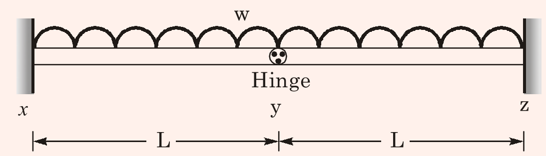


Figure - II

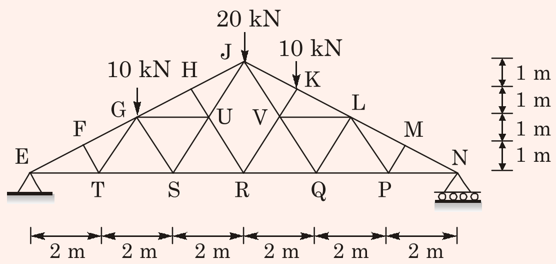
Which one of the following relationship is true?

(a) $\delta_{max1} \neq \delta_{max2}$ and $\theta_{max1} \neq \theta_{max2}$
(b) $\delta_{max1} = \delta_{max2}$ and $\theta_{max1} \neq \theta_{max2}$
(c) $\delta_{max1} \neq \delta_{max2}$ and $\theta_{max1} = \theta_{max2}$
(d) $\delta_{max1} = \delta_{max2}$ and $\theta_{max1} = \theta_{max2}$

Ans. **(d)**

End of Solution

Q.33 A plane truss with applied loads is shown in the figure.



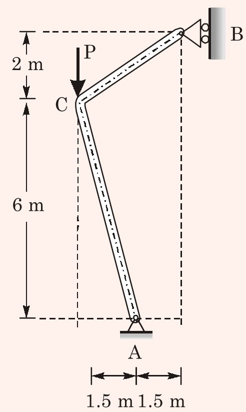
The members which do not carry any force are

(a) FT, TG, HU, MP, PL
(b) ET, GS, UR, VR, QL
(c) FT, GS, HU, MP, QL
(d) MP, PL, HU, FT, UR

Ans. **(a)**

End of Solution

Q.34 A rigid member *ACB* is shown in the figure. The member is supported at *A* and *B* by pinned and guided roller supports, respectively. A force ***P*** acts at *C* as shown. Let R_{Ah} and R_{Bh} be the horizontal reactions at supports *A* and *B*, respectively, and R_{Av} be the vertical reaction at support A. Self-weight of the member may be ignored.



Which one of the following sets gives the correct magnitudes of R_{Av}, R_{Bh} and R_{Av}?

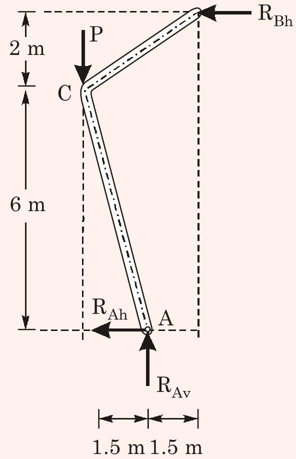
(a) $R_{Av} = 0; R_{Bh} = \frac{1}{3}P$; and $R_{Ah} = \frac{2}{3}P$

(b) $R_{Av} = 0; R_{Bh} = \frac{2}{3}P$; and $R_{Ah} = \frac{1}{3}P$

(c) $R_{Av} = P; R_{Bh} = \frac{3}{8}P$; and $R_{Ah} = \frac{1.5}{8}P$

(d) $R_{Av} = P; R_{Bh} = \frac{1.5}{8}P$; and $R_{Ah} = \frac{1.5}{8}P$

Ans. **(d)**



$$\Sigma F_y = 0 \Rightarrow R_{av} = P$$

$$\Sigma F_x = 0 \Rightarrow R_{Bh} = R_{Ah}$$

$$\Sigma M_A = 0$$

$$R_{Bh} \times 8 - P \times 1.5 = 0$$

$$\Rightarrow \quad R_{Bh} = \frac{1.5P}{8}$$

$$\Rightarrow \quad R_{Ah} = \frac{1.5P}{8}$$

$$R_{Av} = P;\ R_{Bh} = \frac{1.5P}{8};\ R_{Ah} = \frac{1.5P}{8}$$

End of Solution

Q.35 A reinforced concrete (RC) beam with width of 250 mm and effective depth of 400 mm is reinforced with Fe415 steel. As per the provisions of IS 456-2000, the minimum and maximum amount of tensile reinforcement (expressed in mm^2) for the section are, respectively

