SSC JE CONVENTIONAL 2017

GENERAL ENGINEERING (CIVIL)

1. (a) Determine the dissolved oxygen at the end of 2 days for the following data

Characteristics	Stream water	Waste water
Flow (m^3/sce)	22	3
DO (mg/litre)	10	0
BOD (mg/litre)	3	190

Assume: Deoxygenation constant K= 0.11 per day
Reoxygenation constant R = 0.33 per day **[15 Marks]**

Solution : $(\text{BOD}_{\text{mix}}) = \dfrac{22\times 3+3\times 190}{25} = 25.44 mg/l$

Assume saturation D_o = 9.2 mg/l

D_o = initial Deficit = 9.2 – 8.8 = 0.4 mg/l

Deficit at any time t is given by stretcher phelp

Equation :

$$D_t = \frac{K_D \times L_o}{K_R - L_D}\left[(10)^{-K_D.t} - (10)^{-K_R.t}\right] + \left[D_0 \times (10)^{-K_R.t}\right]$$

$$= \frac{0.11\times 25.44}{0.33\times 0.11}\left[(10)^{-0.11\times 2} - (10)^{-0.33\times 2}\right] + \left[0.4\times (10)^{-0.33\times 2}\right]$$

= 12.72 × 0.38378 + 0.08751

= 4.969 mg/l

(b) A clay stratum has 2.5 m thickness and has initial overburden pressure of 45 kN/m². The clay is over consolidated with a preconsolidation pressure of 65 kN/m². Find the final settlement due to increment of pressure of 55 kN/m² at the middle of clay layer. Use the following data :
Initial void ratio =1.2
Compression index = 0.27
Swelling index = 0.06

[15 Marks]

Solution : H = 2.5m $\quad \sigma_0$ = 45 KN/m²

e = 1.2m $\quad \sigma_c$ = 65 KN/m²

c_c = 0.27m $\quad \triangle\bar{\sigma} = 55 KN/m^2$

c_s = 0.06

$$\triangle H = \frac{C_s H}{1+e}\log\left(\frac{\bar{\sigma}_c}{\bar{\sigma}_c}\right) + \frac{C_c}{1+e}\log\left(\frac{\bar{\sigma}_0 + \triangle}{\bar{\sigma}_c}\right)$$

$$= \frac{0.06\times(2.5\times 10^{+3})}{1+1.2}\log_{10}\left(\frac{65}{45}\right)\times\frac{0.27\times 2.5\times 10^{+3}}{1+1.2}\log\left(\frac{45+55}{65}\right)$$

= 10.89 + 57.40

$\boxed{\triangle H = 68.29mm}$

(c) Discuss the factors affecting duty of water

[15 Marks]

Solution: **Factors Affecting duty of water**

1. Types of crop

duty of water varies from crop to crop. The crops which require large quantity of water have lower duty

2. Climate condition

The climatic condition affecting the duty of water are temperature, wind velocity, humidity and rainfall.

3. Method of Irrigation

duty of water is high for sprinkler and drip irrigation method as compared to surface irrigation

4. Types of soil

In coarse grained soil there will be more percolation hence duty of water will be less.

5. Quality of irrigation water

Water containing large amount of salts and alkalies is required in large amount so that salts are leached off. due this duty of water is lowered

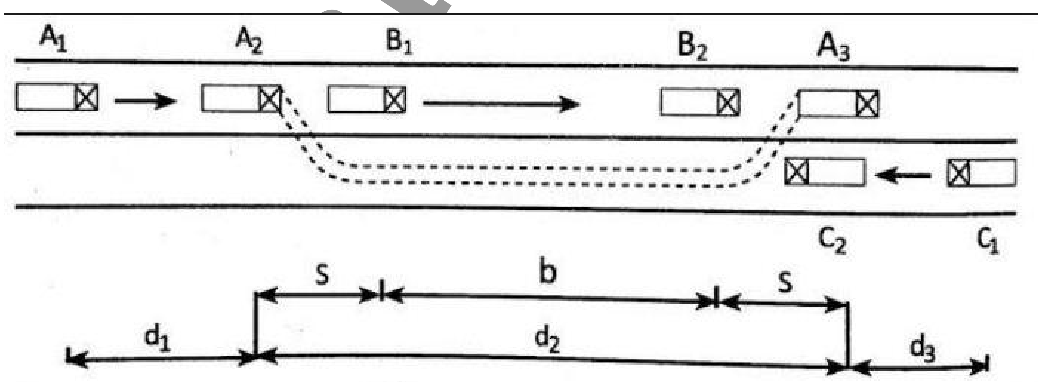
Duty of water also depends on

- Method of cultivation
- canal condition
- topography of land
- base period of crop

(d) Calculate the safe overtaking sight distance. For a design speed of 100 km/hr. Assume maximum overtaking acceleration as 1.92 km/hr/sec.

[15 Marks]

Solution:



Overtaking sight distance:- (OSD)

one lane two way traffic

OSD = $d_1+d_2+d_3$

One lane one way traffic

OSD = d_1+d_2

According to IRC $V_b = V-16$ (V- in Km/h)

$V_b = V-4.5$ - (V in m/s)

Where V = design speed or speed of over taking vehicle.

$V = 100\times\frac{5}{18} = 27.778$ (m/sec)

$V_b = (27.778-4.5)$

V_b = 23.2778 m/s

The time taken by overtakin vehicle is 2 sec (According to IRC)

$d_1 = V_b \times t = 23.2778 \times 2$

$\boxed{d_1 = 46.556m}$

$\boxed{d_2 = b + 2s}$

S = 0.7×Vb+6

According to IRC any length of vehicle = 6m

[S = 0.7×23.2778+6 = 22.294m.]

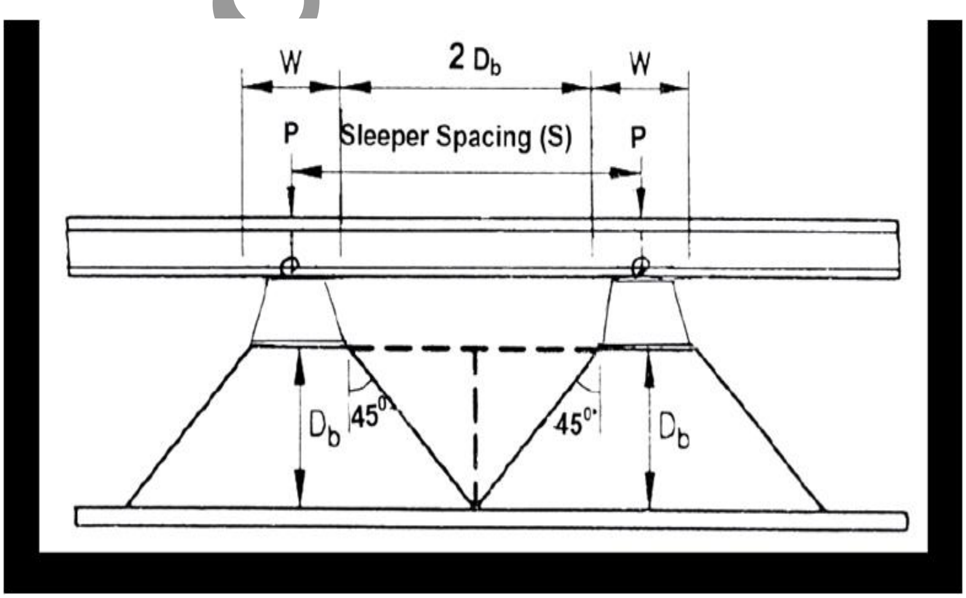
2. (a) What are the requirements of a good ballast in railway engineering ? Explain how the minimum depth of ballast cushion is estimated.

