1200-80} = \frac{1}{7466.67}$$

Scale = (1 : 7467)

End of Solution

127. Aerial photographs are required to be taken to cover an area of 150 km^2. The longitudinal and side overlaps are to be 60% and 30% respectively. The scale of photograph is 1 cm = 100 m, and the size of each photograph is 20 cm × 20 cm. The minimum required number of photographs will be

(a) 170 (b) 158

(c) 146 (d) 134

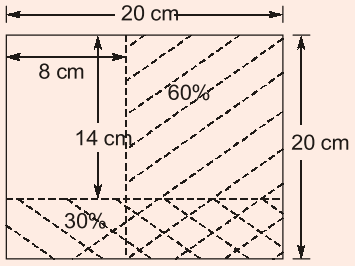
Ans. **(d)**

Area of ground = 150 km^2

Overlap: Longitudnal = 60%; Lateral = 30%

Scale : 1 cm = 100 m = 0.1 km

Photosize = 20 cm × 20 cm



Now l = length covered by 1 photo

= 8 × 0.1 = 0.8 km

b = width covered by 1 photo

= 14 × 0.1 = 1.4 km

a = Area covered by 1 photo

= $l \times b$ = 0.8 × 1.4 = 1.12 km^2

$$\text{Min. no. of photographs} = \left(\frac{A}{a}\right) = \left(\frac{150}{1.12}\right) = 133.92 \approx 134 \text{ photos}$$

End of Solution

128. Which one of the following conditions is **not** correct with respect to the transition curve?

(a) It should be tangential to the straight approaches at the two ends.

(b) It should meet the circular curve tangentially.

(c) Its curvature will necessarily be non-zero at the point of take-off from the straight approaches.

(d) The rate of increase of curvature along the transition reach should match with the increase of cant.

Ans. (c)

its curvature will necessarily be non-zero at the point of take-off from the straight approach.

End of Solution

129. A circular curve has a long chord of 80 m and a versed sine of 4 m. The height and ordinate at a distance of 30 m from the mid-ordinate will be nearly

(a) 3.06 m (b) 2.72 m

(c) 2.24 m (d) 1.76 m

Ans. (d)

By ordinate from the long chord

Ordinate at distance x from the mid point of the chord = O_x

$$O_x = \sqrt{R^2 - x^2} - (R_0 - O_0)$$

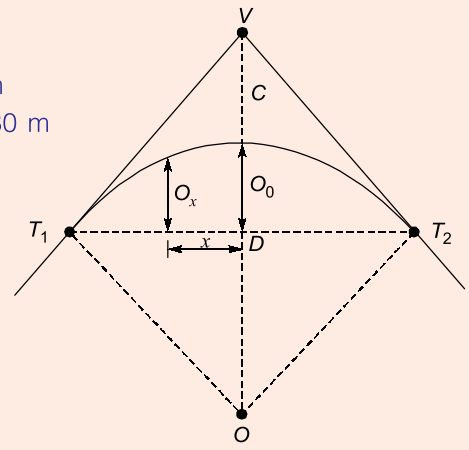
$$O_x = \sqrt{R^2 - x^2} - (R - O_0)$$

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

Given data: O_0 = Versed sine = 4 m

L = Longest chord = 80 m

x = 30 m



Versed Sine (O_0)

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$4 \text{ m} = R - \sqrt{R^2 - \left(\frac{80}{2}\right)^2}$$

$$\Rightarrow \quad R = 202 \text{ m}$$

$$O_x = \sqrt{R^2 - x^2} - (R - O_0)$$

$$O_{30} = \sqrt{202^2 - 30^2} - (202 - 4)$$

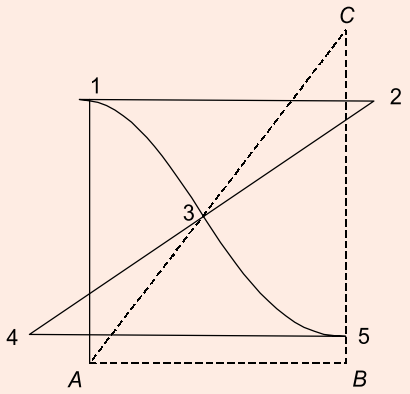
$$= 1.759 \approx 1.76 \text{ m}$$

End of Solution

130. Two parallel railway lines are to be connected by a reverse curve, each section having the same radius. If the lines are 12 m apart and the maximum distance between tangent points measured parallel to the straights is 48 m, then the maximum allowable radius will be

