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# ESE – 2019
## (PRELIMS)
Questions with Detailed Solutions

# CIVIL ENGINEERING

# SET - A

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# ESE – 2019 Prelims Examination

# CIVIL Engineering

## Subject wise Weightage

| SUBJECT | No. of Questions | Marks |
|---|---|---|
| Building Materials | 14 | 28 |
| Solid Mechanics | 19 | 38 |
| Structural Analysis | 12 | 24 |
| Design of Steel structures | 08 | 16 |
| Design of Concrete & Masonry Structures | 10 | 20 |
| Construction Practice, Planning and Management | 12 | 24 |
| Fluid Mechanics & Hydraulic Machines | 12 | 24 |
| Hydrology | 04 | 08 |
| Irrigation Engineering | 10 | 20 |
| Environmental Engineering | 12 | 24 |
| Geotechnical Engineering | 13 | 26 |
| Surveying | 10 | 20 |
| Geology | 01 | 02 |
| Transportation Engineering<br>(Highways, Railways, Airports, Docks & Harbours, Tunnels) | 13 | 26 |
| **Total** | **150** | **300** |

01. Which of the following statements are wholly correct regarding broken-brick aggregate useable 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

**01. Ans: (d)**

**Sol:** Broken bricks can be used as coarse aggregate in less important concrete works like foundations in light buildings, floorings and walkways. Since, these broken bricks have less density compared to conventional coarse aggregates, they can also be used in light-weight reinforced concrete floors. Hence, correct option is (d).

End of Solution

02. 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

**02. Ans: (b)**

**Sol:** The beneficial amount of entrained air depends on the workability requirement of the concrete mix. Strength of aggregates does not have any bearing on the workability of concrete. Hence, option (b) is the correct option.

03. Which one of the following statements is **not** correct with respect to fly 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 equaled depending upon the water content.

**03. Ans: (b)**

**Sol:** Addition of flyash to concrete decreases the initial rate of strength gain of concrete. Hence, correct option is (b).

End of Solution

04. 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

**04. Ans: (a)**

**Sol:** Even in highly reactive pozzolanas, strength gain due to pozzolanic action does not start immediately as Ca(OH)2 is needed, which comes from the hydration of C3S and C2S. Hence, correct option is (a).

Pre GATE - 2019

05. 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 ($C_2S$)

**05. Ans: (d)**

**Sol:** Both $C_3S$ and $C_2S$ contribute towards strength of cement. Since $C_3S$ is more reactive than $C_2S$, it contributes towards initial strength and $C_2S$ contributes towards strength of cement at a later age. Hence, correct option is (d).

End of Solution

06. The creep strain of cement attains its terminal value by

(a) 1 year
(b) 2 years
(c) 5 years
(d) 6 months

**06. Ans: (c)**

**Sol:** The rate of creep decreases with time. The time taken by cement to attain maximum creep strain is 5 years. Hence, correct option is (c).

End of Solution

07. 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

**07. Ans: (a)**

**Sol:** Continuous vibration increases the chances of segregation and in lean dry mix; small quantity of water can improve the cohesion among the ingredients because of which segregation chances reduces. Hence, correct option is (a).

08. 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

**08. Ans: (d)**

End of Solution

09. 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

**09. Ans: (b)**

**Sol:** If the concrete is completely saturated with water, frost action will lead to expansion and thus damage the concrete. Thus, statement 3 is incorrect. Hence, correct option is (b).

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

**10. Ans: (a)**

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

**11. Ans: (d)**

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

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

**12. Ans: (b)**

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

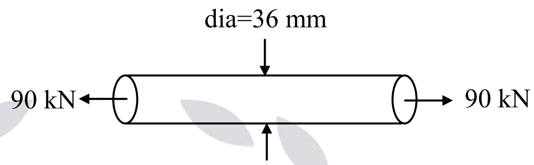
(a) 0.287 (b) 0.265 (c) 0.253 (d) 0.241

**13. Ans: (a)**

**Sol:** $l = 200$ mm

$\delta l = 0.089$ mm

$\delta D = 0.0046$ mm




$$\mu = \frac{\left(\frac{\delta D}{D}\right)}{\left(\frac{\delta \ell}{\ell}\right)} = \frac{\left(\frac{0.0046}{36}\right)}{\left(\frac{0.089}{200}\right)} = 0.287$$

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$^2$

**14. Ans: (b)**

**Sol:** $l = 15$ m

$\Delta t = 65 - 15 = 50°C$

$\alpha = 12\times 10^{-6}/°C$

$E = 200 \times 10^3$ MPa

Temperature stress

$\sigma = E\,\alpha\,\Delta t = (200\times10^3)\,(12\times10^{-6})\,(50)$

$= 120$ MPa (compressive)

Free expansion of bar

$\delta l = l\alpha\Delta t = (15000)\,(12\times10^{-6})\,(50) = 9$ mm

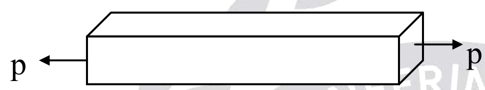
15. A bar of uniform rectangular section of area A is subjected to an axial tensile load P; its Young's modulus is E and its Poisson's ratio is $\frac{1}{m}$. Its volumetric strain $e_v$ is

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

**15. Ans: (c)**

**Sol:**




$$\varepsilon_V = \frac{\sigma_x + \sigma_y + \sigma_z}{E}(1-2\mu)$$

$$\varepsilon_v = \frac{p}{E}(1-2\mu) \qquad \left[\text{Use } p = \frac{P}{A} \text{ and } \mu = \frac{1}{m}\right]$$

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

End of Solution

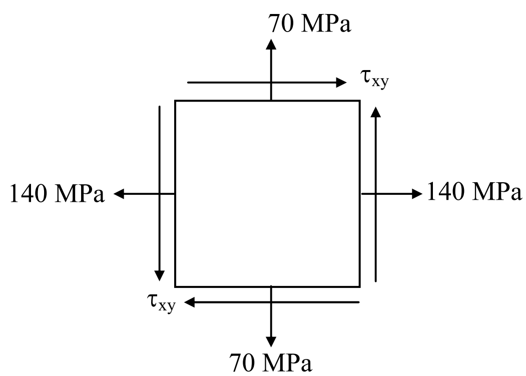
16. The normal stresses on two mutually perpendicular planes are 140 N/mm$^2$ (Tensile) and 70 N/mm$^2$ (Tensile). If the maximum shear stress is 45 N/mm$^2$, the shear stress on these planes will be nearly

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

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

**16. Ans: (c)**

**Sol:**



$\tau_{max} = 45$ MPa

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

$$(45)^2 = \left[\frac{140-70}{2}\right]^2 + \tau_{xy}^2$$

$$2025 = \left(\frac{70}{2}\right)^2 + \tau_{xy}^2$$

$$2025 = 1225 + \tau_{xy}^2$$

$$\tau_{xy} = 28.3 \text{ MPa}$$

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)

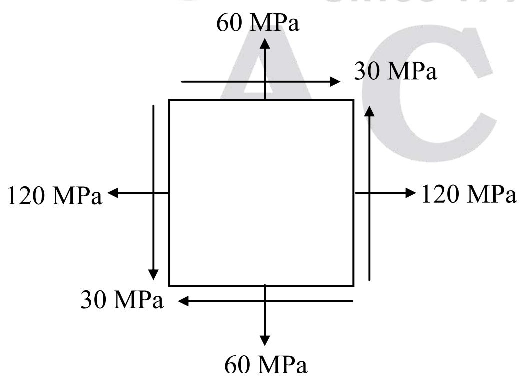
(b) 132 MPa (Tensile) and 24 MPa (Compressive)

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

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

**17. Ans: (d)**

**Sol:**



Principal Stresses $\left.\begin{matrix}\sigma_1\\ \sigma_2\end{matrix}\right\} = \dfrac{\sigma_x+\sigma_y}{2} \pm \sqrt{\left(\dfrac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2}$

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

$$= 90 \pm \sqrt{(30)^2 + 30^2}$$

$$= 90 \pm \sqrt{900+900}$$

$$= 90 \pm 42.43$$

Major stress, $\sigma_1$ = 132 MPa (tensile)

Minor stress, $\sigma_2$ = 90 – 42.43 = 48 MPa (tensile)

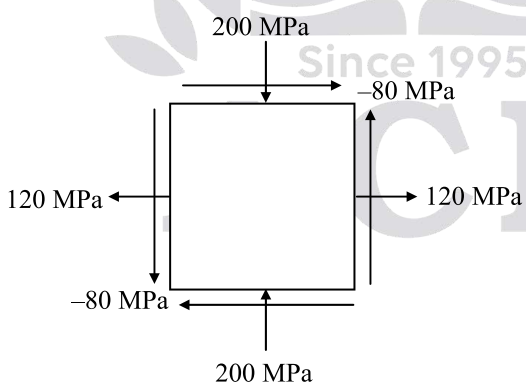
18. At a point in a material, the stresses acting on two planes at right angles to each other are $\sigma_z$ = 120 MPa and $\sigma_y$= –200 MPa and $\tau_{zy}$ = – 80 MPa. The maximum shear stress on the element will be nearly

(a) 142 MPa (b) 155 MPa

(c) 167 MPa (d) 179 MPa

**18. Ans: (d)**

**Sol:**




Given

$\sigma_x$ = 120 MPa

$\sigma_y$ = –200 MPa

$\tau_{xy}$ = – 80 MPa

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

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

$$= \sqrt{(160)^2 + (80)^2}$$

$$= \sqrt{25600 + 6400}$$

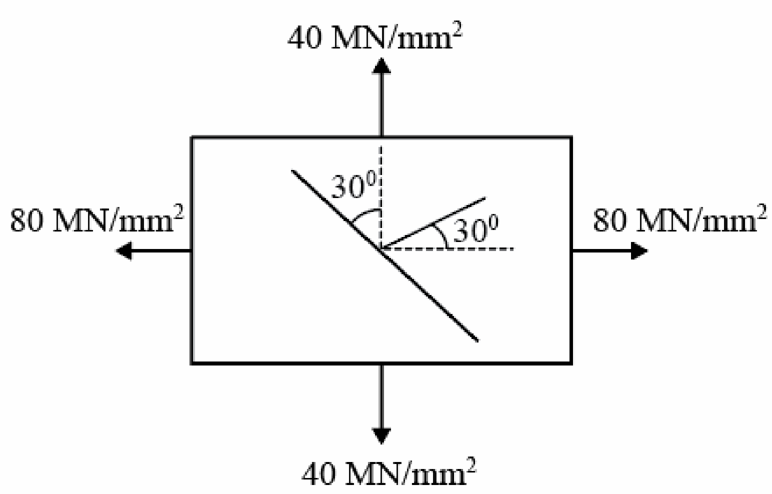
$$= \sqrt{32000}$$

$$= 178.89 \text{ MPa}$$

$$\simeq 179 \text{ MPa}$$

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$^o$ with a direction of maximum principal stress. The resultant stresses (in magnitude) in the plane will be nearly

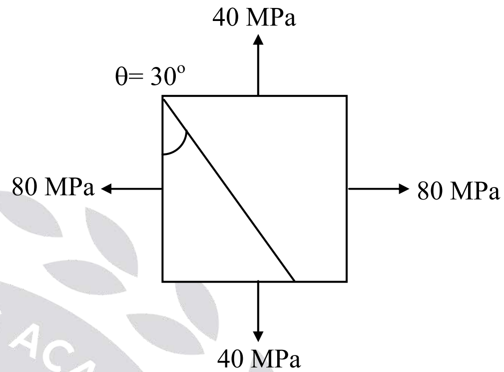



(a) 84 MN/mm$^2$ (b) 72 MN/mm$^2$

(c) 64 MN/mm$^2$ (d) 58 MN/mm$^2$

**19. Ans: (b)**

**Sol:**




$$\sigma_\theta = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos(2\theta) + \tau_{xy}\sin 2\theta$$

$$= \frac{40+80}{2} + \frac{80-40}{2}\cos(2\times 30) + 0$$

$$= 60 + 20\left(\frac{1}{2}\right)$$

$$= 60 + 10 = 70 \text{ MPa}$$

$$\tau_\theta = \frac{\sigma_x - \sigma_y}{2}\sin(2\theta) - \tau_{xy}(2\theta)$$

$$= \frac{80-40}{2}\sin(2\times 30) - 0$$

$$= 20\sin 60 = \frac{20\sqrt{3}}{2} = 10\sqrt{3}$$

$$\sigma_R = \sqrt{\sigma_\theta^2 + \tau_\theta^2} = \sqrt{5200} = 72.11\text{MPa}$$

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

**20. Ans: (a)**

**Sol:** $\frac{dF}{dx} = w$

$dF = w.dx$

Change in SF between any two points equal to area of loading diagram

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

**21. Ans: (b)**

**Sol:** Shear flow = Product of shear stress multiplied with width

Shear Flow $= \tau b = \dfrac{VA\bar{y}}{I}$

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

**22. Ans: (b)**

**Sol:** $P = 2\pi NT$

Frequency, $N \propto \dfrac{1}{T}$

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$^2$

**23. Ans: (c)**

**Sol:** $\tau_{max} = ?$

Diameter, d = 15 cm = 150 mm

P = 150 kW = 150 kN-m/s

$N = 180$ rpm

Power transmitted, $P = \dfrac{2\pi NT}{60}$

$$150 = \frac{2\pi(180)T}{60}$$

$$T = \frac{150}{6\pi} = 7.95 \text{ kN-m}$$

For solid circular section

$$\tau_{max} = \frac{16T}{\pi d^3} = \frac{16(7.95\times10^6)}{\pi(150)^3} = 12\text{MPa}$$

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 $8.16 \times 10^4$ 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

**24. Ans: (b)**

**Sol:** $d = 10$ mm

$n = 15$

$R = 50$ mm

$P = 100$ N

$G = 8.16 \times 10^4$ N/mm$^2$

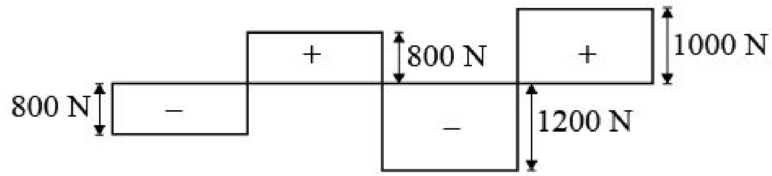
$K = ?$

Stiffness of spring, $K = \dfrac{Gd^4}{64R^3n}$

$$= \frac{(8.16\times10^4)(10^4)}{64\times50^3\times15}$$

$K = 6.8$ N/mm

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



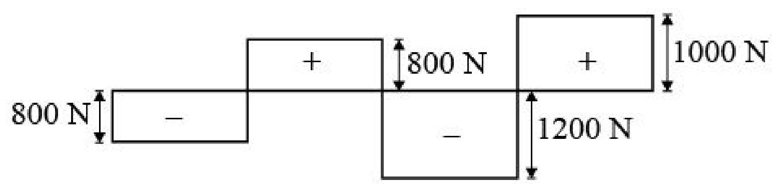

The total of the vertically downward loads on the beam is

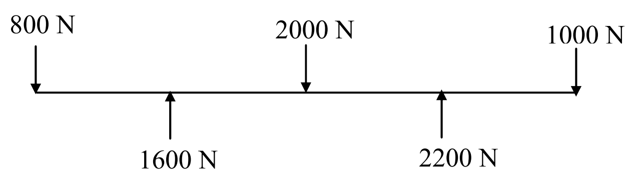
(a) 2600 N (b) 3000 N

(c) 3400 N (d) 3800 N

**25. Ans: (d)**

**Sol:**




Vertical downward forces = upward forces

= 1600 + 2200 = 3800 N

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$^2$

**26. Ans: (b)**

**Sol:** V = 50 kN

b = 250 mm

h = 200 mm

For triangular section

$$\tau_{NA} = \frac{4}{3}[\tau_{avg}] = \frac{4}{3}\left[\frac{50\times10^3}{\frac{1}{2}\times250\times200}\right]$$

