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Detailed Solutions

SSC-JE 2018
Mains Test Series
(PAPER-II)

Civil Engineering
Test No : 2

Q.1 (a) Solution:

Number of people = 300

Water supplied = 135 l/ person/ day

Detention period = 24 hours

Rate of deposition of sludge = 50 l/ person/ year

Quantity of water supplied = 300 × 135 l/ day = 40500 l/ day

∵ 75% of water becomes waste water

∴ Quantity of sewage produced = 0.75 × 40500 = 30375 l/day

Detention period = 24 hours

∴ Quantity of sewage produced during detention period

$$= 30375 \times \frac{24}{24} = 30375\, l$$

Rate of deposition of sludge = 50 l/ person/ year

Period of cleaning = 1 year

∴ Volume of sludge deposited = 50 × 300 × 1 = 15000 l

∴ Total capacity of tank required = capacity for sewage + capacity for sludge

= 30375 + 15000 = 45375 l = 45.375 m^3

Depth of tank = 2 m

∴ Surface area of tank $= \frac{45.375}{2} = 22.6875\,m^2$

Ratio of length to width is 3 : 1

$$\frac{L}{B} = 3$$

$$\Rightarrow \quad L = 3B$$

$$L \times B = 22.6875$$

$$\Rightarrow \quad 3B^2 = 22.6875$$

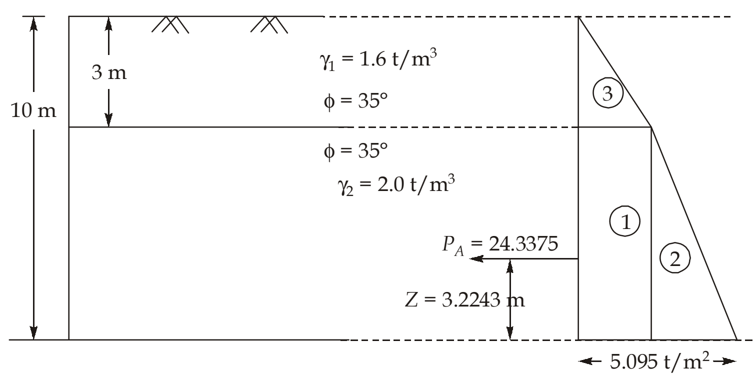
$$\Rightarrow \quad B = 2.75 \text{ m}$$

$$\therefore \quad L = 2.75 \times 3 = 8.25 \text{ m}$$

$$\text{Total depth} = 2 + 0.3 = 2.3 \text{ m}$$

$$\therefore \quad \text{Size of septic tank} = 8.25 \text{ m} \times 2.75 \text{ m} \times 2.3 \text{ m}$$

Q.1 (b) Solution:



$$\phi = 35°$$

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 35°}{1+\sin 35°} = 0.271$$

Active pressure at 3 m below G.L.,

$$p_{a_1} = K_a \times \gamma_1 \times z_1$$

$$p_{a_1} = 0.271 \times 1.6 \times 3 = 1.301 \text{ t/m}^2$$

Active pressure at bottom, $p_{a_2} = (K_a \times \gamma_1 \times z_1) + (K_a \times \gamma_2 \times z_2)$

$$\therefore \quad p_{a_2} = 1.301 + 0.271 \times 2 \times 7 = 5.095 \text{ t/m}^2$$

Active thrust, $P_a = A_1 + A_2 + A_3$

$$P_a = (1.301 \times 7) + \left(\frac{1}{2} \times 7 \times 3.794\right) + \left(\frac{1}{2} \times 3 \times 1.301\right)$$

$$= 24.3375 \text{ t/m}$$

Let location be 'z' m from bottom, $z = \dfrac{A_1 z_1 + A_2 z_2 + A_3 z_3}{A_1 + A_2 + A_3}$

$$= \frac{\left(1.301 \times 7 \times \frac{7}{2}\right) + \left(\frac{1}{2} \times 7 \times 3.794 \times \frac{7}{3}\right) + \left\{\frac{1}{2} \times 3 \times 1.301 \times \left(7 + \frac{3}{3}\right)\right\}}{24.3375}$$

= 3.2243 m from bottom

Q.1 (c) Solution:

Advantages of sprinkler systems are as follows:

(i) Seepage losses which occur in earthen channels in surface irrigation methods are completely eliminated.

(ii) Land levelling is not required and thus avoiding removal of top fertile soil as happens in other surface irrigation methods.

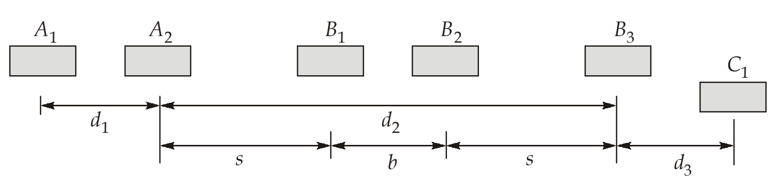
(iii) No cultivation area is lost for making ditches as in surface irrigation methods.

(iv) In sprinkler system, the water is to be applied at a rate lesser than the infiltration capacity of the soil and thus avoiding surface runoff and its ill effects such as loss of water, washing of top soil, etc.

(v) Fertilizers can be uniformly applied because they are mixed with irrigation water itself.

(vi) This method leaches down salts and prevents water logging and salinity of soil.

Q.1 (d) Solution:



Let t = reaction time = 2 sec

V_b = velocity of overtaken vehicle

= 70 kmph = 19.44 m/s

$s = 0.7\, V_b + 6$

$= 0.7 \times 19.44 + 6$

$= 19.6$ m

$$T = \sqrt{\frac{4s}{a}}$$

$$a = 2.5 \times \frac{5}{18} = 0.694 \text{ m/sec}^2$$

$$\therefore \quad T = \sqrt{\frac{4 \times 19.6}{0.694}} = 10.63 \text{ sec}$$

Now $d_1 = V_b \times t = 19.44 \times 2 = 38.88$ m

$d_2 = b + 2s$

$= (19.44 \times 10.63) + 2 \times 19.6$

$= 245.85$ m

$d_3 = vT = 85 \times \frac{5}{18} \times 10.63 = 250.986$ m

$\therefore$ OSD $= d_1 + d_2 + d_3$

$= 38.88 + 245.85 + 250.986$

$= 535.72$ m

Q.2 (a) Solution:

∠A = Bearing of AE – Bearing of AB = 135°15′ – 80°10′ = 55°05′

∠B = Bearing of BA – Bearing of BC = 259° – 120°20′ = 138°40′

∠C = Bearing of CB – Bearing of CD = 310°50′ – 170°50′ = 140°00′

∠D = Bearing of DC – Bearing of DE = 350°50′ – 230°10′ = 120°40′

∠E = Bearing of ED – Bearing of EA = 49°30′ – 310°20′ + 360°

= 99°10′

∴ Sum of all the internal angles = ∠A + ∠B + ∠C + ∠D + ∠E

= 55°05′ + 138°40′ + 140°0′ + 120°40′ + 99°10′ = 553°35′

Theoretical sum = (2n – 4) 90° = 540°

Error = +13°35′

Hence a correction of $-\frac{13°35'}{5} = -2°43'$ is applied to all the angles. The corrected angles are:

∠A = 52°22′; ∠B = 135°57′;

∠C = 137°17′; ∠D = 117°57′ and ∠E = 96°27′

Starting with the corrected bearing of CD, all other bearings can be calculated as under:

Bearing of DE = Bearing of DC – ∠D = 350°50′ – 117°57′ = **232°53′**

∴ Bearing of ED = 232°53′ – 180° = **52°53′**

∴ Bearing of EA = Bearing of ED – ∠E = 52°53′ – 96°27′ + 360° = **316°26′**

∴ Bearing of AE = 316°26′ – 180° = **136°26′**

Bearing of AB = Bearing of AE –∠A = 136°26′ – 52°22′ = **84°4′**

∴ Bearing of BA = 84°4′ + 180° = **264°4′**

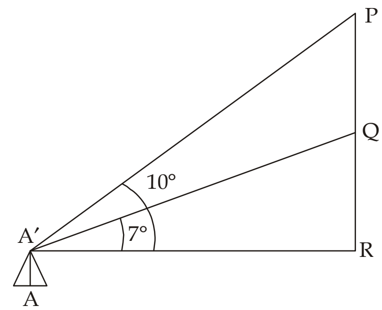
Bearing of BC = Bearing of BA – ∠B = 264°4′ – 135°57′ = **128°7′**

∴ Bearing of CB = 128°7′ + 180° = **308°7′**

Bearing of CD = Bearing of CB – ∠C = 308°7′ – 137°17′ = **170°50′**

∴ Bearing of DC = 170°50′ + 180° = **350°50′**

Q.2 (b) Solution:



$$\text{Height of flag post} = PQ = 2 \text{ m}$$

$$\tan 10° = \frac{2 + QR}{A'R}$$

$$\tan 7° = \frac{QR}{A'R}$$

$$\therefore \quad \frac{2 + QR}{\tan 10°} = \frac{QR}{\tan 7°}$$

$$\Rightarrow \quad QR = 4.587 \text{ m}$$

$$\therefore \quad \text{RL of top flag post} = 100 + 1.245 + 4.587 + 2 = 107.832 \text{ m}$$

Q.2 (c) Solution:

Causes of creep:

1. Unequal contraction and expansion of rails due to variation in temperature given rise to creep.
2. Creep develops in rails when a train starts and stops. While starting, train pushes the rail backwards and while stopping due to application of brakes, creep in rails occurs in the forward direction.

Effects of creep on rails:

1. The most serious effect of creep is the buckling of track in lateral direction.
2. Sleepers move out of position which leads to change in gauge and alignment.
3. Points and crossings get disturbed.
4. Maintenance and replacement of tracks becomes difficult.
5. Smashing of fish plates and bolts are other associated effects of creep.

Q.2 (d) Solution:

Unknown degrees of freedom are θ_B, θ_C and δ_C

Fixed end moments:

$$\bar{M}_{AB} = \frac{-36 \times 4 \times 2^2}{6^2} = -16 \text{ kNm}$$

$$\bar{M}_{BA} = \frac{+36 \times 4^2 \times 2}{6^2} = 32 \text{ kNm}$$

$$\bar{M}_{BC} = 0$$

$$\bar{M}_{CB} = 0$$

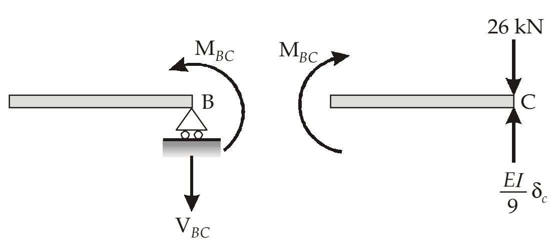
Slope deflection equations:

$$M_{AB} = \bar{M}_{AB} + \frac{2EI}{l}(2\theta_A + \theta_B) = -16 + \frac{2EI}{6}(\theta_B) \quad \text{...(i)}$$

$$M_{BA} = 32 + \frac{2EI}{6}(2\theta_B) \quad \text{...(ii)}$$

$$M_{BC} = \frac{2EI}{3}\left(2\theta_B + \theta_C - \frac{3\delta_C}{3}\right) \quad \text{...(iii)}$$

$$M_{CB} = \frac{2EI}{3}\left(2\theta_C + \theta_B - \frac{3\delta_C}{3}\right) \quad \text{...(iv)}$$



Free body diagram

Joint equilibrium conditions; At joint B;

$$M_{BA} + M_{BC} = 0$$

$$\Rightarrow \quad 32 + \frac{2EI}{6}(2\theta_B) + \frac{2EI}{3}\left(2\theta_B + \theta_C - \frac{3\delta_C}{3}\right) = 0$$

$$\Rightarrow \quad 3\theta_B + \theta_C - \delta_C = \frac{-48}{EI} \quad \text{...(v)}$$

At joint C; $M_{CB} = 0$

$$\Rightarrow \quad \frac{2EI}{3}\left(2\theta_C + \theta_B - \frac{3\delta_C}{3}\right) = 0$$

$$\Rightarrow \quad \delta_C = \theta_B + 2\theta_C \quad \text{...(vi)}$$

Shear condition

Consider free body diagram as shown above of span BC in which the spring is replaced by force equal to stiffness times the displacement.

Take moment of all forces about B

$$\frac{EI\delta_C}{9} \times 3 - 26 \times 3 - M_{BC} = 0$$

Substituting for M_{BC} from equation (iii),

$$\frac{EI\delta_C}{9} \times 3 - 26 \times 3 - \frac{2EI}{3}\left(2\theta_B + \theta_C - \frac{3\delta_C}{3}\right) = 0$$

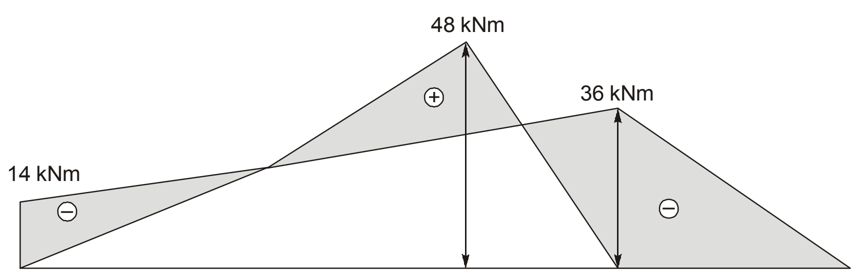
$$\Rightarrow \quad 4\theta_B + 2\theta_C - 3\delta_C = -\frac{234}{EI} \quad \text{...(vii)}$$