(a) 51.1 m (b) 52.3 m
(c) 53.5 m (d) 54.7 m

Ans. (a)



$D = 12$ m

$$AB = \sqrt{AC^2 + BC^2}$$
$$AB^2 = AC^2 - BC^2$$
$$48^2 = (2R)^2 - (2R - D)^2$$
$$48^2 = 4R^2 - 4R^2 - D^2 + 4RD$$
$$\frac{48^2 + D^2}{4 \times D} = R$$
$$\frac{48^2 + 12^2}{4 \times 12} = R$$
$$R = 51 \text{ m}$$

End of Solution

131. In an old map, a line AB was drawn to a magnetic bearing of 5°30′, the magnetic declination at the time being 1° East. If the present magnetic declination is 8°30′ East, the line should be set to a magnetic bearing of

(a) 358° (b) 2°
(c) 6°30′ (d) 357°

Ans. (a)

Old Map

$MB = 5°30'$
$\delta_E = 1°$
$TB = MB + \delta_E$
$= 5°30' + 1° = 6°30'$

Present: $TB = 6°30'$

δ_E(present) $= 8°30'$

$TB = MB + \delta_E$

$6°30' = MB + 8°30'$

$MB = 6°30' - 8°30'$

$= -2°$

$= (360° - 2°)$

$= 358°$

End of Solution

132. An unconformity is

(a) A surface of erosion or non-deposition as detected in a sequence of rocks

(b) A layer of boulders and pebbles in a sequence of rocks

(c) A layer of clay or shale in an igneous mass

(d) A type of joint especially associated with folded and faulted rocks

Ans. (a)

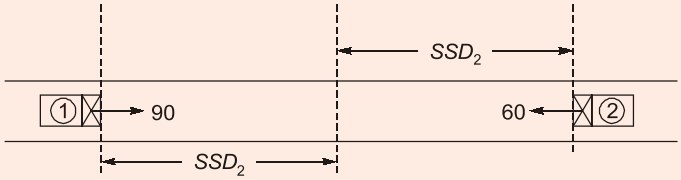
End of Solution

133. Consider two cars approaching from the opposite directions at 90 km/hand 60 km/h. If the reaction time is 2.5 s, coefficient of friction is 0.7 and brake efficiency is 50% in both the cases, the minimum sight distance required to avoid a head-on collision will be nearly

(a) 154 m (b) 188 m

(c) 212 m (d) 236 m

Ans. (d)



Braking eff = 50% $f = 0.7$

$SD = SSD_1 + SSD_2$

$$= \left[0.278V_1t_R + \frac{V_1^2}{254(n_Bf)}\right] + \left[0.278V_2t_R + \frac{V_2^2}{254(n_Bf)}\right]$$

$$= \left[0.278 \times 90 \times 2.5 + \frac{90^2}{254 \times (0.5 \times 0.7)}\right] + \left[0.278 \times 60 \times 2.5 + \frac{60^2}{254(0.5 \times 0.7)}\right]$$

$= 153.67 + 82.195 = 235.865$ m

≈ 236 m

End of Solution

134. What is the extra widening required (as nearest magnitude) for a pavement of 7 m width on a horizontal curve of radius 200 m, if the longest wheel of vehicle expected on the road is 6.5 m and the design speed is 65 km/h?