[10 Marks]

Solution: Requirement of GoodBallast

1. The ballast should be clean and graded crushed stone aggregate with hard, dense, angular particle structure providing sharp corners andcubical fragments with a minimum of flat and elongated pieces. These qualities will provide for proper drainage of the ballast section. The angular property will provide interlocking qualities which will grip the sleeper firmly to prevent movement. Excess flat and elongated particles could restrict proper consolidation of the ballast section
2. The ballast must have high wear and abrasive qualities to with stand the impact of traffic loads without excessive degradation. Excessive abrasion loss of an aggregate will result in reduction of particle size ,failing of the ballast section, reduction of drainage and loss of supporting strength of the ballast section.
3. The ballast particles should have high internal shearing strength to have high stability.
4. The ballast material should possess sufficient unit weight to provide a stable ballast section and in turn provide support and alignment stability to the track structure.
5. The ballast should provide high resistance to temperature changes, chemical attack, exhibit a high electrical resistance and low absorption properties.
6. Ballast material should be free from cementing properties .Deterioration of the ballast particles should not induce cementing together of the degraded particles.
7. The ballast material should have less absorption of water as excessive absorption can result in rapid deterioration during alternate wetting and drying cycles.
8. The Ballast should be cheap and economical.

The depth of ballast can be calculated as



S= sleeper spacing
W = width of sleeper density
Db = Depth of the ballast

Db= $\frac{S-W}{2}$ = minimum Depth of ballast

For example, with a sleeper density as (n+7) ,a sleeper spacing of 65 cm and a width of sleeper of 25 cm the minimum depth of ballast from the above formula works out to be 20 cm, which is minimum depth of ballast generally prescribed on Indian Railways.

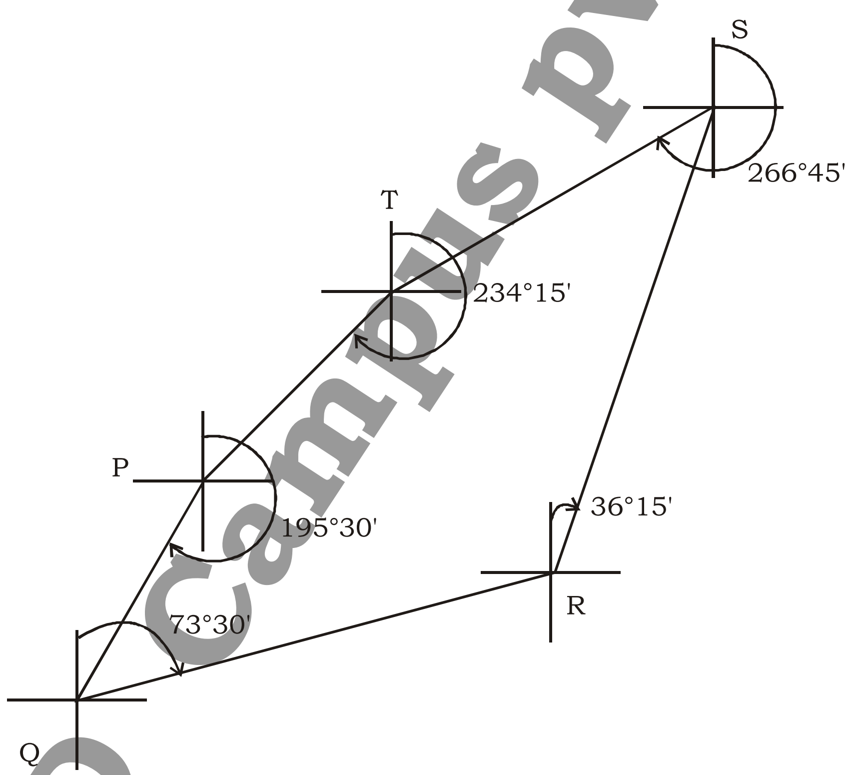
(b) Determine the correct bearings of the lines of a closed traverse PQRSTP. The readings are as follows :

Line	**Fore bearing**	**Back bearing**
PQ	**195°30'**	**17°0'**
QR	**73°30'**	**250°30'**
RS	**36°15'**	**214°30'**
ST	**266°45'**	**84°45'**
TP	**234°15'**	**57°0'**

Identify the stations affected by local attraction.

[15 Marks]

Solution :



Line	**FB**	**B.B**	**F.B. –B.B**
PQ	195°30'	12° 0',	178° 30'
QR	73° 30'	250°30'	–177° 0'
RS	36° 15'	214° 30'	–178° 15'
ST	266° 45'	84° 45'	182° 0'
TP	234°15'	57° 0'	177° 15'

- To find included angles.

$$\angle P = F.B._{PQ} - B.B._{TP} = 195^\circ 30' - 57^\circ 0' = 138^\circ 30'$$

$$\angle Q = F.B._{QR} - B.B._{PQ} = 73^\circ 30' - 17^\circ 0' = 56^\circ 30'$$

$$\angle R = F.B._{RS} - B.B._{QR} = 36^\circ 15' - 250^\circ 30' + 360^\circ = 145^\circ 45'$$

$\angle S = F.B._{ST} - B.B._{RS} = 266°45' - 214°30' = 52°15'$

$\angle T = F.B._{TP} - B.B._{ST} = 234°15' - 84°15' = 150°0'$

Check : $\angle A + \angle B + \angle C + \angle D + \angle E = 543°0'$

& Theoretical sum = (2n – 4)90 = (2×5–4)90 = 540°00'

Error = 543°0' – 540°00' = +3°

Correction = –3°

Correction in each angle = $\frac{-3°}{5} = \frac{-3°}{5} = -0°36'$

So, Correct included angles are,

$\angle P = 138°30' - 36' = 137°54'$

$\angle Q = 56°30' - 36' = 55°54'$

$\angle R = 145°45' - 36' = 145°09'$

$\angle S = 52°15' - 36' = 51°39'$

$\angle T = 150°0' - 36' = \underline{149°24'}$

$540°00'$

Since, here no line has the difference of 180°, so, we take that line which has the nearest difference to 180° as line PQ So, for line PQ,