Solving the above equation, we get

$$\theta_B = \frac{6}{EI},\ \theta_C = \frac{60}{EI} \text{ and } \delta_C = \frac{126}{EI}$$

Substituting in slope deflection equations, the bending moments (kNm) are,

$$M_{AB} = -14 \text{ kNm},\quad M_{BA} = 36,\quad M_{BC} = -36 \text{ kNm and } M_{CB} = 0$$



Q.3 (a) Solution:

Assume general shear failure,

Terzaghi's equation,

Ultimate bearing capacity, $q_u = cN_c + \gamma D_f N_q + 0.5\gamma BN_\gamma$

Net ultimate bearing capacity, $q_{nu} = cN_c + \gamma D_f (N_q - 1) + 0.5\gamma BN_\gamma$

For $\phi = 25°$

We have $N_c = 25.1$, $N_q = 12.7$ and $N_\gamma = 9.7$,

Let B be the width of strip footing

Substituting the values, we get

$$q_{nu} = (20 \times 25.1) + (18 \times 1.6) \times (12.7 - 1) + 0.5 \times 18 \times B \times 9.7$$

$$q_{nu} = 502 + 337 + 87.3\,B = 839 + 87.3\,B$$

∴ Safe bearing capacity, $q_{safe} = \dfrac{q_{nu}}{FOS} + \gamma D_f = \dfrac{839 + 87.3B}{3} + 18 \times 1.6$

$$= 308.47 + 29.1B$$

Applied load intensity $= \dfrac{750}{B \times 1} = \dfrac{750}{B}\,\text{kN/m}^2$

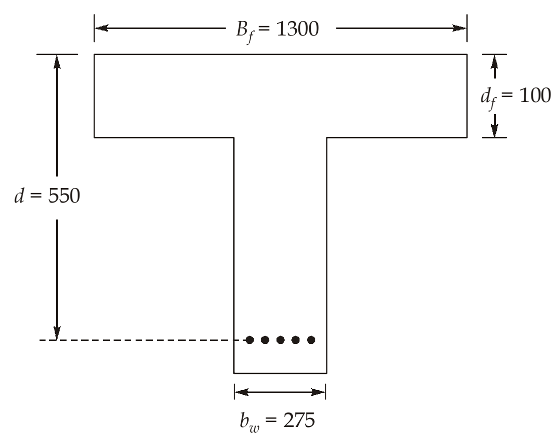
Equating the two, we get $\dfrac{750}{B} = 308.47 + 29.1B$

$\Rightarrow \quad 29.1B^2 + 308.47B - 750 = 0$

∴ $\quad B = 2.04$ m

Q.3 (b) Solution:

Given effective flange width, $B_f = 1300$ mm



Area of steel, $\quad A_{st} = 5 \times \dfrac{\pi}{4} \times 25^2 = 2454.3693\ \text{mm}^2$

Limiting depth of neutral axis, $(x_u)_{lim} = 0.48d$

$$(x_u)_{lim} = 0.48 \times 550 = 264\ \text{mm}$$

Assuming actual depth of neutral axis $x_u < d_f$

$\Rightarrow \quad 0.36 f_{ck} . B_f . x_u = 0.87 f_y . A_{st}$

$$0.36 \times 15 \times 1300 \times x_u = 0.87 \times 415 \times 5 \times \frac{\pi}{4} \times 25^2$$

$\Rightarrow \quad x_u = 126.23 > d_f$

Hence our assumption is wrong.

Assuming $\quad x_u > d_f$

and $\frac{3}{7}x_u < d_f$

$\therefore$ $y_f = 0.15\,x_u + 0.65\,d_f = 0.15\,x_u + 0.65 \times 100$

$= 0.15\,x_u + 65$

Hence, $C_u = 0.36\,f_{ck}\,.\,b_w.\,x_u + 0.45\,f_{ck}\,(B_f - b_w).y_f = 0.87 f_y.\,A_{st}$

$0.36 \times 15 \times 275 \times x_u + 0.45 \times 15\,(1300 - 275)(0.15\,x_u + 65) = 0.87 \times 415 \times 2454.3693$

$\Rightarrow$ $x_u = 172.99 \text{ mm} > d_f$

$\frac{3}{7}x_u = 74.14 \text{ mm} < d_f$

Hence our assumption is correct.

$\therefore$ Depth of neutral axis, $x_u = 172.99$ mm

$y_f = 0.15 \times 172.99 + 65 = 90.95$ mm

Ultimate Moment of Resistance $= \left[0.36 f_{ck}.b_w.x_u(d - 0.42\,x_u) + 0.45\,f_{ck}(b_f - b_w).y_f.\left(d - \frac{y_f}{2}\right)\right]$

$$(M.R)_u = [0.36 \times 15 \times 275 \times 172.99 \times (550 - 0.42 \times 172.99)]$$

$$+ \left[0.45 \times 15 \times (1300 - 275) \times 90.95 \times \left(550 - \frac{90.95}{2}\right)\right]$$

$$(M.R)_u = 440102582.3 \text{ N-mm}$$

$$= 440.1026 \text{ kN-m}$$

Q.3 (c) Solution:

Newtonian Fluids

- Fluids which obey Newton's law of viscosity are known as Newtonian fluids.
- According to Newton's law of viscosity, shear stress is directly proportional to the rate of deformation or velocity gradient across the flow.

  Thus, $\tau \propto \frac{du}{dy}$ or $\tau = \mu\frac{du}{dy}$

  where, μ = absolute or dynamic viscosity
- Water, air, and gasoline are Newtonian under normal conditions.

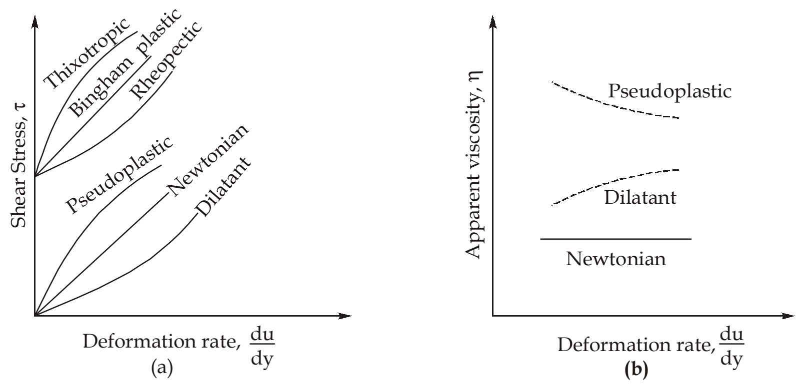
Dynamic Viscosity(μ)

- Dimension of $\mu = [M\,L^{-1}\,T^{-1}]$
- Unit of μ = N-s/m^2 or Pa.s
- In c. g. s. units, μ is expressed as 'poise', 1 poise = 0.1 N-s/m^2
- (μ) water $\approx 10^{-3}$ N-s/m^2;

  (μ) air $\approx 1.81 \times 10^{-5}$ N-s/m^2 (Both at 20°C and at standard atmospheric pressure)

Non-Newtonian Fluids

- Fluids for which shear stress is not directly proportional to deformation rate are non-Newtonian. Toothpaste and paint are the examples of non-Newtonian fluid.
- Non-Newtonian fluids commonly are classified as having time-independent or time-dependent behavior.