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

End of Solution

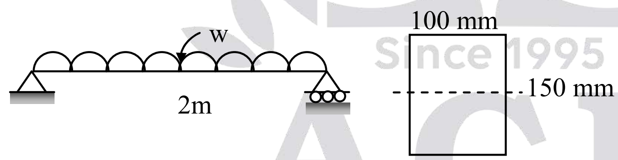
27. A timber beam, 100 mm wide and 150 mm deep, supports a UDL over a span of 2 m. If the safe stresses are not to exceed 28 MPa in bending and 2 MPa in shear, the maximum load that the beam can support is

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

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

**27. Ans: (b)**

**Sol:**




$f_{max}$ = 28 MPa

$\tau_{max}$ = 2 MPa

For rectangular section, $\tau_{max} = \frac{3}{2}[\tau_{avg}] = \frac{3}{2}\left[\frac{F}{bd}\right]$

$$2 = \frac{3}{2}\left[\frac{F}{100\times150}\right]$$

$$F = 20{,}000 \text{ N} = 20 \text{ kN} = \frac{w\ell}{2}$$

w = 20 kN/m ……………….(1)

$$f_{max} = \frac{M}{z} \Rightarrow 28 = \frac{M}{\left[\frac{100 \times 150^2}{6}\right]}$$

M = 10.5 kN-m $= wl^2/8$

w = 21 kN/m …………….(2)

use minimum of 1 & 2

w = 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

**28. Ans: (b)**

**Sol:** L = 1.5 mm

d = 50 mm

$$\alpha = \frac{1}{1600}$$

f = 560 N/mm$^2$

F.S = 3

Radius of gyration, $r_{min} = \sqrt{\frac{I}{A}} = \sqrt{\frac{\frac{\pi}{64}d^4}{\frac{\pi}{4}d^2}} = \frac{d}{4}$

when column is having pinned ends ($l$ = L = 1.5 m)

$$\lambda_1 = \frac{\ell}{r_{min}} = \frac{1500}{\left(\frac{50}{4}\right)} = 120$$

when column is fixed at one end and free ($l$ = 2L) at other end

$$\lambda_2 = \frac{\ell}{r_{min}} = \frac{2L}{r_{min}} = 240$$

$$P_e = \frac{f_c A}{1+\alpha(\lambda)^2}$$

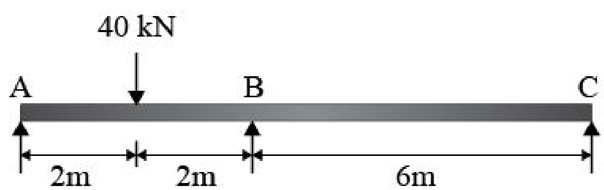
$$P_e = \frac{560\left[\pi/4\times 50^2\right]}{1+\left(\frac{1}{1600}\right)(240)^2}$$

$$= 29717.76 \text{ N}$$

$$\text{Safe load} = \frac{P_e}{F.S} = \frac{29717.76}{3} = 9905.9\text{N} \approx 9906\text{N}$$

End of Solution

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



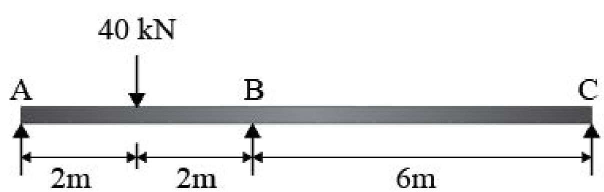

The moment at B is

(a) 18 kNm (b) 16 kNm

(c) 14 kNm (d) 12 kNm

**29. Ans: (d)**

**Sol:**



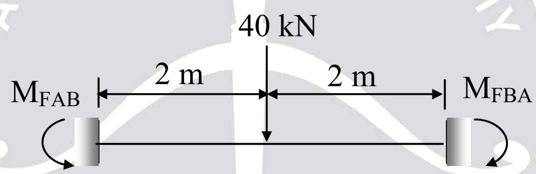
Using moment distribution method

**Step :1** Distribution factors (DF)

| Joint | Member | K | ΣK | $D = \frac{K}{\Sigma K}$ |
|---|---|---|---|---|
| B | BA | $\frac{3}{4}\times\frac{I}{4}$ | $\frac{3I}{16}+\frac{I}{8}=\frac{5I}{16}$ | $\frac{3}{5}$ |
| | BC | $\frac{3}{4}\times\frac{I}{6}$ | | $\frac{2}{5}$ |

**Step 2:** Assume all supports are fixed and fixed end moments (FEM) are calculated for each span

**For span AB:**




$$M_{FBA} = \frac{-WL}{8} = -20 \text{ kN-m}$$

$$M_{FBA} = \frac{WL}{8} = 20 \text{ kN-m}$$

Sign conventions

Anticlockwise moment is negative & clockwise moment is positive.

**For span BC:**

$M_{FBC} = M_{FCB} = 0$ [Because no load on span BC]

**Step 3: Moment distribution.**

| | A | B (3/5) | B (2/5) | C |
|---|---|---|---|---|
| FEM | –20 | 20 | 0 | 0 |
| Release at 'A' and carry over | +20 | 1/2 → $\frac{20}{2}$ | | |
| Initial moments balance | 0 | 30<br>$-30\times\frac{3}{5}$ | 0<br>$-30\times\frac{2}{5}$ | 0 |
| Carry over | 0 | | | 0 |
| Final Moment | 0 | $30-\frac{90}{5}$<br>=12 | $-\frac{60}{5}$<br>= –12 | 0 |

The moment at 'B' is 12 kN-m

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

**30. Ans: (a)**

**Sol:** In a circular section

$$\tau_{max} = \frac{4}{3}\tau_{avg}$$

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

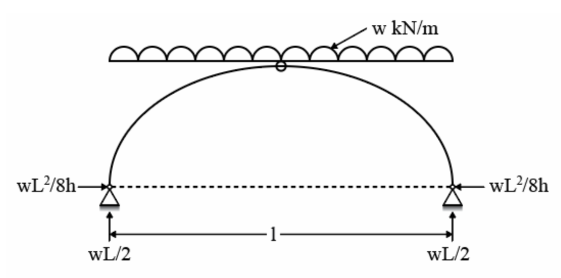
1. No stresses are produced in a three-hinged arch due to temperature change alone.
2. There is a decrease in horizontal thrust due to rise in temperature
3. There is an increase in horizontal thrust due to rise in temperature.

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

**31. Ans: (a)**

**Sol:** While no stresses are produced in a three hinged arch due to temperature change alone, it may be noted that, since the rise of the arch is altered as a consequence of the temperature change, the horizontal thrust for the arch already carrying a load will also alter.

Suppose a three hinged arch of span '*l*' and rise 'h' carries a uniformly distributed load of 'w' per unit run over the whole span



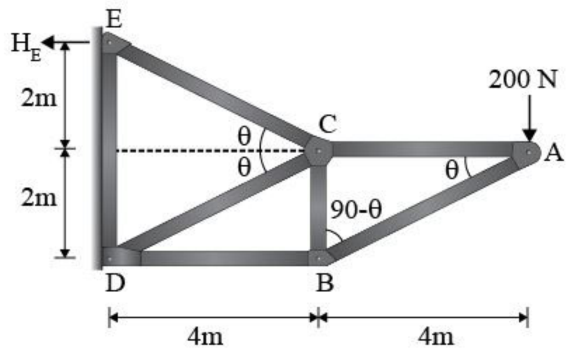

The horizontal thrust for the arch 'H' $= \dfrac{wL^2}{8h}$

Hence, change in the horizontal thrust due to change in the rise of the arch.

$$dH = \frac{-wL^2}{8h^2}dh\,,\ \frac{dH}{H} = \frac{-dh}{h}\ ,\ dH = \frac{-dh}{h}\times H$$

This is the decrease in the horizontal thrust due to rise in temperature

32. Consider the frame as shown in the figure.



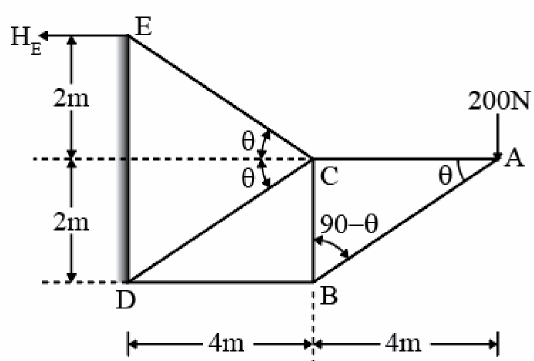

The magnitude of the horizontal support reaction at E is

(a) 400 kN (b) 300 kN

(c) 250 kN (d) 200 kN

**32. Ans: (a)**

**Sol:**




Taking moment about 'D'

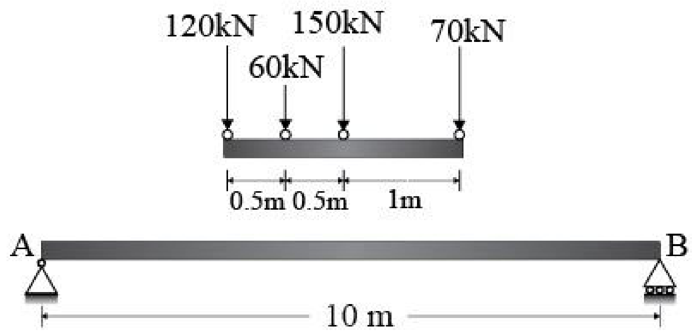
$\Sigma M_D = 0$ –ve +ve

$-H_E \times 4 + 200 \times 8 = 0$

$$H_E = \frac{200 \times 8}{4} = 400\text{N} \text{ or } 4 \times 10^{-3} \text{ kN}$$

**Note:** In the above diagram, load is given in 'Newton'.

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



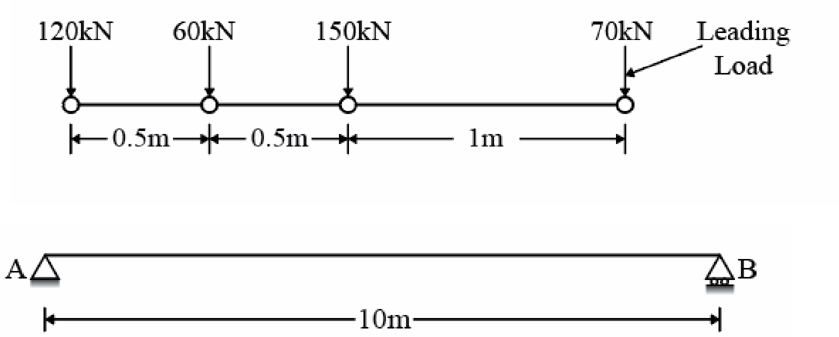

The maximum bending moment for the girder is nearly

(a) 820 kNm (b) 847 kNm

(c) 874 kNm (d) 890 kNm

**33. Ans: (d)**

**Sol:**

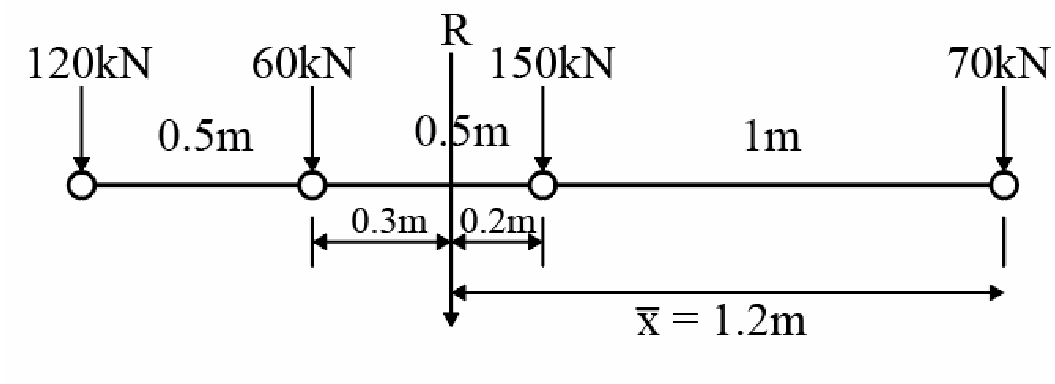



Let the resultant of the wheel loads be at a distance $\overline{x}$ from the leading 70 kN load.

Taking moments of the wheel loads about the leading 70 kN load.

$$\overline{x} = \frac{70\times0+150\times1+60\times1.5+120\times2}{70+150+60+120}$$

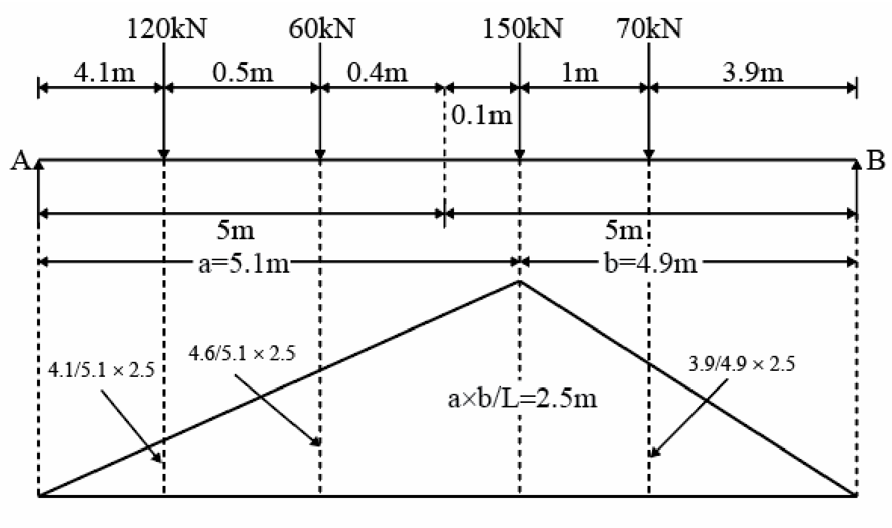
$$\overline{x} = \frac{480}{400} = \frac{6}{5} = 1.2 \text{ m}$$




**Note:** In this problem, the section of the beam is not specified. We have to choose the location of maximum BM. Maximum BM occurs near centre.