(a) 250 and 3500
(b) 205 and 4000
(c) 270 and 2000
(d) 300 and 2500

Ans. **(b)**

Minimum tension reinforcement is given by

$$\frac{A_s}{bd} = \frac{0.85}{f_y}$$

$$A_s = \frac{0.85 \times 250 \times 400}{415} = 205\ \text{mm}^2$$

Maximum compression reinforcement = 0.04 bD

$$= 0.04 \times 250 \times 400 = 4000\ \text{mm}^2$$

End of Solution

Q.36 For M25 concrete with creep coefficient of 1.5, the long-term static modulus of elasticity (expressed in MPa) as per the provisions of IS:456-2000 is ________

Ans. **(10000)**

Long term static modulus of elasticity

$$E_\theta = \frac{E_c}{1+\theta} = \frac{5000\sqrt{f_{ck}}}{1+\theta} = \frac{5000\sqrt{25}}{1+1.5}$$

$$= 10{,}000$$

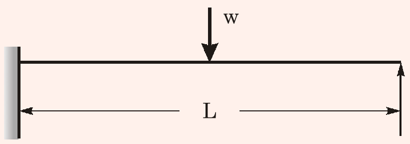
End of Solution

Q.37 A propped cantilever of span L carries a vertical concentrated load at the mid-span. If the plastic moment capacity of the section is M_p, the magnitude of the collapse load is

(a) $\frac{8M_P}{L}$ (b) $\frac{6M_P}{L}$

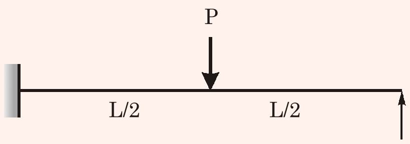
(c) $\frac{4M_P}{L}$ (d) $\frac{2M_P}{L}$

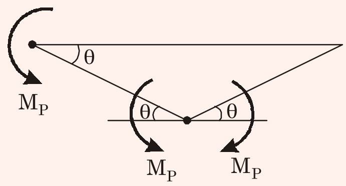
Ans. **(b)**



$D_s = 1$

$\therefore$ No. of plastic hinge required for complete collapse = 1 + 1 = 2





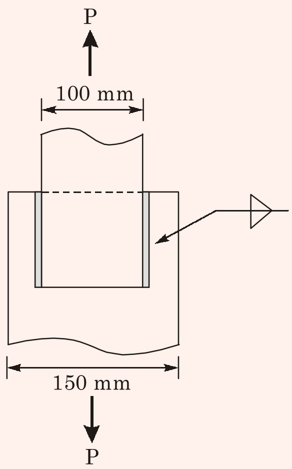
$$-M_P\theta - M_P\theta - M_P\theta + \frac{PL}{2}\theta = 0$$

$$\Rightarrow \quad 3\,M_P = \frac{PL}{2}$$

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

End of Solution

Q.38 Two plates are connected by fillet welds of size 10 mm and subjected to tension, as shown in the figure. The thickness of each plate is 12 mm. The yield stress and the ultimate tensile stress of steel are 250 MPa and 410 MPa, respectively. The welding is done in the workshop (γ_{mw} = 1.25).



As per the Limit State Method of IS 800: 2007, the minimum length (rounded off to the nearest higher multiple of 5 mm) of each weld to transmit a force *P* equal to 270 kN (factored) is

(a) 90 mm (b) 105 mm
(c) 110 mm (d) 115 mm

Ans. **(b)**

Maximum force carried by plates,

$$P = \frac{A_g f_y}{\gamma_{m0}} = \frac{(100 \times 12) \times 250}{1.1} = 272.73 \text{ kN}$$

$$\text{Load carried by each weld} = \frac{P}{2} = 136.36 \text{ kN}$$

For minimum length of weld,

Strength of weld = Load carried by weld

$$l_w t_t \frac{f_u}{\sqrt{3}\gamma_{mw}} = 136.36 \times 10^3$$

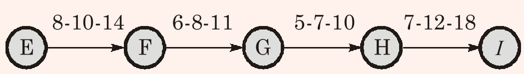
$$l_w \times (10 \times 0.7) \times \frac{410}{\sqrt{3} \times 1.2} = 136.36 \times 10^3$$

$$\Rightarrow \quad l_w = 102.9 \text{ mm}$$

= 105 mm (rounded off to nearest higher multiple of 5 mm)

End of Solution

Q.39 The Optimistic Time (O), Most likely Time (*M*) and Pessimistic Time (*P*) (in days) of the activities in the critical path are given below in the format O-M-P.



