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Detailed Solutions

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

Civil Engineering Test No : 5

Q.1 (a) Solution:

(i) Total solids produced = 1000 kg

$$\text{Mass of volatile solids} = \frac{60}{100} \times 1000 = 600 \text{ kg}$$

$$\therefore \text{Volume of volatile solids, } V_1 = \frac{600}{1.03 \times 1000} = 0.583 \text{ m}^3$$

$$\text{Mass of non volatile solids} = \frac{40}{100} \times 1000 = 400 \text{ kg}$$

Volume of non volatile solids,

$$V_2 = \frac{400}{2.4 \times 1000} = 0.1667 \text{ m}^3$$

Raw sludge has 93% moisture and remaining 7% as solid content.

Let the total mass of raw sludge produced = W

$$\therefore \quad \frac{7}{100} \times W = 1000$$

$$\Rightarrow \quad W = 14285.71 \text{ kg}$$

$$\therefore \text{Moisture content in raw sludge} = \frac{93}{100} \times 14285.71 = 13285.71 \text{ kg}$$

$\therefore$ Volume of water in raw sludge,

$$V_3 = \frac{13285.71}{1000} = 13.286 \text{ m}^3$$

Hence, volume of sludge produced = $V_1 + V_2 + V_3$

$$= 0.583 + 0.1667 + 13.286$$

$$= 14.0357 \text{ m}^3 \simeq 14.04 \text{ m}^3$$

(ii) After digestion,

$$\text{Volatile solids left} = \frac{40}{100} \times 600 = 240 \text{ kg}$$

$$\text{Non-volatile solids} = 400 \text{ kg}$$

$$\therefore \quad \text{Total solids left} = 240 + 400 = 640 \text{ kg}$$

This 640 kg represents 15% of digested sludge because remaining 85% is moisture.

$$\therefore \text{ Moisture in digested sludge} = \frac{85}{100} \times \left[\frac{640 \times 100}{15}\right] = 3626.66 \text{ kg}$$

$$\therefore \text{Volume of sludge after digestion} = \frac{240}{1030} + \frac{400}{2400} + \frac{3626.66}{1000} = 4.026 \text{ m}^3$$

(iii) After dewatering to 80% moisture, there will be no change in either weight or volume of solids and only the moisture will reduce.

$$\therefore \quad \text{Moisture in dewatered digested sludge} = \frac{80}{100} \times \left[\frac{640 \times 100}{20}\right] = 2560 \text{ kg}$$

$$\therefore \quad \text{Volume of dewatered digested sludge} = \frac{240}{1030} + \frac{400}{2400} + \frac{2560}{1000} = 2.9596 \text{ m}^3$$

Q.1 (b) Solution:

As the soil is compressible, the reduced shear strength parameters and bearing capacity factors corresponding to local shear condition are used.

$$\therefore \quad C_1 = \frac{2}{3} C'_{cu} = \frac{2}{3} \times 30 = 20 \text{ kN/m}^2$$

$$\tan\phi = \frac{2}{3} \tan\phi'_{cu}$$

$$\phi_1 = \tan^{-1}\left(\frac{2}{3}\tan\phi'_{cu}\right) = \tan^{-1}\left(\frac{2}{3}\tan 25°\right) = 17.3°$$

For $\phi_1 = 17.3°$, the bearing capacity factors are given as;

$$N_C' = 13.91$$

$$N_\gamma' = 4.02$$

$$N_q' = 5.17$$

$$q_s = \frac{1}{F}\left[C_1 N'_C + q(N'_q - 1) + 0.5\gamma B N'_\gamma\right] + q$$

$$= \frac{1}{3}\left[\begin{matrix} 20 \times 13.91 + 18.3 \times 1.5(5.17 - 1) \\ +0.5 \times 18.3 \times 1 \times 4.02 \end{matrix}\right] + 18.3 \times 1.5$$

$$= \frac{1}{3}[429.45] + 27.45$$

$$= (143.15 + 27.45) = 170.6 \text{ kN/m}^2$$

$$\therefore \quad Q_s = q_s \times B = 170.6 \times 1 = 170.6 \text{ kN/m}$$

∴ The safe load that can be carried by the wall = 170.6 kN/m

Q.1 (c) Solution:

Formation of successive bends of reverse order may lead to the formation of a complete S-curve called **meander**. When consecutive curves of reverse order connected with a short straight reaches are developed in a river reach, the river is said to be a meandering river. The cause of meandering is the excess turbulence generated by excess of river sediment during floods. During floods, the river carries tremendous amount of silt charge. It has been established that when the silt charge is in excess of the quantity required for stability, the river starts building up its slope by depositing the silt on its bed. In other words, the river reach becomes an aggrading or of an accreting type. This accretion is the primary process, which consequently leads to meandering.

Various types of groynes can be grouped under three heads:

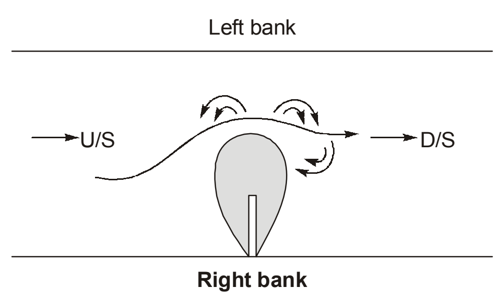
(i) Based on type of alignment

(ii) Based on material of construction

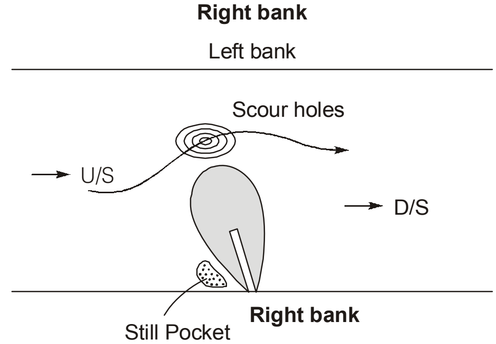
(iii) Special groynes

There are three types of groynes based on type of alignment which are as follows:

(i) Normal groyne: This groyne is aligned perpendicular to the bank line and is also known as ordinary groyne.



(ii) Repelling groyne: This groyne always point upstream and has the property of repelling the flow away from it and scour holes caused by the formation of vertical eddies are developed away from the bank and near the head of the groyne.



Repelling groyne

(iii) Attracting groyne: This groyne points downstream and has the property of attracting the flow towards it. In such a groyne scour holes are developed near the bank as compared to those in a repelling groyne.

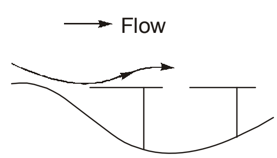
There are two types of groynes based on material of construction:

(i) **Impermeable groyne:** These are also called solid groynes or embankment groynes. These groynes may be rockfill embankments or earthen embankments armoured with stone pitching, concrete blocks, etc.

(ii) **Permeable groynes:** These groynes do permit restricted flow through them. These groynes are more or less temporary structures and are susceptible to damage by floating debris, etc. The common materials used are tree spurs or balli spurs.