To get more BM under a choosen wheel load, the resultant of load system and the choosen load must be at equal distance from centre. Then more BM occurs under the choosen load.

In this problem 150 kN load is greater and nearer to the resultant, then more BM will occur under 150 kN load only.

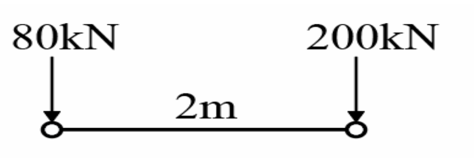


34. Two wheel loads 80 kN and 200 kN respectively spaced 2 m apart, move on a girder of span 16 m. Any wheel load can lead the other. The maximum negative shear force at a section 4 m from the left end will be

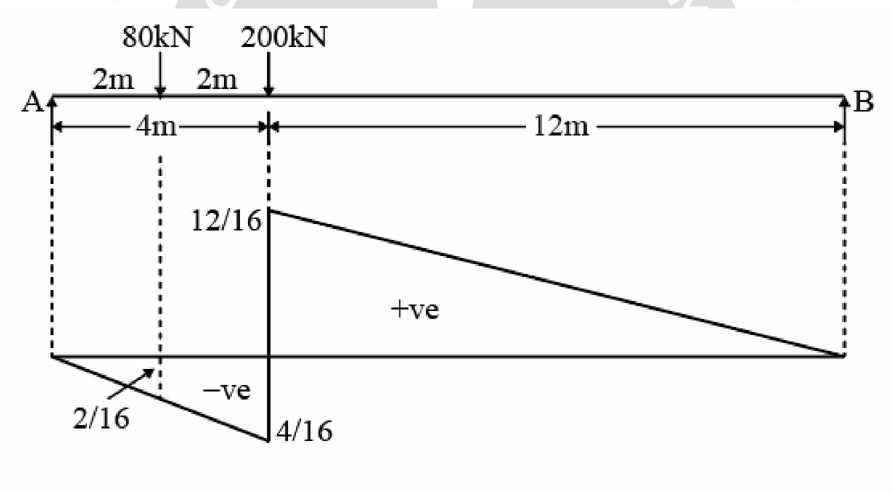
(a) – 50 kN (b) – 60 kN
(c) – 70 kN (d) – 80 kN

**34. Ans: (b)**

**Sol:**




**Note:** Any wheel load can lead the other




ILD for $SF_C$

To get the maximum negative shear force at a section 'C', place the greater load i.e 200 kN just left to the section 'C' and 80 kN load on span 'AC'

Maximum negative shear force at section 'C'

$$= -80 \times \frac{2}{16} - 200 \times \frac{4}{16}$$

$$= -60 \text{ kN}$$

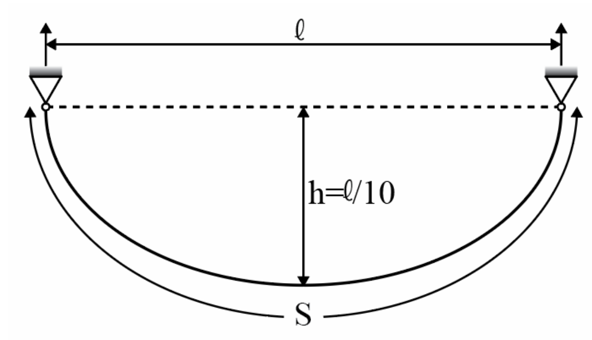
35. The maximum possible span for a cable supported at the ends at the same level (assuming it to be in a parabolic profile) allowing a central dip of $\frac{1}{10}$ of the span with permissible stress of 150 N/mm$^2$ (where the steel weighs 78,000 N/m$^3$) will be nearly

(a) 1270 m (b) 1330 m

(c) 1388 m (d) 1450 m

**35. Ans: (c)**

**Sol:**




Let the maximum horizontal span be ‘*l*’ metres

Dip of the cable ‘h’ $= \frac{\ell}{10}$ meters

Length of the cable ‘s’ = $\ell + \frac{8}{3}\frac{h^2}{\ell}$

$$S = \ell\left[1 + \frac{8}{3}\left(\frac{h}{\ell}\right)^2\right]$$

$$S = \ell\left[1 + \frac{8}{3}\left(\frac{1}{100}\right)\right]$$

$$S = \frac{308}{300}\ell$$

Let the area of the cable be ‘A’ mm$^2$

Weight of the cable ‘W’ = $\frac{308}{300}\ell \times \frac{A}{1000^2} \times 78000\text{N}$

$$W = 0.08008\ Al \text{ Newton}$$

Each vertical reaction ‘V’ = $\frac{W\ell}{2} = \frac{W}{2}$

Horizontal reaction ‘H’ = $\frac{WL^2}{8h} = \frac{W\ell}{8h} = \frac{W}{8} \times 10$

$$H = \frac{5W}{4}$$

Max tension ($\tau_{max}$) = $\sqrt{V^2 + H^2}$

$$= \sqrt{\left(\frac{W}{2}\right)^2 + \left(\frac{5W}{4}\right)^2}$$

$= 1.35\ W$

$\tau_{max} = 1.35 \times 0.08008\ Al$

Maximum stress '$f_{max}$' $= \frac{\tau_{max}}{A}$

$1.35 \times 0.08008\ l = 150$

$l = 1387.5\text{ m} \simeq 1388\text{ m}$

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

**36. Ans: (c)**

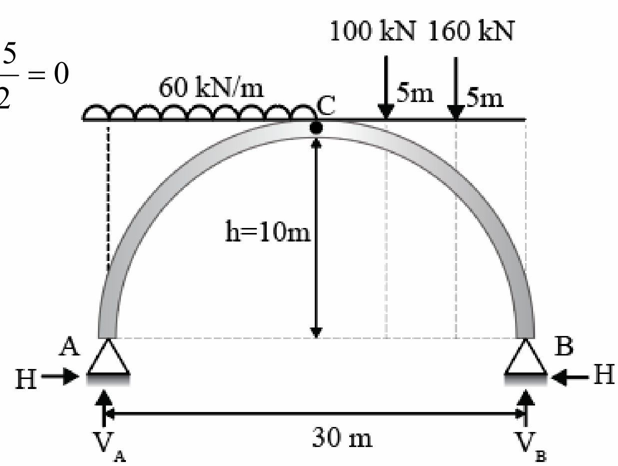
**Sol:**

Taking moment about 'A':

$\Sigma M_A = 0$ –ve +ve

$$-V_B \times 30 + 160 \times 25 + 100 \times 20 + 60 \times 15 \times \frac{15}{2} = 0$$

$V_B = 425\text{ kN}$




$BM_C = 0$ [Look right side]

$$-\underbrace{V_B}_{425} \times 15 + H \times 10 + 160 \times 10 + 100 \times 5 = 0$$

$H = 427.5\text{ kN} \simeq 428\text{ kN}$

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

(a) Galloping (b) Ovalling

(b) Flutter (d) Oscillation

**37. Ans: (b)**

**Sol:** Explanation other terms not related to vibrations of combined bending and twisting.

End of Solution

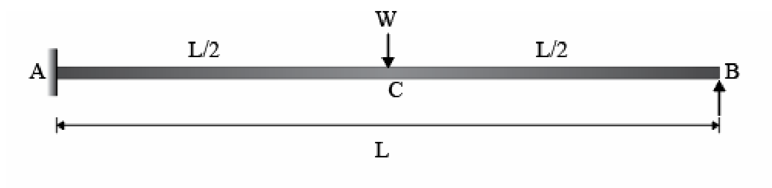
38. A propped cantilever beam of span $l$ and constant plastic moment capacity $M_p$ carries a concentrated load at mid-span. The load at collapse will be

(a) $\frac{2M_p}{\ell}$ (b) $\frac{4M_p}{\ell}$

(c) $\frac{6M_p}{\ell}$ (d) $\frac{8M_p}{\ell}$

**38. Ans: (c)**

**Sol:**




Static indeterminacy $D_S = r - s$

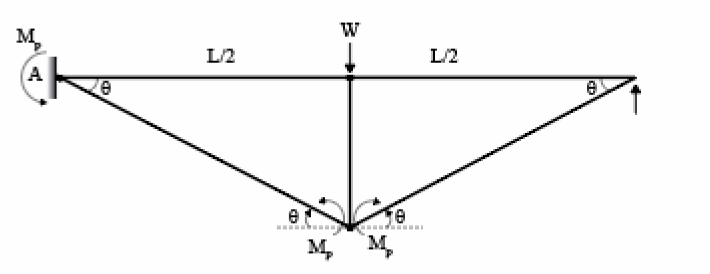
r = No. of support reactions

s = No. of equilibrium equations

$D_S = 3 - 2 = 1$

No. of possible plastic hinges 'N' = 2 [at A & C]

No. of plastic hinges required to form a mechanism 'n' = $D_S + 1 = 2$



External work done ‘$W_e$’ = load × displacement under the load

$$= W_C \times \delta$$

$$\tan\theta \approx \theta = \frac{\delta}{L/2}$$

$$\delta = \frac{L}{2}\theta$$

Internal work done ($w_i$) = Moment × Rotation

$$W_i = M_P\theta + M_P\theta + M_P\theta$$

$$= 3\, M_P\theta$$

Equating $W_e = W_i$

$$W_c \times \frac{L}{2}\theta = 3M_P\theta$$

$$W_C = \frac{6M_P}{L}$$

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$^o$ 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

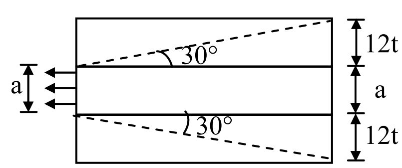
(a) 2a + 12 t (b) a + 12 t

(c) a + 24 t (d) 2a + 24 t

**39. Ans: (c)**

**Sol:** Effective width of plate

= a + 12t + 12t = a + 24t



40. A wind brace is to be provided between two columns spaced at 5 m, at an inclination of $30^o$ 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$^2$

**40. Ans: (*)**

**Sol** The questions seems to have insufficient data hence no solution can be concluded

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$^2$, $\gamma_y = 45.1$, 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

**41. Ans: (c)**

**Sol:** Factored axial load P = 500 kN

Factored moment M = 45 kN –m

For ISHB 200 ; A = 4750 mm$^2$ ; $r_{yy}$ = 45.1 mm

h = 200 mm ; b = 200 mm

Buckling load $P_e = P + \frac{2M}{d} = 500 + \frac{2 \times 45 \times 10^3}{200} = 950$ kN

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

**42. Ans: (b)**

**Sol:** Two important Assumptions are made to achieve ideal beam behaviour

1. The compression flange of beam restrained against lateral buckling (or) lateral-Torsional buckling.
2. Any form of local buckling is prevented

So that a beam loaded predominantly in flexure to attain its full moment capacity and shear capacity, when local buckling and lateral (or) lateral-Torsional buckling of beam are prevented.

Hence option 1 & 3 are correct.

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

**43. Ans: (a)**

**Sol:** Vierendeel girder is a series of rectangular frames, which achieves stability by the rigid connections of vertical web members to the top and bottom chord.

In a vierendeel girder, the loading is carried by a combination of pure flexure and flexure due to shear induced by relative deformation between the ends of the top and bottom chord members.

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

**44. Ans: (d)**

**Sol:** Bearing stiffeners are used to transfer concentrated loads on girder and heavy reactions at support to the full depth of the web. They are required to prevent web yielding, web buckling and web crippling.

Hence bearing stiffeners at point of concentrated load and at support.

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

**45. Ans: (b)**

**Sol:** Let 'S' be spacing of truss

'p' = cost of purlin per unit area

't' = cost of truss per unit area

'r' = cost of roof sheeting per unit area

x = total (or) overall cost of truss per unit area

$$t\alpha\frac{1}{S}\Rightarrow t=\frac{C_1}{S}\Rightarrow C_1=t\times S$$

$$P\propto S^2\Rightarrow p=C_2S^2\Rightarrow C_2=\frac{p}{S^2}$$

$$r\propto S\Rightarrow r=C_3S\Rightarrow C_3=\frac{r}{S}$$

$$x=t+p+r=\frac{C_1}{S}+C_2S^2+C_3S$$

To minimize the over all cost, the condition should be

$$\frac{dx}{dS}=0\Rightarrow\frac{d}{dS}\left[\frac{C_1}{S}+C_2S^2+C_3S\right]=0$$

$$-\frac{C_1}{S^2}+2C_2S+C_3=0$$

$$\frac{C_1}{S^2} = 2C_2S + C_3$$

$$\frac{t \times S}{S^2} = 2\left[\frac{p}{S^2}\right]S + \frac{r}{S}$$

$$\frac{t}{S} = \frac{2p}{S} + \frac{r}{S}$$

$$t = 2p + r$$

End of Solution

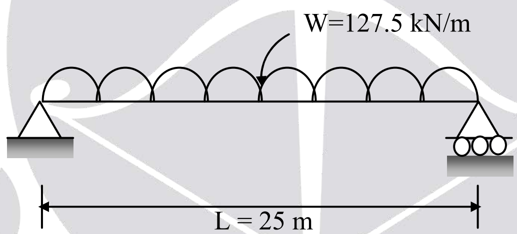
46. A welded plate girder of span 25 m is laterally restrained throughout its length. It has to carry a load of 80 kN/m over the whole span besides its weight. If K = 200 and $f_y$ = 250 MPa, the thickness of web will be nearly

(a) 10 mm (b) 14 mm

(c) 16 mm (d) 20 mm

**46. Ans: (a)**

**Sol:**




Span of girder L = 25 m

$$f_y = 250\,\text{MPa}; K = \frac{d}{t_w} = 200$$

Total load = 80 kN/m

Factored load = 1.5×80 = 120 kN/m

Self weight of welded plate girder $= \frac{W}{400} = \frac{80 \times 25}{400} = 5$ kN/m

Factored self weight = 1.5×5 = 7.5 kN/m

Total factored load inclusive of self weight W = 120 + 7.5

= 127.5 kN/m

Maximum factored bending moment $M_Z = \frac{WL^2}{8}$

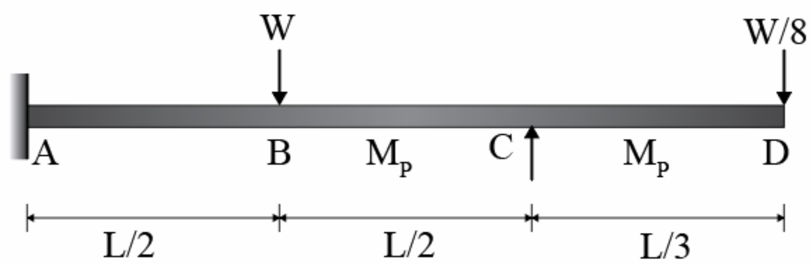
$$M_{ZZ} = \frac{127.5 \times 25^2}{8} = 9960.9375\,kN-m$$