The expected completion time (in days) of the project is ___________

Ans. **(37.83)**

$$T_e = \frac{t_0 + 4t_m + t_p}{6}$$

$$T = T_{e_1} + T_{e_2} + T_{e_3} + T_{e_4}$$

$$= \frac{8 + 4 \times 10 + 14}{6} + \frac{6 + 4 \times 8 + 11}{6}$$

$$+\frac{5+4\times7+10}{6}+\frac{7+4\times12+18}{6}$$

$$= 10.333 + 8.166 + 7.166 + 12.166$$

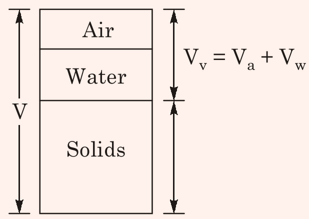
$$= 37.83$$

End of Solution

Q.40 The porosity (n) and the degree of saturation (S) of a soil sample are 0.7 and 40%, respectively. In a 100 m^3 volume of the soil, the volume (expressed in m^3) of air is ______

Ans. **(42)**

$\eta = 0.7,\ S = 40\%,\ V = 100\ \text{m}^3,\ V_a = ?$



$$\eta = \frac{V_v}{V}$$

$$\Rightarrow \quad 0.7 = \frac{V_v}{100}$$

$$\Rightarrow \quad V_v = 70\ \text{m}^3$$

Now,

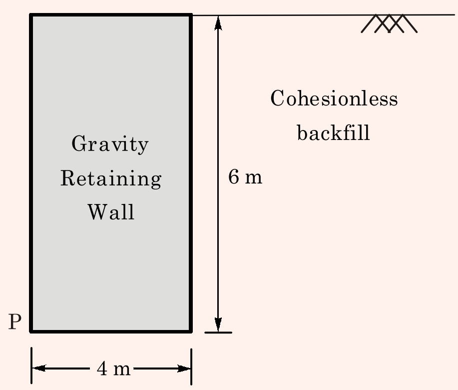
$$S = \frac{V_w}{V_v} = \frac{V_v - V_a}{V_v} = 1 - \frac{V_a}{V_v}$$

$$\Rightarrow \quad 0.40 = 1 - \frac{V_a}{V_v}$$

$$\Rightarrow \quad \frac{V_a}{V_v} = 0.60 \Rightarrow V_a = 0.6 \times 70 = 42\ \text{m}^3$$

End of Solution

Q.41 A homogeneous gravity retaining wall supporting a cohesionless backfill is shown in the figure. The lateral active earth pressure at the bottom of the wall is 40 kPa.

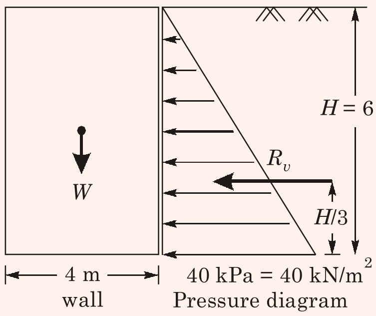


The minimum weight of the wall (expressed in kN per m length) required to prevent it from overturning about its toe (Point *P*) is

(a) 120 (b) 180

(c) 240 (d) 360

Ans. **(a)**



$$W = \text{weight of wall}$$

$$R_v = \text{Reaction from cohesion less backfill}$$

$$= \frac{1}{2} \times 40 \times H$$

$$= \frac{1}{2} \times 40 \times 6$$

$$= 120 \text{ kN}$$

To present overturning about point P,

$$M_0 \le M_R$$

$$R_v \times \frac{H}{3} \le W \times 2$$

$$120 \times \frac{6}{3} \le W \times 2$$

$$\Rightarrow \quad W \ge 120 \text{ kN}$$

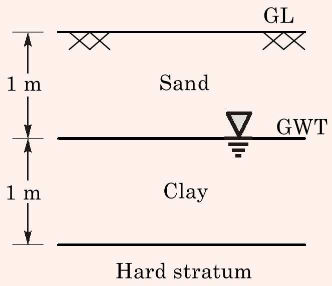
$\therefore$ Minimum weight of wall = 120 kN

End of Solution

Q.42 An undisturbed soil sample was taken from the middle of a clay layer (i.e., 1.5 m below GL), as shown in figure. The water table was at the top of clay layer. Laboratory test results are as follows:

Natural water content of clay	:	25%
Preconsolidation pressure of clay	:	60 kPa
Compression index of clay	:	0.50
Recompression index of clay	:	0.05
Specific gravity of clay	:	2.70
Bulk unit weight of sand	:	17 kN/m^3

A compacted fill of 2.5 m height with unit weight of 20 kN/m^3 is placed at the ground level.