Error = 178°30' –180° = –1°30°

Correction = +1°30'

Correction in F.B. of line $PQ = \frac{+1°30'}{2} = +45'$

So, Correct FB_{PQ} = 195° 30' + 45' = 196° 15'

Correct BB_{PQ} = 196°15' –180° = 16°15'

now, Correct FB_{QR} = Correct BB_{PQ} + Correct ∠R

= 16°15' + 55° 54' = 72°09'

Correct BB_{QR} = 72°09' + 180° = 252°09

Correct FB_{RS} = Correct BB_{QR} + Correct ∠R

= 252° 09' + 145° 09' – 360 = 37° 18'

Correct BB_{RS} = 37° 18' + 180° = 217° 18'

Correct FB_{ST} = Correct BB_{RS} + Correct ∠S

= 217°18' + 51°39' = 268°57'

Correct BB_{ST} = 268°57' – 180° = 88°57'

= 88° 57' + 149° 24' = 238° 21'

Correct BB_{TP} = 238° 21' – 180° = 58° 21'

Correct FB_{TP} = Correct BB_{ST} + Correct ∠T

Correct FB_{PQ} = Correct BB_{TP} + Correct ∠P

= 58°21' + 137° 54'

= 196°15'

(c) What are the factors affecting selection of contour interval ?

[15 Marks]

Solution: Factors affecting selection of contour interval are

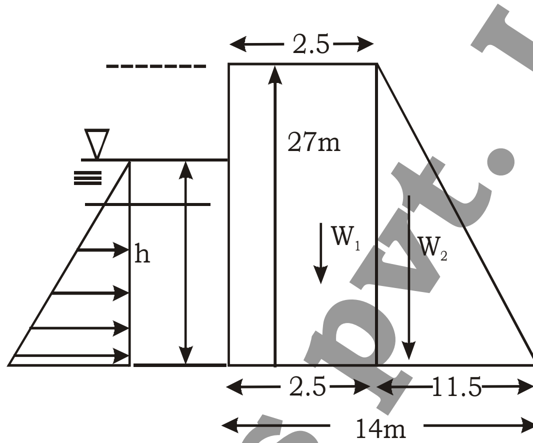
1. **Scale of map:-** If scale of map is large contour interval is kept small where as if scale of map is small contour interval is kept large.
2. **Topography of land:-** For flat ground contour interval is small and for steep slope contour interval is large

3. **Purpose of map:-** contour interval is taken small but it should not be too small else it will increase the cost of work. Therefore C.I should be taken small when plan is required in detail design.
4. **Cost and time:-** C.I should be kept large when time is less and It should be taken large for economical survey.

(d) **A trapezoidal dam with a vertical water face is 2.5 m wide at the top and 14 m wide at the base. The height of the dam is 27 m. Find the maximum depth of water so that the dam section is free from tension. Assume unit weight of dam material as 21 kN/m³ and thatof water as 9.81 kN/m³.**

[20 Marks]

Solution :



For zero tension.

$$e \le \frac{B}{6}$$

$$\Rightarrow \frac{B}{2} - \bar{x} \le \frac{B}{6}$$

$$\Rightarrow \frac{B}{3} \le \bar{x}$$

$$\Rightarrow \frac{B}{3} \le \frac{\Sigma m}{\Sigma U}$$

$$\Rightarrow \frac{B}{3}\Sigma U \le \Sigma m$$

$$\Rightarrow \frac{14}{3}(W-U) \le \frac{W}{2} \times \frac{2B}{3} \frac{-P \times H}{3} \frac{-U \times 2B}{3} + W_1 \times \left(11.5 + \frac{2.5}{2}\right)$$

$$\Rightarrow \frac{14}{3}\left[21 \times \frac{1}{2} \times (14+2.5) \times 27 - \frac{1 \times 9.81 \times 14 \times 27}{2}\right]$$

$$\le \frac{1}{2} \times 11.5 \times 27 \times 21 \times \frac{2}{3} \times 11.5 - \frac{1}{2} \times r_w$$

$$\times \frac{h^3}{3} - \frac{1}{2}.1 \times 9.81 \times 14 \times 27 \times 2 \times \frac{11.5}{3} + 21 \times 2.5 \times 27(12.75)$$

$$\Rightarrow 13177.08 \le 24995.25 - \frac{1}{6} \times 9.81 \times h^3 - 17304.84 + 18.073$$

$$\frac{9.81}{6} \times h^3 \le 1258645$$

$$\Rightarrow h = 19.74 \text{ m}$$

3. (a) Describe plate load test as per IS 1888. Discuss the limitations. What are the effects of size of plate on bearing capacity and settlement ?

[20 Marks]

Solution : Plate load test is usually adopted to find out the Settlement and Engineering Properties of Soil such as Shear strength and Safe bearing Capacity. A plate of circular or Square in shape is placed in the bottom of the Experiment and load is applied incrementally. The Incremental load should be one fourth of the design load. By this test, settlement of load can be calculated and Load Settlement Curve and Time-Settlement Curve can be drawn.

Limitations of Plate Load Test:

(i) The Depth of Influence is Limited to certain extent

(ii) The determined bearing capacity is only for the soil that is up to 2 times of the diameter of the plate

(iii) Long time consolidation of soil can not be found out

(iv) To do this test, small amount of excavation is carried out and this may cause significant Ground Disturbance.

(v) If ground is disturbed, then the soil properties will be changed and this paves the way for wrong observation

(vi) The effect of Scale is very small

Size of plates affect the settelment and bearing capacity as smaller size plates are used in dense or stiff soil where as larger plates are used in loose or soft soil

(b) A classroom is of the size 8.5 m × 3.6 m. Design a simply supported roof slab for this room. The superimposed load is 5 kN/m use M 20 grade concrete and HYSD Fe 415 steel. Use limit state method

$100\ A_s/b_d$	**0.15**	**0.25**	**0.50**	**0.75**	**1.0**
τ_c N/mm^2	**0.19**	**0.36**	**0.49**	**0.57**	**0.64**

[25 Marks]

Solution : Assume $l_{eff} = l = 3.6\text{m} = 3600\text{mm}$

$$\frac{l_{eff}}{d} < K_1\,K_2\,K_3\,K_4\,(value)$$

$$\Rightarrow \quad \frac{3600}{d} < 1\times1.25\times1\times1(20)$$

$\Rightarrow$ d > 144

$\Rightarrow$ provide d = 150 mm. D = 150 + 30 = 180 (E_{ef} cover)

$\therefore$ Space is simply supported.