Optimum thickness of web plate $t_w = \left[\frac{M_{zz}}{f_y \times K^2}\right]^{1/3}$

$$= \left[\frac{9960.9375 \times 10^6}{250 \times 200^2}\right]^{1/3} = 9.99\text{ mm} \simeq 10\text{ mm}$$

End of Solution

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

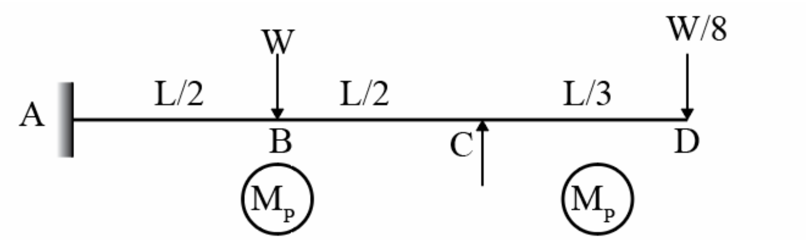



(a) $6.5\frac{M_P}{L}$ (b) $5.6\frac{M_P}{L}$

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

**47. Ans: (a)**

**Sol:**




Static indeterminacy $D_s = r - s$

No. of reactions ‘r’ = 3

No. of equilibrium equations ‘s’ = 2

$D_S = 1$

No. of possible plastic hinges 'N' = 3 [at A , B & C]

No. of plastic hinges required to form a mechanism 'n' = $D_s + 1$

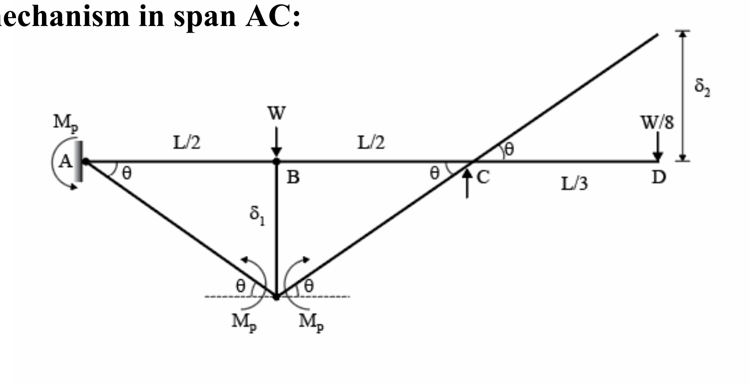
$= 2$

No. of independent mechanism 'I' = $N - D_S$

$= 3 - 1$

$= 2$ [Two beam mechanisms]

**Beam mechanism in span AC:**




External work done $W_e$ = load × displacement under the load

**Note:** If load and displacements are in different direction, then work done is negative.

$$W_e = +W_c \times \delta_1 - \frac{W_c}{8} \times \delta_2$$

$$\delta_1 = \frac{L}{2}\theta$$

$$\delta_2 = \frac{L}{3}\theta$$

$$W_e = W_c \times \frac{L}{2}\theta - \frac{W_c}{8} \times \frac{L}{3}\theta$$

$$= W_c L\theta\left[\frac{1}{2} - \frac{1}{24}\right]$$

$$= \frac{11}{24} W_c L\theta$$

$$W_c = \frac{24M_p}{L}$$

Internal workdone ($w_i$) = Moment × Rotation

$$= M_P\,\theta + M_P\theta + M_P\theta$$

$$= 3M_P\theta$$

$$W_e = W_i$$

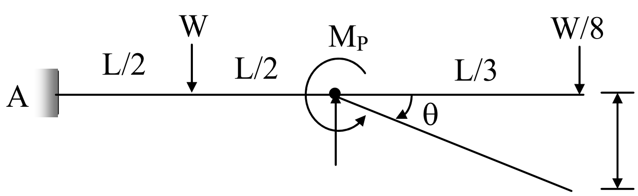
$$\frac{11}{24}W_cL\theta = 3M_P\theta$$

$$W_c = \frac{3\times 24}{11}\times\frac{M_P}{L}$$

$$W_c = \frac{72M_p}{11L}$$

$$W_c = 6.5\frac{M_P}{L}$$

**Beam mechanism in span CD :**




$$W_e = +\frac{W_C}{8}\times\delta_3 = \frac{W_C}{8}\times\frac{L}{3}\theta$$

$$W_i = M_P\,\theta$$

$$W_e = W_i$$

$$\frac{W_C}{8}\times\frac{L}{3}\theta = M_P\theta$$

$$W_c = \frac{24M_P}{L}$$

True collapse load is least of above beam mechanism i.e $6.5\frac{M_P}{L}$

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AIR 7  ROHIT KUMAR CE

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AIR 8  VIJAYA NANDAN CE

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AIR 9  ROOPESH MITTAL CE

AIR 10  PRATHAMESH E&T

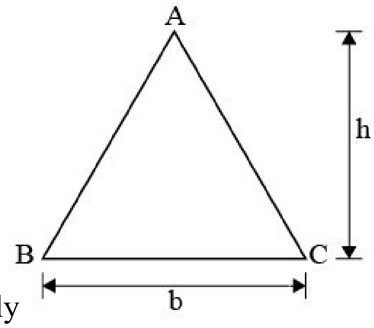
AIR 10  MILAN KRISHNA EE

AIR 10  SRICHAND POONIYA CE

| TOTAL SELECTIONS in Top 10 | E&T TOP 10 | EE TOP 10 | CE TOP 10 | ME TOP 10 |
|---|---|---|---|---|
| 34 | 10 | 10 | 8 | 6 |

and many more...

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



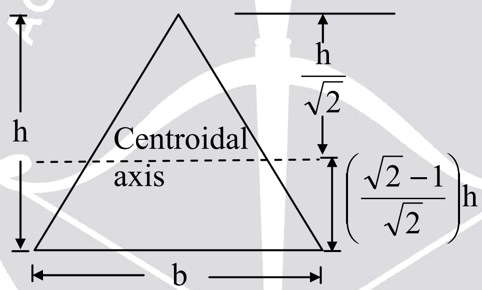

The shape factor will be nearly

(a) 2.3 (b) 3.2

(c) 4.1 (d) 5.0

48. **Ans: (a)**

**Sol:**




Shape factor $= \frac{Z_P}{Z_e}$

Section modulus, $Z_e = \frac{I}{y_{max}}$

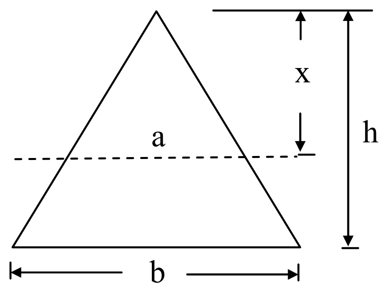
Moment of Inertia, about C.G

$$I = \frac{bh^3}{36}$$

$$y_{max} = \frac{2h}{3}$$

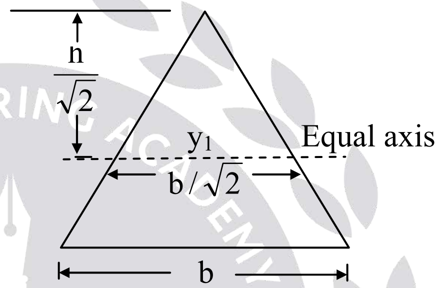
$$Z_e = \frac{bh^3}{36}.\frac{3}{2h}$$

$$Z_e = \frac{bh^2}{24}$$




Plastic modulus, $Z_p = \frac{A}{2}(y_t + y_b)$

Given, $x = \frac{h}{\sqrt{2}}$




$\frac{x}{a} = \frac{h}{b}$

$a = \frac{b}{\sqrt{2}}$

$y_t = \frac{1}{3}\frac{h}{\sqrt{2}} = 0.236\,h$

$y_b = \frac{1}{3}\left(\frac{2b + \frac{b}{\sqrt{2}}}{b + \frac{b}{\sqrt{2}}}\right)\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)h$

$y_b = 0.155\ h$

$Z_P = \frac{1}{2}\left(\frac{1}{2}b \times h\right)(0.236\,h + 0.155\,h)$

$Z_P = 0.09775\ bh^2$

Shape factor $= \frac{Z_p}{Z_e} = \frac{0.09775bh^2}{\frac{bh^2}{24}}$

S = 2.34

49. Fatigue in RCC beams will **not** be a problem if the number of cycles is less than

(a) 20,000 (b) 25,000

(c) 30,000 (d) 35,000

**49. Ans: (*)**

End of Solution

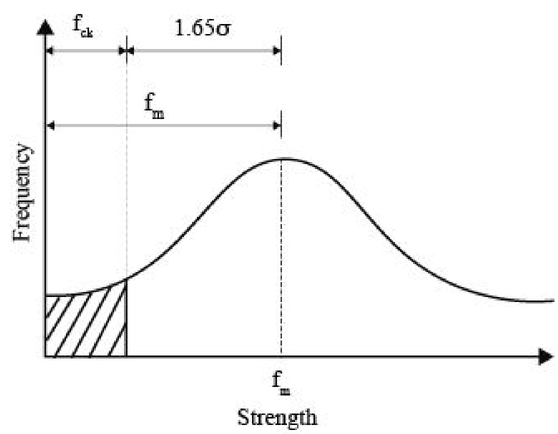
50. The desired characteristic strength of a mix is 20 N/mm$^2$. The standard deviation is 4 N/mm$^2$ for 150 mm size of concrete cubes; and K = 1.645. The average strength of the cubes will be nearly

(a) 38.2 N/mm$^2$ (b) 32.4 N/mm$^2$

(c) 26.6 N/mm$^2$ (d) 22.8 N/mm$^2$

**50. Ans: (c)**

**Sol:**




$f_m = f_{ck} + 1.645\sigma$

$= 20 + 1.645 \times 4$

$= 26.58$ N/mm$^2$

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 M 25, and the value of $\rho_g = \frac{A_{SC}}{A_g} = 2\%$ for Fe 415 steel. The design diameter of the column will be nearly

(a) 446 mm
(b) 432 mm
(c) 424 mm
(d) 410 mm

**51. Ans: (a)**

**Sol:** Factored load, $P_u = 1.5P$

$= 1.5 \times 1600 = 2400$ kN

Load carrying capacity of a circular column with lateral ties (General case)

$P_u = 0.4\ f_{ck}\ A_c + 0.67\ f_y\ A_{sc}$

$2400 \times 10^3 = 0.4 \times 25 \times (A_g - A_{sc}) + 0.67 \times 415 \times A_{sc}$

$$= 0.4 \times 25 \times \left(A_g - \frac{2}{100}A_g\right) + 0.67 \times 415 \times \frac{2}{100}A_g$$

$= 9.8\ A_g + 5.6\ A_g = 15.4\ A_g$

$A_g = 155844.16\ \text{mm}^2$

$$\frac{\pi}{4}D^2 = 155844.16$$

$D = 445.45\ \text{mm} \simeq 446\ \text{mm}$

52. A struct 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

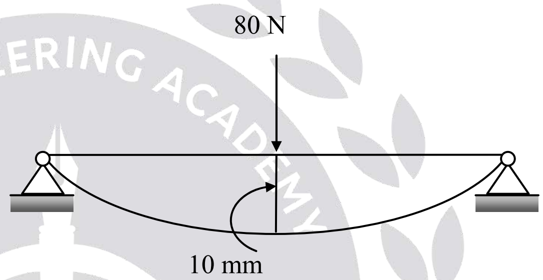
(a) 8485 N (b) 8340 N

(c) 8225 N (d) 8110 N

**52. Ans: (c)**

**Sol:** Due to transverse load of 80 N

$$y_{max} = \frac{w\ell^3}{48EI}$$




$$10 \text{ mm} = \frac{(80)(5000)^3}{48EI}$$

$$EI = 20833 \times 10^6 \text{ N-mm}^2$$

Buckling load (with pin ends)

$$P_e = \frac{\pi^2}{\ell^2}EI$$

$$P_e = \frac{\pi^2}{(5000)^2}(20833\times10^6)$$

$$= 8224.67 \text{ N} \simeq 8225 \text{ N}$$

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/step

**53. Ans: (b)**

**Sol:** As per IS:875, the recommended imposed load on staircase

For Residential builds: 3 kN/m$^2$

For Public buildings: 5 kN/m$^2$ (Over crowd)

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 125 kN/m$^2$, unit weight of 17.5 kN/m$^3$ and angle of shearing resistance of 30$^o$. The depth of footing will be nearly

(a) 0.8 m (b) 0.7 m

(c) 0.6 m (d) 0.5 m

**54. Ans: (a)**

**Sol:** Depth of footing as per Rankine theory

$$D = \frac{P}{r}\left[\frac{1-\sin\phi}{1+\sin\phi}\right]^2$$

$$= \frac{125}{17.5}\left[\frac{1-\sin 30}{1+\sin 30}\right]^2 = 0.79 \simeq 0.8 \text{ m}$$

End of Solution

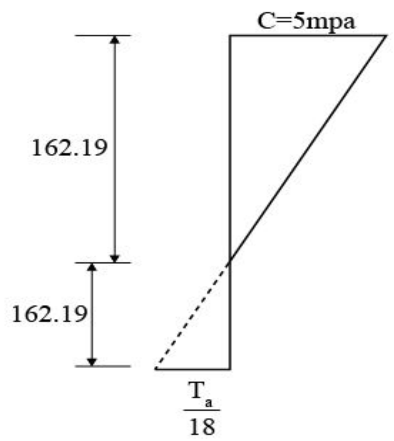
55. A rectangular beam 200 mm wide has an effective depth of 350 mm. It is subjected to a bending moment of 24,000 Nm. The permissible stresses are c = 5 N/mm$^2$, t = 140 N/mm$^2$; and m is 18. The required area of tensile reinforcement will be

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

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

**55. Ans: (b)**

**Sol:**



Design constants

$$K = \frac{m}{m+r} = \frac{18}{18+\frac{140}{5}} = 0.39 \simeq 0.4$$

$$J = 1-\frac{K}{3} = 1-\frac{0.4}{3} = 0.87$$

$$Q = \frac{1}{2}JK = \frac{1}{2}\times 5\times 0.87\times 0.4 = 0.87$$

Moment of Resistance of B.S

$$MR = Qbd^2 = 0.87 \times 200 \times 350^2 = 21.315 \times 10^6 \text{ N-mm}$$

$$= 21.315 \text{ kN-m}$$

B.M > M.R $\therefore$ O.R.S

Actual depth of N.A ($x_a$)

$$B.M = \frac{1}{2}Cbx_a\left(d-\frac{x_a}{3}\right)$$

$$24\times 10^6 = \frac{1}{2}\times 5\times 200x_a\left(300-\frac{x_a}{3}\right)$$

$$x_a = 162.19 \text{ mm}$$

$$\frac{C}{x_a} = \frac{\frac{T_a}{m}}{d-x_a}$$

$$\frac{5}{162.19} = \frac{\frac{T_a}{18}}{350-162.19}$$

$$T_a = 104.2 \text{ N/mm}^2$$

Area of tension steel required

$$C = T$$

$$\frac{1}{2}Cbx_a = T_a.A_{st}$$

$$\frac{1}{2}\times 5\times 200\times 162.19 = 104.2\times A_{st}$$

$$A_{st} = 778.26 \text{ mm}^2$$

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

**56. Ans: (d)**

**Sol:**

- Rich mixes exhibit a relatively greater shrinkage than lean mixes since the contraction of the cement gel increases with the cement content.
- The rate and amount of shrinkage will depend very much upon the ratio of surface area to volume of the member, to minimise shrinkage lesser surface area of coarse aggregate to selected.
- Aggregates of rock types having high modulus of elasticity and low values of deferred strain are more effective in restraining the contraction of the cement paste.