There are two type of special groynes:

(i) **T-shaped groyne:** Denehey's *T*-shaped groyne is a special type of groyne developed in India. It is an ordinary groyne provide with an extra cross groyne at the head given it a *T*-shape. The longer arm of the *T* is provided on U/S and shorter one on D/S.



T-Shaped groyne

(ii) **Hockey shaped groyne:** These groynes are shaped like hockey sticks at their lower end. These groynes exert an attracting type of influence on the flow and hence are not useful for bank protection for repelling the current away from it.

Q.1 (d) Solution:

Area of steel per metre length of longitudinal joint is given by,

$$A_s = \frac{BfhW}{100\sigma_T},$$

Where, $$B = \frac{8.0}{2} = 4.0 \text{ m}$$

$$\therefore \quad A_s = \frac{4.0 \times 1.5 \times 18 \times 2400}{100 \times 1500} = 1.728 \text{ cm}^2/\text{m}$$

Using 1 cm diameter bars having area of cross section $a_s = 0.785 \text{ cm}^2$, the spacing of tie bars is given by,

$$\text{Spacing} = \frac{100 \times 0.785}{1.728} = 45.43 \text{ cm} \simeq 45 \text{ cm}$$

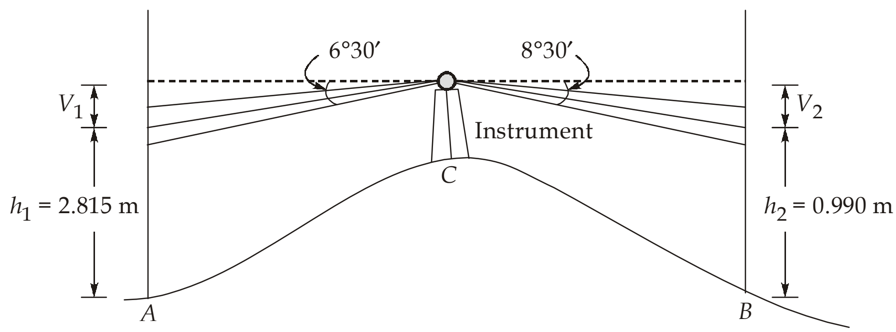
Using 1 cm diameter bars, the length L_t is obtained and is given by

$$L_t = \frac{\phi\sigma_T}{2\sigma_b} = \frac{1\times1500}{2\times25} = 30 \text{ cm}$$

Total length of tie bar = 30 cm

Use 1 cm diameter dia bars of length 30 cm at 45 cm c/c.

Q.2 (a) Solution:



Assuming staff to be held vertical during measurements.

- Instrument at C and staff at A

$$S_1 = 3.500 - 2.130 = 1.370 \text{ m}$$

Let H.I. be height of instrument at C.

We know,
$$V_1 = \frac{kS_1 \sin 2\theta_1}{2} + C\sin\theta_1$$
$$= \frac{50\times1.370\times\sin 13°}{2} + 0.50\sin 6°30'$$
$$= 7.705 + 0.0566 = 7.761 \text{ m}$$

∴ Elevation of staff station, $A = HI - V_1 - h_1$

$$= HI - 7.761 - 2.815 \quad \text{...(i)}$$

Now,

- Instrument at C and staff at B

∴ $$V_2 = \frac{kS_2 \sin 2\theta_2}{2} + C\sin\theta_2$$

θ_2 = 8° 30′ (depression), S_2 = 1.870 – 0.110 = 1.76 m

∴ $$V_2 = \frac{50\times1.76\sin 17°}{2} + 0.50\sin 8°30'$$
$$= 12.86 + 0.074 = 12.938 \text{ m}$$

Hence,

Elevation of staff station $B = HI - V_2 - h_2$

$= HI - 12.938 - 0.990$ ...(ii)

∴ Level difference between points A and B = eq. (i) - eq. (ii)

$= -(HI - 7.761 - 2.815) - (HI - 12.938 - 0.99)$

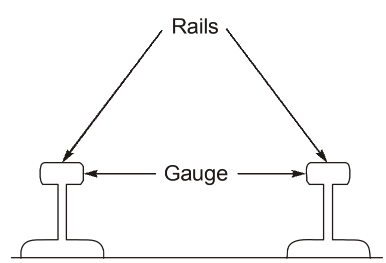
$= 3.351$ m (A is higher)

Q.2 (b) Solution:

Bowditch Rule (Compass Rule)	Transit Rule
1. The correction of an error in latitude by Bowditch's rules affects all lines and angles in the traverse. 2. Balancing the traverse by Bowditch rule distort the angles from the observed values. 3. The Bowditch Rule is particularly used for compass traverse where the angles are susceptible to considerable error. 4. Bowditch rule alters the adjusted bearings. 5. It is used to balance a traverse when linear and angular measurements are equally precise. • Errors in linear measurements $\alpha\sqrt{l}$ • Errors in angular measurements $\alpha \frac{1}{\sqrt{l}}$	1. The correction of the same error by the transit rule only affect lines in the direction of the error because line of sight at right angles to these have no latitudes. 2. Balancing by transit rules the angles are unaltered. 3. The transit rule is more suited for a theodolite traverse where the possibility of error is more in the linear rather than in the angular measurements. 4. Transit rule alters the distance more. 5. It is employed when the angular measurements are more precise as compared to the linear measurements (theodolite traversing).

Q.2 (c) Solution:

The gauge of a railway track is defined as the clear minimum perpendicular distance between the inner faces of the two rails as shown in the figure.



Gauge

Following are the factors affecting the choice of a gauge:

1. **Traffic condition :** If the intensity of traffic on the track is likely to be more, a gauge wider than the standard gauge is suitable.

2. **Development of poor areas :** The narrow gauges are laid in certain parts of the world to develop a poor area and thus link the poor area with the outside developed world.
3. **Cost of track :** The cost of railway track is directly proportional to the width of its gauge. Hence, if the fund available is not sufficient to construct a standard gauge, a metre gauge or a narrow gauge is preferred rather than to have no railways at all. In India, the approximate costs of M.G. track and B.G. track per kilometre length are about Rs. 50 lakhs and Rs. 1 crore respectively. However there is no appreciable increase in cost of track, if a wider gauge is adopted initially because of the following facts:
   (i) There is only proportional increase in the costs of ballast, sleepers, rails, etc. for different gauges.
   (ii) The cost of acquisition of land for the permanent track is not much affected by the change of gauge width.
   (iii) The costs of culverts, bridges, tunnels, signals, staff quarters, level-crossings and other works associated with the permanent track are more or less same for all the gauges.
   (iv) The cost of rolling stock is independent of the gauge of track for carrying the same volume of traffic.
4. **Speed of movement:** The speed of a train is a function of the diameter of wheel which in turn is limited by the gauge. The wheel diameter is usually about 0.75 times the gauge width and thus the speed of a train is almost proportional to the gauge. If higher speeds are to be attained, the B.G. track is preferred to the M.G. or N.G. track.
5. **Nature of country:** In mountainous country, it is advisable to have a narrow gauge of the track since it is more flexible and can be laid to a smaller radius on the curves. This is the main reason why some important railways, covering thousands of kilometres, are laid with a gauge as narrow as 610 mm.