$\therefore$ Let support width = 250mm each.

$$l_{eff} = \min of \begin{Bmatrix} l_c + d = 3.6 + 0.15 = 3.75 \\ l_c + \frac{b_1}{2} + \frac{b_2}{2} = 3.6 + \frac{0.25}{2} + \frac{0.25}{2} = 3.85 \end{Bmatrix}$$

= 3.75 m

Assume 1m width and 1m length of slab.

δL = 0.18 × 1 × 1 × 25 = 4.5 KN/m

Super impsed load = 5 kN/m

Total factored load = (4.5 + 5.1 ×1.5) = 14.25 KN/m

Maximum Bending moment

$$= \frac{w_u l^2}{8} = \frac{14.25\times3.75^2}{8} = 25.05\,KN-m$$

For Fe 415, $BM_{lim} = 0.138\ f_{ck}\ bd^2$

$\Rightarrow$ $25.05 = 0.138 \times 20 \times 1000 \times d^2$

$\Rightarrow$ d = 95.26 mm < 150 mm

$$A_{st} = \frac{0.5 f_{ck} bd}{f_y}\left[1-\sqrt{\frac{1-4.6BM_u}{f_{ck}bd^2}}\right]$$

$$= \frac{0.5 \times 20 \times 1000 \times 150}{415}\left[1 - \sqrt{1 - \frac{4.6 \times 25.05 \times 10^6}{20 \times 1000 \times 150^2}}\right]$$

$= 496.93\ mm^2$

$Ast_{min} = 0.12\ \%$ of bD

$$= 0.12 \times \frac{1}{100} \times 100 \times 180$$

$= 216\ mm^2$

Assuming 12mm bar

$$\text{spacing} = \frac{1000}{\dfrac{496.93}{\frac{\pi}{4} \times (12)^2}} = 227.476 mm$$

check for maximum spacing = $\min of \begin{Bmatrix} 3 \times 150 \\ 300 \end{Bmatrix} = 300 mm$

$\therefore$ Provide 12mm main bars @ 235 mm spacing

Also distribution bars should be provide to present shrinkage

maximum spacing for distribution bars : $\min of \begin{Bmatrix} 5d \to 5 \times 150 \\ 300 mm \end{Bmatrix}$ = 300mm

Distribution bar 8mm @ 225mm also

Now, check for shear

$$P_t = \frac{100A_{st}}{bd} = \frac{100 \times 496.93}{1000 \times 150} = 0.33\%$$

$$\tau_{c(at\,0.33\%)} = 0.36 + \frac{0.49 - 0.36}{0.50 - 0.25}(0.33 - 0.25)$$

$= 0.40116 N/mm^2$

$$(\tau_{v\max}) = \frac{\dfrac{w_u \times l}{2}}{bd} = \frac{14.25 \times 3.75 \times 1000}{2 \times 1000 \times 150} = 0.178 N/mm^2$$

$\therefore \boxed{\tau_v < \tau_c}$

No need to design for shear.

(c) Explain the steps for the design of column with helical reinforcement in limit state method.

[15 Marks]

Solution: Design of circular helical column :

Slenderness ratio = $\frac{l_{eff}}{B} < 12$

Small column else long.

Circular column with helical reinforcement:

(i) Load carrying capacity

LCC of column increases by 5%

$P = 1.05 \times Cr\ [A_c.\sigma_{cc} + A_{sc}.\sigma_{sc}]$

Due to helical reinforcement both the strength and ductiliy is increased.

(ii) Design of helical reinforcement

If following condition is satisfied the pitch of helical reinforcement can be found.

$$0.36\,\frac{f_{ck}}{R_1}\left[\frac{A_g}{A_c}-1\right] \le \frac{V_h}{V_c} \;\ldots\ldots\ldots \text{(i)}$$

Gross diameter = D_g

Gross area (Ag) = $\frac{\pi}{4} \times D^2$

Core diameter (D_C) meosured outside of helical reinforcement

$D_c = D_g - 2 \times (40)$

$= (D_g - 80)$

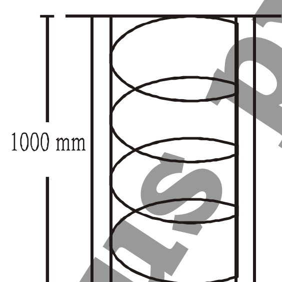
Area of core, $A_c = \frac{\pi}{4} \times D_c^{\,2}$

Volume of core. (for unit lengh)

$V_c = A_c \times 1000$ mm

V_h - volume of helical reinforcement

In some unit length of the column as considered for V_c



V_h = no. of turns × length in one turns × c/s area of helical reinforcement.

$$= \left(\frac{1000}{P}\right)(\pi.\phi_h)\left(\frac{\pi}{4}.\phi_h^{\,2}\right)$$

where,

D_h. diameter

$D_h = D_C - \phi_h$

Actual length of helical reinforcement

In one turn

$= \sqrt{(\pi\phi h)^2 + P^2} \approx \pi D_h$

∴ Calculate P from ..... (i)

As per IS code. the value of 'p' should be such that

(i) $P \ngtr 75$ mm

(ii) $P \ngtr \frac{1}{6} D_c$

(iii) $P \nless 25$ mm

(iv) $P \nless 3\,\phi_h$

Some IS code recommendations:

(i) Minimum % of steel = 0.8%

(ii) Maximum % of steel
 - 4 % (if bars are lapped)
 - 6 % (if bars are not lapped)

(iii) Minimum dia. of bar = 12 mm

(iv) Minimum no. of bars
 - For rectangular – 4
 - For circular – 6

(v) Maximum spacing of longitudinal bars = 300 mm

4. (a) What are the characteristics of a good quality timber ?

[10 Marks]

Solution: Following are the characteristics or qualities of a good timber:

(a) Appearance: A freshly cut surface of timber should have hard and shining appearance.

(b) Colour: The colour of timber should be dark light colour usually indicates timber with low strength.

(c) Smell: A good timber should have sweet. An unpleasant smell indicates decayed timber.

(d) Defects: A good timber should be free from serious defects such as knots, flaws, shakes, etc.

(e) Sound: A good timber should given out a clear ringing sound when struck. A dull heavy sound, when struck indicates decayed timber

(f) Structure: It should be uniform. The fibres should be firmly added. The medullary rays should be hard and compact. The annual rings should be regular and they should be clsely located.

(g) Strength: A good timber should be strong for working as structural member such as joist, beam, rafter, etc. It should be capable of taking loads slowly or suddenly. It should also possess enough strength in direct and transvcrse directions.

(h) Hardness: A good timber should be hard i.e. it should offer resistance when it is being penetrated by another body.

