SJE(PAPER-II) -2018 MAINS
OFFLINE TEST SERIES

Civil and Structural Engineering **Full Length Mock Test-2**

Solutions

01. (a)

Sol: To determine the area required for a landfill site.

Amount of waste generated per day

$$= \frac{150000 \times 10}{7} = 214285.7 \text{ kg/day}$$

Total waste produced in 20 years

$= 214285.7 \times 20 \times 365$

$= 1564285714.3\text{kg}$

$$\Rightarrow \text{volume waste} = \frac{\text{mass}}{\text{density}}$$

$$= \frac{1564285714.3}{500} \text{m}^3$$

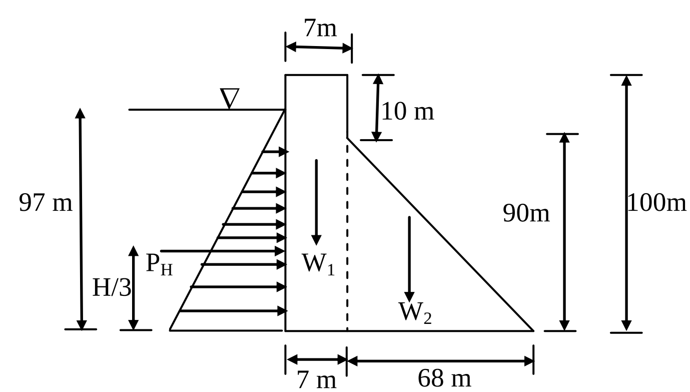
$= 3128571.4 \text{ m}^3$

$$\therefore \text{ Area} = \frac{\text{Volume}}{\text{height}} = \frac{3128571.4}{10}$$

$= 312857.14 \text{ m}^2 = 31.3 \text{ Ha}$

(b)

Sol: Profile of gravity dam



Let,

W_1 = self weight of dam in Rectangular portion

W_2 = self weight of dam in triangular portion

P_H= horizontal forces due to water Pressure

Weight density of concrete (γ) = 2.4 ton/m^3

Coefficient of friction (μ) = 0.75

Force due to	Forces [$\gamma\times$ volume(B×L×H)]
W_1	$2.4\times7\times1\times100 = 1680$ ton
W_2	$2.4\times\frac{1}{2}\times68\times90\times1 = 7344$ ton
	$\sum V = 9024$ ton
P_H	$\frac{\gamma_W H^2}{2} = \frac{1\times97^2}{2} = 4704.5$ ton $\sum H = 4704.5$ ton

Factor of safety against sliding = $\frac{\mu\sum V}{\sum H}$

$\sum V$ = Algebraic sum of vertical forces

$\sum H$ = Algebraic sum of horizontal forces

FOS against sliding = $\frac{0.75\times9024}{4704.5} = 1.44 > 1$

Since factor of safety against sliding is more than 1, the dam is safe.

(c)

Sol: Given:

Dia of pipes = 20 mm

Reynolds number. = 1600

h_L/length = 0.2

We know that, $R_e = \frac{\rho.v.d}{\mu}$

As Reynolds No = 1600 < 2000

$\therefore$ The Given flow is Laminar

$$h_f = \frac{f\,l\,Q^2}{12.1d^5}$$

$$f = \frac{64}{R_e} = \frac{64}{1600} = 0.04$$

$0.2 = \dfrac{0.04 \times Q^2}{12.1 \times (0.02)^5}$

$Q = 4.4 \times 10^{-4}\ m^3/s$

$Q = A\ V$

$V = \dfrac{4.4 \times 10^{-4}}{\frac{\pi}{4} \times (0.02)^2} = 1.4\ m/s$

$R_e = \dfrac{VD}{\nu}$

$1600 = \dfrac{1.4 \times (0.02)}{\nu}$

$\nu = 1.75 \times 10^{-5}\ m^2/s$

1 Stoke = 1 cm^2/s

$\nu = 1.75 \times 10^{-5} \times 10^4$

$\nu = 0.175$ Stokes

(d)

Sol: Given:

Non-recording rain gauge = 5

Error = 10%

Rain gauge station	I	II	III	IV	V
Annual Rainfall in cm	100	120	190	95	125

To find:

Required optimum number of Non recording and recording rain gauges

Rain gauge station	Annual rainfall in cm	$P_i - \overline{P}$	$(P_i - \overline{P})^2$
I	100	–26	676
II	120	–6	36
III	190	64	4096
IV	95	–31	961
V	125	–1	1
	$\overline{P} = 126$		$\sum(P_i - \overline{P})^2 = 5770$

Mean precipitation = $\dfrac{100+120+190+95+125}{5}$

$\overline{P} = 126\text{cm}.$

Standard deviation = σ = $\sqrt{\dfrac{(P_i - \overline{P})^2}{(m-1)}}$

$$\sigma = \sqrt{\frac{5770}{5-1}} = 37.98\text{cm}$$

Coefficient of variation,

$$C_v = \frac{100\sigma}{\overline{P}} = \frac{100 \times 37.98}{126}$$

$C_v = 30.14\%$

Optimum number of Rain gauges = $\left[\dfrac{C_v}{E}\right]^2 = \left[\dfrac{30.14}{10}\right]^2 = 9.08 \simeq 10$

According to IS code,

10% provided for recording type rain gauges

90% provided for Non recording type rain gauges

$\therefore$ No of Non recording type rain guage = 9

$\therefore$ No of recording type rain gauge = 1

02. (a)

Sol: Given:

Mean bucket speed, u = 12 m/s

Discharge, Q = 750 litres/sec

Head, H = 35 m

Angle of deflection, $(180 - \beta) = 160°$

Coefficient of velocity, $C_v = 0.98$

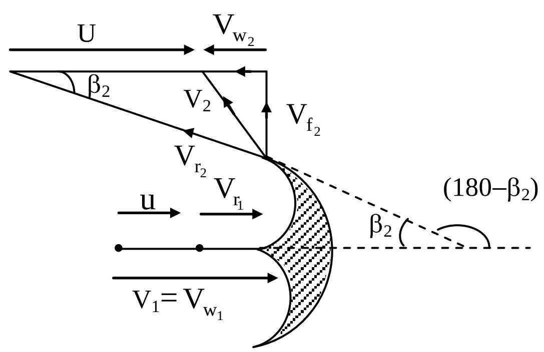
To find:

(i) Power developed

(ii) Efficiency of turbine

(i) Power developed:

Force exerted by the fluid upon the bucket



$$F = \rho Q\left(V_{w_1} + V_{w_2}\right)$$

$$= \rho Q\left(V_1 + V_{r_2}\cos\beta_2 - U\right)$$

$$= \rho Q\left(V_1 + V_{r_1}\cos\beta_2 - U\right)$$

$$= \rho Q\,(V_1 - U + (V_1 - U)\cos\beta_2)$$

$$F = \rho Q\,(V_1 - U)(1 + \cos\beta_2)$$

Power developed = Force × bucket speed

$$P = \rho Q\,(V_1 - U)\,(1 + \cos\beta_2)\,U$$

V_1 – Velocity of jet = $C_V \times \sqrt{2gH}$

$$= 0.98 \times \sqrt{2 \times 9.81 \times 35}$$

$V_1 = 25.68$ m/s

$180 - \beta_2 = 160$

$\beta_2 = 20°$

$P = 1000 \times 0.75 \times (25.68 - 12) \times 12 \times (1 + \cos 20)$

$P = 238.8$ KW

(ii) Efficiency of turbine: (η)

$$\eta_h = \frac{\text{Power delivered to the Wheel}}{\text{K.E. of the Jet / sec}}$$

$$\text{K.E.} = \frac{1}{2}\rho Q V_1^2$$

$$= \frac{1}{2} \times 1000 \times 0.75 \times (25.68)^2 = 247.298 \text{ KW}$$

$$\eta_h = \frac{238.8}{247.298}$$

$\eta_h = 96.56\%$**05.**

(b) (i)

Sol: Bubble tube A

The distance of the bubble from the centre of its run

(i) $n_1 = \frac{1}{2} \times (13 - 5) = 4$ division

(ii) $n_2 = \frac{1}{2} \times (12 - 8) = 2$ division

The total number of divisions n through which bubble has moved = $n_1 + n_2 = 6$

The staff intercept s = 1.767 – 1.618 = 0.149 m

The sensitivity of the bubble tube

$$\alpha'_A = 206265 \times \frac{s}{nD} \text{seconds}$$

$$= 206265 \times \frac{0.149}{6 \times 80} \text{seconds} = 1'4''$$

Bubble tube B

The distance of the bubble from the centre of its run

(i) $n_1 = \frac{1}{2} \times (15 - 3) = 6$ division

(ii) $n_2 = \frac{1}{2} \times (14 - 6) = 4$ division

The total number of divisions n through which bubble has moved = $n_1 + n_2 = 10$

The staff intercept s = 1.788 – 1.635 = 0.153 m

The sensitivity of the bubble tube

$$\alpha'_B = 206265 \times \frac{0.153}{10 \times 80} \text{seconds} = 40''$$

Since $\alpha'_A > \alpha'_B$, the bubble A is more sensitive than B.

(ii)

Sol:

The contours have the following characteristics:

1. Contour lines must close, not necessarily in the limits of the plan.
2. Widely spaced contour indicates flat surface.
3. Closely spaced contour indicates steep ground.
4. Equally spaced contour indicates uniform slope.
5. Irregular contours indicate uneven surface.
6. Approximately concentric closed contours with decreasing values towards centre, indicate pond.
7. Concentric closed contours with increasing values towards centre, indicate hills.
8. Contour lines with V-shape with convexity towards higher ground indicate valley.
9. Contour lines with U –shape with convexity towards lower ground indicate ridge.
10. Contour lines generally do not meet or intersect each other.

(c)

Sol:

Cant: When train is running along a straight track, the heads of the rail must be kept absolutely at the same level. But when it is moving curved path, it has a constant radial acceleration which produced centrifugal force. In order to counteract this force, the outer rail of the track is raised slightly higher than the inner rail. This is known as the super elevation (or) Cant.

Cant deficiency: It is the difference between equilibrium cant necessary for the maximum permissible speed on a curve and the actual cant provided as per average speed of the trains.

Given, cant e = 14 cm

V_{max} = 80 kmph

To find length of transition curve

As per Indian railway, length of transition curve based on following.

(a) Based on arbitary gradient of 1 in 720:

L = 7.20 e

L in meters, e = actual cant in cm

$L = 7.20 \times 14 = 100.8$ m

(b) Based on rate of change of cant deficiency:

$L = 0.073\ V_{max}\ D$

D = 7.5 cm for B.G track [for speeds upto 100 kmph]

$L = 0.073 \times 80 \times 7.5$

L = 43.8 m

(c) Based on rate of change of superelevation:

$L = 0.073\ eV_{max}$

$L = 0.073 \times 14 \times 80$

L = 81.76 m

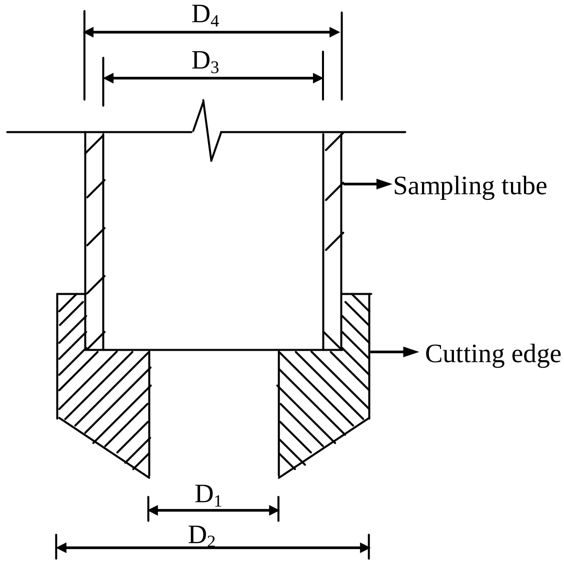
Take maximum of above three

L = 100.8 m say 101 m

(d)

Sol: (i) Area Ratio:

It indicates the ration of displaced volume of soil to that of the soil sample collected



$$A_r = \frac{\text{Maximum cross sectional of cutting edge} - \text{Sectional area of cutting edge}}{\text{Area of soil sample}} \times 100$$

$$A_r = \frac{D_2^2 - D_1^2}{D_1^2} \times 100$$

Where, D_1 = inner diameter of the cutting edge

D_2 = Outer diameter of the cutting edge

- Area ratio should be kept as low as possible, so as to reduce sample disturbance.

Soils	Area ratio range
Stiff formation	$A_r \ngtr 20\%$
Soft sensitive clays	$A_r \leq 10\%$

(ii) Inside Clearance:

Inside clearance = $C_i = \dfrac{D_3 - D_1}{D_1} \times 100$

Where, D_3 = inside diameter of sampling tube.