(a) 0.3 m (b) 0.5 m
(c) 0.7 m (d) 0.9 m

Ans. (c)

Road width = 7 m (i.e., No of lane 2)

Extra widening

$$W_E = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}} \qquad (R = 200 \text{ m};\ l = 6.5 \text{ m};\ V = 65 \text{ kmph})$$

$$= \frac{2 \times 6.5^2}{2 \times 200} + \frac{65}{9.5\sqrt{200}}$$

$$= 0.695 \text{ m} \approx 0.7 \text{ m}$$

End of Solution

135. A vehicle moving at 40 km/h speed was stopped by applying brake and the length of the skid mark was 12.2 m. If the average skid resistance of the pavement is 0.70, the brake efficiency of the test vehicle will be nearly

(a) 80% (b) 74%
(c) 68% (d) 62%

Ans. (b)

$u = 40$ kmph; $L = 12.2$ m; $f = 0.7$

$$f_{\text{obtained}} = \frac{u^2}{2gL} = \frac{(0.278 \times 40)^2}{2 \times 9.81 \times 12.2} = 0.5166$$

$$\eta_{\text{Braking}} = \left(\frac{f_{\text{obtained}}}{f_{\max}} \times 100\right) = \left(\frac{0.5166}{0.7} \times 100\right) = 73.8\% \approx 74\%$$

End of Solution

136. The main drawback of automatic counters-cum-classifiers, used for traffic volume studies, is that it is not yet possible to classify and record

(a) Vehicle type (b) Axle spacing
(c) Axle load (d) Speed

Ans. (a)

End of Solution

137. Which one of the following is **not** a part of 'speed and delay' studies?

(a) Floating car method (b) Vehicle number method
(c) Interview technique (d) License number method

Ans. (b)

End of Solution

138. Consider the following data with respect to the design of flexible pavement:
Design wheel load = 4200 kg
Tyre pressure = 6.0 kg/cm^2
Elastic modulus = 150 kg/cm^2
Permissible deflection = 0.25 cm
(take $\pi^{1/2} = 1.77$, $\pi^{-1/2} = 0.564$, $\frac{1}{\pi} = 0.318$, and $\pi^2 = 9.87$)
The total thickness of flexible pavement for a single layer elastic theory will be nearly
(a) 42 cm (b) 47 cm
(c) 51 cm (d) 56 cm

Ans. (c)

$P = 4200$ kg; $p = 6$ kg/cm^2; $E = 150$ kg/cm^2; $\Delta = 0.25$ cm

$$p = \frac{P}{\pi a^2}$$

$$\Rightarrow \quad 6 = \frac{4200}{\pi \times a^2} \Rightarrow a = 14.92 \text{ cm}$$

Radius of contact area = a = 14.92 cm
Thickness of pavement by single layer elastic theory

$$T = \sqrt{\left(\frac{3P}{2\pi E_S \Delta}\right)^2 - a^2}$$

$$= \sqrt{\left(\frac{3 \times 4200}{2\pi \times 150 \times 0.25}\right)^2 - 14.92^2}$$

$$= 51.352 \text{ cm} \approx 51 \text{ cm}$$

End of Solution

139. The minimum possible grade that can be provided in a tunnel and its approaches with providing adequately for proper drainage is
(a) 0.1% (b) 0.2%
(c) 0.3% (d) 0.4%

Ans. (*)

End of Solution

140. The section of the tunnel adopted perfectly in lieu of ease of construction and maintenance in hard rock tunnels, where the risk of roof failure or collapse caused by external pressure from water, or from loose or unstable soil conditions on tunnel lining is practically non-existent, is
(a) Circular section (b) Segmental roof section
(c) Horse-shoe section (d) Egg-shaped section

Ans. (b)

End of Solution

141. Which one of the following methods is adopted for tunneling in soft soils?
(a) Pilot tunnel method
(b) Drift method
(c) Needle beam method
(d) Heading and benching method

Ans. (c)