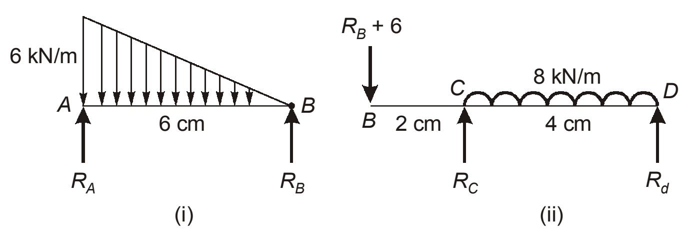
Following are the advantages of uniformity of gauges:

1. **No transport-bottlenecks:** In a unigauge system there is no transport bottleneck. It gives improved operational efficiency and fast movements of goods and passengers.
2. **No transhipment hazards:** In unigauge system there is no need of changing trains, hence no damage to goods and no inconvenience to the passengers.

3. **Improved utilization of track:** In unigauge system the track can be used to the full capacity, resulting in reduction of working expenses of the railway.
4. **Provision of alternate routes:** The unigauge system provides alternate routers for free movement of traffic, resulting in reduced pressure on the track.
5. **Better turn round:** The unigauge system provides better turn round of wagons and locomotives resulting in improved operating ratio of the railway system. This will result in immense benefits to the nation.
6. **Balanced economic growth:** Due to the unigauge system the development of all areas will be uniform resulting in balanced economic growth.
7. **No multiple tracking works:** The unigauge system eliminates the duplicate traffic facilities and tracking works, resulting in saving of resources.

Q.2 (d) Solution:

Beams with interval hinge, seperate at the point of hinge.



From beam (i),

$$R_A + R_B = \frac{6\times 6}{2} = 18 \text{ kN}$$

$$\Sigma M_B = 0$$

$$\Rightarrow \quad R_A \times 6 - \left(\frac{6\times 6}{2}\right)\times\frac{2}{3}\times 6 = 0$$

$$\Rightarrow \quad R_A = 12 \text{ kN}$$

$$R_B = 6 \text{ kN}$$

From beam (ii),

$$\Rightarrow \quad R_C + R_D = (6+6) + 8\times 4$$

$$= 44 \text{ kN}$$

$$\Sigma M_D = 0$$

$$\Rightarrow \quad -12\times 6 + R_C \times 4 - (8\times 4\times 2) = 0$$

$$\Rightarrow \quad R_C = 34 \text{ kN}$$

$$\therefore \quad R_D = 10 \text{ kN}$$

Shear force, (left to right)

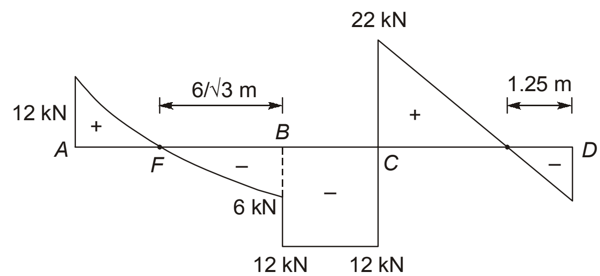
$$\text{At point } A = 12 \text{ kN}$$

$$\text{At point } B = +12 - \frac{6\times 6}{2} = -6 \text{ kN (Exclusing the point load)}$$

$$\text{At point } B = -6 - 6 = -12 \text{ kN}$$

$$\text{At point } C = -12 + 34 = 22 \text{ kN}$$

$$\text{At point } D = +22 - 8 \times 4 = -10 \text{ kN}$$



SFD

Bending moment,

$$\text{At point } A = 0$$

$$\text{At point } F = +13.65 \text{ kNm}$$

$$\text{At point } B = 0 \quad \text{(Hinge)}$$

$$\text{At point } C = -12 \times 2 = -24 \text{ kNm}$$

$$\text{At point } E = 10 \times 1.25 - 8 \times 1.25 \times \frac{1.25}{2} = +6.25 \text{ kNm}$$

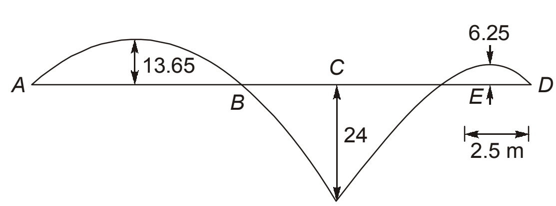
$$\text{At point } D = 0$$

Location of point of contraflexure (BM = 0) in beam 2 (as at CBM is '–ve' and at DBM is 0)

$\Rightarrow$ $$M_x = RD \times x - 8(x)(x/2)$$

$\Rightarrow$ $$0 = 10 \times x - 4 \times 2 \quad (\because M_x = 0)$$

$\Rightarrow$ $$x = 2.5 \text{ m} \quad \text{(from point } D)$$



BMD (in kNm)

Q.3 (a) Solution:

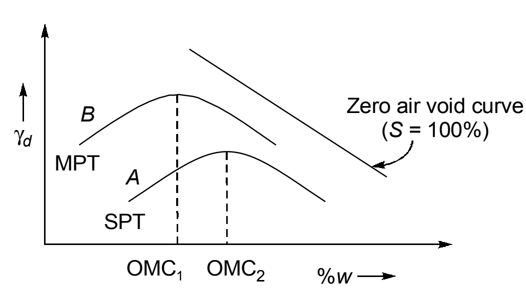
There are four main factors which influence compaction and they are as follows:

(i) Water Content: There are two theories to explain the typical water content-dry unit weight relationship. They are the Lubrication theory by Proctor and the Electrical Double Layer theory by Lambe.

According to Lubrication theory at lower water contents, the soil is stiff and the soil grains offer more resistance to compaction. As the water content increases, the dry density increases and air voids are decreased till the optimum water content is reached, a stage when lubrication effect is maximum. With further increase in moisture content, however the water starts to replace the soil particles and since $\gamma_w << \gamma_s$, the dry unit weight starts decreasing.

Lambe uses concept of soil structure and the Electrical Double Layer theory to explain the effect of water content on dry unit weight. In case of cohesive soils, there is an attractive force namely the Van-der Waal's forces which acts between two soil particles and a repulsive force which is due to double layers of adsorbed water tending to come into contact with each other. While the attractive forces remains same in magnitude, the repulsive force is directly related to the size of double layers. If the net force between the particles is attractive, flocculated structure is the result; if it is repulsive, the particles tends to move away - 'disperse'. At low water contents attractive forces are predominant which makes it difficult for the particles to move about when compactive effort is applied. A low dry unit weight is the consequence. As the water content is increased, the double layer expands and inter particle repulsive forces increase. The particles easily slide over one another and get packed more closely, resulting in higher dry unit weight.

The maximum expansion of the double layer is at the OMC, beyond that, the addition of water does not add any further to the expansion of double layer but the water tends to occupy space which otherwise would have been occupied by soil particles. Hence a decrease in unit weight. It also explains why the shape of the compaction curve is not the typical inverted V shape in the case of soils which are not cohesive and plastic in nature.