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

**57. Ans: (c)**

**Sol:** The corner and edge columns during earthquakes may be subjected to combined biaxial bending and torsion.

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

(a) 4 (b) 6

(c) 8 (d) 10

**58. Ans: (a)**

**Sol:** The minimum number of bars required in a rectangular column for an earthquake resist design : 4

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

**59. Ans: (b)**

**Sol:** Efflorescence of bricks does not affect the strength of brick or brick masonry. Hence, correct option is (b)

End of Solution

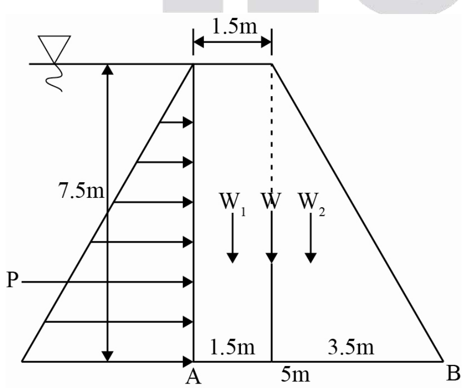
60. A masonry dam 8 m high, 1.5 m wide at the top and 5 m wide at the base retains water to a depth of 7.5 m, the water face of the dam being vertical. If the weight of water is 9.81 kN/m$^3$, weight of masonry is 22 kN/m$^3$, the maximum intensity of stress developed at the base will be nearly

(a) 196 kN/m$^2$ (b) 182 kN/m$^2$

(c) 160 kN/m$^2$ (d) 148 kN/m$^2$

**60. Ans: (b)**

**Sol:**



Total water pressure = $\gamma H^2/2$

Taking moments about 'B' overturning moment due to water pressure $=\left(\frac{\gamma H^2}{2}\right)\times\frac{H}{3}$

$$=\frac{\gamma H^3}{6}=9.81\times\frac{7.53^3}{6}=689.76\,\text{KNm/m}$$

Resisting moment = $W_1\times\left(3.5+\frac{1.5}{2}\right)+W_2\left(2\times\frac{3.5}{3}\right)$

$W_1$ = 22 ×1.5×8=264 kN/m length of dam

$W_2$ = 22×0.5×3.5×8=308 kN/m length of dam

Resisting moment = 264(4.25)+(308×7/3)

= 1122 + 718.67

= 1840.67 kNm/m.

Net moment = 1840.67 – 689.76

= 1150.91 kNm

Total downward force = $W_1 + W_2$

= 264 + 308 = 572 kN

Point of application of resultant force from B

$$=\frac{M}{P}=\frac{1150.91}{572}$$

= 2.01 m

Eccentricity

$$e=\frac{b}{2}-\bar{x}=\frac{5}{2}-2.01=0.49\text{m}.$$

Maximum pressure occurs at the

$$=\frac{\sum W}{b}\left(1+\frac{6e}{b}\right)$$

$$=\frac{572}{5}\left(1+\frac{6\times 0.49}{5}\right)$$

= 181.66 kN/m$^2$

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

**61. Ans: (a)**

**Sol:**

Given data

Volume of front - end loader bucket capacity (V) = 1.5 $m^3$ /cycle

Cycle time (CT) = 1.2 minutes

= 1.2×60 = 72 sec

$$\text{Output capacity of loader} = \frac{\text{Volume of bucket} \times 3600}{\text{cycle time}} \times (\text{factors if any})$$

$$= \frac{1.5 \times 3600}{72} \times (1 \times 1) = 75 \text{ m}^3/\text{hr}$$

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

**62. Ans: (a)**

**Sol:** Project Planning and scheduling techniques

1. Charts:

i) Horizontal bar chart

ii) Linked bar chart

iii) Mile stone chart

2. Network Diagrams:

i) CPM

ii) PERT

3. Precedence Network:

4. Line of Balance

Linear Programme Chart is not existing.

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

**63. Ans: (b)**

**Sol:** Initial cost (P) = 2,00,000

Salvage value (SV) = 50,000

Life period (n) = 5 years

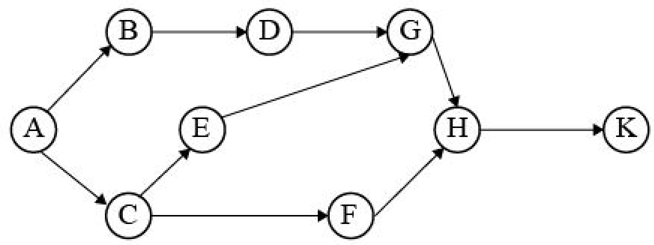
Rate of depreciation $= \frac{1}{n}$

$= \frac{1}{5} = 0.2$

Total depreciation = P – SV

= 2,00,000 – 50000 = 1,50,000/-

64. Consider the following assembly with different operations:



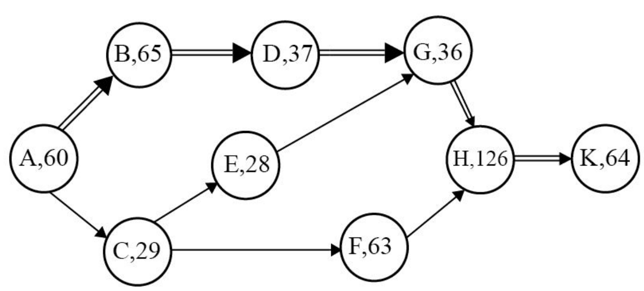

| Operation | Standard time minutes |
|---|---|
| A | 60 |
| B | 65 |
| C | 29 |
| D | 37 |
| E | 28 |
| F | 63 |
| G | 36 |
| H | 126 |
| K | 64 |

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

**64. Ans: (a)**

**Sol**:



| Path | Duration |
|---|---|
| A – B – D – H – K | 388 |
| A – C – E – G – H – K | 343 |
| A – C – F – H – K | 342 |

Time required to complete one product = 388 min.

Total time required to produce 4000 units = 4000 × 388

= 15,52,000 min

Available time = 250 × 8 × 60 = 1,20,000 min

Minimum number of work stations $= \frac{\text{Total time required}}{\text{Available time}}$

$= \frac{15,52,000}{1,20,000} = 12.93 \approx 13$

End of Solution

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

(a) Compaction (b) Consolidation

(c) Grading (d) Ditch digging

**65. Ans: (c)**

**Sol**: Flattening and smoothing by road roller is called Compaction.

Flattening and smoothing by scrapper is called grading

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

**66. Ans: (b)**

**Sol:** Free float is a permissible delay period within which the activity can be delayed without affecting the occurrence of next activity.

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

**67. Ans: (b)**

**Sol:** Crew : 2 carpenters

1 helper

Hourly rate of crew = $(2 \times 85 + 69.5)$

$= 239.5$

Average hourly rate per worker $= \dfrac{239.5}{3} = 79.83$

$\simeq 80$

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%

**68. Ans: (c)**

**Sol:** Labour cost = 20% of project cost

$= 0.2 \times 100$

$= 20$ Cr

Productive cost $= 0.4 \times 20$

$= 8$ Cr

Non-productive cost $= 0.6 \times 20 = 12$ Cr

Savings by improved method = 0.15 × Non-productive cost

$= 0.15 \times 12$

$= 1.8$ Cr

$$\% \text{ of savings} = \frac{1.8}{8} \times 100.8 \quad = 22.5\%$$

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 tin standard man days is 1200

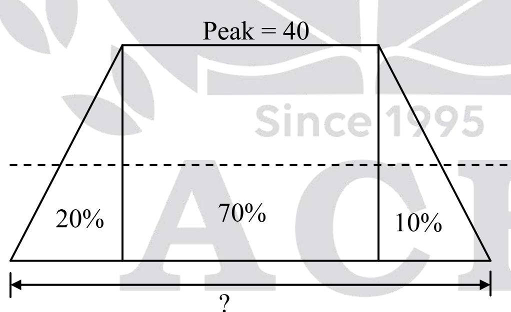
The duration of work by Trapezoidal manpower distribution pattern will be

(a) 5.5 weeks (b) 6.5 weeks

(c) 7.5 weeks (d) 8.5 weeks

**69. Ans: (a)**

**Sol:**




$$\text{Average number of workers/day} = \frac{1}{2} \times 0.2 \times 40 + 0.7 \times 40 + \frac{1}{2} \times 0.1 \times 40$$

$= 34$

Working time/week = over time ×number of working days = 1.5 × 5 = 6.5 days

No. of man days available = 6.5 × 34 = 221

No. of man days required = 1200

$$\text{No. of weeks required} = \frac{1200}{221} = 5.42 \simeq 5.5 \text{ weeks}$$

# ESE / GATE / PSUs - 2020 ADMISSIONS OPEN

| CENTER | COURSE | BATCH TYPE | DATE |
|---|---|---|---|
| HYDERABAD - DSNR | GATE + PSUS – 2020 | Regular Batches | 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019 |
| HYDERABAD - DSNR | ESE + GATE + PSUs - 2020 | Regular Batches | 21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019 |
| HYDERABAD - DSNR | GATE + PSUs - 2020 | Short Term Batches | 29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019 |
| HYDERABAD - DSNR | GATE + PSUs - 2020 | Morning/Evening Batch | 21st Jan 2019 |
| HYDERABAD - DSNR | ESE – 2019 STAGE-II (MAINS) | Regular Batch | 17th Feb 2019 |
| HYDERABAD - Abids | GATE + PSUS – 2020 | Regular Batches | 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019 |
| HYDERABAD - Abids | GATE + PSUs - 2020 | Short Term Batches | 29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019 |
| HYDERABAD - Abids | ESE + GATE + PSUs - 2020 | Morning Batch | 21st Jan 2019 |
| HYDERABAD - Abids | ESE – 2019 STAGE-II (MAINS) | Regular Batch | 17th Feb 2019 |
| HYDERABAD - Abids | GATE + PSUs - 2020 | Weekend Batch | 19th Jan 2019 |
| HYDERABAD - Abids | ESE+GATE + PSUs - 2020 | Spark Batches | 11th May, 09th June 2019 |
| HYDERABAD - Kukatpally | GATE + PSUs - 2020 | Morning/Evening Batch | 21st Jan 2019 |
| HYDERABAD - Kukatpally | GATE + PSUS – 2020 | Regular Batches | 17th May, 1st, 16th June, 1st July 2019 |
| HYDERABAD - Kukatpally | GATE + PSUs - 2020 | Short Term Batches | 29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019 |
| HYDERABAD - Kothapet | ESE + GATE + PSUS – 2020 | Regular Batches | 21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019 |
| HYDERABAD - Kothapet | ESE+GATE + PSUs - 2020 | Spark Batches | 11th May, 09th June 2019 |
| DELHI | ESE+GATE+PSUs - 2020 | Weekend Batches | 13th Jan, 2nd Feb 2019 |
| DELHI | ESE+GATE+PSUs - 2020 | Regular Evening Batch | 18th Feb 2019 |
| DELHI | ESE+GATE+PSUs - 2020 | Regular Day Batch | 11th May 2019 |
| DELHI | ESE+GATE+PSUs - 2020 | Spark Batch | 11th May 2019 |
| DELHI | ESE+GATE+PSUs - 2021 | Weekend Batch | 13th Jan 2019 |
| DELHI | GATE+PSUs - 2020 | Short Term Batches | 11th, 23rd May 2019 |
| BHOPAL | ESE + GATE+PSUs - 2020 & 21 | Evening Batch | 09th Jan 2019 |
| BHOPAL | ESE+GATE+PSUs - 2020 | Regular Day Batch | 01st Week of June 2019 |
| PUNE | GATE+PSUs - 2020 | Weekend Batch | 19th Jan 2019 |
| PUNE | ESE+GATE+PSUs - 2021 | Weekend Batch | 26th Jan 2019 |
| BHUBANESWAR | GATE+PSUs - 2020 & 21 | Weekend Batch | 12th Jan 2019 |
| BHUBANESWAR | GATE+PSUs - 2020 | Regular Batch | 02nd Week of May 2019 |

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 attainabale standards is called

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

**70. Ans: (c)**

**Sol**: **Safety Inspection:** A formalized and properly documented process of identifying hazards in the workplace. It can also be called as 'Safety Audit'

**Safety Plan**: A formal procedure to be followed to ensure safety of workers at a work place. It generally contains rules and regulations to be followed and the site plan map.

**Safety Committee**: A group of members from management, workforce from all departments to promote and communicate safety and health at a work place.

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) 6 (c) 7 (d) 8

**71. Ans: (d)**

**Sol:** No. of workers/week = 100

Working hours/week = 50

Project duration = 35 weeks

Project duration in lakhs of man hours $= \frac{35 \times 50 \times 100}{10^5}$

$= 1.75$ lakh man hrs

No. of injuries = 14

Injury frequency rate $= \frac{\text{No. of injuries}}{\text{Man hrs in lakh}}$

$= \frac{14}{1.75} = 8$

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

**72. Ans: (b)**

**Sol:** Mile stone chart is a graphical representation of a project in which the project activities are identified by horizontal bars. The long duration activity can be divided into key segmental elements. Events are known as mile stones which show the occurance as well as completion of a particular segment.