D_1 = inside diameter of cutting edge

- The inside clearance allows elastic expansion of the sample when it enters the tube
- It helps in reducing the frictional drag on the sample.
- If the inside clearance is too large, there will be too much of lateral expansion.
- IS code recommends that, inside clearance, C_i should be from 1 to 3%

(iii) Outside Clearance:

Outside clearance, = $C_D = \dfrac{D_2 - D_4}{D_4} \times 100$

Where, D_2 = outside diameter of cutting edge

D_4 = outside diameter of sampling tube.

- The outside clearance should not be much greater then inside clearance.

  It values lie between 0 to 2%.

(iv) Design of non-return valve:

The non-return valve provided on the sampler should be of proper design. It should have an orifice of large area to allow air, water or slurry to escape quickly when the sampler is driven. It should immediately close when the sampler is withdrawn.

03. (a)

Sol:

(i) Capitalized value: The capitalized value is the present worth of a property calculated at the highest prevailing rate of interest.

Capitalized value = Annual net income × Years purchase

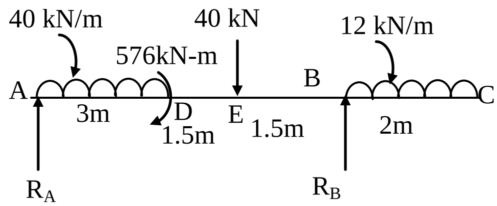
(ii) Detailed estimate: Detailed estimate is the complete and comprehensive estimate of the project calculated by multiplying the quantity of the item of work in the project by its unit rate.

Detailed estimate comprises of:

1. Report
2. General specifications
3. Detailed specifications
4. Drawings
5. Design calculations
6. Standard schedule of rates

(b) (i)

Sol:



$\Sigma M_B = 0$

Support Reaction:

$\Sigma M_B = 0$

$R_A \times 6 - 40 \times 3 \times [3 + \frac{3}{2}] + 576 - 40 \times 1.5 + 12 \times 2 \times 1 = 0$

$R_A = 0\text{kN}$

$R_A + R_B = 40 \times 3 + 40 + 12 \times 2$

$R_A + R_B = 184\text{kN}$

$R_B = 184\text{kN}$

SF calculation:

$SF_A = 0$

$SF_D = 40 \times 3 = -120\text{kN}$

$(SF_E)_{left} = -120\text{kN}$

$(SF_E)_{right} = -120 - 40 = -160\text{kN}$

$(SF_B)_{left} = -184 + 12 \times 2 = -160\text{kN}$

$(SF_B)_{right} = +12 \times 2 = +24\text{kN}$

BM calculation:

$BM_A = 0$

$BM_{D(left)} = -40\times3\times1.5$

$= -180$ kN-m

$BM_{D(right)} = -40\times3\times1.5 + 576$

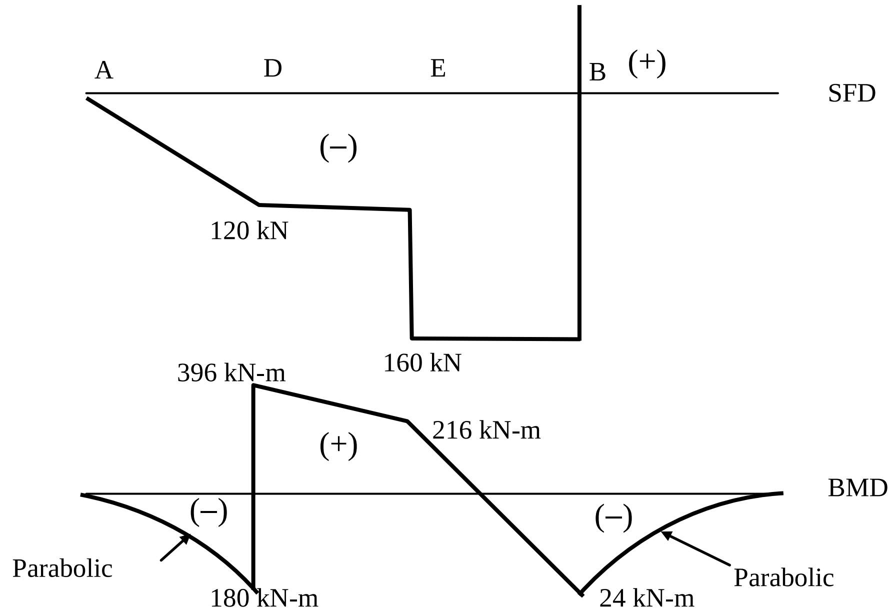
$= 396$ kN-m

$BM_E = 184\times1.5 - 12\times2\times2.5$

$= 216$ kN–m

$BM_B = -24$ kN-m

$BM_C = 0$



(ii)

Sol: Given:

Power, P = 250 kw

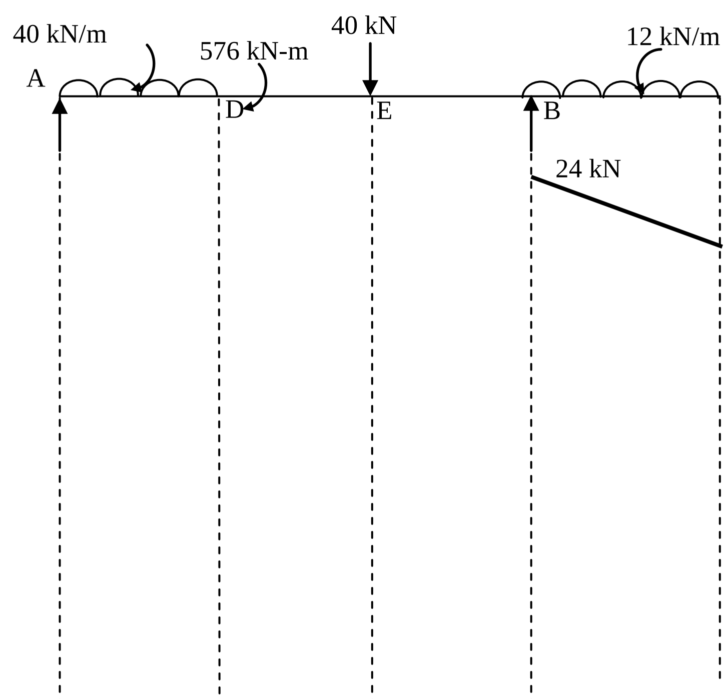
N = 100 r.p.m

$\tau = 75\ \text{N/mm}^2$

$$P = \frac{2\pi NT}{60}$$

$$250 = \frac{2\pi\times100\times T}{60}$$

T = 23.87 kN-m



Torsion Equation:

$$\frac{T}{J} = \frac{G\theta}{\ell} = \frac{\tau}{R}$$

$$\frac{T}{J} = \frac{\tau}{R}$$

$$T = \tau Z_p$$

$$T = \tau\frac{\pi}{16}d^3$$

$$23.87\times10^6 = \frac{75\times\pi}{16}\times d^3$$

$d = 117.47$ mm

$d = 0.6\,D$

$$\frac{T}{J} = \frac{\tau}{R}$$

$$\frac{23.87\times10^6}{\frac{\pi}{32}\left[D^4 - d^4\right]} = \frac{75}{D/2}$$

$$\frac{23.87\times10^6}{\frac{\pi}{32}\left[D^4 - (0.6D)^4\right]} = \frac{150}{D}$$

$$\frac{23.87\times10^6}{\frac{\pi}{32}D^4\left[1 - 0.6^4\right]} = \frac{150}{D}$$