(ii) Compactive Effort: For a given type of compaction, the higher the compactive effort, the higher the maximum dry unit weight and lower the OMC. In the above figure compaction curve *B* corresponds to the higher compactive effort in a MPT, comparing it with the compaction curve *A* for SPT, one can see the compaction curve shifts to the top and to the left when compactive effort is increased. However, the margin of increase becomes smaller and smaller even on the dry side of the OMC while on the wet side of OMC, there is hardly any increase at all. If the peaks of compaction curves for different compactive efforts are joined together a 'line of optimums' is obtained which is nearly parallel to zero air void line. This brings out the fact that even a higher compactive effort does not result in a higher efficiency of compaction.

(iii) Types of Soil:

(a) Coarse grained, well graded soils compact to high dry unit weight especially if they contain some fines.

(b) Poorly graded sands lead to lowest dry unit weight values.

(c) In clay soils, the maximum dry unit weight tends to decrease as plasticity increases.

(d) Cohesive soils have generally high values of OMC.

(e) Heavy clays with high plasticity have very low maximum dry density and very high OMC.

(iv) Methods of Compaction:

Ideally speaking, the laboratory test must reproduce a given field compaction procedure, because the mode of compaction does influence somewhat the shape and the position of the 'γ_d' vs 'w' plot. Since the field compaction is essentially a kneading type compaction or rolling type compaction and the laboratory tests use the dynamic impact type compaction, one must expect some divergence in the OMC and $\gamma_{d(max)}$ in the two cases.

Q.3 (b) Solution:

$$B = 250 \text{ mm},$$
$$D = 500 \text{ mm},$$
$$d_c = 40 \text{ mm},$$
$$d = D - d_c = 460 \text{ mm}$$
$$A_{st} = 3 \times \frac{\pi}{4} \times 20^2 = 942.5 \text{ mm}^2,$$
$$A_{sc} = 2 \times \frac{\pi}{4} \times 12^2 = 226.2 \text{ mm}^2$$

(i) Limiting depth of neutral axis,

$$\text{For Fe500, } x_{u,\,\text{lim}} = 0.46\,d = 0.46 \times 460 \simeq 212 \text{ mm}$$

(ii) Actual depth of neutral axis,

$$\text{Total compressive force} = \text{Total tensile force}$$

$$0.36 f_{ck} B x_u + A_{sc}\left(f_{sc} - 0.45 f_{ck}\right) = 0.87 f_y A_{st}$$

$$0.36 \times 25 \times 250 \times x_u + 226.2\left(f_{sc} - 0.45 \times 25\right) = 0.87 \times 500 \times 942.5$$

$$2250 x_u + 226.2\,(f_{sc} - 11.25) = 409987.5$$

$$2250 x_u + 226.2 f_{sc} = 412532.25$$

$$\Rightarrow \quad x_u = \frac{412532.25 - 226.2 f_{sc}}{2250}$$

Trial 1:

Assuming, $f_{sc} = 420$ MPa

$$\Rightarrow \quad x_u = \frac{412532.25 - 226.2 \times 420}{2250} = 141.12 \text{ mm}$$

$$\text{Value of } \in_{sc} = \frac{0.0035}{x_u}\left(x_u - d_c\right)$$

$$= \frac{0.0035}{141.12}\left(141.12 - 40\right) = 0.00251$$

$$f_{sc} \text{ for } \in_{sc} \text{ value of } 0.00251 = 391.3 + \frac{(413 - 391.3)}{(0.00277 - 0.00226)} \times (0.00251 - 0.00226)$$

$$= 401.94 \text{ MPa} \neq 420 \text{ MPa as assumed}$$

Trial 2:

$$\text{Putting, } f_{sc} = 401.94 \text{ MPa}$$

$$x_u = \frac{412532.25 - 226.2 \times 401.94}{2250} = 142.94 \text{ mm}$$

$$\text{Value of } \in_{sc} = \frac{0.0035}{142.94}\left(142.94 - 40\right) = 0.00252$$

$$f_{sc} \text{ for } \in_{sc} \text{ value of } 0.00252 = 391.3 + \frac{(413 - 391.3) \times (0.00252 - 0.00226)}{(0.00277 - 0.00226)}$$

$$= 402.36 \text{ MPa} \neq 401.94 \text{ MPa}$$

Trial 3:

$$\text{Putting, } f_{sc} = 402.36 \text{ MPa}$$

$$x_u = 142.89 \text{ mm}$$

$$\text{Value of } \in_{sc} = 0.00252$$

$$\text{Hence, adopting } f_{sc} = 402.36 \text{ MPa and } x_u = 142.89 \text{ mm} < x_{u,\,\text{lim}} \; (= 212 \text{ mm})$$

$\because$ Section is under reinforced and $f_{st} = 0.87 f_y$

(ii) Moment of resistance:

$$MR = 0.36 f_{ck} B x_u \times (d - 0.42 x_u) + (f_{sc} - 0.45 f_{ck}) A_{sc} (d - d_c)$$

$$= 0.36 \times 25 \times 250 \times 142.89 (460 - 0.42 \times 142.89) + (402.36 - 0.45 \times 25)226.2 \times (460 - 40)$$

$$= 165.75 \text{ kNm}$$

Q.3 (c) Solution:

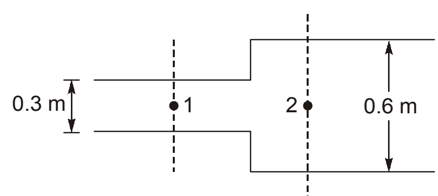
Let V_1 and V_2 be the velocities of flow in 0.3 m and 0.6 m pipes respectively. Then by continuity equation

$$A_1 V_1 = A_2 V_2$$

$$\Rightarrow \quad \frac{\pi}{4}(0.3)^2 \times V_1 = \frac{\pi}{4}(0.6)^2 \times V_2$$

$$\Rightarrow \quad V_1 = 4V_2$$

Applying Bernoulli's equation between the points 1 and 2 lying on either side of the enlargement, we have



$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

From the given date

$$z_1 = z_2$$

and $$\left(\frac{p_2}{\gamma} - \frac{p_1}{\gamma}\right) = 0.125 \text{ m}$$

and $$h_L = \frac{(V_1 - V_2)^2}{2g} = \frac{(4V_2 - V_2)^2}{2g} = \frac{9V_2^2}{2g}$$

Thus by substitution, we have

$$\frac{(4V_2)^2}{2g} = 0.125 + \frac{V_2^2}{2g} + \frac{9V_2^2}{2g}$$

$$\Rightarrow \quad V_2 = 0.639 \text{ m/s}$$

$$\therefore \quad \text{Discharge, } Q = a_2 V_2 = \frac{\pi}{4}(0.6)^2 \times 0.639$$

$$= 0.181 \text{ m}^3/\text{s}$$

Q.3 (d) Solution:

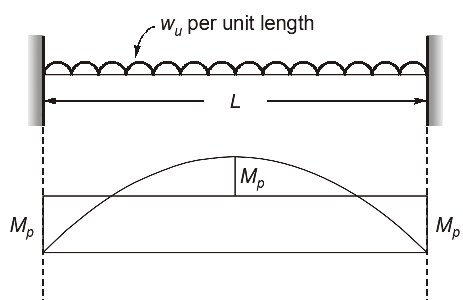
Lower Bound Theorem:

If any bending moment distribution can be found which satisfies

(i) Equilibrium condition and

(ii) Yield condition (i.e. bending moment no where exceed M_p)

That system is safe and statically sufficient and corresponding load is less than or equal to the true collapse load.