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 10m, the angle of displacement of the plumb line is 2°16′. The metacentric height will be nearly

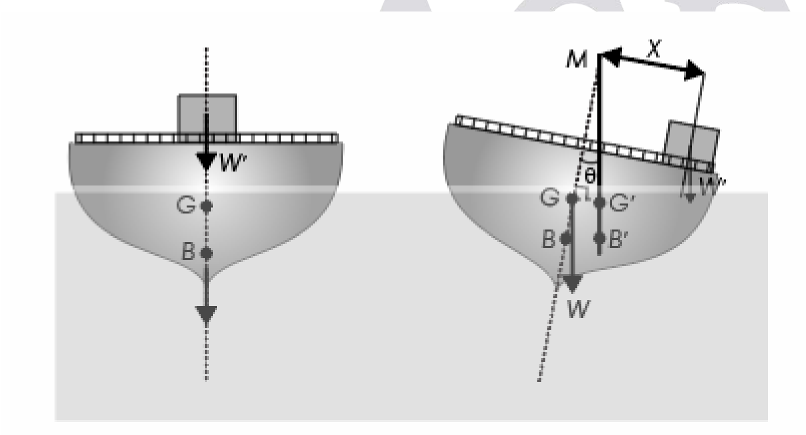
(Take sin 2°16′ = 0.04, cos 2°16′ = 0.9992 and tan 2°16′ = 0.04)

(a) 1.73 m (b) 1.42 m

(c) 1.18 m (d) 0.87 m

**73. Ans: (c)**

**Sol:**



Experimental determination of meta centric height

$$\overline{GM} = \frac{W'x}{(W + W')\tan\theta}$$

$W'$ = Movable weight on a ship = 600 kN

x = Transverse displacement of weight $W'$ = 10 m

W = Weight of ship alone = 127 MN

$\theta$ = Angle of tilt = $2^o\ 16'$

$\tan\theta = 0.04$

$$\overline{GM} = \frac{0.6\times 10}{(127+0.6)\times 0.04}$$

$$= \frac{0.6\times 10\times 100}{127.6\times 4}$$

$$= \frac{600}{4\times 127.6} = \frac{150}{127.6} = 1.18 \text{ m}$$

Slightly less than $\frac{6}{5}$

Slightly less than 1.2

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

**74. Ans: (b)**

**Sol:** For adiabatic flow

Bernoullis Equation is

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

$\because$ the flow is frictionless ($h_L = 0$)

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

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

**75. Ans: (b)**

**Sol:** **Magnus Effect:** The lifting effect generated on a rotating body when placed in a stream of fluid.

**Ex:** Backspin of a table tennis ball

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

**76. Ans (b)**

**Sol:**

- Before and after the jump formation, the flow is essentially one-dimensional
  Hence assumption '1' is wrong.
- The channel floor is horizontal (or) the slope is gentle so that the weight component of the water mass comprising the jump is very less. Hence assumption '3' is wrong.
- Only assumption '2' is correct

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

**77. Ans: (b)**

**Sol: For each identical pump**

$$N_s = \frac{N\sqrt{Q}}{H^{3/4}}$$

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

$$H^{3/4} = \frac{10}{9}\sqrt{150} = \frac{10}{9}\times 12.247 = 13.6$$

$$H = 32.46$$

No of pumps to be connected in series

$$= \frac{\text{Total Head}}{\text{Head of each pump}}$$

$$= \frac{95}{32.46} = 2.92$$

Say '3'

**Note:** Difficult to do with out calculator

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

**78. Ans: (b)**

**Sol**: The jet velocity is given by

$$V = \frac{Q}{a} = \frac{0.18}{7500\times10^{-6}} = 24\ m/s$$

Head lost in nozzle ($h_{fn}$) is given by

$$h_{fn} = H - \frac{V^2}{2g}$$

$\therefore$ Power lost in nozzle = $\rho\ g\ Q\ h_{fn}$

$$= \rho g Q\left[H - \frac{V^2}{2g}\right] \quad = \rho g Q H - \frac{\rho Q}{2}V^2$$

$$= 9810\times0.18\times32 - \frac{1000\times0.18\times24^2}{2}$$

$$= 4.67\ kw$$

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

**79. Ans: (d)**

**Sol**: Hydro power plant with small or no storage of water is called run of river hydro power plant.

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%

**80. Ans: b**

**Sol**: Plant capacity = sum of capacity of each unit

$= 2 \times 25,000$

$= 50,000$ kW

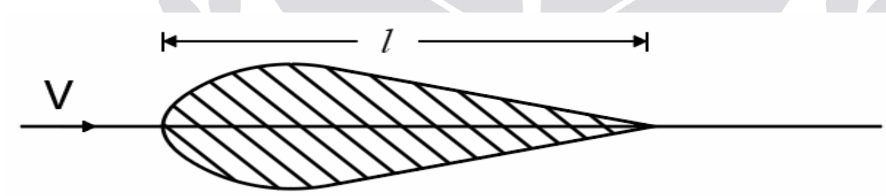
The load factor is defined as

$$\text{Load factor} = \frac{\text{Average load}}{\text{Maximum load}}$$

$$= \frac{\frac{1}{2}(15,000 + 40,000)}{40,000} = 0.6875$$

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

**81. Ans: (b)**

**Sol:** Since the separation takes place much later, the wake formation is minimum and consequently small pressure drag.

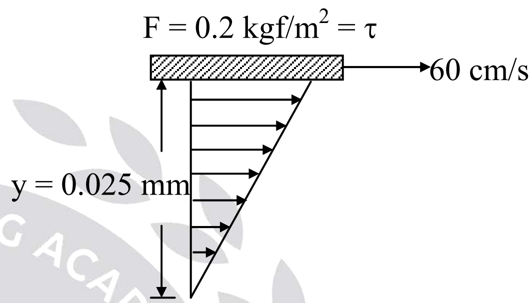
82. A plate 0·025 mm distant from a fixed plate moves at 60 cm/s and requires a force of 0·2 kgf/m$^2$ to maintain this speed. The dynamic viscosity of the fluid between the plates will be nearly

(a ) $9{\cdot}2 \times 10^{-10}$ kgfs/cm$^2$ (b) $8{\cdot}3 \times 10^{-10}$ kgfs/cm$^2$

(c) $7{\cdot}4 \times 10^{-10}$ kgfs/cm$^2$ (d) $6{\cdot}5 \times 10^{-10}$ kgfs/cm$^2$

**82. Ans: (b)**

**Sol:** $\tau = \mu \dfrac{dv}{dy}$ $\tau = 0.2 \times 10^{-4}$ kgf/cm$^2$




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

$$\mu = \frac{0.2\times10^{-4}\times0.025}{60} = \frac{0.0050}{60}\times10^{-4}$$

$$= \frac{50\times10^{-9}}{60} = \frac{5}{6}\times10^{-9} = 8.3\times10^{-10}\ \text{kgf/cm}^2$$

**Note:** This can be done with out calculator

End of Solution

83. Which of the following are component parts for an oil pressure governor in modem 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

**83. Ans: (a)**

**Sol:** Governing of turbines is executed by servomechanism which consists of

1. Servomotor ( relay cylinder)
2. Oil sump
3. Oil pump drive

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 $m^3$ 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

**84. Ans: (c)**

**Sol**: Theoretical discharge for double acting reciprocating pump is given by

$$Q_{th} = \frac{2(A - A_p)LN}{60} \approx \frac{2ALN}{60}$$

Where $A_p$ = Area of piston rod.

$$\therefore Q_{th} = \frac{2 \times 0.1 \times 0.3 \times 45}{60} = 0.045\, m^3/s$$

Slip = $Q_{th}$ – Q = 0.045 – 0.04 = 0.005 $m^3$/s

The power required to drive the pump is given by

$$P = \frac{\rho g Q[H + h_f]}{\eta_o}$$

Assuming overall efficiency 1 & neglecting frictional losses

$$P = \frac{9810 \times 0.04 \times 10}{1} = 3.92\, kW$$

**Note:** If 'g' is considered as 10 m/$s^2$ and theoretical discharge is considered instead of actual discharge then answer is 4.4 kW.

End of Solution

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

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

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

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

**85. Ans: (d)**

**Sol:** Empirical IDP formula by Sherman

$$i = \frac{a}{(d+b)^e}$$

i = rainfall intensity (mm/hour)

d = duration in mins

a, b & e are constants

Similarly,

$$i = \frac{a}{(t+b)^n}$$

a, b & n are constants

t – time

i – intensity of rainfall

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.

**86. Ans: (d)**

**Sol:** The distance between the rainguage and nearest obstruction should be atleast twice the height of obstruction.

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

**87. Ans: (a)**

**Sol: Retarding Reservoirs:**

A retarding reservoirs is the one in which the spillway and outlets are not controlled by gates or valves.

**Advantages:**

→ No gates at the outlets and hence the possibility of human error in reservoirs operation is eliminated.

→ The cost of expensive gate installation and operation is saved.

**Disadvantages:**

→ Automatic regulation may cause coincedence of flood crest farther downstream where two or more channels taking off from retarding reservoirs join together.

All statements 1, 2 and 3 are related to retarding reservoirs.

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) $\frac{Q}{2.72\Delta S}$ (b) $\frac{Q}{1.72\sqrt{\Delta S}}$ (c) $\frac{Q}{2.72}\Delta S$ (d) $\frac{Q}{2.72}\sqrt{\Delta S}$

**88. Ans: (a)**

**Sol**: Confined Aquifer:-

$$Q = \frac{2\pi T(S_1 - S_2)}{\ln(r_2 / r_1)}$$

$$T = \frac{Q \times \ln(r_2 / r_1)}{2\pi(S_1 - S_2)}$$

$$T = \frac{Q}{\Delta S} \times \frac{\ln(r_2 / r_1)}{2\pi}$$

Assume $r_2 = 100$ m & $r_1 = 10$ m

$$T = \frac{Q}{\Delta S} \times \frac{\ln(100/10)}{2\pi}$$

$$T = \frac{Q}{\Delta S} \times \frac{\ln(10)}{2 \times 3.142}$$

$$T = \frac{Q}{\Delta S} \times \frac{2.3}{6.284}$$

$$T = \frac{Q}{\Delta S} \times 0.366$$

$$T = \frac{Q}{2.72\,(\Delta S)}$$

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

**89. Ans: (c)**

**Sol:** The water stored in the reservoir below the minimum pool level is called dead storage.

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 irrigation

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

**90. Ans: (b)**

**Sol:** Flow irrigation will have components

1. River canal irrigation
2. Reservoir or tank irrigation and
4. Combined storage and diversion irrigation only, lift irrigation is not included.

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%

**91. Ans: (d)**

**Sol:** d = 2m

mc = 5% Volume Supplied = 500 $m^3$

$$S = \frac{\gamma}{\gamma_w} = \frac{15}{9.81}$$ Loss = 10%

$d_w$ = Sd( FC-mc) Net volume = 0.9 × 500 = 450 m$^3$

Volume = A $d_w$

$$450 = 1000 \times \frac{15(2)}{9.81} \times \frac{(FC-5)}{100}$$

$\Rightarrow$ FC = 19.7%

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

**92. Ans: (b)**

**Sol:** $$SAR = \frac{Na^+}{\sqrt{\frac{Mg^{++}+Ca^{++}}{2}}} = \frac{24}{\sqrt{\frac{3.6+2}{2}}} = 14.3$$

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.

The weir is of the type

(a) Vertical drop weir (b) Masonry or concrete sloping weir

(c) Dry stone slope weir (d) Parabolic weir

**93. Ans: (b)**

**Sol:** Masonry or concrete slope weir is the one suitable for soft sandy foundations. It is used where difference in weir crest and downstream river is limited to 3 meters.

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 throat = 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

**94. Ans: (b)**

**Sol:** Mitra's transition

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

Given

$B_n = 15$ m

$B_f = 9$ m

$L_f = 16$ m

**at x = 8 m**

$$B_x = \frac{15(9)(16)}{16(15) - 6(8)}$$

$$= \frac{15(9)(16)}{192} = 11.25\,\text{m}$$

**at x = 16 m**

$$B_x = \frac{15(9)(16)}{16(15) - 6(16)} = \frac{15(9)(16)}{144} = 15\,\text{m}$$

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

**95. Ans: (b)**

**Sol:** Tile drain

$$\frac{4K(b^2 - a^2)}{L} = \frac{\overline{P}L}{100 \times 86400}$$

$$\frac{4(10^{-5})(10.3^2 - 10^2)}{50} = \frac{\overline{P}\ 50}{100\ (86400)}$$

$\Rightarrow \overline{P} = 0.84\,\text{m} = 84$ 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

**96. Ans: (c)**

**Sol:** Main purpose of groyne is as a river training work

i.e., to train the flow along a certain course

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

**97. Ans: (d)**

**Sol**: Methemoglobinema also known as blue baby syndrome caused by Nitrates (Nitrate nitrogen)

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 $\gamma = 1$

The height and 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

**98. Ans: (c)**

**Sol:** $\sigma = \gamma_w H (G - C + 1)$

$$H = \frac{\sigma}{\gamma_w (G - C + 1)} = \frac{3500}{1(2.4 - 0.6 + 1)} = 125 \text{ m}$$

$$B = \frac{H}{\sqrt{G - C}} = \frac{125}{\sqrt{2.4 - 0.6}} = 93.16 \text{ m} \simeq 93 \text{ m}$$

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*

**99. Ans: (c)**

**Sol**: $Q = 25000\ m^3/day = 25\ MLD$

Total $Cl_2$ usage = 9 kg/day

Total $Cl_2$ usage : Q × $Cl_2$ dose

9(kg/day) : 25(MLD) × $Cl_2$ dose(mg/l)

$Cl_2$ dose : $\frac{9}{25}$ mg/lit

Residual $Cl_2$ = 0.2 mg/l

$Cl_2$ demand = $Cl_2$ dose – Residual $Cl_2$

$$= \frac{9}{25} - 0.2 = 0.16\ mg/l$$

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 consideration will be

(a) 1025 $m^2$ (b) 1075 $m^2$

(c) 1125 $m^2$ (d) 1175 $m^2$

**100. Ans: (c)**

**Sol**: Q = Population × per capita water demand

$Q_{min} = 1.5\ Q$

$= 1.5 \times 100000 \times 150$ lit / day

Surface over flow rate = 20000 lit/day/$m^2$

Surface area of sedimentation tank = $\frac{Q}{SOR}$

$$= \frac{1.5 \times 100000 \times 150}{20000} = 1125 m^2$$

# ESE / GATE / PSUs - 2020 ADMISSIONS OPEN

| CENTER | COURSE | BATCH TYPE | DATE |
|---|---|---|---|
| CHENNAI | GATE+PSUs - 2020 & 21 | Weekend Batch | 19th Jan 2019 |
| CHENNAI | GATE+PSUs - 2020 | Regular Batch | 02nd Week of May 2019 |
| BANGALORE | GATE+PSUs - 2020 & 21 | Weekend Batch | 19th Jan 2019 |
| BANGALORE | GATE+PSUs - 2020 | Regular Batch | 17th June 2019 |
| BANGALORE | KPSC-AE (CE) – PAPER 1 & PAPER 2 | Regular Batch | 19th Jan 2019 |
| LUCKNOW | ESE+GATE+PSUs - 2020 & 21 | Evening Batch | 06th Feb 2019 |
| LUCKNOW | GATE+PSUs - 2020 | Regular Batch | Mid - May 2019 |
| PATNA | GATE+PSUs - 2020 | Weekend Batch | 19th Jan 2019 |
| TIRUPATHI | GATE+PSUs - 2020 & 21 | Weekend Batch | 19th Jan 2019 |
| KOLKATA | GATE+PSUs - 2020 | Weekend Batch | 19th Jan 2019 |
| KOLKATA | ESE+GATE+PSUs - 2021 | Regular Batch | 19th Jan 2019 |
| AHMEDABAD | ESE+GATE+PSUs - 2020&21 | Weekend Batch | 19th Jan 2019 |
| AHMEDABAD | GATE+PSUs - 2020 | Regular Batch | 02nd Week of June 2019 |

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 rate of 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) 5.9 $m^3/s$

**101. Ans: (b)**

**Sol**: A = 54 ha

R = 50 mm/hr

$$I = \frac{\sum A_i I_i}{A}$$

$$= \frac{0.3\times0.9+0.3\times0.2+0.4\times0.4}{1} = 0.49$$

$$Q_{WWT} = \frac{AIR}{360} = \frac{54\times0.49\times50}{360} = 3.675 m^3/sec \approx 3.7\ m^3/sec$$

End of Solution

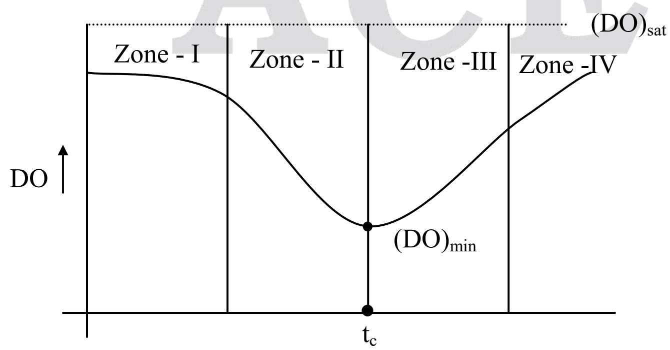
102. Critical dissolved oxygen (D.O) deficit occurs in which one of the following zones of pollution of 'oxygen sag curve' in case of self-purification of natural streams?