End of Solution

142. Which one of the following features does ***not*** pertain to Littoral drift?
(a) It depends on length of wave
(b) It is the process of erosion of deposition by waves
(c) Waves caused by prevailing wind, stir up and move sand particles
(d) Wind tends to carry drifting sand in a zigzag way

Ans. (d)

End of Solution

143. Consider the following data for designing a taxiway for operating Boeing 707-320 aeroplane:
Wheel base = 17.70 m
Tread of main loading gear = 6.62 m
Turning speed = 40 km/h
Coefficient of friction between tyres and pavement surface = 0.13
The turning radius of the taxiway will be
(a) 98.5 m
(b) 94.5 m
(c) 89.5 m
(d) 86.5 m

Ans. (a)

1. $$R = \frac{V^2}{125f} = \frac{40^2}{125 \times 0.13} = 98.46 \text{ m}$$

2. $$R = \frac{0.388w^2}{\frac{T}{2} - S} = \frac{0.388 \times 17.7^2}{\frac{22.5}{2} - \left(\frac{6.62}{2} + 6\right)} = 62.66 \text{ m}$$

End of Solution

144. Which one of the following instances of performance of aircraft is ***not*** considered for determining basic runway length?
(a) Normal landing case
(b) Normal take-off case
(c) Engine failure case
(d) Emergency landing case

Ans. (d)

End of Solution

Directions : Each of the next **six (06)** items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are individually true, and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true, but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true, but Statement (II) is false
(d) Statement (I) is false, but Statement (II) is true

Q.145 **Statement (I) :** Expansive cement is used in repair work for opened up joints.

Statement (II) : Expansive cement expands while hardening.

Ans. (a)

End of Solution

Q.146 **Statement (I) :** Plastic hinges are developed when stress at every point is equal to yield stress.

Statement (II) : Plastic hinges are formed at sections subjected to the greatest curvature.

Ans. (b)

End of Solution

Q.147 **Statement (I) :** If degree of fixity at supports is lessened, the maximum hogging moment at the ends will decrease.

Statement (II) : If degree of fixity at supports is lessened, the maximum sagging moment at mid-span decreases.

Ans. (c)

End of Solution

Q.148 **Statement (I) :** Torsion reinforcement is provided at (and near) corners in a two-way slab which is simply supported on both edges meeting at the corner.

Statement (II) : The area of reinforcement in each of the layers shall be three-quarters of the area required for maximum mid-span moment in the slab.

Ans. (b)

End of Solution

Q.149 **Statement (I) :** The inclination of the resultant stress with normal can exceed the angle of repose (adopting old terminology).

Statement (II) : The ratio of the difference between greatest and least intensities of pressure to their sum cannot exceed the sine of the angle of repose (adopting old terminology).

Ans. (d)

The maximum slope at which a material, dropped down through a natural process, remains stable, is called angle of repose.

The angle of repose of a granular soil can be determined by pouring the material on a level surface from a small height and measuring the angle between the sloping surface and the horizontal.

The angle of repose is approximately equal to the angle of internal friction of the soil.

At the failure plane angle of obliquity is maximum, which is also termed as internal angle of friction.

At failure plane, resultant stress with normal stress makes maximum angle of obliquity.

$$\Rightarrow \quad \sigma_1 = \sigma_3 \tan^2\left(45 + \frac{\phi}{2}\right) + 2c\tan\left(45 + \frac{\phi}{2}\right)$$

$$\sigma_1 = \sigma_3\left(\frac{1+\sin\phi}{1-\sin\phi}\right)$$

$$\sin\phi = \frac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3}$$

End of Solution

Q.150 **Statement (I) :** Alum works in slightly alkaline range.

Statement (II) : At higher temperatures, viscosity of water (resistance to settling) decreases and flocs settle better.

Ans. (b)

Statement-II alum works in pH range of 6.5 – 8.5, hence works in slightly alkaline range.

Statement-I with increase in temperature viscosity of water decrease hence resistance to seltting decreasing there by flocs settle better.

End of Solution