Alternatively, the theorem can be stated in a simple manner as follows:

"A load computed on the basic of an assumed equilibrium moment diagram in which moments $M \leq M_p$, is less than or at best equal to the true ultimate load."

$$\frac{w_u L^2}{8} = M_p + M_p$$

$$\Rightarrow \quad 2M_p = \frac{w_u L^2}{8}$$

$$\Rightarrow \quad w_u = \frac{16 M_p}{L^2}$$

Upper Bound Theorem :

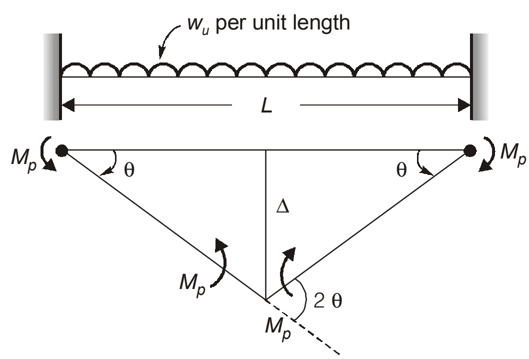
If a collapse mechanism can be found such that the associated moments satisfy

(i) Equilibrium condition and

(ii) Mechanism condition

The mechanism is kinematically sufficient and the corresponding load is greater than or equal to the true collapse load.

Alternatively,



"A load computed on the basis of an assumed mechanism will be always greater than or at best equal to the true ultimate load."

Applying principle of virtual work, we get

$$w_u \times \frac{1}{2} \times L \times \Delta - M_p\theta - M_p(\theta + \theta) - M_p\theta$$

$$= \left[\Delta = \frac{L}{2} \times \theta\right]$$

$$\Rightarrow \quad \frac{w_u L}{2} \times \frac{L}{2} \times \theta = 4\, M_p\theta$$

$$\Rightarrow \quad w_u = \frac{16 M_p}{L^2}$$

Q.4 (a) Solution:

Seasoning of Timber: It is a process by which the moisture content of timber is reduced to a suitable level depending upon the use. Seasoned timber is definitely superior to unseasoned timber. While seasoning does not make timber safe from all destructive agencies, this is a prime process before timber can be put to use. By nature timber is hygroscopic and takes in moisture from air depending upon many factors. Timber should be seasoned as early as possible after felling because felled timber is nothing but dead vegetation that will rot and decay due to many environmental agencies.

The reasons or objectives for which seasoning is done are:

(i) To reduce the tendency to split, warp and shrink.

(ii) To make it immune from attack by insects.

(iii) To increase the strength, durability, workability and resilience.

(iv) To make the timber receptive to finish like preservative, paints and varnish.

(v) To reduce the weight and minimise cost of transportation.

(vi) To make the timber burn readily, if used as a fuel.

Seasoning methods can be basically classified into two groups namely, natural seasoning and artificial seasoning:

Natural Seasoning: In this method, the seasoning of timber is carried out by natural air and hence it is also sometimes referred to as air seasoning. The timber has to be stacked properly depending upon the species of timber and the environmental conditions. The timber log is cut and sawn into suitable section of planks or scantlings. Then they are stacked either horizontally or vertically. The stack is to be protected from fast blowing wind, rain and extreme heat of sun. Hence the stack should preferably be covered by a roof material. The advantage of natural seasoning is that it does not require skilled supervision. This method of seasoning timber is cheap and simple. The disadvantage of natural seasoning is that, as the process depends on the natural air, it some times become difficult to control it as well as the drying of different surface may not be even and uniform.

Artificial Seasoning: It is a quicker method of seasoning timber to the desired moisture content under controlled conditions. The drying conditions required for different species of timber are different and artificial seasoning makes it possible to provide conditions cited to each species. The advantages of artificial seasoning are speed, adaptability and precision.

The various methods of artificial seasoning are boiling, chemical seasoning, electrical seasoning and water seasoning which are as follows:

(i) Boiling : In this method of artificial seasoning, the timber is immersed in water and water is then boiled. This is a very quick method. The timber is thus boiled with water for about three to four hours. It is then dried very slowly under a shed. The periods of seasoning and shrinkage are reduced by this method, but it affects the elasticity and strength of wood. In place of boiling water, the timber may be exposed to the action of hot steam. This method of seasoning proves to be costly.

(ii) Chemical Seasoning : This is also known as salt seasoning. In this method, the timber is immersed in a solution of suitable salt. It is then taken out and seasoned in the ordinary way. The interior surface of timber dries in advance of exterior one and chances of formation of external cracks are reduced.

(iii) Electrical seasoning : In this method, the use is made of high frequency alternating currents. The timber, when it is green offers less resistance to the flow of electric current. The resistance increases as the wood dries internally which also results in the production of heat. This is the most rapid method of seasoning. But the initial and maintenance costs are so high that it becomes uneconomical to season timber on commercial basis by this method.

(iv) Kiln Seasoning: In this method, the drying of timber is carried out inside an airtight chamber or oven. Depending upon the mode of construction and operation, the kilns are of two types namely stationary kilns and progressive kilns. Stationary kiln is adopted for seasoning timber which requires a close control of humidity and temperature. It gives better results. Progressive kiln is used for seasoning timber on a large scale. If not properly attended the drying in this kiln may prove to be unsatisfactory. The kiln seasoning though costly gives well seasoned timber as it controls three important conditions namely circulating air, relative humidity and temperature.

(v) Water seasoning: The water seasoning is a quick method and it renders timber which is less liable to shrink or warp. It also removes organic materials contained in sap of timber. It however weakens the timber and make it brittle.

Q.4 (b) Solution:

Given:

A horizontal rectangular channel with,

Width of channel, B = 4 m, Discharge, Q = 16.0 m^3/s; Initial depth, y_1 = 0.50 m

Whether jump occurs at depth y_1?

$$\text{Froude's number, } F_{r_1} = \frac{V_1}{\sqrt{gy_1}}$$

$$V_1 = \frac{Q}{By_1} = \frac{16}{4 \times 0.50} = 8 \text{ m/s}$$

$$\therefore \quad F_{r_1} = \frac{8.0}{\sqrt{9.81 \times 0.50}} = 3.61 > 1 \quad \text{(Super-critical flow)}$$

Hence, hydraulic jump forms.