(a) Zone of recovery (b) Zone of active decomposition

(c) Zone of degradation (d) Zone of clear water

**102. Ans: (b)**

**Sol**: Critical deficit occur at critical time '$t_c$' which fall in the zone of active decomposition



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*

**103. Ans: (c)**

**Sol**: $\text{SDI} = \frac{100}{\text{SVI}}$ MLSS = 2000 mg/l = 2 gm/lit

$$\text{SVI} = \frac{\text{space occupied}}{\text{MLSS}} = \frac{176}{2} = 88 \text{ ml/gm}$$

$$\text{SDI} = \frac{100}{88}\text{gm/ml} = 1.136 \text{ gm/ml} = 1.14 \text{ gm/ml}$$

SDI = 1.14 gm/ml

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

**104. Ans: (d)**

**Sol**: Principal by product of anaerobic decomposition is methane

End of Solution

105. Consider the following statements with reference to the 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 is 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

**105. Ans: (c)**

**Sol**: Industrial waste water if it contain very high BOD can be mixed to domestic waste water to moderate BOD

Industrial waste water if it contain high pH can also be mixed with domestic waste to neutralize pH.

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

**106. Ans: (a)**

**Sol:** 1 M of $OH^-$ : 1 M of KOH

$\therefore$ KOH : $OH^-$

pH + pOH : 14

pOH = 14 – pH

= 14 – 10

= 4

$OH^- = 10^{-4}$ mol/liter

$\therefore$ KOH = $OH^- = 10^{-4}$ mol/liter

Molecular weight of KOH = 56.105 gm/mol

KOH(mg/lit) = KOH(mg/lit) × Molecular weight of KOH × 1000

= $10^{-4} \times 50.105 \times 1000$

= 5.6105

Total quantity KOH = Q × KOH = 0.8 × 5.6105

= 4.48 ≈ 4.5 kg/day

107. Fanning type of plume behaviour takes place when

(a) Super-adiabatic lapse rate prevails with light to moderate wind speed

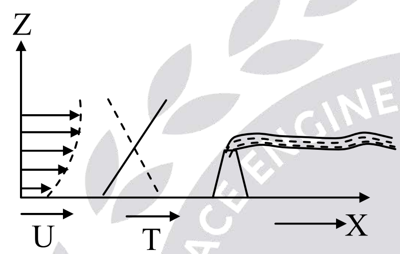
(b) Extreme inversion conditions exist in the presence of light wind

(c) There exists a strong super-adiabatic lapse rate above a surface of inversion

(d) Plume is caught between two inversion layers

**107. Ans: (b)**

**Sol:** Fanning type plume behaviour occur during inversion.




Fanning plume

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

**108. Ans: (b)**

**Sol**: Rate of coal burning = 8 t/hr $= \frac{8\times1000\times1000}{60\times60}\text{gm/sec}$

Total sulphur emission $= \frac{4.5}{100}\times\frac{8\times1000\times1000}{60\times60}\text{gm/sec}$ = 100 gm/sec

$S + O_2 \rightarrow SO_2$

1 part of S = 2 parts of $SO_2$

$SO_2$ emission = 2 × 100 = 200 gm/sec

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

**109. Ans: (a)**

**Sol:** **Thixotropy:** It is the property by virtue of which the soil regains, if left alone for a time, a part of the strength lost due to remoulding, at constant moisture content.

**Sensitivity:** It is the ratio of the undisturbed compressive strength to the remoulded compressive strength of the same soil at unaltered water content.

**Consistency:** It indicates the relative ease with which a soil can be deformed.

$$\textbf{Activity} = \frac{\text{Plasticity Index}}{\text{\% of soil particles weight finer than } 2\mu}$$

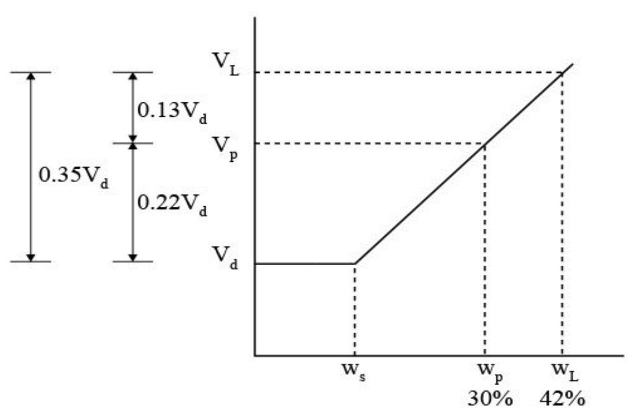
End of Solution

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

**110. Ans: (d)**

**Sol:**



$$\text{Shrinkage Ratio, SR} = \frac{\frac{V_L - V_P}{V_d} \times 100}{w_L - w_P}$$

$$= \frac{\frac{0.13V_d}{V_d} \times 100}{42 - 30} = \frac{13}{12} = 1.1$$

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

**111. Ans: (c)**

**Sol:** **Shrinkage Ratio (SR):** It is defined as the ratio of a given volume change in a soil, expressed as a percentage of the dry volume, to the corresponding change in water content.

$$SR = \frac{\frac{V_1 - V_2}{V_d} \times 100}{w_1 - w_2}$$

End of Solution

112. A masonry dam 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

**112. Ans: (b)**

**Sol:** $i_c = (G_s - 1)(1 - n) = (2.65 - 1)(1 - 0.45) = 0.91$

$$i = \frac{i_c}{FOS} = \frac{0.91}{4} = 0.23$$

113. The representative liquid limit and plastic limit values of a saturated consolidated 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. At a 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$^2$

**113. Ans: (a)**

**Sol:** $I_P = w_L - w_P = 60 - 30 = 30\%$

$\sigma_v' = 8\gamma + 2\gamma'$

Take $\gamma \simeq \gamma_{sat}$ since $\gamma$ is not given

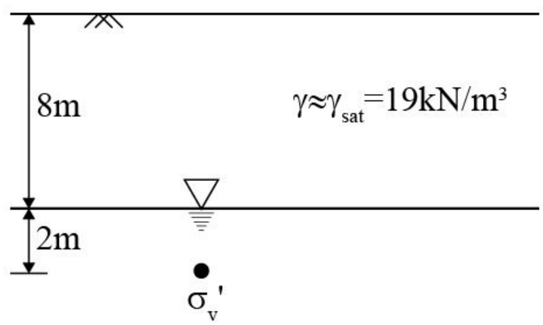
$\sigma_v' = 8 \times 19 + 2[19 - 9.81] = 170.4$ kPa

From Skempton & Henkel,

$$\frac{C_u}{\sigma_v'} = 0.11 + 0.0037 I_p(\%)$$

$$\frac{C_u}{\sigma_v'} = 0.11 + 0.0037 \times 30 = 0.221$$

$C_u = 0.221 \times 170.4 = 37.7$ kPa



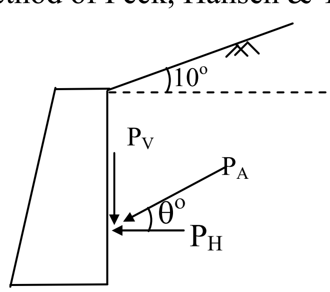

End of Solution

114. A 6 m high retaining wall with a vertical back has a backfill of silty sand with a slope of 10° for the backfill. With values of $K_H$ = 760 kg/m$^2$/m and $K_V$ = 100 kg/m$^2$/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

**114. Ans: (c)**

**Sol:** Using the approximate method of Peck, Hansen & Thornburn



$$\theta^o = \tan^{-1}\left[\frac{P_V}{P_H}\right]$$

$$P_H = \frac{1}{2}\times K_H \times H^2 = \frac{1}{2}\times 760\times 6^2 = 13{,}680 \text{ kg/m} = 136.8 \text{ kN/m}$$

$$P_V = \frac{1}{2}\times K_V.H^2 = \frac{1}{2}\times 100\times 6^2 = 1800 \text{ kg/m} = 18 \text{ kN/m}$$

$$P_A = \sqrt{P_H^2 + P_V^2} = \sqrt{136.8^2 + 18^2} = 138 \text{ kN/m}$$

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

**115. Ans: (c)**

**Sol:** Boussinesq's equation $\sigma_z = \frac{Q}{Z^2}.\frac{3}{2\pi}\left[\frac{1}{1+\left(\frac{r}{Z}\right)^2}\right]^{5/2}$

$$\sigma_z = \frac{Q}{Z^2}k_B$$

Westergaard's equation $\sigma_z = \frac{Q}{Z^2}.\frac{1}{\pi}\left[\frac{1}{1+2\left(\frac{r}{Z}\right)^2}\right]^{3/2} = \frac{Q}{Z^2}k_W$

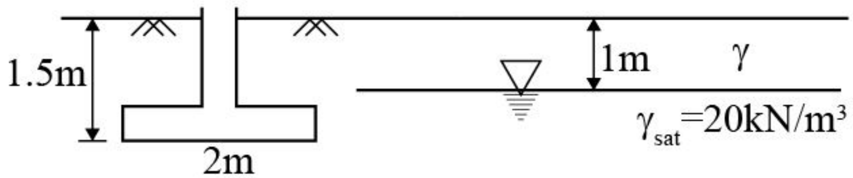
$$\text{For } \frac{r}{Z} \geq 1.5, \quad k_B \simeq k_W$$

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 $\gamma_{sat}$ = 20 kN/m$^3$, $c_u$ = 40 kN/m$^2$, $\phi_u$ = 0, c' = 10 kN/m$^2$ and $\phi'$ = 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$^2$

**116. Ans: (d)**

**Sol:**




The value of $N_c$ is 5.14 for $\phi_u$ = 0 condition

$\therefore$ For $\phi_u = 0$, $q_u = C_uN_c + q'$

$= 40 \times 5.14 + [\gamma \times 1 + \gamma' \times 0.5]$

$= 205.6 + [20 \times 1 + [20 - 10]\ 0.5]$

$= 230.6$ kN/m$^2$

$\gamma$ is taken equal to $\gamma_{sat}$ and $\gamma_w$ = 10 kN/m$^3$

End of Solution

117. The settlement due to secondary compression is predominant in

(a) Granular soil (b) Inorganic clays

(c) Organic clays (d) Very fine sand and silts

**117. Ans: (c)**

**Sol:** Secondary compression is predominant in the case of organic clays.

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

**118. Ans: (d)**

**Sol:** For rectangular footings in clays,

Gross ultimate bearing capacity, $q_u = CN_c\left(1+0.3\frac{B}{L}\right)+(\gamma D_f+q)$

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

$$= 85.5 + 16D_f + 20$$

$$= 105.5 + 16\ D_f$$

Base failure will occur when $q_u$ is equal to zero

$$\therefore\ 0 = 105.5 + 16\ D_f$$

$$D_f = -6.6\text{ m}$$

(the minus sign indicates that it is excavation)

$\therefore$ Critical depth = 6.6 m

$$\text{Safe depth} = \frac{\text{Critical depth}}{\text{Factor of Safety}}$$

$$= \frac{6.6}{1.2} = 5.5\,\text{m}$$

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

**119. Ans: (d)**

**Sol:** Skin frictional resistance of pile in sands, $Q_s = A_s$. k. $\sigma'_{va}$ $\tan\delta$

The skin frictional resistance depends on the lateral earth pressure coefficient (k) and the angle of friction between pile and soil ($\delta$). This angle of friction in turn will depend on the type of pile material.

In the case of sandy soils, effective stress analysis is generally used; not the total stress analysis.

Inview of the above, the correct answer is (d).

End of Solution

120. An excavation is made with a vertical face in a clay soil which has $C_u = 50$ kN/m$^2$, $\gamma_t = 18$ 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

**120. Ans: (a)**

**Sol:** Stability number, $S_n = \dfrac{C}{F_c.\gamma.H}$ or $\dfrac{C}{\gamma.H_c}$

$\therefore$ Critical height, $H_c = \dfrac{C}{S_n.\gamma}$

$$= \frac{50}{0.261 \times 18} = 10.6 \text{ m}$$

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 of survey

(b) Object of surveying

(c) Instruments used

(d) Method employed

**121. Ans ( b)**

**Sol:** Classification based on object of surveying

**(i)** **Engineering survey:** For data collection for designing roads, railways, irrigation and water supply projects.

a) Reconnaissance survey: For feasibility of estimation

b) Preliminary survey: For collecting move details for estimating cost of survey

c) Location survey: To set out the work

**(ii)** **Military survey**

**(iii)** **Mine survey**

**(iv)** **Geological survey**

**(v)** **Archealogical survey**

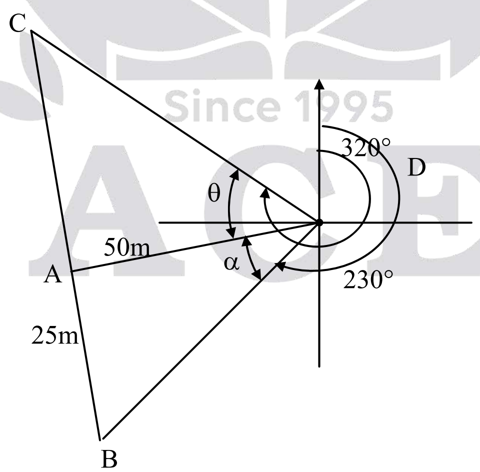
End of Solution

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 perpendicularly 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

**122. Ans: (c)**

**Sol:**




$$\frac{CA}{AD} = \frac{AD}{AB}$$ From similar triangles, $\Delta CDA \approx \Delta ABD$

$$CA = \frac{AD^2}{AD} = \frac{50^2}{25} = 100\,\text{m}$$

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

**123. Ans: (b)**

**Sol:** Correction for refraction is positive.

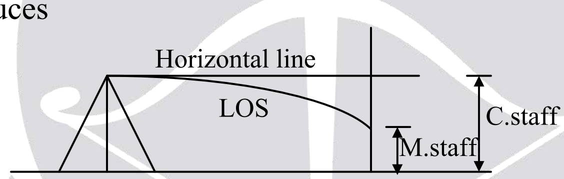
$\Rightarrow$ Error due to refraction is negative

$\Rightarrow$ Measured staff refraction is less than correct staff reading.