(a) Shear stress, τ and **(b)** Apparent viscosity, η

- Relation between shear stress and rate of deformation for non-Newtonian fluid can be represented as

$$\tau = k\left(\frac{du}{dy}\right)^n$$

Where, n = flow behavior index; k = consistency index

For newtonian fluid, $n = 1$; $k = \mu$

Above equation can also be represented as

$$\tau = k\left(\frac{du}{dy}\right)^{n-1}\left(\frac{du}{dy}\right) = \eta\frac{du}{dy}$$

where, $\eta = k\left(\frac{du}{dy}\right)^{n-1}$ is referred as the apparent viscosity

- Various types of non-Newtonian fluids are :

1. **Pseudoplastic** : Fluids in which the apparent viscosity decreases with increasing deformation rate ($n < 1$) are called pseudoplastic fluids (or shear thinning). Most non-Newtonian fluids fall into this group.

   Ex.: Polymer solutions, colloidal suspensions, milk, blood and paper pulp in water.

2. **Dilatant :** If the apparent viscosity increases with increasing deformation rate (n >1), the fluid is termed as dilatant (or shear thickening).

   Ex.: Suspensions of starch, saturated sugar solution.

3. **Bingham Plastic :** Fluids that behave as a solid until a minimum yield stress, τ_y, and flow after crossing this limit are known as ideal plastic or Bingham plastic. The corresponding shear stress model is $\tau = \tau_y + \mu \frac{du}{dy}$.

   Ex.: Clay suspensions, drilling muds, creams and toothpaste.

4. **Thixotropic :** Apparent viscosity (η) for thixotropic fluids decreases with time under a constant applied shear stress.

   Ex.: Paints, Printer inks

5. **Rheopectic :** Apparent viscosity (η) for rheopectic fluids increases with time under constant shear stress.

   Ex.: Gypsum pastes.

Q.3 (d) Solution:

Different types of failure in tension members are:

(a) **Yielding of gross section (T_{dg}):** In this type of failure, the yielding of the gross section occurs and there is a significant amount of deformation before the material actually gets fractured. This significant amount of deformation makes the structure unserviceable.

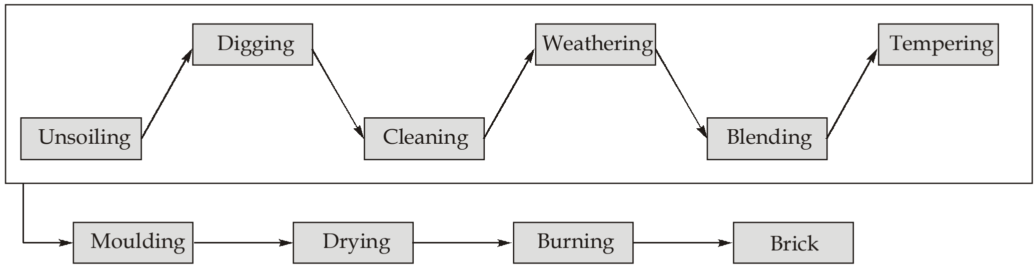
(b) **Rupture of net section (or fracture) (T_{dn}):** When the net section of the member reaches the ultimate stress, then rupture (or fracture) of member takes place.

(c) **Block shear failure (T_{db}):** Here a segment of the block of the material at the corner of the connection shears out due to possible high bearing strength of steel and high strength of bolts.

Q.4 (a) Solution:

Brick manufacturing involves four stages:

1. Brick clay/brick earth preparation.
2. Moulding of bricks.
3. Air drying of bricks.
4. Burning of bricks.



Flow chart for preparation of Brick

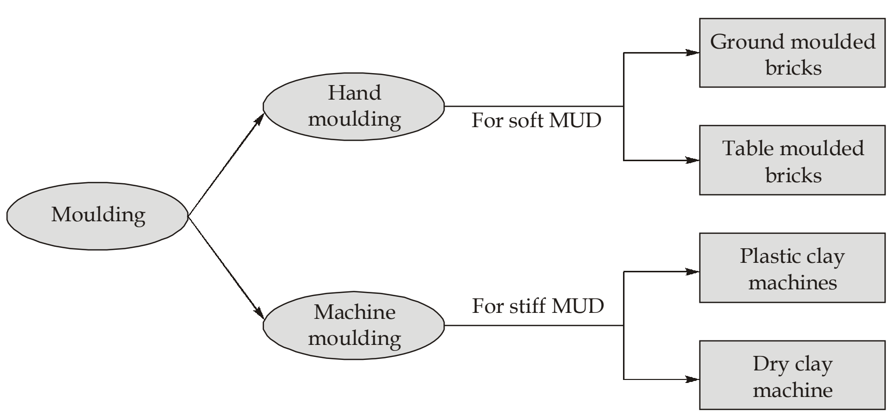
1. **Preparation of brick earth**

   Various steps involved in sequence are:

a. Unsoiling
b. Digging
c. Cleaning
d. Weathering
e. Blending
f. Tempering

Unsoiling is removal of top soil of about 200 mm depth as it may contain impurities. **Digging** is taking out and spreading clay on a levelled ground. **Cleaning** is for removal of impurities such as stones, organic matter through washing and screening. **Weathering** is exposure to atmosphere for softening or mellowing, (exposure period ranges from few weeks to full season). **Blending** is mixing of added ingredients with the prepared loose clay. **Tempering** is adding water to clay and kneading it under the feet of men or cattle. It is done in pug mills through pugging.

2. **Moulding:** Moulding is filling the prepared clay into moulds of definite size and pattern.



Hand Moulding: Are of two types:

(a) **Ground moulded** is done where large levelled land is available. To avoid moulded bricks from sticking to the side of the mould, either sand is sprinkled on the inner sides of the mould or the mould may be dipped in water every time before moulding is done.

Sand moulded bricks are better because they have rough surface necessary for having good bond between bricks and mortar.