Calculation of sequent depth,

$$\frac{y_2}{y_1} = \frac{1}{2}\left[-1 + \sqrt{1 + 8F_{r_1}^2}\right]$$

$$\Rightarrow \quad \frac{y_2}{y_1} = \frac{1}{2}\left[-1 + \sqrt{1 + 8(3.61)^2}\right]$$

$$\Rightarrow \quad y_2 = 2.315 \text{ m}$$

Energy loss in the jump

We know,
$$\Delta E = \frac{(y_2 - y_1)^3}{4y_1y_2} = \frac{(2.315 - 0.50)^3}{4 \times 2.315 \times 0.50} = 1.291 \text{ m}$$

Q.4 (c) Solution:

$$\text{Coefficient of earth pressure, } k_a = \frac{1-\sin\phi}{1+\sin\phi}$$

$$= \left(\frac{1-\sin 30°}{1+\sin 30°}\right) = \frac{1}{3}$$

Consider 1 m length of retaining wall;

$$\text{Maximum BM at the bottom of stem} = \frac{1}{6}k_a\gamma H^3$$

$$M = \frac{1}{6}\times\frac{1}{3}\times 18\times(4.35)^3 = 82.31 \text{ kNm}$$

$$\text{Factored BM} = M_u = 1.5M = 1.5 \times 82.31 = 123.48 \text{ kNm}$$

$$\text{Effective depth required, } d = \sqrt{\frac{M_u}{0.138 f_{ck}B}} = \sqrt{\frac{123.48\times10^6}{0.138\times20\times1000}} = 211.52 \text{ mm}$$

Let d = 240 mm with effective cover of 60 mm, therefore total depth = 300 mm.

Let us keep same thickness throughout,

$$\text{Reinforcement in stem, } A_{st} = \frac{f_{ck}}{2f_y}\left\{1-\sqrt{1-\frac{4.6M_u}{f_{ck}bd^2}}\right\}bd$$

$$= \frac{0.5\times20}{415}\left\{1-\sqrt{1-\left(\frac{4.6\times123.48\times10^6}{20\times1000\times240^2}\right)}\right\}\times1000\times240$$

$$= 1665.57 \text{ mm}^2$$

$$\text{Use 16 mm } \phi \text{ bar at spacing} = \frac{1000}{1665.57}\times\frac{\pi}{4}\times(16)^2$$

$$= 120.71 \text{ mm say } 120 \text{ mm}$$

∴ Provide 16 mm ϕ bars @ 120 mm c/c distance.

Continue alternate bars to toe slab for distance, 45ϕ = 720 mm

Curtailment of 50% A_{st} may be provided for $h = 0.78H$

However, bars should not be extended for 12ϕ or d whichever is more.

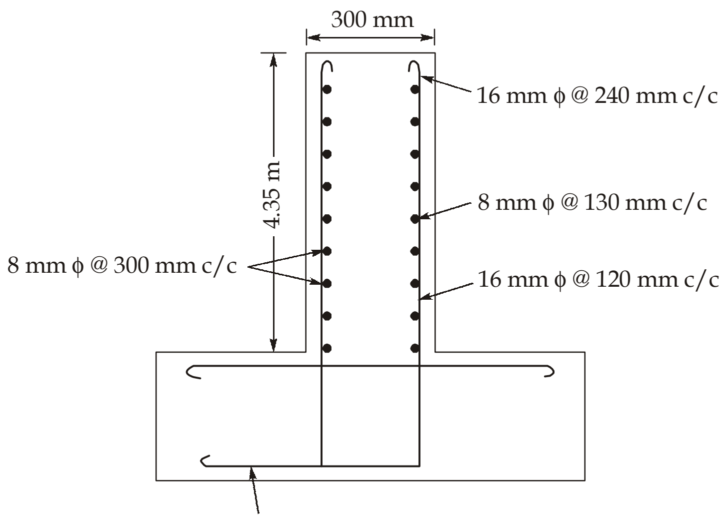
∴ Depth of curtailment from top = $(0.78 \times 4.35 - 0.240) \simeq 3.20$ m

$$\text{Distribution reinforcement} = \frac{0.12}{100} \times 1000 \times 300 = 360 \text{ mm}^2$$

$$\text{Using 8 mm } \phi \text{ at spacing} = \frac{1000}{360} \times \frac{\pi}{4} \times (8)^2 = 139.6 \text{ mm}$$

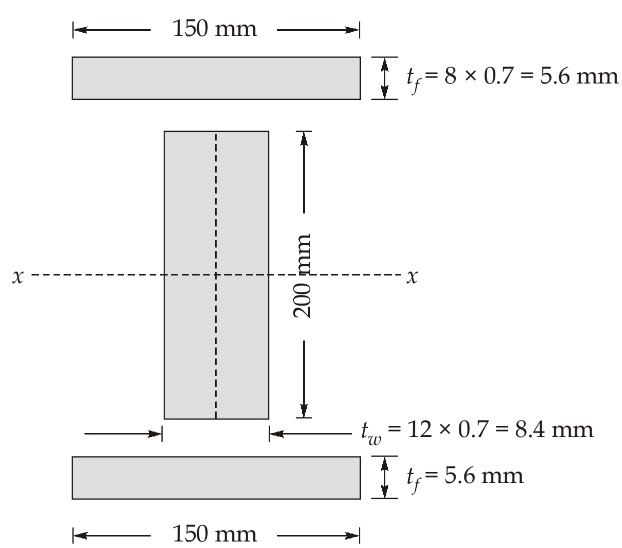
∴ Provide 8 mm ϕ @ 130 mm c/c at inner face of wall along length.

Temperature reinforcement : Provide 8 mm ϕ @ 300 mm c/c both ways on shear face.



Detailing of reinforcement

Q.5 (a) Solution:



$$I_{xx} = \frac{150 \times 5.6^3}{12} \times 2 + 150 \times 5.6 \times 2 \times 127.8^2 + \frac{200^3 \times 8.4}{12}$$

$$= 33.04 \times 10^6 \text{ mm}^4$$

$$\text{Direct shear stress, } f_1 = \frac{W}{A} = \frac{W \times 10^3}{150 \times 5.6 \times 2 + 8.4 \times 200}$$

$$= 0.297 \text{ W N/mm}^2$$

Due to moment

$$f_2 = \frac{M}{z} = \frac{W \times 10^3 \times 200 \times 130.6}{33.04 \times 10^6} = 0.79\,\text{W}$$

$$\because \quad \sqrt{f_2^2 + 3f_1^2} \le \frac{f_u}{\sqrt{3} \times \gamma_m}$$

$$\Rightarrow \quad W\sqrt{0.79^2 + 3 \times 0.297^2} \le \frac{410}{\sqrt{3} \times 1.25}$$

$$W \le 200.876 \text{ kN}$$

$$\text{Service load, } W_s = \frac{200.876}{1.5} = 133.92 \text{ kN}$$

Q.5 (b) Solution:

RMC : Ready mixed concrete (RMC) is a concrete, delivered at site or into the purchaser's vehicle, in plastic condition and requires no further treatment before being placed in position in which it is to set and harden.