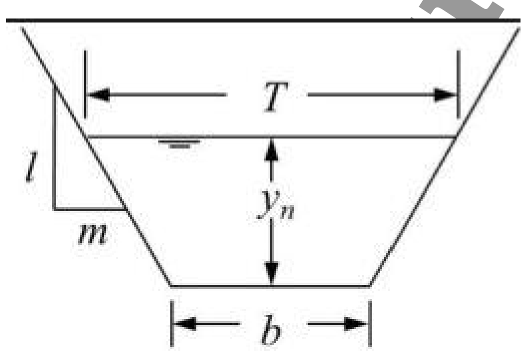
(i) Durability: A good timber should be durable. It should be capable of resisting the action of fungi insccts, chemicals, physical agencies and mechanical agencies.

(j) Fire Resistance: A dense wood offers good resistance to the fire and it required sufficient heat to cause a flame.

(b) Derive the condition for the trapezoidal channel of best section. Prove that the hydraulic mean depth for such a channel is one-half the depth of flow.

[15 Marks]

Solution :



Area, A = $\frac{1}{2}(B+B+2my)y$

A = $\frac{1}{2}(2B+2my)y$

$\boxed{A=(B+my)y}$

Top flow width, $\boxed{T=B+2ym}$

perimeter, $P=B+2y\sqrt{m^2+1}$

Substituting, B = $\frac{A}{y}-my$

$\boxed{P=\frac{A}{y}-my+2y\sqrt{m^2+1}}$ ....(i) (A & m are constant)

For efficient channel is the wetted permeter should be minimum so.

$$= \frac{d\rho}{dy} = 0$$

So differentiation of eq^n θ w.r.t. y

$$\frac{d\rho}{dy} = \frac{-A}{y^2} - m + 2\sqrt{1+m^2}$$

$$0 = \frac{-A}{y^2} - m + 2\sqrt{1+m^2}$$

$$\frac{A}{y^2} + m = 2\sqrt{1+m^2}$$

$$\frac{(B+my)y}{y^2} + m = 2\sqrt{1+m^2}$$

$$B + 2my = 2y\sqrt{1+m^2}$$

$$\boxed{\left(\frac{B+2my}{2}\right) = y\sqrt{1+m^2}}$$

For the most efficient channel the half the top width of trapezoidal section is equal to the one side of triangular section.

Hydraulic Mean Depth (R) : $R = \frac{\text{Wetted Area}}{\text{Wetted Perimeter}}$

$$= \frac{By + my^2}{\left(B + 2y\sqrt{1+m^2}\right)}$$

$$= \frac{y(B+my)}{(B+B+2my)} = \frac{y(B+my)}{2(B+my)}$$

$$\boxed{R = \frac{y}{2}}$$ Hence proved

(c) The discharge of a Pelton wheel turbine is 5 m³/sec at a head of 300 m at the nozzle. There are two runners and each runner has two jets. The length of the pipeline is 1900 m. The efficiency of the transmission for the pipe is 90%. Assume friction factor f as 0.008. Determine jet diameter, pipe diameter and output of the turbine. The overall efficiency of turbine is 85%. **[15 Marks]**

solution: Given - Q = 5m²/s

Hg = 300

L = 1900

F = 0.008

η_o = 85%

η pipe = 90%

Solution: (1) η pipe = $1 - \frac{h_F}{H_g}$

$$0.9 = \frac{1 - h_F}{300}$$

h_f = 30m.

2. $V_1 = \sqrt{2gH_{net}}$

$= \sqrt{2 \times 9.81 \times 270}$

$= 92.78 m/s$

3. $\frac{\text{Total discharge(Q)}}{\text{Total no. of jet}}$ = discharge required per jet (q)

$\frac{5}{4} = q$

$q = 1.25 m^3/s.$

$q = \frac{\pi}{4} \times d^2 \times V_1$

$d = .130 m$

4. Assume dia of pipe (D)

$h_f = \frac{4fLV^2}{2gD}$

V = average velocity in pipe

$V = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4}D^2}$

$h_f = \frac{8fLV^2}{\pi^2 g D^5}$

$30 = \frac{8 \times .008 \times 150 \times 5^2}{\pi^2 \times 9.81 \times D^5}$

$D^5 = 1.046$

$D = 1.009 m$

5. $\eta_0 = \frac{output\ power}{\rho Qg H_{net}}$

$0.85 \times \rho QgH_{net}$ = output power

P = 11256.975 KW

(d) What is workability of concrete ? Explain slump test and compacting factor test. Discuss the factors affecting workability. [20 Marks]

Solution: Workability can be defined as that property of freshly mixed concrete or mortar determines the ease and homogeneity with which it can be mixed, placed, compacted and finished.

The factors affecting the workability of concrete are:

1. Water Content:

Water content in a given volume of concrete will have significant influences on the workablility. The higher will be the fluidity of concrete, which is one of the important factors affecting workablity.

2. Mix Proportions:

Aggregate cement ratio is an important factor influencing workablity. The higher the aggregate cement ratio, the leaner is the concrete.

3. Size of Aggregates:

The bigger the size of aggregate, the less is the surface area and hence less amount of water is required for wetting the surface

4. Shape of Aggregates:

The shape of aggregates influences workablitiy in good measure. Angular, elongated or flaky aggregate makes the concrete very harsh when compared to rounded aggregates of cubical shaped aggregates.

5. **Surface Texture:**
The influence of surface texture on workability is again due to the fact that the total surface area rough textured aggregate is more than the surface area of smooth rounded aggregate of same volume. Thus the rough textured aggregate will show poor workablity and smooth or glassy textured aggregate will give better workability

6. **Grading of Aggregates:**
This is one of the factors which will have maximum incluence on workbality.

1. Slump test

- Slump test does not measure workability of concrete, although it gives a measure of consistency but is very useful in detecting variations in uniformity of mix of given nominal proportions.
- Dimensions of the mould are, bottom diameter = 200 mm, top diameter = 100 mm, and height = 300 mm.
- Mould is filled in with fresh concrete in four layers, each layer of approximately one quarter of the height of the mould and tamped with 25 strokes of the rounded end of the tamping rod (Dia = 16mm and length is 60 mm).
- Strokes are distributed in uniform manner over the cross-section and for the second and subsequent layers should penetrate into the underlying layer.
- After the top layer has been rodded, the concretc is struck off level with a trowel or the tamping rod, such that the mould is exactly filled.
- Mould is removed immediately by raising it slowly and carefully in a vertical direction.
- It allows the concrete to subside and the slump is meansured immediately by determining the difference between the height of the mould and that of the highest point of the specimen being tested.
- Slump measured is recorded in terms of millimeters of subsidence of the specimen.

2. Compacting Factor test

- This test is more accurate and sensitive than the slump test especially for it is useful for concrete mixes of medium and low workabilities i.e. compacting factor of 0.9 to 0.8.
- Sample of concrete to be tested is placed gently in the upper hopper, and levelled.
- Trap-door is then opened to allow the concrcte to fall into the lower hopper.
- Sticked concrete in the upper hopper at sides is gently pushed into lower one.
- The trap-door of the lower hopper is opened so that the concrete falls in the cylinder.
- Weight of the concrete in the cylinder is then determined to the nearest 10 gm this is known as wt of partially compacted concrete.
- Cylinder is refilled with concrete from the same sample in layers of 50 mm deep. each layer being heavily rammed or preferably vibrated so as to obtain full compaction.
- The mass of concrete in the cylinder should be measured and it is known as the mass of fully compacted concrete.
- Compacting factor is defined as ratio of the weight of partially compacled concrete to the weight of fully compacted concrete. i.e. C.F = $\frac{\text{mass of partially compacted concrete}}{\text{mass of fully compacted concrete}}$

5. (a) A 6 m high vertical wall supports a saturated cohesive soil with horizontal surface. The top 3.5 m of the backfill has bulk density 18 kN/m³ and apparent cohesion of 16 kN/m². The bulk density and apparent cohesion of the bottom 2.5 m is 19.5 kN/m² and 18 kN/m² respectively. What will be total active earth pressure on the wall ? Draw the pressure distribution diagram. Assume that tension cracks will develop. Locate the point of application of the resultant pressure.

[20 Marks]

Solution : Soil I

$p_a = k_a \gamma z - 2c\sqrt{k_a}$

$\phi' = 0$

$K_{a1} = \frac{1-\sin\phi'}{1+\sin\phi'} = 1$

at point A Z = 0

$P_a = 0 - 2 \times 16\sqrt{1} = -32 \text{ KN/m}^2$

at point B $p_b = K_a\gamma H - 2c\sqrt{k_a}$

H = 3.5m

$= 1\times18\times3.5 - 2\times16\sqrt{1} = 31 KN/m^2$

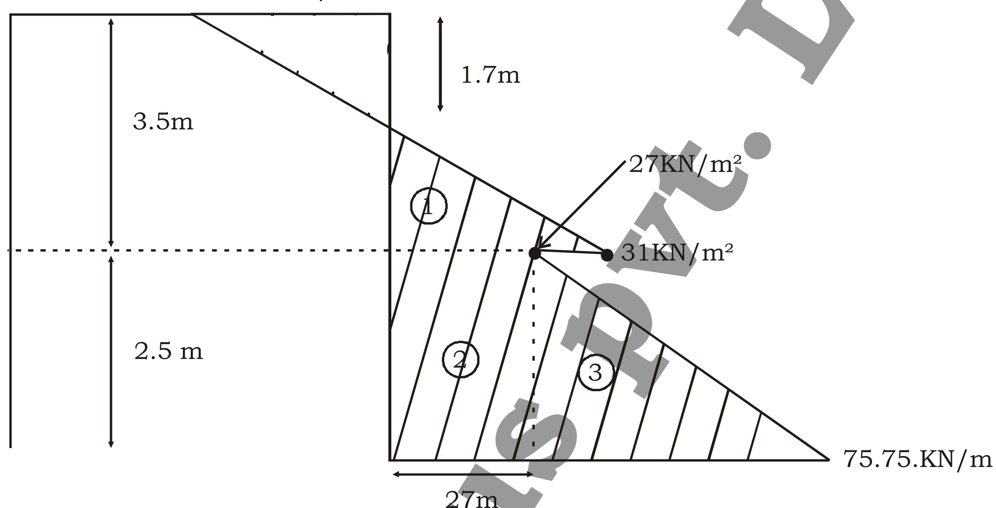
$Z_0 = \frac{2c}{\gamma\sqrt{k_a}} = \frac{2\times16}{18\sqrt{1}} = 1.78m$

Soil II Overburden $q = \gamma h = 18\times3.5 = 63\ KN/m^2$

$P_b = K_a(\gamma z+q) - 2c\sqrt{k_a}$

$= 1(0+63) - 2\times18\sqrt{1} = 27\ KN/m^2$

$P_c = 1(19.5\times2.5+63) - 2\times18\sqrt{1} = 75.75\ KN/m$



Total active pressure on wall due to soil = $\frac{1}{2}(3.5-1.78)31 + \left(\frac{27+75.75}{2}\right)$

= 26.66 + 128.43

$\boxed{Pa = 155.09\,KN/m^2}$

Point of application Z = $\frac{26.66\left(2.5+\left(\frac{3.5-1.78}{3}\right)\right)+27\times2.5\times\frac{2.5}{2}+\frac{1}{2}(75.75-27)2.5}{26.66+27\times2.5+\frac{1}{2}(75.75-27)2.5}$

Z = 5.26m. From base

(b) A direct shear test was conducted on a silty sand. At failure the normal and shear stresses were found to be 66 kPa and 40 kPa respectively. Draw Mohr's circle and determine :

(i) Angle of shearing resistance

(ii) Principal stresses at failure

(iii) Locate the pole and find orientation of failure plane.

[20 Marks]

Solution: $\sigma = 66$ kpa

$\tau = 40$ kpa

(i) $\phi = \tan^{-1}\left(\frac{\tau}{\sigma}\right) = \tan^{-1}\left(\frac{44}{66}\right)$

$\boxed{\phi = 31.22^0}$

(ii) $\sigma = \left(\frac{\sigma_1+\sigma_3}{2}\right) + \left(\frac{\sigma_1+\sigma_3}{2}\right)\cos 2\theta_f$

$\theta_f = 45 + \frac{\phi}{2} = 45 + \frac{31.22}{2} = 60.61°$

$66 = \left(\frac{\sigma_1+\sigma_3}{2}\right) + \left(\frac{\sigma_1-\sigma_3}{2}\right) + \cos(2\times60.61°)$

$66\times2 = (\sigma_1+\sigma_3)+(\sigma_1-\sigma_3)+(-0.52)$

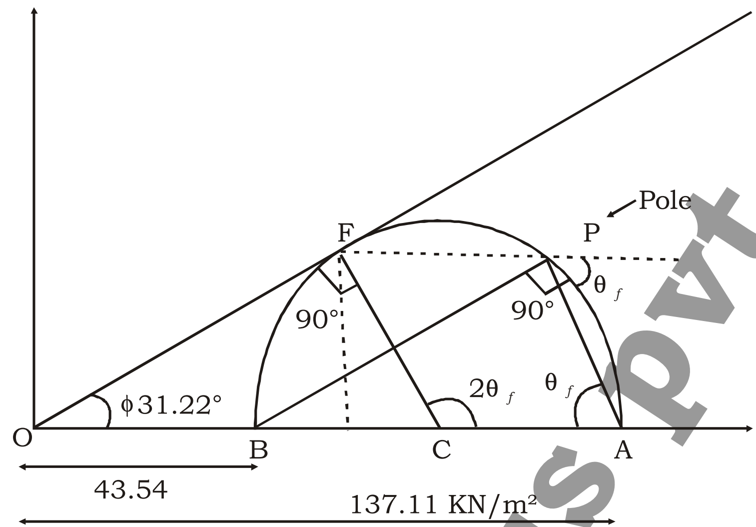
$$\tau = \left(\frac{\sigma_1-\sigma_3}{2}\right)\sin 2\theta_f$$

$$40 = \left(\frac{\sigma_1-\sigma_3}{2}\right)\sin(2\times60.61°)$$

$0.855\sigma_1 - 0.855\sigma_3 = 80$

$$\boxed{\begin{array}{l}\sigma_1 = 137.11\,KN/m^2\\ \hline \sigma_3 = 43.54\,KN/m^2\end{array}}$$

(iii)



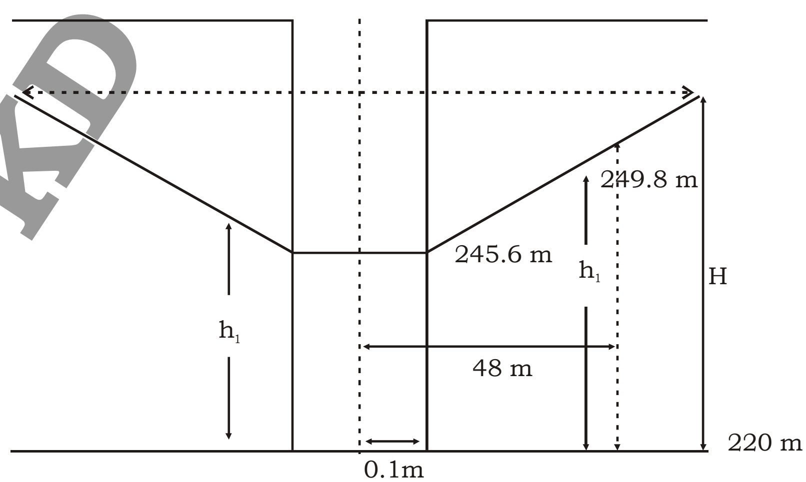
PA = Major principal plane
PB = Minor Principal plane
Obliquity of PB = 29.31°

(c) The pump-out test was performed to determine the field permeability of an unconfined aquifer and the following observations were made ;
RL of original water table before pumping = '250.5 m
RL of water in the well at constant pumping = 245.6 m
RL of the rock of impervious layer = 220.0 m
RL of water in observation well = 249.8 m
The distance of observation well from tubewell ≈ 48 m Determine

(i) Coefficient of permeability of the aquifer (k)
(ii) Error in k if observations are not taken in the observation well and radius of influence is assumed to be 298 m
(iii) Actual radius of influence based on the observations of observation well
(iv) Radius of influence using Sichart equation

The diameter of the well is 20 cm and discharge is 250 m³/hr **[20 Marks]**

Solution :



H = 30.5m
q = 250 m^3/s

$$= \frac{250}{60 \times 60} = 0.07m^3 / s$$

h = 25.6 m
h_1 = 28.6m

(i) $$q = \frac{1.36R\left(h_2^2 - h_1^2\right)}{\log 10\left(\frac{r_2}{r_1}\right)}$$

$$\therefore \quad 0.07 = \frac{1.36R\left((29.8)^2 - (25.6)^2\right)}{\log_{10}\left(\frac{48}{0.1}\right)}$$

$$\boxed{R = 5.93 \times 10^{-4} cm / s}$$

(ii) Error in K if R = 298m.
if R = 298 m

$$q = \frac{1.36R\left(H^2 - h^2\right)}{\log_{10}\left(\frac{R}{r}\right)}$$

$$0.07 = \frac{1.36R\left((30.5)^2 - (25.6)^2\right)}{\log_{10}\left(\frac{298}{0.1}\right)}$$

R = 6.505×10^{-4} m/s
Error = $6.505 \times 5.93 \times 10^{-4}$

$$\boxed{\Delta K = 0.575 \times 10^{-4} m / s}$$

(iii) Actual radius of influence

$$q = \frac{1.36R\left(H^2 - h^2\right)}{\log_{10}\left(\frac{R}{r}\right)}$$

$$\log_{10}\left(\frac{R_1}{0.1}\right) = \frac{1.36 \times 5.93 \times 10^{-4}\left((30.5)^2 - (25.6)^2\right)}{0.07}$$

$$\log_{10}\left(\frac{R_1}{0.1}\right) = 3.167$$

$$\frac{R}{0.1} = 10^{3.167}$$

$$\frac{R}{0.1} = 1.469.08$$

$$\boxed{R = 146.90m}$$

(iv) According to sichart equation

R = 3000 s $\sqrt{R}$

S = Drawdown = $H - h$

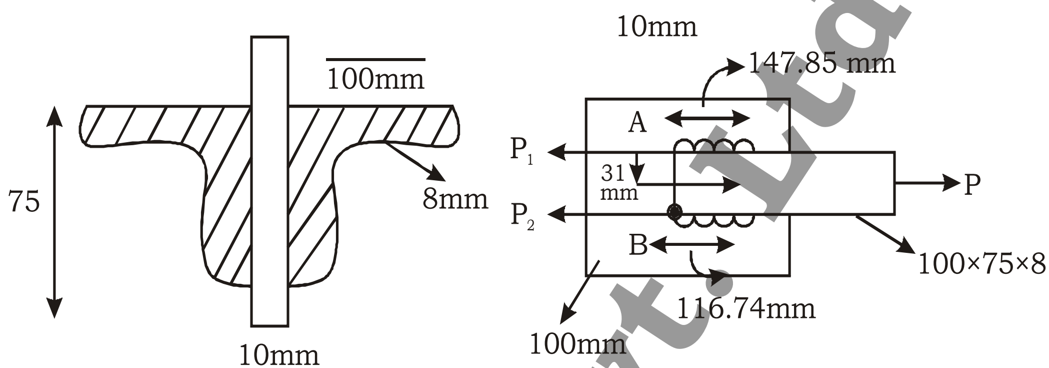
R = 3000×4.9 $\sqrt{5.93 \times 10^{-4}}$

$\boxed{R = 357.968m}$

6.(a) **In a roof truss, the member consists of 2 ISA 100 × 75 × 8 mm. The angles are connected to either side of a 10 mm gusset plate and member is subjected to a working pull of 280 kN. Design the welded connection assuming they are made in the workshop. The centre of gravity of the section from the top may be considered as 31 mm.**

[25 Marks]

solution:



Working load = 280 KN

Design load = 280 ×1.5 = 420 KN

Since angles are connected two side of gusset plate

$\therefore$ Load on each angle = $\frac{420}{2} = 210KN$

Moment abt. B

$P \times (75 - 31) = P_1 \times 75$

$\Rightarrow$ $210 \times 42 = P_1 \times 75$

$\Rightarrow$ $P_1 = 117.6$ KN

$P_2 = 210 - 117.6 = 92.4$ KN

$P_1 = K_s\, l_{eff} \times \frac{fu}{\sqrt{3} \times r_{min}}$ (workshop weld $r_{mn} = 1.25$)

$\Rightarrow$ $117.6 = 0.7 \times S\, l_{eff} \times \frac{410}{\sqrt{3} \times 1.25}$

S = ?

At A Square Edge. (size of weld)

Minimum size of weld is 3mm $\rightarrow$ Plate thickness (10mm)

Maximum on size of weld $\rightarrow$ 8 –1.5 = 6.5mm

At B $\rightarrow$ Rounded Edge. (size of weld)

Minimum size $\rightarrow$ 30mm

Maximum size $\rightarrow$ 3/4 × 8 = 6mm

$P_1 = 117.6 = 0.7 \times 6 \times l_{eff} \times \frac{410}{1.25 \times \sqrt{3}}$

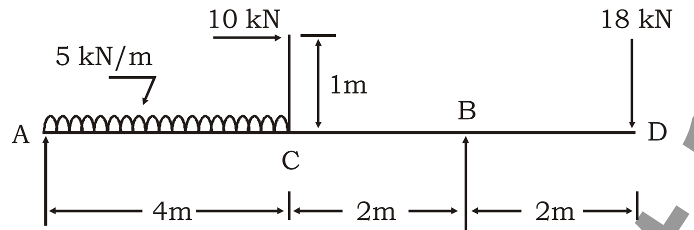
$= l_{eff} = 147.85$mm

$P_2 = 92.4 = 0.7 \times 6 \times l_{eff} \times \frac{410}{1.25 \times \sqrt{3}}$

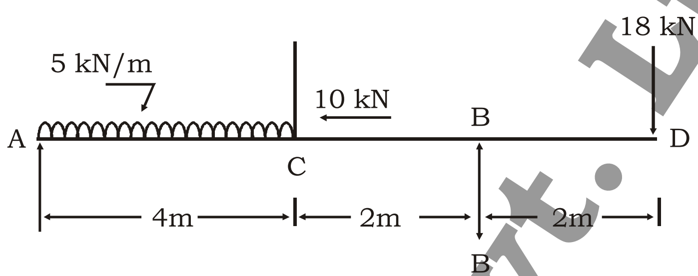
$= l_{eff} = 116.174$mm

So provide 147.85 mm and 116.174 mm weld length on top and bottom side of angles, and both side

(b) Draw the shear force and bending moment diagram for the beam as shown below : [25 Marks]



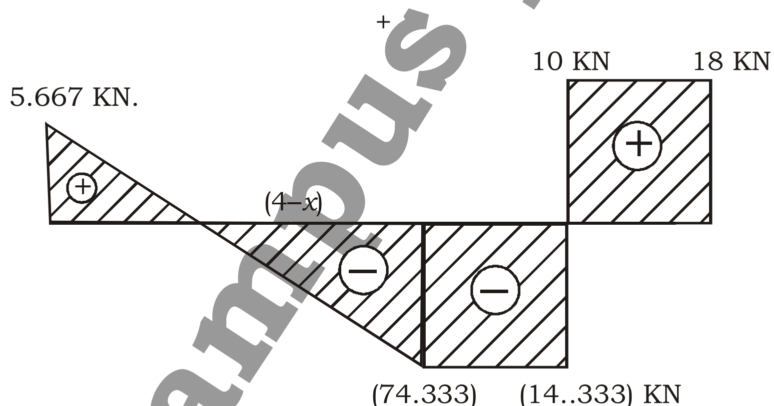
Solution:



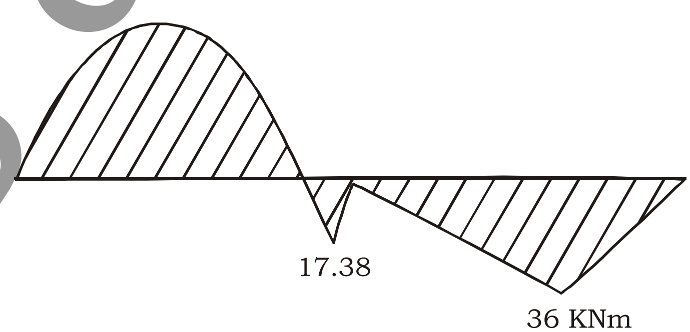
$$V_A = \frac{20 \times 4}{6} - \frac{46}{6} \qquad VB = \frac{20 \times 2}{6} + 18 + \frac{46}{6}$$

$$\boxed{V_A = 5.667KN} \qquad \boxed{V_B = 32.333KN}$$

SFD



BMD



Stear force calculation:-

from left side $\begin{bmatrix} \uparrow & \downarrow \\ + & - \end{bmatrix}$

$V_A = 0$

$V_A = 5.667\ [\uparrow]$

$V_C = 5.667 - 5 \times 4 = -14.33$

$= 14.33(KN)\ [\downarrow]$

$V_B = 14.33\ (KN)\ [\downarrow]$

$V_B = -14.33 + 32.333$

$V_B = 18\ KN\ [\uparrow]$

$V_D = 18\ KN\ [\uparrow]$

$V_D = 18 - 18 = 0$ [OK]

Location of zero S. F from support 'A'

$$\frac{5.667}{x} = \frac{14.333}{(4-x)}$$

5.667 (4–x) = 14.33x

$\boxed{x = 1.1334m}$

Bending moment calculation:-

[↻ ↺]

$M_A = 0$

$M_C = 5.667 \times 4 - 5 \times 4 \times \frac{4}{2} = (-17.33\ KNm)$

$= 17.33$ [G]↻

$M_C = -17.33 + 10 = -7.333KN = 7.333$[G]↻

$M_B = 5.667 \times 6 - 5.4 = -3.6$

$M_D = 0$

Note:- Maximum bending moment of the location of qero shear force [x = 1.133m form left suppost]

$$B.Mmax = 5.667 \times 1.133 - 5 \times 1.333 \times \left(\frac{1.333}{2}\right)$$

$\boxed{B.Mmax = \oplus 3.2115KNM}$

(c) Define the following terms :
Scrap value, Salvage value, Sinking fund and Depreciation

[10 Marks]

Depreciation is the gradual exhaustion of the usefulness of a property. This may be defined as the decrease or loss in the value of a property due to structural deterioration, life wear and tear, decay and obsolescence.

Scrap value of an asset may be defined as the maximum value that can be fetched by salvaging or selling it after its useful life. It is also known as salvage value, residual value or break-up value.

A sinking fund is an account that is used to deposit and save money to repay a debt or replace a wasting asset in the future. In other words, it's like a savings account that you deposit money in regularly and can only be used for a set purpose.

Salvage value is the estimated value that the owner is paid when the item is sold at the end of its useful life.