(b) **Table moulded** is done on tables and send for further process of drying. Here as time passes efficiency of the moulder decreases and cost of moulding increases.

Machine Moulding

(a) Plastic clay machine method: It is adopted for stiffer clay.

(b) Dry clay machine method (pressed bricks): The strong clay is first converted into powder form. Then after adding water a stiff plastic paste is prepared, which is used for moulding.

3. Drying: Moulded bricks are dried to remove moisture far controlling of shrinkage and saving of fuel. Green bricks have moisture content about 7-30%, which is dried upto 5 to 7%. Drying period ranges from 7-14 days.

There are two methods of drying.

(a) Natural drying

(b) Artificial drying

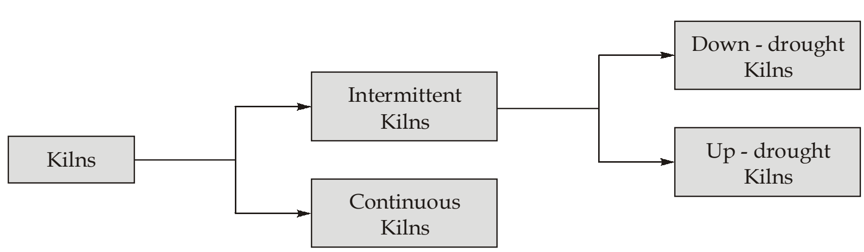
4. Burning: Proper uniform burning results into dense and durable brick. Bricks are burnt to a temperature of about 900 - 1200°C.

Burning is done in kilns or damps. Kiln is a permanent structure far large scale manufacturing and clamp is a temporary structure far small scale manufacturing.

Kiln is of two types:

1. **Intermittent Kilns:** Where only single process takes place at a time. Processes are loading, unloading, cooling and burning of moulded brick earth.

2. **Continuous Kiln:** Multiple processes takes place at a time.



As far as efficiency is concerned down-drought kilns are better compared to up-drought kilns because of evenly burnt bricks are produced.

Types of continuous kilns are:

1. Bull's trench Kiln (popular in India)
2. Hoffman's Kiln, and
3. Tunnel Kiln.

Q.4 (b) Solution:

For a rectangular channel

$$A = By \text{ and } V = \frac{Q}{A} = \frac{Q}{By}$$

$$\text{Specific energy, } E = y + \frac{V^2}{2g} = y + \frac{Q^2}{2gB^2y^2}$$

$$1.50 = y + \frac{(6.48)^2}{2 \times 9.81 \times (2.5)^2 \times y^2}$$

$$= y + \frac{0.34}{y^2}$$

Solving this equation by trial and error, the alternate depths y_1 and y_2 are 1.296 m and 0.625 m

$$\text{Froude number, } F = \frac{V}{\sqrt{gy}} = \frac{6.48}{(2.5y)\sqrt{9.81y}}$$

$$= \frac{0.83}{y^{3/2}}$$

At $y_1 = 1.296$ m, $F_1 = 0.561$ and at $y_2 = 0.625$ m, $F_2 = 1.675$

The depth $y_1 = 1.296$ m is in the subcritical flow region and the depth $y_2 = 0.625$ m is in the supercritical flow region.

Q.4 (c) Solution:

Given: $R = 150$ mm, $T = 270$ mm, effective span, $l = 1.5$ m

$$\Rightarrow \quad \sqrt{R^2 + T^2} = \sqrt{(150)^2 + (270)^2} = 309 \text{ mm}$$

- Assume a nominal waist slab thickness, $t = 80$ mm. Further assuming a flexural resistance to be provided entirely by waist slab, with 20 mm clear cover (mild exposure) and 10ϕ bars.

$$\text{Effective depth, } d = 80 - 20 - \frac{10}{2} = 55 \text{ mm}$$

Loads acting vertically over each tread width

(i) Selfweight of slab @ 25 kN/m^3 × $(0.080 \times 0.309)\,m^2 = 0.618$ kN/m

(ii) Self weight of step @ 25 kN/m^3 × $\left(\frac{1}{2} \times 0.15 \times 0.27\right)\,m^2 = 0.506$ kN/m

(iii) Finishes @ 0.6 kN/m^2 × 0.27 m = 0.162 kN/m

(iv) Live loads @ 3 kN/m^2 × 0.27 m = 0.810 kN/m

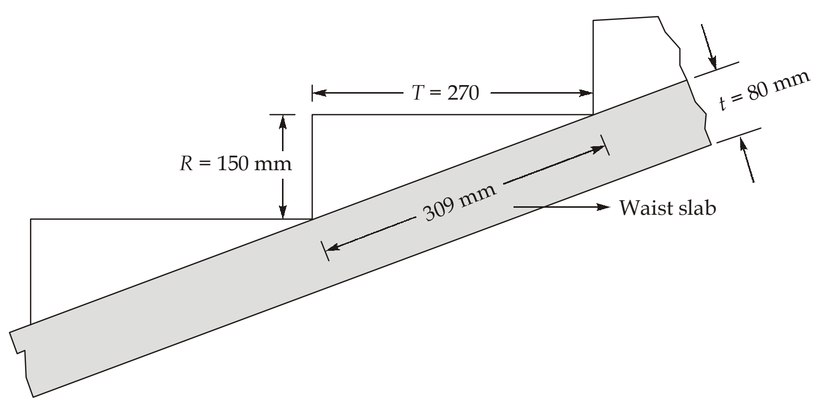
Total, W = 2.096 kN/m

Factored load causing flexure in transverse direction

$$(W \times 1.5)\cos\theta = 2.096 \times 1.5 \times \frac{270}{309} = 2.747 \text{ kN/m}$$

Distributed factored load per m width along inclined slab.

$$= \frac{2.747}{0.309} = 8.89 \text{ kN/m}^2$$



Design of main bars (spanning transversely)

Maximum moment at midspan,

$$M_u = \frac{8.89 \times 1.5^2}{8} = 2.50 \text{ kNm/m}$$

$$R = \frac{M_u}{bd^2} = \frac{2.50 \times 10^6}{1000 \times 55^2} = 0.826 \text{ MPa}$$

$$\Rightarrow \quad \frac{P_t}{100} = \frac{A_{st}}{bd} = \frac{f_{ck}}{2f_y}\left[1 - \sqrt{1 - 4.598\frac{R}{f_{ck}}}\right]$$

$$= \frac{20}{2 \times 250}\left[1 - \sqrt{1 - \frac{4.598 \times 0.826}{20}}\right]$$

$$= 0.4 \times 10^{-2}$$

$$\Rightarrow \quad (A_{st})_{required} = (0.4 \times 10^{-2}) \times 10^3 \times 55 = 220 \text{ mm}^2/\text{m}$$