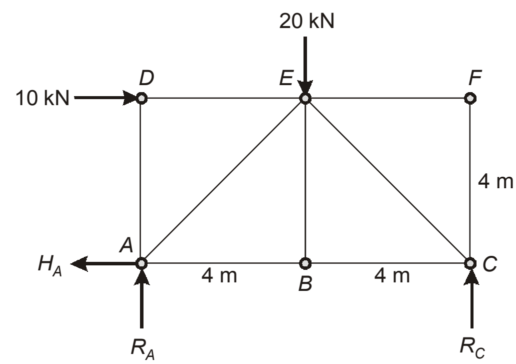
It is high quality concrete of required grade produced under strictly controlled conditions in a centralised automatic batching plant and supplied to the customer in a transit mixer truck for its placement at site. The concrete can be mixed either dry at the batching plant, loaded into agitator truck mixers and water added during transportation or it can be mixed wet at the batching plant, discharged into agitator truck mixers and transported to site.

Advantages of Ready Mixed Concrete:

- Enhanced quality and durability resulting in lower maintenance costs and increased speed of construction.
- Ready mixed concrete is consistently of the same quality and provides a high quality of construction material and construction time is also reduced.
- It reduces congestion at the site and prevents traffic jams.
- It speeds up infrastructure development and thus provides more employment opportunities.
- It is an environmentally safe alternative.
- With RMC, modern construction techniques can be followed.
- RMC is delivered at the site with minimum logistical hassles.

Q.5 (c) Solution:

The frame may first be analyzed for the applied loads. The internal forces are designated as forces (P) in the members.



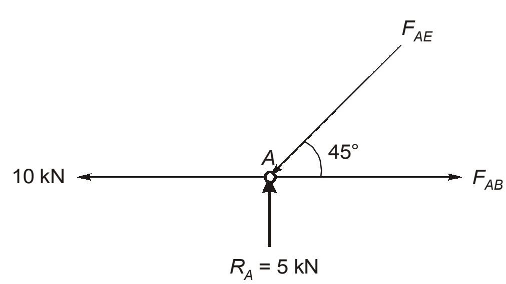
$$\Sigma F_x = 0 \quad \Rightarrow \quad H_A = 10 \text{ kN} \quad (\leftarrow)$$
$$\Sigma F_y = 0 \quad \Rightarrow \quad R_A + R_C = 20 \text{ kN}$$
$$\Sigma M_A = 0 \quad \Rightarrow \quad 10 \times 4 + 20 \times 4 - R_C \times 8 = 0$$
$$\Rightarrow \quad R_C = 15 \text{ kN}$$
$$\therefore \quad R_A = 5 \text{ kN}$$

As there is no external load at joint F, hence forces in members EF and FC are zero. Force is also zero in member BE.

At joint D load 10 kN is in line with member DE, hence force in member AD will be zero

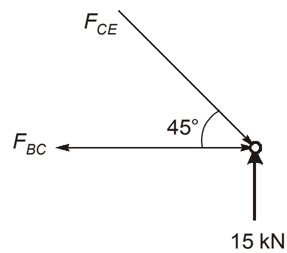
and $$P_{DE} = -10 \text{ kN (Comp.)}$$

At joint A:



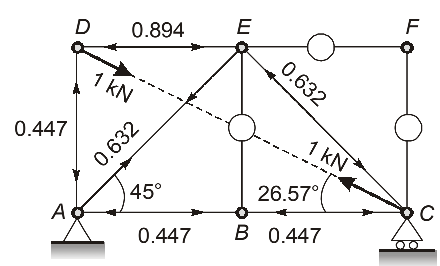
$$\Sigma F_y = 0$$
$$\Rightarrow \quad F_{AE} \sin 45° = 5$$
$$\Sigma F_x = 0$$
$$\therefore \quad F_{AE} = 7.071 \text{ kN}$$
$$7.071 \times \cos 45° + 10 - F_{AB} = 0$$
$$\therefore \quad F_{AB} = 15 \text{ kN} \quad \text{(Tensile)}$$

At joint C:



$$\Sigma F_y = 0$$
$$F_{CE} \sin 45° = 15$$
$$\therefore \quad F_{CE} = 21.213 \text{ kN} \quad \text{(Comp.)}$$
$$\Sigma F_x = 0$$
$$21.213 \times \cos 45° - F_{BC} = 0$$
$$\therefore \quad F_{BC} = 15 \text{ kN} \quad \text{(Tensile)}$$

In order to determine the desired displacements, unit load is applied at coordinate 1 as shown below



Member	P(kN)	p	Pp(kN)
AB	15	–0.447	–6.705
BC	15	–0.447	–6.705
AD	0	–0.447	0
DE	–10	–0.894	8.94
BE	0	0	0
AE	–7.071	0.632	–4.469
EC	–21.213	–0.632	13.407
EF	0	0	0
CF	0	0	0
Tension + ve Compression – ve			$\Sigma = 4.468$

Relative displacement of joints C and D,

$$\Delta = \Sigma \frac{PpL}{AE} = \frac{L}{AE} \Sigma Pp$$

$$= 0.2 \times 4.468 = 0.894 \text{ mm}$$

Q.5 (d) Solution:

Upstream side, h_1 = 16 m and downstream side, h_2 = 2 m,

Therefore, h = 16 – 2, = 14 m

N_f = 4, N_d = 12

k_h = 6 × 10^{-3} cm/sec, k_v = 3 × 10^{-4} cm/sec

$$k_e = \sqrt{k_h k_v} = \sqrt{(6\times10^{-3})\times(3\times10^{-4})}$$

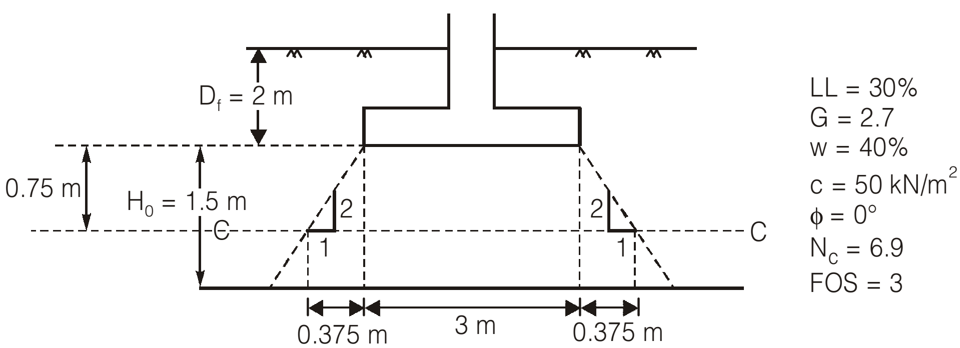
$$= 1.34 \times 10^{-3} \text{ cm/sec}$$

∴ Seepage flow, $$q = k_e h\frac{N_f}{N_d} = (1.34\times10^{-3})\times(14\times100)\times\frac{4}{12}$$

$$= 0.625 \text{ cm}^3\text{/sec/unit length}$$

Q.6 (a) Solution:

The statement of the given problem can be represented with the help of the diagram shown below:



The ratio $\frac{D_f}{B} = \frac{2}{3}$ = 0.67 < 1, hence the foundation is a shallow foundation

Also c = 50 kN/m^2

We know that soft clay fails in local shear.