(or)

Due to refraction LOS bonds towards earth surface

$\therefore$` staff reading reduces




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

**124: Ans: (c)**

**Sol:** Sidereal Day: The time between 2 consecutive transit of first point of Aries.

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

**125. Ans: (d)**

**Sol:** In order to control the accumulation of errors, subsidiary bases are selected. At certain stations astronomical observation for azimuth and longitude are also made. They are known as 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

**126. Ans: (b)**

**Sol:**

Flying height, H = 1200 m

Elevation, h = 80 m

Focal length, f = 15 cm

= 0.15 m

$$\text{Elevation scale, } S_n = \frac{f}{H-h} = \frac{0.15}{1200-80}$$

$$= \frac{1}{7466.66} = \frac{1}{7467}$$

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

**127. Ans: (d)**

**Sol:** $P_l\,\% = 60\%$ Scale = 1 cm = 100 m = $\dfrac{1}{10,000}$

$P_w\% = 30\%$ $l \times w = 20\text{ cm} \times 20\text{ cm}$

$= 0.2\text{ m} \times 0.2\text{ m}$

Ground area per photograph, $a = (1-P_l\,\%)(1-P_w\%)\dfrac{\ell w}{S^2}$

$$= (1-0.6)(1-0.3)\frac{0.2\times 0.2}{\left(\dfrac{1}{10,000}\right)^2}$$

$= 1120000\text{ m}^2 = 1.12\text{ km}^2$

Total area (A) = 150 km$^2$

$\therefore$ Number of photographs, $N = \dfrac{A}{a}$ numbers

$$= \frac{150}{1.12} = 133.92 \approx 134 \text{ numbers}$$

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.

**128. Ans: (c)**

**Sol:** Transition curve should meet straight line & curved positions tangentially

→ It should have same properties (curvature or radius) as that of straight line & curved positions at their respective junctions

→ It should introduce centrifugal force with curvatures & super elevation with same rate.

Hence option (c) is incorrect.

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

**129. Ans: (d)**

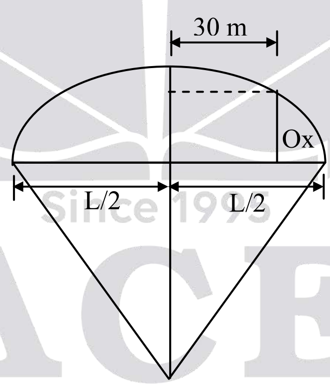
**Sol:** L = 80 m

$$O_x = O_o - \frac{x^2}{2R}$$

$O_o$ =4m

$$\Rightarrow O_o = L\left[1 - \cos\frac{\Delta}{2}\right]$$

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




$$= \frac{\left(\frac{L}{2}\right)^2}{2R} = \frac{L^2}{8R}$$

$$\Rightarrow \frac{L^2}{8R} = 4\,\text{m}$$

$$\Rightarrow \frac{80^2}{8 \times R} = 4\,\text{m}$$

$$\Rightarrow R = 200\text{ m}$$

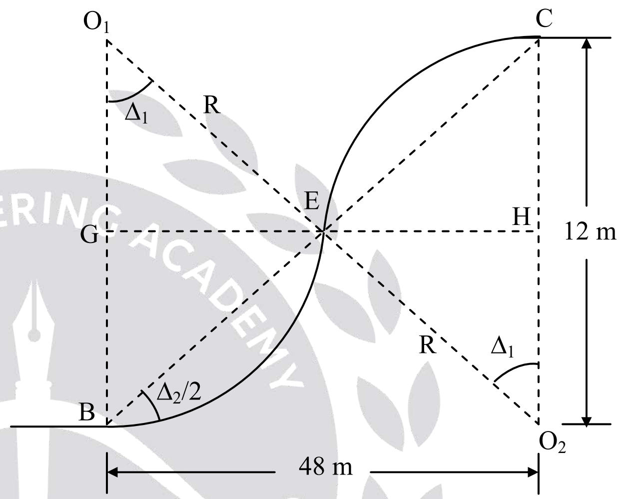
$$\Rightarrow O_x = O_o - \frac{n^2}{2R} = 4 - \frac{30^2}{2 \times 200} = 1.75\text{ m}$$

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 48m, then the maximum allowable radius will be

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

**130. Ans: (a)**

**Sol:** $\tan\left(\frac{\Delta_1}{2}\right) = \frac{12}{48} = \frac{1}{4}$




$\therefore \frac{\Delta_1}{2} = 14^0 2^1$

$\therefore \Delta_1 = 28^0 4^1$

From fig

$GE = R \sin \Delta_1$

$EH = R \sin \Delta_1$

$GH = GE + EH = 48m \;\; = 2R \sin \Delta_1$

$2R \sin \Delta_1 = 48m$

$R = \frac{48}{2 \sin \Delta_1} = \frac{48}{2 \sin 28^0 4^1} = 51.1m$

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°

**131. Ans: (a)**

**Sol:** True bearing remains constant

$\Rightarrow TB = MB_1 \pm D_1 = MB_2 \pm D_2$

$MB_1 = 5°30'$ ; $MB_2 = ?$

$D_1 = 1°E$ $D_2 = 8°30'E$

$5°30' + 1° = MB_2 + 8°30'$

$\Rightarrow MB_2 = -2° \Rightarrow 358°$

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

**132. Ans: (a)**

**Sol:** It is defined as a surface of erosion or non deposition occurring within a sequence of rocks.

End of Solution

133. Consider two cars approaching from the opposite directions at 90 km/h and 60 km/h. If the reaction time is 2.5s, 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

**133. Ans: (d)**

**Sol:** $SSD = SSD_1 + SSD_2$

$$SSD_1 = \nu t + \frac{\nu^2}{2gf\eta}$$

$$= 25 \times 2.5 + \frac{25^2}{2 \times 10 \times (0.7 \times 0.5)}$$

$= 151.78$ m

Similarly

$$SSD_2 = 16.67 \times 2.5 + \frac{16.67^2}{2 \times 10 \times (0.7 \times 0.5)}$$

$= 81.36$ m

$SSD = SSD_1 + SSD_2 = 233.13 \text{ m} \simeq 236 \text{ m}$

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

**134. Ans: (c)**

**Sol:** $W_e = W_m + W_{ps}$

$$= \frac{n\ell^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$= \frac{(2)(6.5)^2}{2 \times 200} + \frac{65}{9.5\sqrt{200}} = 0.211 + 0.48 = 0.7 \text{ m}$$

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%

**135. Ans: (b)**

**Sol:** $S_b = 12.2$ m

$f = 0.7$

$$v = 40 \times \frac{5}{18} = 11.11 \text{ m/s}$$

$$S_b = \frac{v^2}{2gf} = \frac{11.11^2}{2 \times 10 \times 0.7} = 8.81 \text{ m}$$

$$\text{But } S_b = 12.2 = \frac{v^2}{2g\eta f} = \left[\frac{v^2}{2gf}\right] = \frac{1}{\eta}$$

$$\frac{8.81}{\eta} = 12.2$$

$$\eta = \frac{8.81}{12.2} = 72\% \simeq 74\%$$

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

**136. Ans: (a)**

**Sol:** Type of vehicle cannot be justified by automatic counters

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

**137. Ans: (b)**

**Sol:** Vehicle number method is not a part of speed and delay studies.

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

**138. Ans: (c)**

**Sol:** Pressure, $P = \frac{P}{\pi a^2} \Rightarrow \frac{4200}{\pi (a)^2} = 6$

a = 15 cm

Thickness of pavement layer, $h = \sqrt{\frac{3P}{2\pi E\delta} - a^2}$

$$= \sqrt{\frac{3 \times 4200}{2 \times \pi \times 150 \times 0.25} - 15^2} = 51 \text{ cm}$$

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%

**139. Ans: (b)**

**Sol:** For proper drainage in a tunnel

Minimum gradient $= \frac{1}{500} = \frac{1}{500} \times 100 = 0.2\%$

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

**140. Ans: (c)**

**Sol:** Horse shoe tunnel are generally employed in hard rock tunnels where there is a risk of roof failure the arch action.

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

**141. Ans: (c)**

**Sol:** Needle beam method is commonly used method in soft soils.

The other methods are

- Fore poling method
- Belgian method

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

**142. Ans: (d)**

**Sol:** Wind tends to carry drifting sand in a linear way.

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

**143. Ans: (b)**

**Sol:** Comfort/Centrifugal criteria

$$e + f = \frac{v^2}{gR} = -\frac{v^2}{127R}$$

No super elevation is required on taxiway

$$0 + 0.13 = \frac{40^2}{127(R)}$$

R = 94.5 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

**144. Ans: (d)**

**Sol:** Emergency landing case is not considered.

***Directions:*** *Each of the next* ***six (06)*** *items consists of two statements, one labelled as* ***'Statement (I)'*** *and the other as* ***'Statement (II)'.*** *You are to examine the two statements carefully and select the answer 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

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

**Statement (II):** Expansive cement expands while hardening

**145. Ans: (a)**

**Sol:** When expanding or expansive cement is used to fill concrete cracks or opened up joints, it expands while hardening and thus effectively packs the crack or joint. Both the statements are correct and Statement (II) is the correct explanation for Statement (I). Hence, correct option is (a).

End of Solution

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.

**146. Ans: (a)**

**Sol:** A section is said to develop a plastic hinge when due to flexure, the stress at every point of the section is equal to the yield stress.

Plastic hinges are developed first at sections subjected to the greatest curvature. It is due to the formation of plastic hinges one after the other a redistribution of moment takes place.

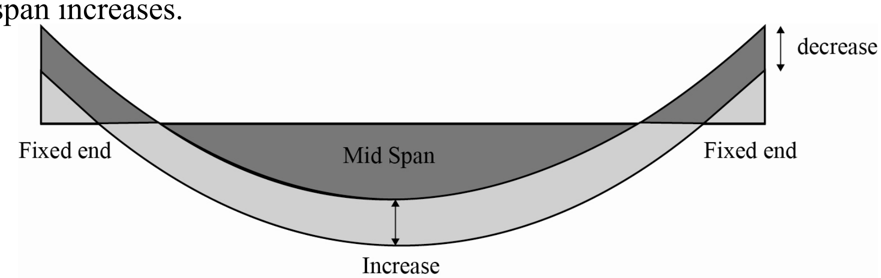
End of Solution

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.

**147. Ans: (c)**

**Sol:** Due to redistribution of moments as the fixed end moment decreases the sagging moment at midspan increases.

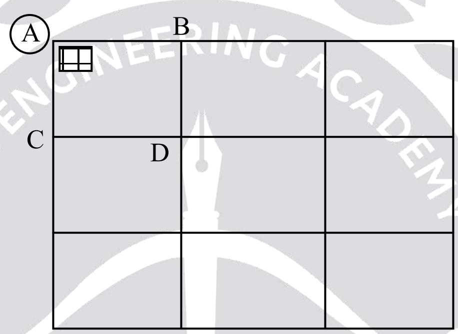


148. **Statement (I):** Torsion reinforcement is provided at (and near) corners in a two-way slab which is simply supported on both edges meeting at the corner.

**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.

**148. Ans: (b)**

**Sol:** Torsion reinforcement is provided in a two way slab, at any corner if both edges are discontinuous (simply supported edge), the magnitude of such reinforcement is three fourth of max mid span moment steel.




At corner (A) $\frac{3}{4}A_{stxx}$ (For each layer)

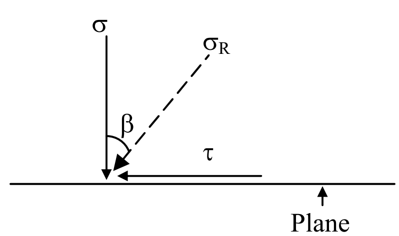
End of Solution

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).

**149. Ans: (d)**

**Sol:** The inclination of resultant stress with normal is called angle of obliquity (β) as shown below.



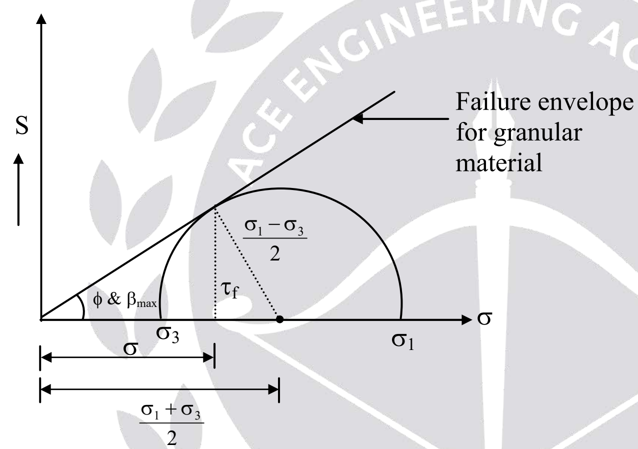
$\sigma_R$ = Resultant stress = $\sqrt{\sigma^2 + \tau^2}$

$$\beta = \tan^{-1}\left[\frac{\tau}{\sigma}\right]$$

The angle of repose of a granular material is the steepest angle at which the soil can be piled without slumping.

The term "angle of repose" is generally used with respect to granular material like sand. In the case of loose granular material, the angle of friction ($\phi$) and angle of repose are equal to each other.

Failure envelope for granular material is shown below.




For failure plane, the $\beta$ will be maximum

$$\beta_{max} = \tan^{-1}\left[\frac{\tau_f}{\sigma}\right]$$

From the above, $\beta_{max} = \phi$

$\therefore$ Statement I is false

$$\sin\phi = \frac{\frac{\sigma_1 - \sigma_3}{2}}{\frac{\sigma_1 + \sigma_3}{2}} \quad \text{(or)} \quad \sin\phi = \frac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3}$$

$\therefore$ Statement II is true

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.

**150. Ans: (b)**

**Sol:** Alum need alkalinity to produce flock and it settle better at when viscosity of water is less both statements are correct and statement 2 is not correct explanation of statement 1.

End of Solution