$D = 123.03$ mm

$d = 73.82$ mm

$w = \gamma V$

$w = \gamma \times A \times l$

$w \propto A$

$$\frac{w_h}{w_s} = \frac{\frac{\pi}{4}\left[123.03^2 - 73.82^2\right]}{\frac{\pi}{4}\left[117.47\right]^2}$$

$$\frac{w_h}{w_s} = 0.701$$

$\therefore$ Percentage saving in weight

$= (1 - 0.701)\times 100$

$= 29.8\%$

(c)

Sol: Given:

b = 300 mm

LL = 12 kN/m

l_{eff} = 8 m

M15, Fe415

Design a reinforced concrete beam with balanced section by working stress method.

Step1: Assume the depth of beam = 1000 mm

Effective cover = 50 mm

Step 2: Load calculations:

Dead load,

$W_D = \gamma_c \times b \times D$

$= 25 \times 0.3 \times 1$

$= 7.5$ kN/m

Live load, w_L = 12 kN/m

Total load = 7.5 + 12 = 19.5 kN/m

Step3: Moment calculation:

Design moment, $M = \dfrac{w\ell^2}{8} = \dfrac{19.5 \times 8^2}{8}$ = 156 kN-m

Step4: Check for depth:

$M_{lim} = Q\, bd^2$

Calculation of constants

From IS: 456

$\sigma_{cbc} = 5\,\text{MPa}$

σ_{st} = 230 MPa

$m = \dfrac{280}{3\sigma_{cbc}} = \dfrac{280}{3 \times 5} = 18.67$

$$K = \frac{m\sigma_{cbc}}{m\sigma_{cbc} + \sigma_{st}} = \frac{18.67 \times 5}{18.67 \times 5 + 230} = 0.289$$

$$j = 1 - \frac{K}{3} = 0.904$$

$$Q = \frac{1}{2}\sigma_{cbc}\, jK = \frac{1}{2} \times 5 \times 0.289 \times 0.904 = 0.653$$

$$M = Q\, bd^2$$

$$156 \times 10^6 = 0.653 \times 300 \times d^2$$

$$d = 892.37 \simeq 900 \text{ mm}$$

$$D = 900 + 50$$

$= 950$ mm < Assumed one

Hence safe

Step5: Reinforcement in tension:

$$M = \sigma_{st} A_{st}\, jd$$

$$156 \times 10^6 = 230 \times A_{st} \times 0.904 \times 900$$

$$A_{st} = 833.654 \text{ mm}$$

Use 16 mm ϕ bar

$$\text{Number of bars, } n = \frac{833.654}{\frac{\pi}{4}[16]^2}$$

$$n = 4.14 \simeq 5$$

Step6: Calculation of minimum reinforcement: (From IS: 456)

$$\frac{(A_{st})_{min}}{bd} = \frac{0.85}{f_y}$$

$$(A_{st})_{min} = \frac{0.85 \times bd}{f_y}$$

$$= \frac{0.85 \times 300 \times 900}{415} = 553 \text{ mm}^2$$

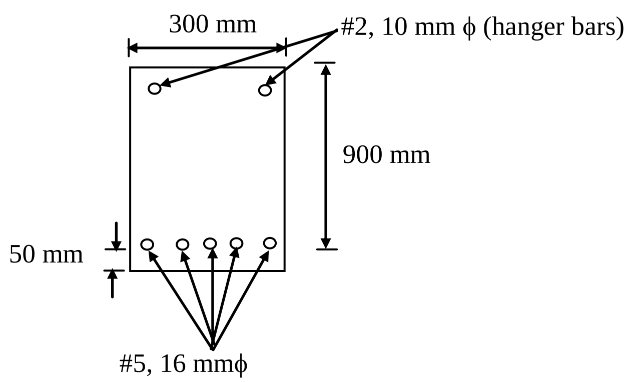
Step7:Calculation of maximum reinforcement: (From IS: 456)

$(A_{st})_{max} = 4\%\ bD$

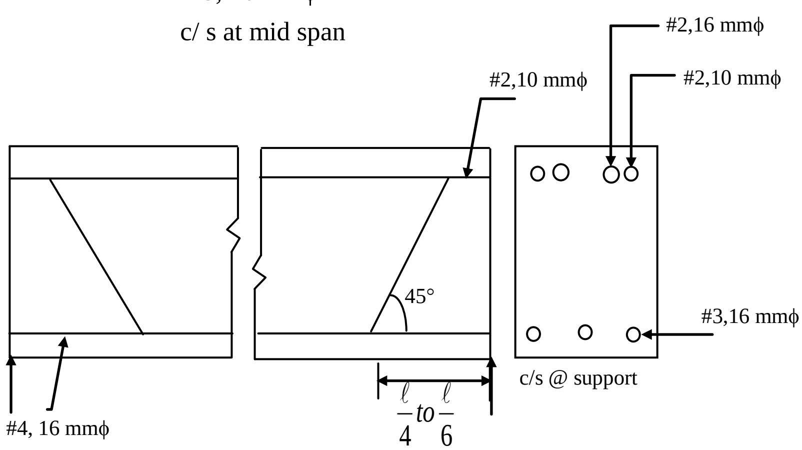
$$= \frac{4}{100} \times 300 \times 950 = 11400\ mm^2$$

Provide # 2 of 10 mm ϕ Hanger bar in compression zone

Design Detail:

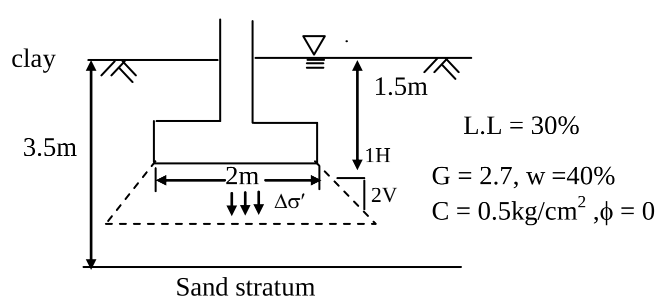


c/ s at mid span



04. (a)

Sol:



$$\Delta H = C_c \frac{H}{1+e_o} \log\left(\frac{\Delta\sigma' + \sigma_o'}{\sigma_o'}\right)$$

$C_c = 0.009\,(w_L - 10\%)$

$C_c = 0.009\,(30\% - 10\%) = 0.18$

H = 2.0m,

$e_0 = 2.7\times0.4 = 1.08$

Given: load intensity = safe bearing capacity of soil

$$\gamma_{sat} = \frac{\gamma_w[G + se]}{1+e} \qquad S_r = 1$$

$$\gamma_{sat} = \frac{10[2.7+1.08]}{1+1.08} = 18.17\,kN/m^3$$

$$\sigma'_o = \sigma - u$$

$$= 18.17\times(2.5) - (2.5\times10)$$

$$= 20.43\ kN/m^2$$

$$\Delta\sigma' = \frac{Q}{(B+Z)^2} = \frac{Q}{(2+1)^2}$$

$Q = q_{ns} \times$ Area of footing

($C = 0.5kg/cm^2 = 49.050\ kN/m^2$)

$q_{nu} = 1.2\times C\times N_c$

$= 1.2\times49.050\times6.9$

$q_{nu} = 406.134\ kN/m^2$

$$q_{ns} = \frac{q_{nu}}{FOS} = \frac{406.134}{3}$$

$$= 135.38\ kN/m^2$$

Load = Q = 135×4 = 540kN

$$\Delta\sigma' = \frac{540}{(2+1)^2} = 60\,kN/m^2$$

$$\Delta H = 0.18\times2.0\times\frac{1}{1+1.08}\times\log_{10}\left(\frac{60+20.43}{20.43}\right)$$

ΔH = 103 mm

(b)

Sol: Given data:

Water content w = 0.18

Weight of empty cutter = W_1 = 2000 g

Weight of cutter with soil = W_2 = 4500 g

V = volume of cutter = 1250 cc

Hence, weight of soil = W_2 - W_1

W = 4500 - 2000 = 2500 g

Bulk density $\gamma = \frac{W}{V} = \frac{2500}{1250}$ = 2 g/cc

Given G = 2.7

We know, Se = wG

$$\gamma = \frac{\gamma_w(G+Se)}{1+e} = \frac{\gamma_w(G+wG)}{1+e}$$

$$2 = \frac{1(2.7+(0.18\times 2.7))}{1+e}$$

e = 0.593

But,

Se = wG

$S \times 0.593 = 0.18 \times 2.7$

= 0.819 = 81.9% (say)

When, embankment gets saturated

$$\gamma_{sat} = \frac{\gamma_w(G+e)}{1+e} = \frac{1(2.7+0.593)}{1+0.593}$$

= 2.067 g/cm^3

Also, $w = \frac{Se}{G} = \frac{1\times 0.593}{2.7}$

w = 0.2196

w = 21.96%

(c)

Sol: Given:-

Design speed, V = 65 kmph;

Length of wheel base = 6.1 m

Radius of Horizontal curve = R = 325 m.

Pavement width = B = 10.5m.

To Design:

(i) Super elevation

(ii) Extra widening

(iii) Length of Transition curve

(i) Design of super elevation:

It is designed for

- 75% of design speed
- Neglecting the friction

$$e_{mixed} = \frac{V^2}{225R}$$

$$= \frac{65^2}{225 \times 325} = 0.057 < 7\ \%$$

$\therefore$ provide super elevation 5.7 %

(ii) Extra widening:

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

Where,

$n \rightarrow$ no of traffic lanes

$\ell \rightarrow$ length of wheel base, m

$R \rightarrow$ radius of horizontal curve, m

$V \rightarrow$ Design speed in kmph.

No of lanes = $\dfrac{\text{Width}}{3.5} = \dfrac{10.5}{3.5} = 3$

$$W_e = \frac{3\times 6.1^2}{2\times 325} + \frac{65}{9.5\sqrt{325}}$$

$W_e = 0.55\text{m}$

$\therefore$ Provide extra width = $W+W_e$ = 10.5+.55 = 11.05 m

(iii) Length of transition curve:

The length of transition curve is designed to fulfill 3 conditions

(1) Rate of change of centrifugal acceleration

(2) Rate of introduction of super elevation

(3) By empirical formula.

(1) Rate of change of centrifugal acceleration:

$$L_s = \frac{V^3}{CR}; C = \frac{80}{75+V}$$

Where,

C- Allowable rate of change of centrifugal Acceleration

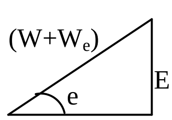
$C = \dfrac{80}{75+65} = 0.571 \quad (0.5 < C < 0.8)$

$L_s = \dfrac{(0.278)^3 \times (65)^3}{0.571\times 325} = 31.79\,\text{m}$

(2) Rate of Introduction of super elevation:

Assuming the pavement is rotated about inner edge,

$L_s = EN \qquad e = \dfrac{E}{W+W_e}$



$L_s = eN(W+W_e)$

$= 0.0571\times 150 \times (10.5+0.551)$

(Assume N = 150)

$L_s = 94.65\text{m}$

(3) By empirical formula:

Assuming plain & rolling terrain,

$$L_s = \frac{2.7V^2}{R} = \frac{2.7\times 65^2}{325} \Rightarrow L_s = 35.1$$

Adopt highest of above three values,

$\therefore L_s = 94.65$ m

(d) (i)

Sol: Assumptions involved in terzaghi's general theory for bearing capacity under a strip footing:

1) The base of the footing is rough
2) The footing is laid at shallow depth, i.e. $D_f \leq B$.
3) The shear strength of soil above the base of footing is neglected
4) The soil above the base of footing is replaced by a uniform surcharge γDf.
5) The load on the footing is vertical and is uniformly distributed.
6) The footing is long, i.e L/B ratio is infinite.
7) The shear strength of the soil is governed by the Mohr-coulomb equation
8) General shear failure is assumed to take place and the soil volume is unchanged prior to failure.