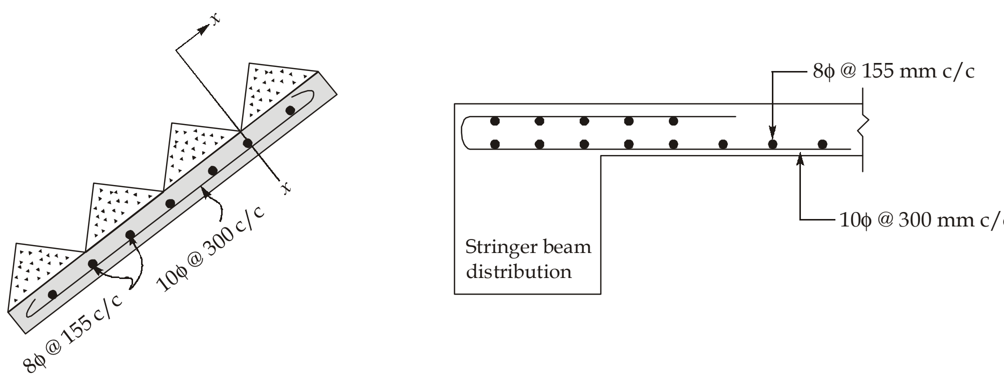
$$\Rightarrow \quad \text{Required spacing of } 10\phi \text{ bars} = \frac{78.5 \times 10^3}{220} = 357 \text{ mm}$$

Thus providing spacing of 300 mm.

$$\text{Required spacing of } 8\phi \text{ bars} = \frac{50.0 \times 10^3}{220} = 227 \text{ mm}$$

(Minimum spacing = $3d = 3 \times 55 = 165$ mm)

Provide 8ϕ bars @ $\frac{309}{2} = 155$ mm c/c as shown below



Detailing of reinforcement

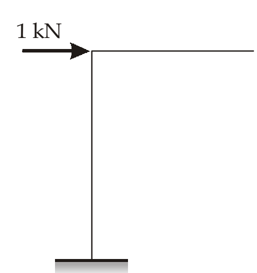
Q.5 (a) Solution:

To develop the I[st] column of flexibility matrix, apply unit force in direction (1) only and measure the deflection in direction (1), (2) and (3)

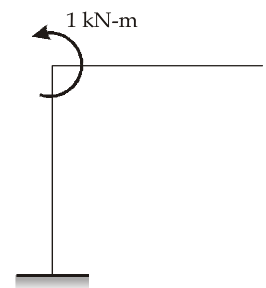
$$f_{11} = \frac{L^3}{3EI}$$

$$f_{21} = -\frac{L^2}{2EI}$$

$$f_{31} = \frac{L^2}{2EI}$$



To develop the second column of flexibility matrix apply unit moment in the direction (2) only and measure the deflections in direction (1), (2) and (3)

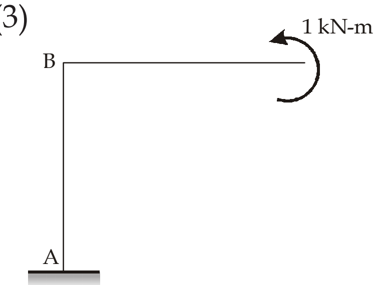


$$f_{12} = -\frac{L^2}{2EI}$$

$$f_{22} = \frac{L}{EI}$$

$$f_{32} = \frac{L}{EI}$$

To develop the third column of flexibility matrix apply unit moment in the direction (3) only and measure the deflections in direction (1), (2) and (3)



$$f_{13} = -\frac{L^2}{2EI}$$

$$f_{23} = \frac{L}{EI}$$

$$f_{33} = \frac{2L}{EI}$$

$\because$ $$U = U_{CB} + U_{BA}$$

$$= \frac{M^2L}{2EI} + \frac{M^2L}{2EI} = \frac{M^2L}{EI}$$

$\therefore$ $$\frac{dU}{dM} = \theta = \frac{2ML}{EI}$$

$\therefore$ $$f_{33} = \frac{\theta}{M} = \frac{2L}{EI}$$

$\therefore$ Flexibility matrix, $$[F] = \begin{bmatrix} \frac{L^3}{3EI} & -\frac{L^2}{2EI} & -\frac{L^2}{2EI} \\ -\frac{L^2}{2EI} & \frac{L}{EI} & \frac{L}{EI} \\ -\frac{L^2}{2EI} & \frac{L}{EI} & \frac{2L}{EI} \end{bmatrix}$$

Q.5 (b) Solution:

(i)

Light weight or foam concrete is broadly classified into three categories:

1. **Light weight aggregate concrete:** Naturally available light weight aggregates are Pumice, diatomite, Scoria, Volcanic cinders, rice husk and Sawdust. And

artificially light weight, aggregates are cinder, foamed slag, sintered flyash, exfoliated vermiculite, bloated clay and expanded perlite. These light weight aggregates are used to form light weight concrete.

2. **Aerated concrete:** It is manufactured by Raw materials are calcarious and Silicious materials like cement, lime, pulverized sand, flash; by entrapping air cells. It is also known as foam/gas/cellular concrete.
3. **No. Fines concrete:** Here, the fine aggregate fraction is omitted in concrete manufacturing. The aggregated/cement ratio ranges from 6 : 1 to 10 : 1. And the w/c ratio ranges from 0.38 to 0.52.

(ii)

Underwater concreting is done with the use of tremie pipe. Concrete is poured with the help of funnel and bottom end is closed with polyethylene. Thus pipe is filled with concrete having slump 150 to 200 mm. Pipe is slightly lifted and jerk is given to cause tearing of polythene, resulting in the discharge of concrete at the place of deposition.

Q.5 (c) Solution:

$\because \quad \Sigma M_B = 0$

$\Rightarrow \quad 20R_A = 1000 \times 10 \times 15 + 2000 \times 5 - 3000 \times 5$

(all loads are taken into account for equilibrium, the distribution load acting as its centre of gravity)

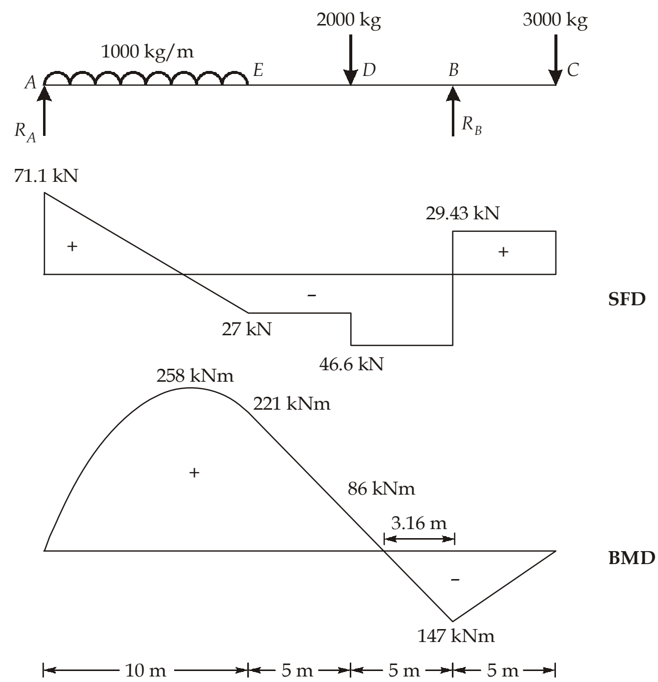
$\therefore \quad R_A = 7250 \text{ kg} = 7250 \times 9.81 \times 10^{-3} = 71.1 \text{ kN}$

$\therefore \quad R_B = \text{Total load} - R_A$

$= 7750 \text{ kg} = 76.03 \text{ kN}$

Shearing force: Starting at the left-hand end, $F = 71.1$ kN at A. As the section moves away from A, shear force decreases at a uniform rate of w (i.e. $F = 71.1 - wx$), reaching a value of –27 kN at E.

Between E and D, shear force is constant (no load on ED), and at D it suffers a sudden decrease of 19.6 kN (i.e. the load at D). Similarly there is an increase of 76.03 kN at B (the reaction at B), making the value of $F = 29.4$ kN between B and C (checking with the end load at C).



Bending moment: From *A* to *E*

$$M = R_A x - \frac{wx^2}{2}$$

$$= 71.1x - 4.9x^2 \text{ kNm}$$

A parabola which can be sketched by evaluating for several values of *x*.

For *x* beyond *E* the distributed load may be treated as a single load of 98.1 kN acting at 5 m from *A*.

Between *E* and *D*

$$M = 71.1x - 98.1\,(x - 5)$$

$$= -27x + 490$$

Producing a straight line between *E* and *D*, similar equations applying for sections *DB* and *BC*.

However, it is only necessary to evaluate *M* at the points *D* and *B* (it is zero at *C*), and draw straight lines between these values.

At *D* : $M = -27 \times 15 + 490 = 86$ kNm

At *B* : $M = -29.4 \times 5 = -147$ kNm (Calculated for the portion *BC*)

(i) The maximum bending moment is where the shearing force is zero.

For portion AE : Shear force $= 71.1 - 9.81x = 0$

$\Rightarrow \quad x = 7.25$ m from A

$\therefore \quad \overline{M} = 71.1 \times 7.25 - 4.9 \times 7.25^2 = 258$ kNm

(ii) Let the point of contraflexure (zero BM) occurs at a distance of x from B.

$\Rightarrow \quad 3 \times 9.81 \times (5 + x) - 76.03x = 0$

$\therefore \quad x = 3.16$ m

Q.5 (d) Solution:

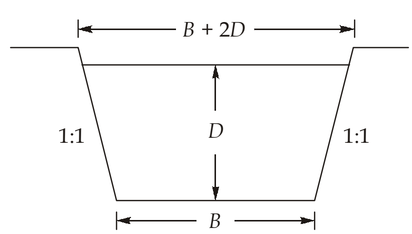
(i) Discharge, $Q = \left[\dfrac{f^{5/3}}{3340 \times S}\right]^6 = \left[\dfrac{(0.95)^{5/3}}{3340 \times 0.0002}\right]^6 = 6.74$ cumec $\quad \left(S = \dfrac{1}{5000} = 0.0002\right)$

(ii) Mean velocity, $V = \left[\dfrac{Qf^2}{140}\right]^{1/6} = \left[\dfrac{6.74 \times (0.95)^2}{140}\right]^{1/6} = 0.59$ m/sec

(iii) Cross-sectional area, $A = \dfrac{6.74}{0.59} = 11.42$ m^2

(iv) Wetted perimeter, $P = 4.75\sqrt{Q} = 4.75\sqrt{6.74} = 12.33$ m

(v) Hydraulic mean radius, $R = \dfrac{A}{P} = \dfrac{11.42}{12.33} = 0.93$ m



Again, $\quad R = \dfrac{5}{2}\dfrac{V^2}{f} = \dfrac{5}{2}\dfrac{(0.59)^2}{0.95} = 0.92$ m

Let, $\quad B$ = bed width, D = full supply depth

Cross-sectional area, $A = (B + D)D$

$\Rightarrow \quad 11.42 = (B + D)D \quad$ ...(i)

Wetted perimeter, $P = B + 2\sqrt{2}D$

$\Rightarrow \quad 12.33 = B + 2.83\,D$

$\Rightarrow \quad B = 12.33 - 2.83\,D \quad$ ...(ii)

From (i) and (ii), we get

$$11.42 = (12.33 - 2.83D + D)D$$

$$\Rightarrow \quad 11.42 = 12.33\,D - 1.83\,D^2$$

$$\Rightarrow \quad 1.83\,D^2 - 12.33\,D + 11.42 = 0$$

$$D = \frac{12.33 \pm \sqrt{(12.33)^2 - 4 \times 1.83 \times 11.42}}{2 \times 1.83}$$

$$= \frac{12.33 \pm 8.27}{3.66} = 5.63 \text{ m or } 1.11 \text{ m}$$

When $D = 5.63$ m, $B = 12.33 - 2.83 \times 5.63 = -3.6$ m (which is absurd)

When $D = 1.11$ m, $B = 12.33 - 2.83 \times 1.11 = 9.2$ m (which is acceptable)

So, bed width = 9.2 m, full supply depth = 1.11 m, discharge, $Q = 6.74$ cumec.

Q.6 (a) Solution:

$$Q = 450 \text{ m}l \text{ in 10 minutes} = 0.45\ l \text{ in 600 seconds}$$

$$= \frac{0.45 \times 1000 \text{ cm}^3}{600 \text{ seconds}} = 0.75 \text{ cm}^3/\text{sec}$$

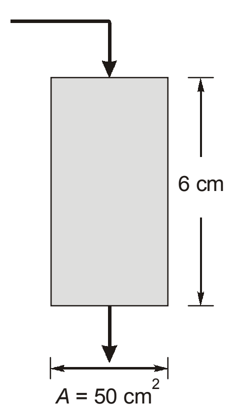
But $\quad Q = KiA$

where $i = \frac{H_L}{L} = \frac{40 \text{ cm}}{6 \text{ cm}} = 6.67$

$$\therefore \quad 0.75 \text{ cm}^3/\text{s} = K \times 6.67 \times 50 \text{ cm}^2$$

$$\Rightarrow \quad K = \frac{0.75}{6.67 \times 50} \text{ cm/s}$$

$$= 2.25 \times 10^{-3} \text{ cm/sec}$$



On oven drying, the volume of sample remains the same; i.e. equal to $50 \text{ cm}^2 \times 6 \text{ cm} = 300 \text{ cm}^3$. Its weight is found to be 495 gm.