Now using Terzaghi's equation for square footing when the natural water table is very close to ground surface, we get

$$q_u = 0.867\, cN_c + \gamma D_f N_q + 0.4\, \gamma N_\gamma$$

But for $\phi = 0°$, $N_\gamma = 0$ and $N_q = 1.0$

∴ $$q_u = 0.867\, cN_c + \gamma D_f$$

The net ultimate bearing capacity of soil is given by

$$q_{nu} = q_u - \gamma D_f$$

∴ $$q_{nu} = 0.867\, cN_c + \gamma D_f - \gamma D_f$$

$$q_{nu} = 0.867\, cN_c$$

Thus the net safe bearing capacity of soil,

$$q_{ns} = \frac{q_{nu}}{FOS} = \frac{0.867\, cN_c}{3}$$

$$\therefore \quad q_{safe} = q_{ns} + \gamma' D_f = \frac{0.867\, cN_c}{3} + \gamma' D_f$$

But $\gamma' = \left(\frac{G-1}{1+e}\right)\gamma_w$ [for a saturated soil, e = Gw]

$$= \left(\frac{2.7-1}{1+Gw}\right)\gamma_w = \left(\frac{1.7}{1+(2.7\times 0.4)}\right)\times 9.81$$

$$= 8.02 \text{ kN/m}^3$$

$$\therefore \quad q_{safe} = \frac{0.867\times 50\times 6.9}{3} + 8.02\times 2 = 115 \text{ kN/m}^2$$

Now, increase in pressure intensity at the level of C-C,

$$\Delta\bar{\sigma} = \frac{q_{safe}\times 3\times 3}{3.75\times 3.75} = \frac{115\times 3\times 3}{3.75\times 3.75} = 73.6 \text{ kN/m}^2$$

Initial effective overburden pressure at the level of C-C,

$$\bar{\sigma}_0 = \gamma'(D_f + 1) = 8.02\times(2+0.75) = 22.055 \text{ kN/m}^2$$

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

The settlement of the foundation will be given as

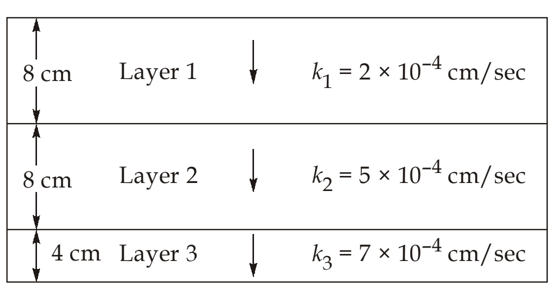
$$\Delta H = \frac{C_c H_0}{1+e_0}\log_{10}\left(\frac{\bar{\sigma}_0 + \Delta\bar{\sigma}}{\bar{\sigma}_0}\right)$$

$$= \frac{0.18\times 1.5}{1+(2.7\times 0.4)}\log_{10}\left(\frac{22.055+73.6}{22.055}\right)$$

$$= 0.0827 \text{ m}$$

$$= 82.71 \text{ mm}$$

Q.6 (b) Solution:



$$k_v = \frac{Z}{\left(\frac{Z_1}{k_1} + \frac{Z_2}{k_2} + \frac{Z_3}{k_3}\right)}$$

$$= \frac{20}{\frac{8}{(2\times10^{-4})}+\frac{8}{(5\times10^{-4})}+\frac{4}{(7\times10^{-4})}}$$

$$= 3.24 \times 10^{-4} \text{ cm/sec}$$

Now, $$k = \frac{2.3aL}{A(t_1-t_0)}\log\left(\frac{h_0}{h_1}\right)$$

$\Rightarrow$ $$(t_1 - t_0) = t = \frac{2.3aL}{Ak}\log\left(\frac{h_0}{h_1}\right)$$

$$= \frac{2.3\times2\times20}{24\times3.24\times10^{-4}}\log\left(\frac{25}{12}\right)$$

$$= 3775.56 \text{ sec} = 62.9 \text{ min}$$

Q.6 (c) Solution:

The main purposes of valuation are

1. **For purchase :** If a property is to be purchased, the value of the property should be assessed.
2. **Sale :** For selling a property, in order to fix up the sale price, valuation should be done.
3. **Tax fixation :** To fix up the municipal tax of the building, valuation is essential.
4. **Rent fixation :** Valuation of a property is required of fix up the standard rent or fair rent of a property.
5. **Mortgage value :** To raise loan against a property, the valuation of the property is necessary.
6. **Compulsory acquisition :** When the government takes over a property, for paying the compensation, valuation of the property is required.
7. **Wealth tax :** For the assessment of wealth tax, the valuation of the property should be done.
8. **Capital gains tax :** In the assessment of capital gains tax, valuation is required.
9. **Partition :** In case of partition, market value of each property has to be determined to divide the property among the heirs properly.
10. **Assessment of stamp fees :** For a newly built property, valuation of the property is required for determining the stamp fees for transaction.
11. **Insurance premium :** Valuation is required in order to fix up the insurance premium of a property.

12. **Gift tax :** If a property is gifted, the valuation of the property is needed for determining the gift tax.

Factors affecting the value of a property

1. **Supply and demand :** If there are few buyers compared to the number of properties available for sale in a particular locality, this will result in low prices and vice versa.
2. **Increase in population :** Sudden increase in population due to the growth of new industries or influx or due to multiplication will result in heavy demand for land, buildings and properties.
3. **Cost of construction :** The present cost of construction affects the value due to rapid change in price index of materials compared to depreciation.
4. **Purpose of purchase :** The value of property is usually more if the property is for occupational purposes.
5. **Interest and security of capital :** If the interest in scheduled banks and Govt. securities are lowered, it will result in making more money available for investment in land and property and thereby the market value increases.
6. **Rent restriction act :** The value of a property is calculated from the probable annual income through rent and so due to certain enactment of a rent restriction act by the government, it may cause slump in property market.
7. **Improvement of Public Schemes :** Any public service scheme like sewer line, water line, electricity supply etc. to an area which is lacking in such amenities will make the land value go up. Town planning acts may also alter the value of properties.
8. **Abnormal conditions :** The value of property may go down due to abnormal conditions like war, riots or due to insecure conditions.

Q.6 (d) Solution:

(i) Fluorides:

- The fluorides upto 1 mg/l helps to prevent dental cavities. During formation of permanent teeth, it combines chemically with tooth enamel, resulting in harder, stronger teeth that are most resistant to decay.
- The excess consumption (>1.5 mg/l to 2 mg/l) results in decolouration of teeth called mottling of teeth. It affects mainly the infants.
- Greater than 5 mg/l causes deformation of bones called bone fluorosis.
- The acceptable limit is upto 1 mg/l and greater than 1.5 mg/l is cause for rejection.

(ii) Total hardness: It is defined as the concentration of multivalent metallic cations in solution. Multivalent metallic cations most abundant in natural water are calcium and magnesium. Hard water leads to lesser foam formation, hence consumption of soap would be more. It leads to scaling of boilers. It causes corrosion and incrustation of pipes. It makes food tasteless. Acceptable limit is 200 mg/*l* and permissible limit is 600 mg/*l*.

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