(ii)

Sol: Liquidity Index:

Liquidity Index is defined as the ratio of difference between the natural water content of the soil and its plastic limit to its plasticity Index.

$$I_L = \frac{w - w_P}{I_P}$$

The insitu behaviour of a saturated, fine grained soil deposit at its Natural water content may be studied by their Liquidity Index.

Activity Number:

Activity Number is defined as the ratio of plasticity Index to the percentage of clay-size particles by weight.

- Activity number indicates swelling and shrinkage of soil.
- Higher the activity number, higher the compressibility, swelling of a soil.

Eg: Bentonite has high Activity number

Thixotrophy:

- It is the property of certain clays by virtue of which they regain, if left alone for a time, a part of the strength lost due to remoulding, at same moisture content.
- For example: A pile which is driven into a clay soil has the effect of disturbing the soil structure, leading to a loss of shear strength. Due to thixotropy of soil a part of shear strength will be regained if the driven pile is left alone for sometime. Hence the frictional resistance of a driven pile immediately upon installation will have less value. However, after some time, the strength of pile increases.

Sensitivity:

Sensitivity is defined as the ratio of the unconfined compressive strength of an undisturbed specimen of the soil to the unconfined compressive strength of the same soil after remoulding at unaltered water content.

$$S = \frac{(q_u)\,\text{undisturbed}}{(q_u)\,\text{remoulded}}$$

05. (a)

Sol: The timber which is prepared scientifically in a factory is termed as the industrial timber and such timber possesses desired shape, appearance, etc. Following are the five varieties of industrial timber:

(1) Vaneers

(2) Plywood

(3) Fibre boards

(4) Impreg timber

(5) Compreg timber

(6) Block board and laminated board

(7) Glulam

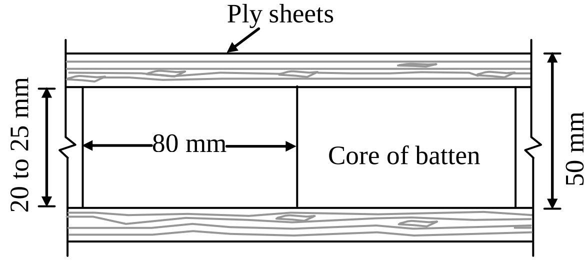
(8) Flushdoor shutters

(9) Particle board or chip board

(10) Hardboard.

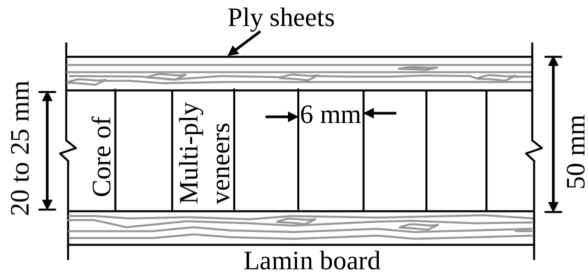
(i) Plywood (IS: 303-1989): The meaning of term ply is a thin layer. The plywood are boards which are prepared from thin layers of wood or veneers. The three or more veneers in odd numbers are placed one above the other with the direction of grains of successive layers at right angles to each other. They are held in position by application of suitable adhesives. The placing of veneers normal to each other increases the longitudinal and transverse strengths of plywood. The plywood is used for various purposes such as ceilings, doors, furniture, partitions, paneling walls, packing cases, railway coaches, formwork for concrete, etc. The plywood are available in different commercial forms such as battenboard, lamin board, metal faced plywood, multiply, three-ply, veneered plywood, etc.

(ii) Batten Board: The batten board is a solid block with core of sawn thin wood as shown below fig. The thickness of core is about 20 mm to 25 mm and total thickness of board is about 50 mm. The direction of the grains of core battens is at right angles to that of the adjacent outer ply sheets. These boards are light and strong.



Batten board

(iii) Laminated Board: The laminated board is similar to the batten board except that the core is made of multiply veneers as shown below.



(iv) Fibre boards (IS: 12406-2003): These are rigid boards and they are also known as the pressed wood or reconstructed wood. The thickness varies from 3 mm to 12 mm. They are available in lengths varying from 3 m to 4.50 m and in widths varying from 1.20 m to 1.80 m. The weight of Fibre boards depends on the pressure applied during manufacture. The maximum and minimum limits of weight are respectively 9600 N/m^3 and 500 to 600 N/m^3.

Following is the procedure adopted in the manufacture of Fiber boards:

(i) The pieces of wood, cane or other vegetable fibres and chippings are collected and they are heated and boiled in a hot water boiler.

(ii) The wood fibres separated by heat are put in a vessel.

(iii) The steam under pressure is admitted in the vessel.

(iv) The pressure of steam is then suddenly increased to 7 N/mm^2. This increased pressure is maintained for few seconds only.

(v) The valve located at the bottom of vessel is opened and the steam is allowed to expand.

(vi) The sudden release of pressure makes the wood pieces to explode and in doing so, the natural adhesive contained in the wood fibres is separated out.

(i) The wood fibres are then allowed to flow out.

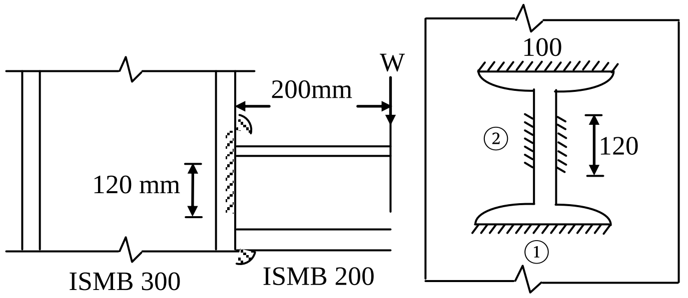
(ii) These fibres are cleaned of all superfluous or extra gums.

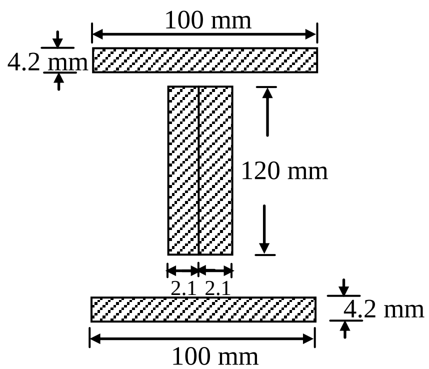
(iii) Such cleaned fibres are spread on wire screens in the form of loose sheets or blankets of required thickness.

(iv) Such loose sheets of wood fibres boards are obtained.