Assuming unit weight of water as 10 kN/m^3, the ultimate consolidation settlement (expressed in mm) of the clay layer is______

Ans. (36.7)

Unit weight of clay, $\gamma_{sat} = \frac{G+e}{1+e} \times \gamma_w$

$\because$ $Se = wG$

$$e = \frac{wG}{S} = \frac{wG}{1} = 0.25 \times 2.7 = 0.675$$

$\therefore$ $\gamma_{sat} = \frac{2.7 + 0.675}{1 + 0.675} \times 10 = 20.15\ \text{kN/ m}^3$

Present effective stress at the middle of clay layer

$$\bar{\sigma}_0 = \sigma - U = 1 \times \gamma_{sand} + 0.5\,(\gamma_{sat} - \gamma_w)$$
$$= 1 \times 17 + 0.5\,(20.15 - 10) = 22.075\ \text{kN/m}^2$$

Change in effective stress due to compacted fill

$$\Delta\bar{\sigma}_0 = 2.5 \times 20 = 50\ \text{kN/m}^2$$

Since pre-consolidation pressure is 60 kPa, hence

from 22.075 to 60 kPa — Over consolidation stage

from 60 kPa + 0 (20.075 + 60 = 72.075) — Normal consolidated stage

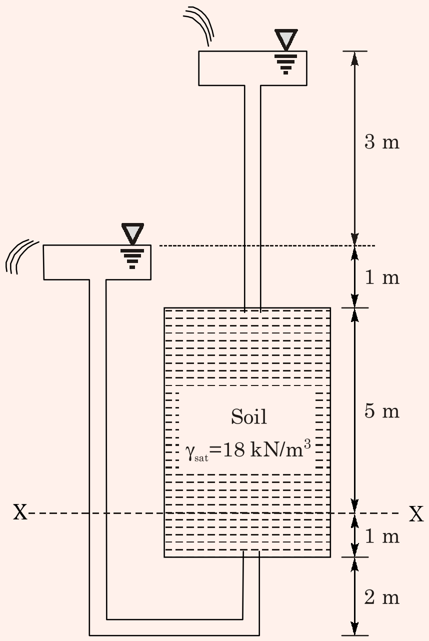
Hence consolidation settlement

$$\Delta H = \frac{H_o c_r}{1+e_0}\log\left(\frac{\bar{\sigma}_1}{\bar{\sigma}_0}\right) + \frac{H_o c_c}{1+e_0}\log\left(\frac{\bar{\sigma}_2}{\bar{\sigma}_1}\right)$$

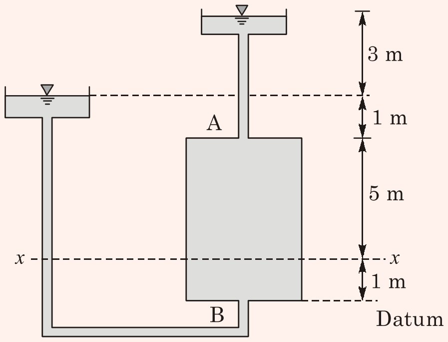
$$\Delta H = \frac{1 \times 0.05}{1 + 0.675}\log\left(\frac{60}{22.075}\right) + \frac{1 \times 0.50}{1 + 0.675}\log\left(\frac{72.075}{60}\right) = 0.0367\,\text{m} = 36.7\,\text{mm}$$

End of Solution

Q.43 A seepage flow condition is shown in the figure. The saturated unit weight of the soil γ_{sat} = 18 kN/m^3. Using unit weight of water, γ_w = 9.81 kN/m^3, the effective vertical stress (expressed in kN/m^2) on plane X-X is ______



Ans. **(65.475)**



	Datum head	Pressure head	Total head
A	6	4	10
B	0	7	7
x-x	1	6.5	7.5

Hydraulic gradient, $i = \dfrac{\text{Hydraulic head difference}}{\text{Length}} = \dfrac{H_A - H_B}{6}$

$$i = \frac{10-7}{6} = \frac{3}{6} = \frac{1}{2}$$

Force $= h\gamma_w$

Head loss at *x-x* $= i \times 5 = 2.5\,\gamma_w$

$$\begin{aligned}\text{Effective stress at } x\text{-}x &= 5\,\gamma_{sub} + 2.5\,\gamma_w \\ &= 5 \times (18 - 9.81) + 2.5 \times 9.81 \\ &= 65.475 \text{ kN/m}^2\end{aligned}$$

End of Solution

Q.44 A drained triaxial compression test on a saturated clay yielded the effective shear strength parameters as $c' = 15$ kPa and $\phi' = 22^o$. Consolidated Undrained triaxial test on an identical sample of this clay at a cell pressure of 200 kPa developed a pore water pressure of 150 kPa at failure. The deviator stress (expressed in kPa) at failure is__________

Ans. **(104.376)**

Cell pressure, $\sigma_3 = 200$ kPa

Pore water pressure, $u = 150$ kPa

$\therefore \quad \bar{\sigma}_3 = \sigma_3 - U = 200 - 150 = 50$ kPa

Effective shear parameters ($c' = 150$ kPa and $\phi° = 22°$) is given

$$\therefore \quad \bar{\sigma}_1 = \bar{\sigma}_3 \tan^2\left(45 + \frac{\phi'}{2}\right) + 2c' \tan\left(45 + \frac{\phi'}{2}\right)$$

$$\bar{\sigma}_1 = 50 + \tan^2\left(45 + \frac{22}{2}\right) + 2 \times 15 \tan\left(45 + \frac{22}{2}\right)$$

$$\bar{\sigma}_1 = 154.376 \text{ kPa}$$

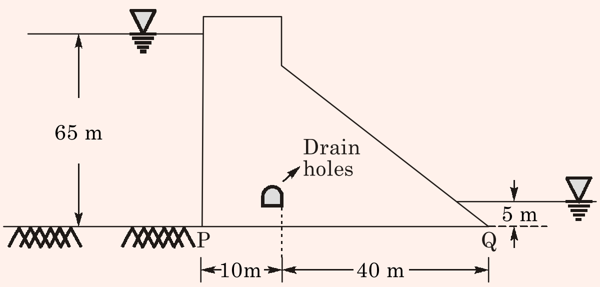
Now, $\bar{\sigma}_1 = \bar{\sigma}_3 + \sigma_d$

$$\sigma_d = \bar{\sigma}_1 - \bar{\sigma}_3 = 154.376 - 50$$

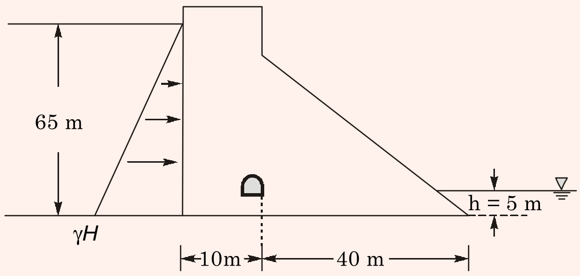
Deviator stress, $\sigma_d = 104.376$ kPa

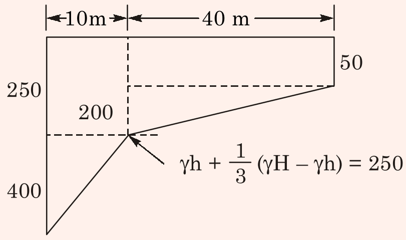
End of Solution

Q.45 A concrete gravity dam section is shown in the figure. Assuming unit weight of water as 10 kN/m^3 and unit weight of concrete as 24 kN/m^3, the uplift force per unit length of the dam (expressed in kN/m) at PQ is______



Ans. **(10500)**





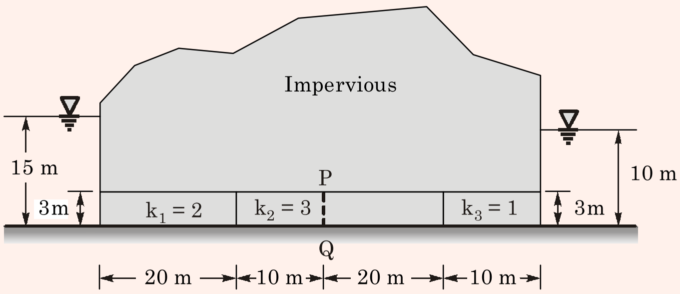
$$\text{Total uplift pressure} = 250 \times 10 + 40 \times 50 + \frac{1}{2} \times 200 \times 40 + \frac{1}{2} \times 400 \times 10$$

$$= 2500 + 2000 + 4000 + 2000$$

$$= 10500 \text{ kN/m}^2$$

End of Solution

Q.46 Seepage is occurring through a porous media shown in the figure. The hydraulic conductivity values (k_1, k_2, k_3) are in m/day.



The seepage discharge (m^3/day per m) through the porous media at section PQ is

(a) $\frac{7}{12}$

(b) $\frac{1}{2}$

(c) $\frac{9}{16}$

(d) $\frac{3}{4}$

Ans. **(b)**

Flow is normal to bedding plane

$$\therefore \quad k_{avg} = \frac{\Sigma z_i}{\Sigma \frac{z_i}{k_i}} = \frac{20+30+10}{\frac{20}{2}+\frac{30}{3}+\frac{10}{1}} = 2 \text{ m/ day}$$

Hydraulic gradient,

$$i = \frac{\text{Head difference}}{\text{Length}} = \frac{15-10}{60} = \frac{5}{60}$$

Seepage discharge,

$$= k_{avg}\, i\, A = 2 \text{ m/ day} \times \frac{5}{60} \times 3 \text{ m}$$

$$= 0.5 \text{ m}^3\text{/day per meter}$$

End of Solution

Q.47 A 4 m wide rectangular channel, having bed slope of 0.001 carries a discharge of 16 m^3/s. Considering Manning's roughness coefficient = 0.012 and g = 10 m/s^2, the category of the channel slope is

(a) horizontal
(b) mild
(c) critical
(d) steep

Ans. **(b)**

$$Q = \frac{1}{n} AR^{2/3} S^{1/2}$$

$$A = By$$

$$R = \frac{By}{B+2y}$$

$$16 = \frac{1}{0.012} \times By \times \left(\frac{By}{B+2y}\right)^{2/3} \times (0.001)^{1/2}$$

$$6.07 = 4 \times \frac{y^{5/3}}{(4+2y)^{2/3}}$$

$$1.5178 = \frac{y^{5/3}}{(4+2y)^{2/3}}$$

$$y = \left[1.5178 \times (4 \times 2y)^{2/3}\right]^{3/5} = 3.3 \text{ m}$$

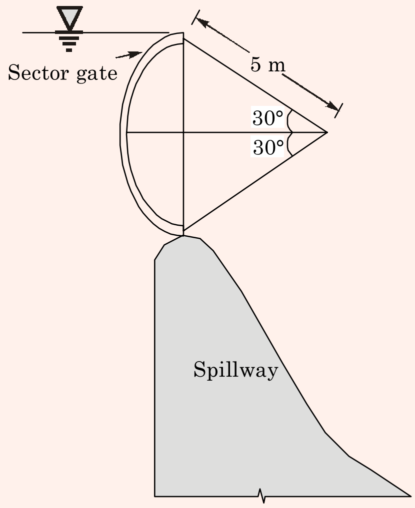
$$\text{Critical depth, } y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{4^2}{10}\right)^{1/3} = 1.169$$

$$y > y_c \Rightarrow \text{Flow is subcritical.}$$

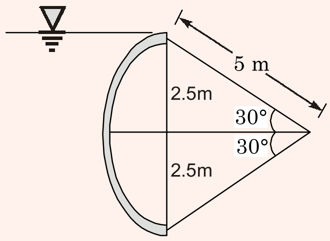
Hence channel slope is mild.

End of Solution

Q.48 A sector gate is provided on a spillway as shown in the figure. Assuming g = 10 m/s^2, the resultant force per meter length (expressed in kN/m) on the gate will be_____



Ans. **(127.03)**



$$F_x = \rho g \bar{h} A_v$$

$$= (10^3)(10)\left(\frac{5}{2}\right)(5\times 1)$$

$$= 125 \text{ kN per unit width}$$

$$F_y = \rho g \forall$$

where $\forall = \frac{\pi(5)^2}{6} - \left(\frac{1}{2}\times 5\times 5\cos 30^\circ\right) = 2.264$

$$F_y = (10)^3\,(10)\,(2.264) = 22.64 \text{ kN}$$

Resultant force per unit width (kN) $= \sqrt{F_x^2 + F_y^2}$

$$= \sqrt{125^2 + 22.64^2} = 127.03$$

End of Solution

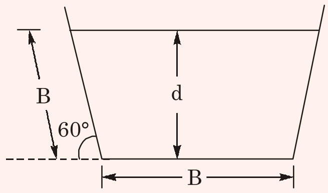
Q.49 A hydraulically efficient trapezoidal channel section has a uniform flow depth of 2 m. The bed width (expressed in m) of the channel is __________

Ans. **(2.31)**

For hydraulically efficient trapezoidal channel,

lateral side = horizontal side

From figure,



$\Rightarrow$ $$B \sin 60° = d$$

$$B = \frac{d}{\sin 60°} = 2.31 \text{ m}$$

End of Solution

Q.50 Effluent from an industry '*A*' has a pH of 4.2. The effluent from another industry '*B*' has double the hydroxyl (OH^-) ion concentration than the effluent from industry '*A*'. pH of effluent from the industry '*B*' will be ________

Ans. **(4.5)**

pH of Effluent from on industry *A* = 4.2

$\because$ $$\text{pH} + \text{pOH} = 14$$

$\Rightarrow$ $$\text{pOH} = 14 - 4.2 = 9.8$$

$\Rightarrow$ $$-\log[OH^-] = 9.8$$

$$[OH^-] = 1.5898 \times 10^{-10}\left(\frac{\text{mol}}{\text{lit}}\right)$$

So $[OH^-]$ of effluent from on industry $B = 2 \times [OH]_A$

$$[OH^-]_B = 3.6196 \times 10^{-10}$$

$\therefore$ $$[\text{pOH}]_B = 9.5$$

$\therefore$ $$[\text{pH}]_B = 14 - 9.5$$

$$[\text{pH}]_B = 4.5$$

End of Solution

Q.51 An electrostatic precipitator (ESP) with 5600 m^2 of collector plate area is 96 percent efficient in treating 185 m^3/s of flue gas from a 200 MW thermal power plant. It was found that in order to achieve 97 percent efficiency, the collector plate area should be 6100 m^2. In order to increase the efficiency to 99 percent, the ESP collector plate area (expressed in m^2) would be __________

Ans. **(8011.78)**

As per Deutsch-Anderson equation, to determine the collection efficiency of the precipitator under ideal conditions,

$$\eta = 1 - e^{-w(A/Q)}$$

η = Collection efficiency of the precipitator

w = Migration velocity, cm/s

$$A = \text{The effective collecting plate area of the precipitator, m}^2$$

$$Q = \text{Gas flow through the precipitator, m}^3\text{/s}$$

$$0.96 = 1 - e^{-\left(\frac{w}{Q}\right)\times 5600} \quad \text{...(i)}$$

$$0.97 = 1 - e^{-\left(\frac{w}{Q}\right)\times 6100} \quad \text{...(ii)}$$

From both equations,

$$\frac{w}{Q} = 5.748 \times 10^{-4}$$

Now for 99% efficiency, plate area required,

$$0.99 = 1 - e^{-5.748\times 10^{-4}\times A}$$

$$\Rightarrow \quad A = 8011.78 \text{ m}^2$$

End of Solution

Q.52 The 2-day and 4-day BOD values of a sewage sample are 100 mg/L and 155 mg/L, respectively. The value of BOD rate constant (expressed in per day) is________.

Ans. **(0.299)**

$$Y_2 = 100 \text{ mg/L} \qquad t_2 = 2 \text{ day}$$

$$Y_4 = 155 \text{ mg/L} \qquad t_4 = 4 \text{ day}$$

$$K_D = ?$$

$$Y_2 = Y_0(1 - e^{-K_D \cdot t_2})$$

$$Y_4 = Y_0(1 - e^{-K_D \cdot t_4})$$

$$\frac{Y_2}{Y_4} = \frac{1 - e^{-K_D \times 2}}{1 - e^{-K_D \times 4}}$$

$$\frac{100}{155} = \frac{1 - e^{-2K_D}}{1 - e^{-4K_D}}$$

$$1.55 = \frac{1 - e^{-4k}}{1 - e^{-2k}}$$

$$1.55 - 1.55x = 1 - x^2$$

$$x^2 - 1.55x + 0.55 = 0$$

$$x = 1 \text{ or } x = 0.55$$

$$e^{-2k} = 1 \text{ or } e^{-2k} = 0.55$$

$$-2k = \ln 1 \text{ or } -2k = \ln 0.55$$

$$k = 0 \text{ or } k = 0.299$$

$$\therefore \quad k = 0.299$$

End of Solution

Q.53 A two lane, one-way road with radius of 50 m is predominantly carrying lorries with wheelbase of 5 m. The speed of lorries is restricted to be between 60 kmph and 80 kmph. The mechanical widening and psychological widening required at 60 kmph are designated as $W_{me,60}$ and $W_{ps,60}$, respectively. The mechanical widening and psychological widening required at 80 kmph are designated as $W_{me,80}$ and $W_{ps,80}$, respectively. The correct values of $W_{me,60}$, $W_{ps,60}$, $W_{me,80}$, $W_{ps,80}$, respectively are

(a) 0.89 m, 0.50 m, 1.19 m, and 0.50 m
(b) 0.50 m, 0.89 m, 0.50 m, and 1.19 m
(c) 0.50 m, 1.19 m, 0.50 m, and 0.89 m
(d) 1.19 m, 0.50 m, 0.89 m, and 0.50 m

Ans. **(b)**

$$W_{me'60} = \frac{nl^2}{2R} = \frac{2 \times 5^2}{2 \times 50} = 0.5 \text{ m}$$

$$W_{ps'60} = \frac{V}{9.5\sqrt{R}} = \frac{60}{9.5\sqrt{60}} = 0.89 \text{ m}$$

$$W_{me'80} = \frac{nl^2}{2R} = \frac{2 \times 5^2}{2 \times 50} = 0.5 \text{ m}$$

$$W_{ps'80} = \frac{V}{9.5\sqrt{R}} = \frac{80}{9.5\sqrt{50}} = 1.19 \text{ m}$$

End of Solution

Q.54 While traveling along and against the traffic stream, a moving observer measured the relative flows as 50 vehicles/hr and 200 vehicles/hr, respectively. The average speeds of the moving observer while traveling along and against the stream are 20 km/hr and 30 km/hr, respectively. The density of the traffic stream (expressed in vehicles/km) is__________

Ans. **(3)**

Let us assume

q = traffic flow
k = traffic density
V_w = velocity of test vehicle along the stream
V_a = velocity of test vehicle against the stream

$\Rightarrow$ $q - kV_w = 50$

$\Rightarrow$ $q - k \times 20 = 50$ ...(*i*)

$q + kV_a = 200$

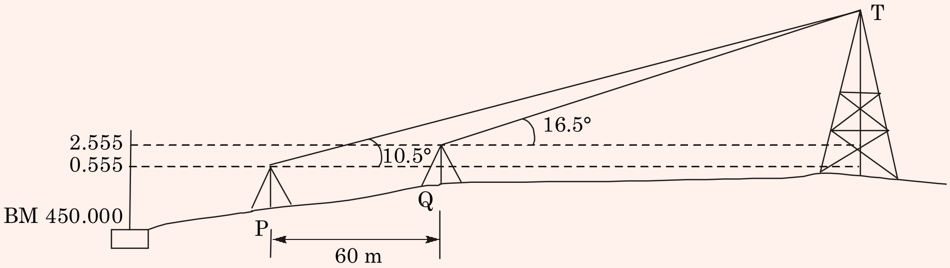
$\Rightarrow$ $q + k \times 30 = 200$ ...(*ii*)

Solving equation (*i*) and (*ii*), we get

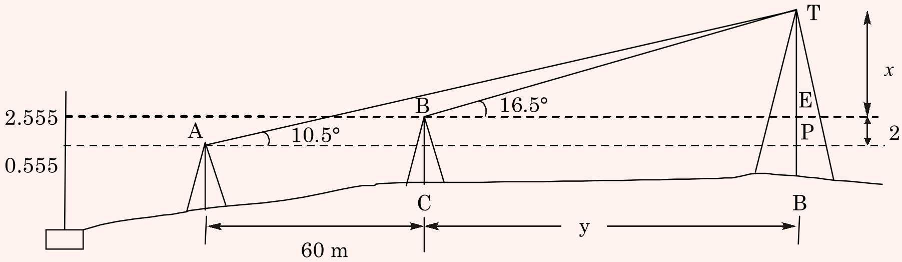
$$k = 3 \text{ Veh/km}$$

End of Solution

Q.55 The vertical angles subtended by the top of a tower *T* at two instrument stations set up at *P* and *Q*, are shown in the figure. The two stations are in line with the tower and spaced at a distance of 60 m. Readings taken from these two stations on a leveling staff placed at the benchmark (*BM* = 450.000 m) are also shown in the figure. The reduced level of the top of the tower *T* (expressed in m) is__________



Ans. **(476.911)**



In ΔBET, $\tan 16.5° = \dfrac{x}{y}$

$\Rightarrow$ $y = 3.3759x$ ...(*i*)

In ΔAOT, $\tan 10.5 = \dfrac{x+2}{60+y}$ ...(*ii*)

Put value of *y* in eq. (*ii*)

$$0.1853 = \frac{x+2}{60+3.3759x}$$

$$11.1203 + 0.6255x = x + 2$$

$$x = 24.3568 \text{ m}$$

So, the reduced level of tower T = 450.000 + 2.555 + 24.356

= 476.911 m

End of Solution

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