$\therefore$ Dry density, $\gamma_d = \dfrac{495 \text{ gm}}{300 \text{ cm}^3} = 1.65 \text{ gm/cm}^3$

Using $\gamma_d = \dfrac{\gamma_w G}{1+e}$,

We get, $1.65 = \dfrac{1 \times 2.65}{1+e}$

$e = 0.6061$

Seepage velocity, $v_s = \dfrac{v}{n}$

where, $n = \text{Porosity} = \dfrac{e}{1+e} = \dfrac{0.6061}{1+0.6061} = 0.377$

$v = \text{Discharge velocity} = \dfrac{\text{Discharge}}{\text{Area of sample}}$

$= \dfrac{0.75 \text{ cm}^3/\text{s}}{50 \text{ cm}^2} = 0.015 \text{ cm/s}$

$\therefore$ $v_s = \dfrac{0.015 \text{ cm/s}}{0.377} = 0.0398 \text{ cm/s} = 0.398 \text{ mm/sec}$]

Q.6 (b) Solution:

Geo-physical methods:

These method consists of identification of underground material by measuring change in the character of surface material due to presence of different types of sub-surface materials.

These method are very useful to explore large areas much more rapidly and economically than boring methods.

The various geophysical methods of sub surface exploration are:

(i) Seismic refraction method

(ii) Electrical resistivity method

Seismic refraction method

- This method is based on the fact that seismic waves have different velocities in different type of soils and rock and refracted when they cross the boundary between different types of soil.
- Velocity of seismic wave is faster in denser or consolidated medium.
- In this method, the shock waves are created into the soil at their ground level or certain depth below by exploding small charge of high velocity dynamite or by striking a plate on the soil with a hammer.

- The radiating shock waves are received by a device called geophone, where the time of travel gets recorded.
- To record shock waves, a number of geophones are installed at known intervals on the ground along a line of produced shock waves.
- From the sources, three kinds of waves are produced; primary waves, secondary waves and surface wave. In general only primary waves are observed. These primary waves are of three types; direct waves, reflected waves, refracted waves.
- Direct waves travel directly from the shock source along the ground surface in the direction of geophones and other waves travel in a downward direction at various angles to the horizontal. Later waves get reflected and refracted when they meet a boundary separating media of different seismic velocities.
- If underlying layer is denser, the refracted waves travel much faster. As the distance between the shock source and the geophones increases, the refracted wave reach the geophones earlier than the direct wave.
- The direct waves travelling with velocity, V_T in the top layer arrive first at the geophones nearer to the shot point. The wave with the higher velocity V_B, reach the farther geophones first by travelling in the lower velocity material (top layer), horizontally in the higher velocity material and return to the surface.
- The arrival time is plotted against the distance between the source and the geophone. The point B in distance-time graph represents the point of simultaneous arrival of direct and refracted waves.
- The depth of the boundary between the two strata can be estimated from the equation

$$D = \frac{d}{2}\sqrt{\left(\frac{V_B - V_T}{V_B + V_T}\right)}$$

The above is under assumption that thickness of upper stratum is unvarying.

(ii) Electrical resistively method

- This method is based on the fact that different types of soil offer different resistance to the flow of an electrical current.
- The resistance to flow of current is determined by measurement of resistivity (ρ).

- The test is conducted by driving four equally spaced electrodes into the ground at a straight line. Current (I) from a battery, flow through the soil between the two outer electrodes, producing an electrical field within the soil. The potential difference E between the two inner electrodes is then measured. The apparent resistivity, ρ is given by the equation

$$\rho = \frac{2\pi DE}{I}$$

Where D = Electrode spacing

The two methods are adopted for exploration.

(i) Resistivity profiling

(ii) Resistivity sounding

(i) Resistivity profiling

- This method is used for investigation of lateral variation of soil types:
- In this method, four electrodes are kept at a constant spacing and moves across the area and profile lines are plotted with station point on horizontal axis and resistivity along the vertical axis.

(ii) Resistivity sounding

- This method is used to get information on the variation of sub-surface materials with depth.
- In this method, the electrode spacing D is progressively increased to pick up changes in resistivity with depth.

Q.6 (c) Solution:

Raw materials used in the manufacture of cement are classified into Argillaceous and Calcareous type.

Argillaceous material are shale, clay, blast furnace slag and state.

Calcareous material are cement rock, limestone, chalk, marine Shells and Marl.

Difference between wet process and dry process for manufacturing of cement:

S.No.	Dry Process	Wet Process
1.	In this process quite hard raw materials are used.	Here crushed raw materials are used, along with water.
2.	Economical process because less consumption of fuel in the kiln	Comparatively, process is not ecnonomical
3.	Short kiln are used.	Longer kilns are used and these are less responsive to a variable clinker demand.
4.	Control over homogeneity of the mixture is not good.	Control over homogeneity of the slurry is good.

Q.6 (d) Solution:

Noise can be defined as that unwanted sound pollutant which produces undesirable physiological and psychological effects in an individual, by interfering with one's social activities like work, rest, recreation, sleep, etc.

The unwanted sound certainly produces several undesirable effects on human health, and it can therefore be called as a pollutant. The basic reason why noise has so far not been regarded as a killer pollutant is the fact that so far noise has generally not exceeded to such levels as to cause drastic adverse impacts on human beings. Except in industrial areas and big cities, noise pollution is not prominent and hence has generally remained ignored from being treated as an environmental pollutant. However, with the increasing industrialization and commercialisation of our society, and with consequential increase in noise producing automobiles and machines, noise is becoming a slow poison and is becoming more and more prominent as a pollutant.

Causes:

(i) Traffic including air traffic, road traffic and sea shore and inland water traffic.

(ii) Industrialization

(iii) Human activities such as blaring of loud speaker and sirens, shouting of hawkers and playing of children, etc.

Effects:

Noise of sufficient intensity and duration can induce health problems like temporary and sometimes permanent hearing loss, besides causing several other diseases like general annoyance, irritation, disturbance, headaches, insomnia, fatigue, mental torture, nausea, high blood pressure, high pulse rate, greater perspiration, etc.

Remedies:

(i) By enforcing laws and ordinances, the sounds from loudspeakers, sirens, etc., can be controlled.

(ii) By the use of good technology in vehicles and others machines which produces noise.

(iii) By proper town planning techniques e.g. the residential complexes should be separated from commercial and industrial complexes. Parks, playgrounds should be provided for children separately.

(iv) Noise produced by trains and automobiles can be abated by construction of walls on both sides of railway lines and roads respectively.

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