(b) (i)

Sol:





Direct concentric load W

Bending moment M= We=200 W kN-mm

Weld 1:

Given that size, S_1 = 6 mm

$\therefore$ Throat thickness, $t_{t1} = 0.7 \times S = 4.2$ mm

Weld 2:

Given that size, S = 3 mm

$\therefore$ Throat thickness, $t_{t2} = 0.7 \times S = 2.1$ mm

Direct vertical shear stress due to W

$$q_{cal} = \frac{W}{\text{Effective sectional area of weld}}$$

$$= \frac{W}{(100 \times 4.2) \times 2 + (120 \times 4.2)}$$

$$q_1 = \frac{W}{1344} N/mm^2$$

stress in weld due to M at extreme fiber

$$q_2 = \frac{M}{I_{xx}} y$$

Moment of inertia of weld I_{xx}

$$= \left[\frac{100\times 4.2^3}{12} + 100\times 4.2\times 100^2\right]\times 2 + \left[\frac{4.2\times 120^3}{12}\right]$$

$I_{xx} = 9.09 \times 10^6$ mm^4

$$q_2 = \frac{W\times 200}{9.09\times 10^6}\times 100 \quad = \frac{W}{454.8} N/mm^2$$

Maximum resultant stress at extreme fiber

$$q_r = \sqrt{q_1^2 + q_2^2}$$

$$q_r = \sqrt{\left(\frac{W}{1344}\right)^2 + \left(\frac{W}{454.8}\right)^2}$$

$$q_r = \frac{W}{430.80} \text{ N/mm}^2$$

Permissible shear stress in the weld, τ_{vf} = 100 MPa

$$q_w \le \tau_{vf}$$

$\therefore \dfrac{W}{430.80} = 100 \Rightarrow$ W = 43.08 kN

$\therefore$ Safe load, W = 43.08 kN

(ii)

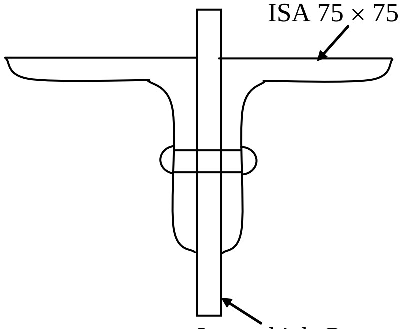
Sol: Permissible shear stress τ_{vf} = 100 MPa

Permissible bearing stress σ_{pf} = 300 MPa

Axial load P = 150 kN

Assume nominal diameter of rivet

$\phi = 6.04\sqrt{t} = 6.04\sqrt{6} = 14.79$ mm $\simeq$ 16 mm



Gross diameter of rivet

d = 16 + 1.5 = 17.5 mm

Strength of one rivet in double shear

$$P_s = 2\times\frac{\pi}{4}(d)^2\times\tau_{vf} = 2\times\frac{\pi}{4}(17.5)^2\times 100$$

$$= 48.11\times 10^3 \text{ N} = 48.11 \text{ kN}$$

Strength of one rivet in bearing

$$P_b = dt\,\sigma_{pf} = 17.5\times 6\times 300$$

$$= 31.5\times 10^3 \text{ N} = 31.5 \text{ kN}$$

Strength of one rivet or Rivet Value R_v = lesser of P_s (or) P_b = 31.5 kN

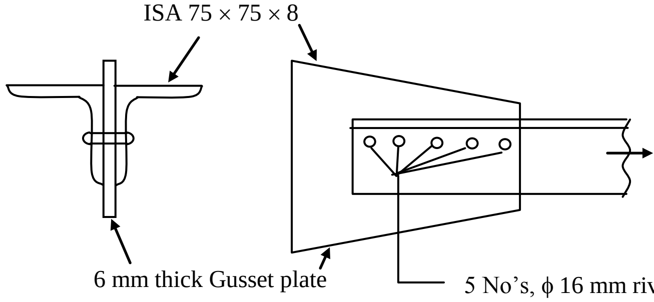
No. of rivets required $n = \dfrac{Axial\ load}{Rivet\ Value} = \dfrac{P}{R_v}$

$$= \frac{150}{31.5} = 4.76 \simeq 5 \text{ No's.}$$

Assume minimum end (or) edge distance

$e = 1.5\times 17.5 = 26.25$ mm $\simeq$ 30 mm

Minimum pitch = 2.5×16 = 40 mm



(c)

Sol: By Straight line method

Initial cost of the construction equipment, $C_i =$ Rs.1,50,000

Estimated salvage value, C_S = SV = Rs.20,000

Useful life = n = 10 years

For straight-line method,

The depreciation amount for a given year is calculated , $D_m = \dfrac{C_i - C_S}{n} = \dfrac{1{,}50{,}000 - 20{,}000}{10} = 13{,}000$

The book value at the end of a 3rd year is $= C_i - D_m \times m = 1{,}50{,}000 - 13{,}000 \times 3 = 1{,}11{,}000$

By Double declining balance method

d_m = constant annual depreciation rate $= \dfrac{2}{n} = \dfrac{2}{10} = 0.2$

Book value in Double declining balance method $= C_i(1 - d_m)^m$

$BV_3 = 1{,}50{,}000(1 - 0.2)^3 = 76{,}800$

By Sum of years digit method

The depreciation amount for a given year is calculated,

$$D_m = (C_i - C_S) \times \dfrac{n - m + 1}{\dfrac{n(n+1)}{2}}$$

$$D_1 = (1{,}50{,}000 - 20{,}000) \times \dfrac{10 - 1 + 1}{\dfrac{10(10+1)}{2}} = 23{,}636.36$$

$$D_2 = (1{,}50{,}000 - 20{,}000) \times \dfrac{10 - 2 + 1}{\dfrac{10(10+1)}{2}} = 21{,}272.72$$

$$D3 = (1{,}50{,}000 - 20{,}000) \times \dfrac{10 - 3 + 1}{\dfrac{10(10+1)}{2}} = 18909.09$$

$BV_3 = C_i - D_1 - D_2 - D_3$ = 1,50,000 – 23,636.36 – 21,272.72 – 18909.09 = 86181.83

Alternatively for sum of years digit method

$$BV_m = C_i - \frac{(Ci - Cs)}{\frac{n(n+1)}{2}} \times \left[mn - \frac{m(m-1)}{2}\right]$$

$$= 1{,}50{,}000 - \frac{(1{,}50{,}000 - 20{,}000)}{\frac{10(10+1)}{2}} \times \left[3 \times 10 - \frac{3(3-1)}{2}\right]$$

$$= 86181.83$$

06. (a)

Sol: Given data:

Discharge = 1MLD

Detention time, DT = 2.5 hours

Velocity of flow = 8cm / minute

Depth of water & sediment = 4.5 m

(i) To find the length of the tank, L

Length of the tank = velocity of flow × Detention time

$$= \frac{8 \times 10^{-2}\,\text{m}}{\text{min}} \times 2.5 \times 60\,\text{min}$$

L = 12 m

Volume of the tank

= Discharge × Detention time

$$= \frac{1 \times 10^6 \times 10^{-3}}{24} \times 2.5$$

Volume of the tank = 104.17 m^3

(ii) Depth of water = 4.5 – 1.5 = 3m

(Sediment depth = 1.5 m given)

Volume = width × length × depth

104.17 = B × 12 × 3

B = 2.89 m ≃ 2.9 m

(iii) To find overflow rate of the tank, V_0

$$V_0 = \frac{Q}{B \times L} = \frac{10^6}{24 \times 2.9 \times 12}$$

V_0 = 1197.31 lt/hr/ m^2

(b)

Sol: Three –Point Problem

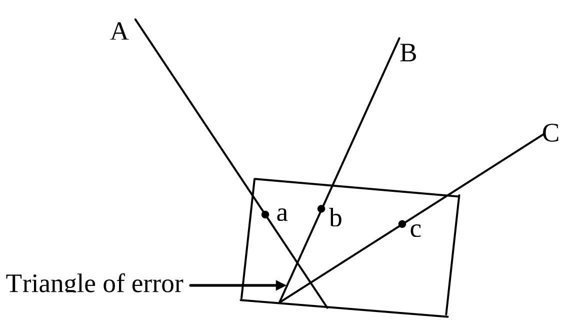
Fixing the plotted position of the station occupied by the plane table by means of observations to three well-defined points whose plotted positions are known, is called three –point problem.

Say A, B and C are three well-defined points and their plotted positions are a, b and c, respectively. The plane table is at station P and its plotted position 'p' is to be found.

Trial and Error Method

This method is also known as Lehman's method and Triangle of Errors method. The method is as given below:

1. Set the table above point P and orient approximately by looking at station A,B,C and their plotted positions a, b, and c, Clamp the table.
2. Draw the rays aA, bB and cC. If orientation is not correct a triangle is formed. This is called triangle of error.
3. To eliminate the triangle of error and get a point 'p' an approximate position of p say p′ is selected near the triangle of error. Keeping alidade along p′ a orientation of table is slightly changed to sight A. Table is clamped and resectors Bb and Cc are drawn. The size of triangle of error reduces.
4. Step 3 is repeated till triangle of error is eliminated and all the three resectors Aa, Bb, Cc pass through a point. That point is the position of station P and that orientation is the required orientation.



The following rules presented by Lehman assist in getting correct orientation quickly.

Rule 1: The distance of point sought (p) is in the same proportion from the corresponding rays as the distance of those from the plane table station.

Rule2: The point sought ‘p’ is on the same side of all the three resectors (Aa, Bb and Cc).

(c)

Sol: Rapid hardening cement (IS: 8041-1990): The initial and final setting time of this cement are the same as those of ordinary cement. But it attains high strength in early days. It contains high percentage of tricalcium silicate C_3S to the extent of about 56% . This is due to the following facts:

1. Burning at high temperatures.
2. Increased lime content in cement composition.
3. Very fine grinding.

This cement is slightly costlier than ordinary cement, but it offers the following advantages.

(i) It sets rapidly, the construction work may be carried out speedily.

(ii) The formwork of concrete can be removed earlier and it can therefore be used frequently.

(iii) It obtains strength in a short period. The compressive strength at the end of one day is about 11.50 N/mm^2 and that at the end of 3days is about 21 N/mm^2. Similarly the tensile strength at the end of one day is about 2 N/mm^2 and that at the end of 3 days is about 3 N/mm^2.

(iv) It is light in weight

(v) It is not damaged easily.

(vi) The structural members constructed with this cement may be loaded earlier.

(vii) This cement requires short period of curing

(viii) The use of this cement allows higher permissible stresses in the design. It therefore results in economic design.

Sulphate resisting cement (IS: 12330–1998): Ordinary Portland cement is susceptible to the attack of sulphate . Free calcium hydroxide and hydrate of calcium aluminium present in the set cement react with sulphate and form calcium sulphate and calcium aluminate respectively. The product formed by reactions within the framework of hydrated cement paste results in expansion and subsequently disruption of the set concrete occurs.

The remedy of sulphate attack is sulphate resisting cement. It is cement with low C_3A content and comparatively lower C_4AF content. The percentage of C_3A (tricalcium aluminate) is kept below 5 percent and it results in the increase in resisting power against sulphate attack.

Sulphate resisting cement is used for the following conditions:

(i) For the structures which are likely to be damaged by severe alkaline conditions such as canal linings, culverts, siphons, etc

(ii) In constructions of sewage treatment worker.

(iii) In foundations and basements where soil contains sulphate

(iv) In marine construction

(v) In pile fabrication which are likely to be buried in marshy region or sulphate bearing soils.

(d)

Sol: Given:

Size: 200 mm × 300 mm

Effective length, l_{eff} = 3m

A_{sc} = 6 Nos-20 mm ϕ

f_y = 415 MPa; f_{ck} = 20 MPa

Safe load = ?

$$\lambda = \frac{\ell_{eff}}{LLD} = \frac{3000}{200} = 15 > 12$$

$\therefore$ Long columns

Load carrying capacity by using working stress method

$P = C_r(\sigma_{cc} A_c + \sigma_{sc} A_{sc})$

Reduction factor, $C_r = 1.25 - \frac{\ell_{eff}}{48 \times b} = 1.25 - \frac{3000}{48 \times 200} = 0.94$

For Fe415 $\rightarrow \sigma_{sc}$ = 190 MPa

(From IS : 456 – 2000)

For M20 $\rightarrow \sigma_{cc}$ = 5 MPa

$A_c = 200 \times 300 - 6 \times \frac{\pi}{4}(20)^2 = 58115.04 mm^2$

$$P = 0.94[58115.04 \times 5 + 6 \times \frac{\pi}{4} \times 20^2 \times 190]$$

P = 609.79 kN

LATERAL TIES

Diameter:

Greater of the following

(i) $\not< \frac{1}{4}(20) = 5$ mm

(ii) $\not<$ 6mm

$\therefore$ Provide 6mm

Pitch:

Smaller of the following

(i) LLD = 200 mm

(ii) 16×20 = 320 mm

(ii) $\not> 48 \times 6 = 288$ mm

$\therefore$ Provide 6mm ϕ @ 200 mm c/c

Assume nominal cover = 40 mm

Design details: