

**DETAILS EXPLANATIONS****1.(a) Concrete in Plastic Stage :**

- **Consistency** : Consistency of a concrete mix is a measure of the stiffness or sloppiness or fluidity of the mix for effective handling, placing and compacting the concrete, consistency must be the same for each batch. It is therefore necessary to measure consistency of concrete at regular intervals. Slump test is commonly used to measure consistency of concrete.
- **Workability** : The workability of a concrete mix is the relative ease with which concrete can be placed, compacted and finished without separation or segregation of the individual materials, workability is not the same thing as consistency. Mixes with the same consistency can have different workabilities, if they are made with different size of stone, the smaller the stone the more workable the concrete.  
It is not possible to measure workability, but the slump test, together with an assessment of properties like stone content, cohesiveness and plasticity. Gives a useful indication.
- **Settlement and Bleeding** : Cement and aggregate particles have densities about three times that of water. In fresh concrete they consequently tend to settle and displace mixing water which migrates upward and may collect on the top surface of the concrete. This upward movement of mixing water is known as bleeding, water that separates from the rest of the concrete is called bleed water.
- **Plastic Shrinkage** : If water is removed from the compacted concrete before it sets, the amount of water removed. This volume reduction is called plastic shrinkage.  
Water may be removed from the plastic concrete by evaporation or by being absorbed, by dry surface such as soil or old concrete or by the dry wooden formwork.
- **Slump Loss** : From the time of mixing, fresh concrete gradually loses consistency. This gives rise to the problems only if the concrete becomes too stiff to handle, place and compact properly.

**Concrete in Harden Stage :**

- **Strength** : When we refer to concrete strength, we generally talk about compressive strength of concrete. Because concrete is strong in compression but relatively weak in tension and bending. Compressive strength mostly depends upon amount and type of cement used in concrete mix.

It is also affected by the water cement ratio, mixing method placing and currying concrete tensile strength ranges from 7% to 12% of compressive strength both tensile strength and bending strength can be increased by adding reinforcement.

- **Creep** : Deformation of concrete structure under substained load is defined as concrete creep. Long term pressure or stress on concrete can make it change shape.
- **Durability** : Durability might be defined as the ability to maintain satisfactory performance over and extended service life. The design service life of most buildings is often 30 years, although building often last 50 to 100 years.
- **Shrinkage** : Shrinkage is the volume decrease of concrete caused by drying and chemical changes. In another word, the relation of volume for the setting and hardening of concrete is defined as shrinkage.
- **Modulus of Elasticity** : the modulus of Elasticity of concrete depends on the modulus of Elasticity of the concrete ingredients and their mix proportions.

$f_{ck}$  = 28 Days compressive strength of concrete

$$E_C = 5000\sqrt{f_{ck}}$$

- **Water Tightness** : Another property of concrete is water tightness. Sometime, it's called impermeability of concrete, water tightness of concrete is directly related to the durability of concrete.

### 1.(b) Treatment of Glass :

Following are the treatment that are commonly given to glass :

- (i) Bending
  - (ii) Cutting and Grinding
  - (iii) Opaque making
  - (iv) Silvering
- **Bending** : Glass in the form of rods, sheets or tubes are bent into desired shape by placing these in special ovens in which temperature can be regulated properly. When they are heated to suitable temperature, they are taken out and bent.
  - **Cutting and Grinding** : Glass is cut in required size and shape with the help of either a diamond cutter or rough glass or small wheels of hardened steel. the edges of the glass so cut can be ground and rounded by means of suitable grinding stone or wheels.
  - **Opaque Making** : Normally, glass is transparent. It can be made opaque mechanically by grinding the surface by emery. The surface of glass can also be made opaque chemically by the application of hydrofluoric acid.

- **Silvering** : Silvering consists of applying a very thin coat of tin on the surface of glass. The silver is deposited on this layer of tin. The silvered surface is protected against the atmospheric effects by applying a suitable paint over it.

### 1.(c) Retardation of Decay of Stones :

The decaying action of weathering agencies on the stones can be retarded by taking the following precautions :

- **Use of Compact Siliceous Stones** :  
It is desirable to use only the compact siliceous stones for the external faces of the walls exposed to atmosphere. These stone units must have dense crystalline texture. Sand stones used for the construction should be cemented with silicious binding material. Lime stone and calcareous sand stones with open texture should not be sand stones with open texture should not be used for external walls, specially in industrial towns.
- **Use of Large Size Stone Units** :  
Large size stone units should be used for the construction of external walls so that the joints are reduced to a minimum, as joints are the agents of weakness.
- **Use of Dressed Stones** : Use of well dressed, finished and polished stones should be preferred to rough faced stones.
- **Use of External Renderings** : External renderings such as pointing or plastering should be given at the time of construction. The use of cement plaster or cement pointing. Using pure silica sand, is advisable. If only pointing is used, the pointing should be repaired frequently.
- **Laying Stone on Natural Bed** :  
During construction, stone should be laid on its natural bed.
- **Filling of Joints** :  
All the joints between the stone blocks, both external as well as internal should be completely filled, using cement mortar in pure silica sand. No hollow or cavity should be left, so that a sound and solid structure is obtained.
- **Use of Seasoned Stone** :  
It is observed that freshly quarried stone contains sap which may accelerate the decaying action. Hence only seasoned stone should be used.
- **Cleaning of External Surfaces** :  
the exposed stone surfaces should be kept as clean as possible, by dusting it properly and then washing it with water at frequent intervals.

2.(a) Given, Diagonals of aperture,

$$AC = BD = 2 \text{ m}$$

∴ Area of square aperture,

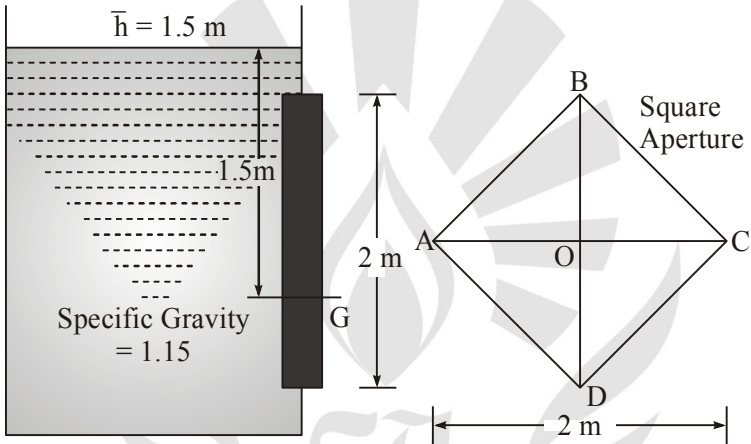
$$\begin{aligned} A &= \text{Area of } \triangle ACB + \text{Area of } \triangle ACD \\ &= \frac{AC \times BO}{2} + \frac{AC \times OD}{2} = \frac{2 \times 1}{2} + \frac{2 \times 1}{2} \\ &= 1 + 1 = 2.0 \text{ m}^2 \end{aligned}$$

Specific Gravity of liquid = 1.15

∴ Density of liquid,

$$\rho = 1.15 \times 1000 = 1150 \text{ kg/m}^3$$

Depth of centre of aperture from free surface,



- The thrust on the plate is given by

$$F = \rho g A \bar{h} = 1150 \times 9.81 \times 2 \times 1.5 = 33844.5$$

- Centre of pressure ( $h^*$ ) is given by

$$h^* = \frac{I_G}{A \bar{h}}$$

Where,  $I_G$  = M.O.I. of ABCD about diagonal AC  
 = M.O.I. of triangle ABO about AC + M.O.I. of triangle ACD about AC

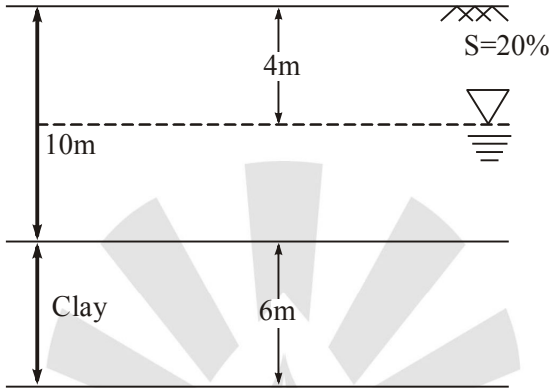
$$= \frac{AC \times OB^3}{12} + \frac{AC \times OD^3}{12}$$

(∵ M.O.I. of a triangle about its base =  $bh^3/12$ )

$$= \frac{2 \times 1^3}{12} + \frac{2 \times 1^3}{12} = \frac{1}{6} + \frac{1}{6} = \frac{1}{3} \text{ m}^4$$

$$h^{**} = \frac{(1/3)}{2 \times 1.5} + 1.5 = \frac{1}{3 \times 2 \times 1.5} + 1.5 = 1.611 \text{ m}$$

2.(b)  $\gamma(\text{sat})_c = 2.1 \times 9.81 = 20.60 \text{ kN/m}^3$   
 $\gamma(\text{sat})_s = 1.8 \times 9.81 = 17.66 \text{ kN/m}^3$   
 $g(\text{d})_{\text{soil}} = 1.7 \text{ g/cm}^3 = 16.68 \text{ kN/m}^3$   
 $g(\text{sat})_s = \left[ \frac{G+e}{1+e} \right] \gamma_w = 17.66$



$$\frac{G+e}{1+e} = 1.8 \quad \dots(1)$$

$$\gamma_d = \frac{G\gamma_w}{1+e} = 16.68$$

$$\frac{G}{1+e} = 1.7 \quad \dots(2)$$

From equation (1) and (2), we get

$$\Rightarrow G = 1.7(1+e)$$

$$\frac{1.7(1+e)+e}{1+e} = 1.8$$

$$\Rightarrow e = 0.11$$

$$\Rightarrow G = 1.89$$

$\Rightarrow$  of soil above water level

$$\Rightarrow \gamma = \left( \frac{G+Se}{1+e} \right) \cdot \gamma_w$$

$$\gamma = \left( \frac{1.89+0.11 \times 0.2}{1+0.11} \right) \times 9.81$$

$$\Rightarrow = 16.898 \text{ kN/m}^3$$

Effective stress at centre of clay layer when water table is at ground level

$$\begin{aligned} &= \gamma'_{\text{sand}} \times 10 + \gamma'_{\text{sand}} \times 3 \\ &= (17.66 - 9.81) \times 10 + (20.60 - 9.81) \times 3 \\ &= 110.87 \text{ kN/m}^2 \end{aligned}$$

After lowering of water table

$$\begin{aligned}
 &= (\gamma \times 4) + (\gamma'_{\text{sand}} \times 6) + (\gamma'_{\text{sand}} \times 3) \\
 &= 16.898 \times 4 + (17.66 - 9.81) \times 6 + (20.60 - 9.81) \times 3 \\
 &= 147.062 \text{ kN/m}^2
 \end{aligned}$$

$$\Delta\sigma = 147.062 - 110.87 = 36.192 \text{ kN/m}^2$$

**2.(c) Contour Gradient:**

A line laying on the ground surface through out, and maintaining a constant inclination to the horizontal is termed as contour-gradient. In the field it can be located quickly by means of a clinometer, theodolite or a gradienter. The tracing of contour gradients is a common field operations in the location of road and railway routes over a range of hills.

Generally contour gradient between two points on any contour map is the ratio of contour interval and horizontal equivalent.

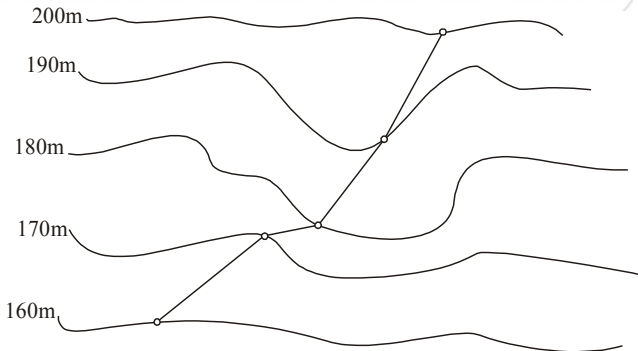
**Importance in the location of hill road :**

This lines having equal gradient along a slope elevation of two points of grade contours divided by the distance between them is always a constant gradient. Figure represents a contour plan for a valley. Suppose it is required to locate a road from p descending down to S along the grade 1.5 in 30. Let the counter interval be 1 m, suppose, the point of commencement of road, i.e., the point p lies on the 12 m contour.

The contour interval is 1 m and the road is to be laid on a grade of 1.5 in 30 m. This implies that 1.5 m vertical interval is attained

in 30 m. Hence 1 m vertical interval will be attained in  $\left(\frac{30}{1.5}\right) \times 1 = 20 \text{ m}$ . With point P as centre draw an arc on 20 m, to be chasen scale, on the contour, map cutting the next contour in points Q and Q'. PQ and PQ' can be the possible road alignments. It is important to note that the arc may cut the contour in more that one place showing that more than one alignment is possible.

This procedure is repeated at the other successive points R and S.



3.(a) Area of steel per meter of longitudinal joint is :

$$A_s = \frac{bfhw}{100S_s}$$

$$b = \frac{7.2}{2} = 3.6 \text{ m}$$

$$h = 18 \text{ cm}$$

$$\therefore A_s = \frac{3.6 \times 1.5 \times 18 \times 2400}{100 \times 1750} = 1.333 \text{ cm}^2/\text{m}$$

Using 1 cm diameter bars having area of cross-section

$$a_s = 0.7854 \text{ cm}^2$$

The spacing of bars shall be given by

$$\text{Spacing} = \frac{100 \times 0.7854}{1.333} = 58.9 \text{ cm} \approx 58 \text{ cm (say)}$$

Using 1 cm diameter tie bars, the length  $L_t$  is obtained from equation

$$L_t = \frac{dS_s}{2S_b} = \frac{1 \times 1400}{2 \times 24.6} = 28.5 \text{ cm}$$

Total length of tie bar = 30 cm, say

Use 1 cm diameter bars of length 30 cm at 50 - 58 cm center to center.

3.(b) **Prevention of Water Pollution :**

- ***Sewage Treatments :***

The household water should be treated properly so that they become environmentally safe. Adequate care should be taken to ensure that effective sewage treatment process is in place and that contaminated water does not get mixed with the environment in order to prevent water pollution, human and animal excreta should be prevented from mixing with its sources.

- ***Prevent River Water to get Polluted :***

The following water of the river cannot be cleaned easily by natural process. Since, a large number of external substances are discharged into the water, the river water becomes polluted. This may cause diseases to the people using river water. thus, every effort should be made to prevent the river water to get contaminated, people should not be allowed to throw wastes into the river water.

- ***Treatment of Wastes before Discharge :***

Factories are expected to treat its effluent wastes prior to discharge. toxic material must be treated chemically and converted into harmless materials. If possible, factories should try to recycle the treated water.

- **Strict Adherence to Water Laws :**  
Laws and legislation relating to pollution should be strictly followed by all. People should be made aware that adherence to water laws are in their own interest.
- **Treatment of Drainage Water :**  
In cities, a huge amount of water is put into drain every day. The water that flows through the city drainage system should be properly treated.
- **Treatment Plants :**  
Big cities and towns usually have effluent treatment plants. These plants filter out undissolved materials. Chemical treatment is also given to separate out unwanted dissolved chemicals.
- **Keep the Pond Water Clean and Safe :**  
Washing, bathing of cattle in the pond that is used by human should not be done.

3.(c) Water required daily

$$\begin{aligned}
 &= \text{Population} \times \text{Per capita demand} \\
 &= 2,75,000 \times 200 \text{ L/C/d} \\
 &= 55 \times 10^6 \text{ L/d} = 55 \text{ MLD} \qquad \dots(1)
 \end{aligned}$$

$$\begin{aligned}
 \text{Filtered water required for backwashing} \\
 &= 5\% \\
 &= 5\% \times 55 \text{ MLD} = 2.75 \text{ MLD} \qquad \dots(ii)
 \end{aligned}$$

∴ Daily water demand of filtered water

$$(i) + (ii) = 55 + 2.75 = 57.75 \text{ MLD}$$

Since 30 minutes (i.e., 0.5 hr) is lost daily in back washing the filters, the effective time left for working of filter units

$$= 24 - 0.5 = 23.5 \text{ hr}$$

∴ Filtered water required per hour

$$= \frac{57.75}{23.5} = 2.457 \text{ ML/h}$$

Now, filtration rate = 15 m<sup>3</sup>/m<sup>2</sup>.h (given)

∴ Area of filter required

$$\begin{aligned}
 &= \frac{[2.457 \times 10^6] \text{ m}^3 / \text{h}}{15 \text{ m}^3 / \text{m}^2 \text{h}} = 163.83 \text{ m}^2
 \end{aligned}$$

Size of filter (given) 10 m × 4 m

Area of one filter unit = 40 m<sup>2</sup>

Number of units required

$$= \frac{163.83}{40} = 4.01; \text{ say } 4$$

(i) Using one filter unit as stand by unit, total number of filters required = 5

Use equation for settling velocity ( $V_s$ ) are

$$V_s = \sqrt{\frac{(4/3) \cdot g \cdot d \cdot (G-1)}{C_D}}$$

$$= \sqrt{\frac{(4/3) \times 9.81 \times (0.6 \times 10^{-3}) (2.5-1)}{5.02}}$$

$$= 0.048 \text{ m/s}$$

Now, use equation as

$$\frac{D_c}{D} = \left[ \frac{1-n}{1-n_e} \right]$$

Where,  $m = 0.5$  (given)

$$\therefore \frac{0.66m}{0.60m} = \frac{1-0.5}{1-n_e}$$

$$\text{or } (1 - n_e) = \frac{0.5 \times 0.6}{0.66} = 0.455$$

$$\text{or } n_e = 0.545$$

Now, use equation as :

$$n_e = \left( \frac{V_b}{V_s} \right)^{0.22}$$

$$0.545 = \left( \frac{V_b}{0.048} \right)^{0.22}$$

$$\text{or } V_b = 3.04 \times 10^{-3} \text{ m/s}$$

$$= 0.304 \text{ m/s} = 18.2 \text{ cm/min}$$

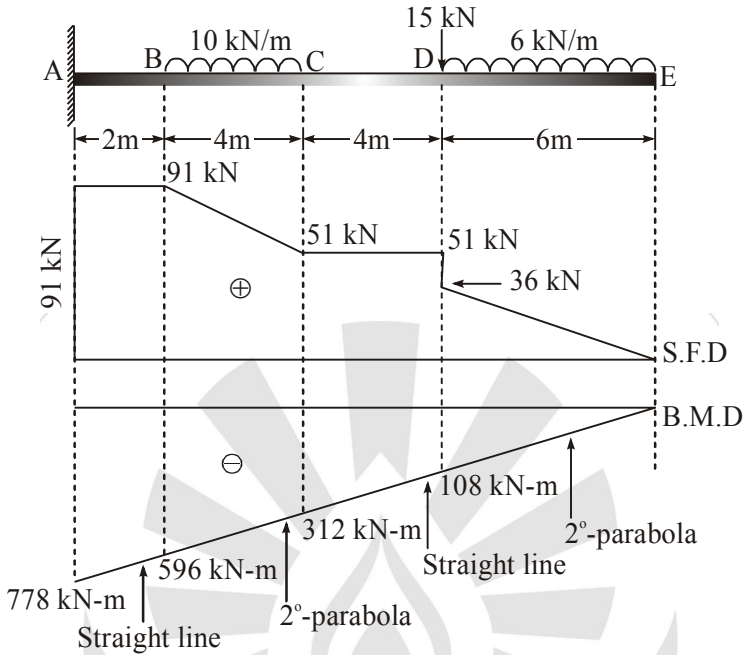
Hence the backwash upflow velocity = 18.2 cm/min

Head loss through the expanded medium is given by equation as

$$h_{L_c} = (1 - n_e) D_c \cdot (G - 1)$$

$$= (1 - 0.545) 0.66 (2.5 - 1) = 0.45 \text{ m}$$

**4.(a) Shear Force and Bending Moment Diagram :**



**For SFD :**

**DE-Portion**

$$F_E = 0$$

$$F_D = +6 \times 6 = +36 \text{ kN}$$

**BC-Portion**

$$F_C = 51 \text{ kN}$$

$$F_B = (6 \times 6) + 15 + (10 \times 4)$$

$$F_B = +91 \text{ kN}$$

**CD-Portion**

$$F_D = +(6 \times 6) + 15 = 51 \text{ kN}$$

$$F_C = 51 \text{ kN}$$

**AB-Portion**

$$F_B = +91 \text{ kN}$$

$$F_A = +91 \text{ kN}$$

**For Bending Moment :**

**DE-Portion :**

$$M_E = 0$$

$$M_D = -6 \times 6 \times \frac{6}{2} \\ = -108 \text{ kN-m}$$

**CD-Portion :** (Straight line)

$$M_D = -108 \text{ kN-m}$$

$$M_C = -\left\{6 \times 6 \times \left(\frac{6}{2} + 4\right)\right\} - (15 \times 4) \\ = -312 \text{ kN-m}$$

**BC-Portion :** ( $2^\circ$ -Parabola)

$$M_C = -312 \text{ kN.m}$$

$$M_B = -(6 \times 6 \times 11) - (15 \times 8) - (10 \times 4 \times 2) = -596 \text{ kN-m}$$

**AB-Portion :** (Straight line)

$$M_A = -(6 \times 6 \times 13) - (15 \times 10) - (10 \times 4 \times 4)$$

$$M_A = -778 \text{ kN-m}$$

Diagram are drawn with loading diagram.

**4.(b) (i) Connection using lap Joint :**

$$\text{Plate strength} = \frac{f_y A_g}{\gamma_{m_0}} = \frac{250 \times (250 \times 12)}{1.10 \times 1000} = 681.82 \text{ kN}$$

Size of weld;

Minimum = 5 mm

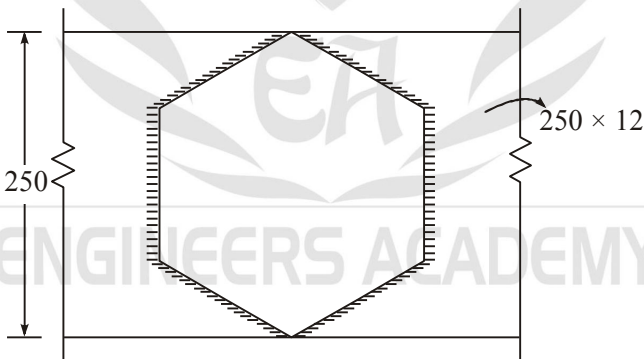
Maximum =  $12 - 1.5 = 10.5$  mm

Though the minimum size is preferable, let us take the size of the weld as 8 mm in order to reduce the length of the connection.

$$\text{Strength of the weld} = \frac{f_u t_t}{\sqrt{3} \times 1.25} = \frac{410 \times 0.7 \times 8}{\sqrt{3} \times 1.25} = 1058 \text{ N/mm}$$

**Required length of Weld :**

$$l = \frac{681.82 \times 1000}{1058} = 644 \text{ mm (say 650 mm)}$$



Here no long joint correction is required.

**(ii) Connection using butt Joint :**

Assume width of cover plate

$$= 250 - 2 \times 15 = 220 \text{ mm}$$

Use an 8-mm thick cover plate.

Area of cover plate

$$= 220 \times 8 = 1760 \text{ mm}^2$$

Required area of cover plate

$$= 1.05 \times 250 \times \frac{12}{2} = 1575 \text{ mm}^2 < 1760 \text{ mm}^2$$

Use a 5-mm fillet weld

Strength of 5 mm weld

$$= 189 \times 0.7 \times 5 = 661.5 \text{ N/mm}$$

Required length of weld

$$= \frac{681.82 \times 1000}{661.5} = 1031 \text{ mm (say 1040 mm)}$$

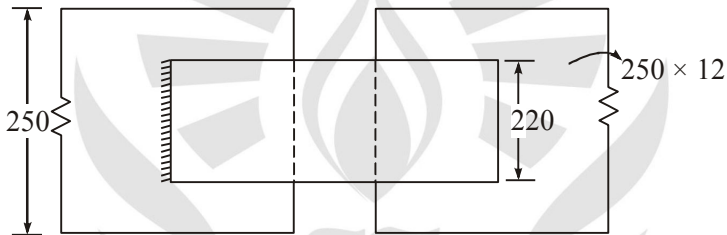
Length of the connection

$$= \left[ \frac{(1040 - 2 \times 220)}{4} \right] \times 2 = 300 \text{ mm}$$

$$< 150 \times 0.7 \times 8$$

Hence, here also long joint correction not required.

Hence, provide two cover plates of size  $300 \times 200$



**5.(a)** Lear span = 3.5 m

Thickness of lime concrete layer = 18.5 mm

Unit weight of lime concrete = 19.2 kN/m<sup>3</sup>

Super imposed load = 3 kN/m<sup>2</sup>

Grade of concrete M20 and Fe415 steel depth as per deflection

criteria =  $\frac{\text{Span}}{20}$

$$d_{\text{eff}} = \frac{\text{Span}}{20} = \frac{3500}{20} = 175 \text{ mm}$$

Let us take a clear cover of 25 mm. Then overall depth

$$= 175 + 25 = 200 \text{ mm}$$

It should be designed as beam of width 1 m,

**Louds :**

Dead load of slab

$$= 1 \times 0.2 \times 25 = 5 \text{ kN/m}$$

Dead load of lime concrete

$$= 1 \times 0.185 \times 19.2 = 0.3552 \text{ kN/m}$$

Imposed load

$$= 3 \times 1 = 3 \text{ kN/m}$$

$$\text{Total} \Rightarrow 8.3552 \text{ kN/m}$$

$$\text{Factored load} = 1.5 \times 8.3552 = 12.5328 \text{ kN/m}$$

$$\text{Bending moment} = \frac{wl^2}{8}$$

$$= \frac{12.5328 \times (3.5)^2}{8} = 19.19 \text{ kN-m}$$

$$\text{Shear force} = \frac{wl}{2} = \frac{12.5328 \times 3.5}{2} = 21.9324 \text{ kN}$$

$$\text{Check for depth} = \sqrt{\frac{M}{Q.B}} = \sqrt{\frac{19.19 \times 10^6}{2.759 \times 10^3}} = 83.39 < d_{\text{provided}} \text{ OK.}$$

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

$$= \frac{20}{2 \times 415} \left[ 1 - \sqrt{1 - \frac{4.6 \times 19.19 \times 10^6}{20 \times 1000 \times (175)^2}} \right] (1000 \times 175)$$

$$= 315.685 \text{ mm}^2$$

$$p_t = \frac{315.685}{1000 \times 175} = 0.18\% > 0.12\%$$

Let take diameter of bar = 10 mm

$$\text{Spacing} = \frac{A_\phi}{A_{ST}} \times 1000 = \frac{\frac{\pi}{4}(10)^2}{315.68} \times 1000 = 248.79 \text{ mm}$$

Provide 10 mm  $\phi$  @ 230 mm c/c spacing

For  $p_t = 0.18\%$  and M20

$$\tau_c = 0.28 + \frac{(0.36 - 0.28)}{(0.25 - 0.15)} (0.18 - 0.15)$$

$$= 0.304 \text{ N/mm}^2$$

Nominal Shear Stress

$$\tau_v = \frac{V_u}{Bd}$$

$$\Rightarrow \tau_v = \frac{21.9324 \times 1000}{1000 \times 175} = 0.125 \text{ N/mm}^2$$

$$\Rightarrow \tau_v < \tau_c$$

Hence safe

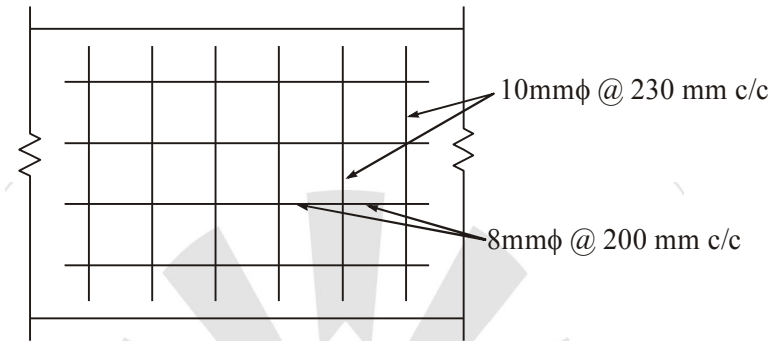
Distribution steel = 0.12% of  $A_g$

$$= \frac{0.12}{100} \times 1000 \times 200 = 240 \text{ mm}^2$$

Take 8 mm  $\phi$  bars

$$\text{Spacing} = \frac{\pi (8)^2}{4} \times 1000 = 209.43 \text{ mm}$$

Let, Spacing = 200 mm



- 5.(b)** Unless the axis about which buckling will occur is obvious, all possibilities must be checked. For ISMB section,  $r_y$  is normally between one fourth to one fifth of  $r_z$  and hence the likely mode of failure is by buckling about the minor axis. However, in case Where different effective lengths apply for the two planes, both possibilities should normally be checked.

Cross-Section Properties :

Flange-thickness,  $t_f = 14.2 \text{ mm}$

Thickness of web,  $t_w = 8.1 \text{ mm}$

Flange-width,  $b = 140 \text{ mm}$

Self-weight,  $w = 524 \text{ N/m}$

Cross-sectional area,  $A = 6670 \text{ mm}^2$

$$r_z = 143 \text{ mm}$$

$$r_y = 28.4 \text{ mm}$$

- (i) Buckling Curve Classification :**

$$\frac{h}{b} = \frac{350}{140} = 2.5 > 1.2$$

$$t_f = 14.2 \text{ mm} < 40 \text{ mm}$$

Hence, we should use buckling curve 'a' about z - z axis and 'b' about y-axis.

- (ii) Effective Length :** Since both ends are pinned effective length.

$$kL_y = kL_z = 3.0 \text{ m}$$

- (iii) Non-Dimensional Slenderness Ratio :**

Abut z-z axis,  $\alpha = 0.21$

$$\lambda_z = \sqrt{\left[ \frac{f_y \left( \frac{kL}{r} \right)^2}{(\pi^2 E)} \right]} = \sqrt{\left[ \frac{250 \times \left( \frac{3000}{143} \right)^2}{(\pi^2 \times 2 \times 10^5)} \right]} = 0.2361$$

$$\begin{aligned} \phi &= 0.5[1 + \alpha (\lambda - 0.2) + \lambda^2] \\ &= 0.5[1 + 0.21(0.231 - 0.2) + 0.2361^2] = 0.532 \end{aligned}$$

$$f_{cd} = \frac{\frac{f_y}{\gamma_{m_0}}}{[\phi + (\phi^2 - \lambda^2)^{0.5}]} = \frac{\frac{250}{1.1}}{[0.532 + (0.532^2 - 0.2361^2)^{0.5}]} = 225.3 \text{ N/mm}^2$$

About y-y axis;  $\alpha = 0.34$

$$\lambda_y = \sqrt{\left[ \frac{f_y \left( \frac{kL}{r} \right)^2}{(\pi^2 E)} \right]} = \sqrt{\left[ \frac{250 \times \left( \frac{3000}{28.4} \right)^2}{(\pi^2 \times 2 \times 10^5)} \right]} = 1.189$$

$$\begin{aligned} \phi &= 0.5[1 + \alpha (\lambda - 0.2) + \lambda^2] \\ &= 0.5[1 + 0.34(1.189 - 0.2) + 1.189^2] = 1.375 \end{aligned}$$

$$f_{cd} = \frac{\frac{f_y}{\gamma_{m_0}}}{[\phi + (\phi^2 - \lambda^2)^{0.5}]} = \frac{\frac{250}{1.10}}{[1.375 + (1.375^2 - 1.189^2)^{0.5}]} = 110 \text{ N/mm}^2$$

The same result may be obtained by using table given with paper.

Thus for  $\frac{kL}{r} = 105.63$

and  $f_y = 250 \text{ N/mm}^2$

**(iv) Design Stresses :**

*in z-direction :*

$$f_{cd} = 225.3 \text{ N/mm}^2$$

*in y-direction :*

$$f_{cd} = 110.0 \text{ N/mm}^2$$

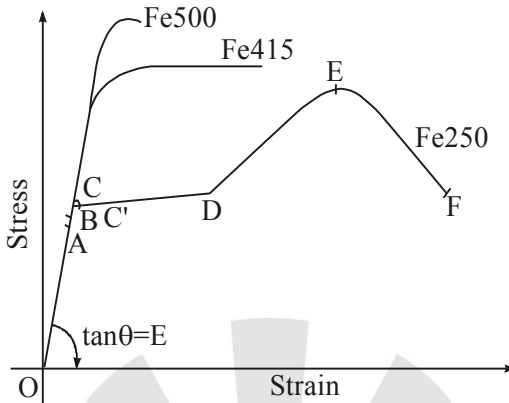
Hence design axial compressive stress

$$f_{cd} = 110 \text{ N/mm}^2$$

The design strength

$$p_d = \frac{6670 \times 110}{1000} = 733.7 \text{ kN}$$

**5.(c) Mild Steel Curve Diagram :**



**The points on mild steel Curve :**

- O → Initial point
- A → Linear elastic limit
- B → Non-linear elastic limit
- C → Upper yield point
- C' → Lower yield point
- OA → Proportional limit
- AN → None linear elastic
- CC' → Due to slippage of carbon atoms
- CD → Yield plateau
- DE → Strain hardening zone
- E → Ultimate strength
- EF → Necking
- F → Fracture point

**6.(a) Weight of the dam**

$$w = w_1 + w_2$$

Where,  $w_1 = 0.5 \times 20 \times 15 \times 24 = 3600 \text{ kN}$   
 ( $w_1$  acting at 10 m from Toe)

$$w_2 = 6 \times 30 \times 24 = 4320 \text{ kN}$$

(at 18 m from toe)

Water pressure :

$$P = 0.5 wH^2 = 0.5 \times 10 \times (27)^2 = 3645 \text{ kN,}$$

acting at 9 m above base

$$\Sigma V = w = 3600 + 4320 = 7920 \text{ kN}$$

$$\Sigma H = 3645 \text{ kN}$$

**(i) Factor of safety against sliding, from equation**

$$F_s = \frac{\mu \Sigma V}{\Sigma H} = \frac{0.7 \times 7920}{3645} = 1.52$$

**(ii) Shear friction factor, from equation**

$$\begin{aligned} \text{S.F.F.} &= \frac{\mu \Sigma V + bq}{\Sigma H} = \frac{0.7 \times 7920 + 21 \times 1400}{3645} \\ &= 9.58 \end{aligned}$$

**(iii) Factor of safety against overturning, from equation**

$$F_o = \frac{\Sigma M_R}{\Sigma M_o}$$

Where,  $\Sigma M_R = 3600 \times 10 + 4320 \times 18 = 113760 \text{ kN-m}$

and  $\Sigma M_o = 3645 \times 9 = 32805 \text{ kN-m}$

$$F_o = \frac{113760}{32805} = 3.47$$

**(iv) Maximum stress :** Taking the moment of all the forces about toe,

$$\begin{aligned} \Sigma M &= 3600 \times 10 + 4320 \times 18 - 3645 \times 9 \\ &= 80955.00 \text{ kN-m} \end{aligned}$$

The moment of resultant about toe =  $(\Sigma V)_x^{\text{kN-m}}$

Where  $\bar{x}$  is the distance from the toe of the point where the resultant strikes the base.

Therefore,

$$\bar{x} = \frac{80955.0}{7920.0} = 10.22 \text{ m}$$

Eccentricity,

$$e = \frac{B}{2} - \bar{x} = \frac{21}{2} - 10.22 = 0.28 \text{ m}$$

$$\frac{B}{6} = \frac{21}{6} = 3.50 \text{ m}$$

As the eccentricity is less than  $\frac{B}{6}$ , there is no denson.

Vertical stress at toe,

$$f_{yd} = \frac{7920}{21.0} \left[ 1 + \frac{0.28 \times 6}{21} \right] = 407.31 \text{ kN/m}^2$$

Principal stress at toe

$$\begin{aligned} \sigma_d &= \phi_{yd} \sec^2 \Phi \\ \sigma_d &= 407.31 [1 + (0.75)^2] \\ &= 636.42 \text{ kN/m}^2 \end{aligned}$$

Shear Stress at toe,

$$\begin{aligned} \tau_d &= \phi_{yd} \tan \Phi_d \\ &= 407.31 \times 0.75 \\ &= 305.48 \text{ kN/m}^2 \end{aligned}$$

**6.(b)** The estimation of runoff of a catchment is required for various water resources projects. The runoff can be estimated by the following methods :

- **Empirical Methods :**

Several empirical formulae have been developed by various investigators. These formulae relate the annual runoff (R) and the annual precipitation (P).

There are generally two forms :

$$R = aP + b \quad \dots(1)$$

$$R = cP^n \quad \dots(2)$$

(i) Inglis and De Souza' formulae :

Ghat-areas,

$$R = 0.85 P - 30.5$$

Plain areas

$$R = \frac{(P - 17.8)P}{254}$$

Where, R = Average annual runoff (cm)

P = Average annual rainfall (cm)

(ii) Lacey Formula :

$$R = \frac{P}{1 + \frac{304.8}{P} \left( \frac{F}{S} \right)}$$

(iii) Khosla's Formula :

$$R = P - 0.48 T_m$$

(iv) Parker's Formula :

British Isles

$$R = 0.94P - 35.6$$

- **Curves and Tables Method :**

Several Curves and tables have been given by investigators for the estimation of yield for different catchments.

*Example:* Binnie's percentages

Strange's Table and curves.

- **Runoff Coefficient Method :**

The runoff and rainfall can be co-related as

$$R = kP$$

Where, k = Runoff coefficient

Type of Catchment	k
Heavy-Forest	0.1 – 0.2
Sandy Soil	0.2 – 0.3
Cultivated, absorbed soil	0.3 – 0.4
Slightly Permeable	0.4 – 0.6

- **Infiltration Method :**

In this method, the runoff is estimated from the hyetograph by subtracting the infiltration loss.

- **Hydrograph Method :**

The runoff from a catchment of a river may be estimated by direct measurements. Stream gauging is done to determine the storm hydrograph. If hydrographs are available, the runoff can be estimated from the area of hydrograph.

Volume of runoff = Area of storm hydrograph

- **Rational Method :**

the rational method is mainly used for the estimation of the maximum discharge from a catchment. however, the same can also be used for the estimation of runoff.

- **Rainfall-Runoff Correlation Method :**

Runoff can be easily computed if the rainfall runoff correlation has been established for the catchment. However the relationship between rainfall and the resulting runoff is quite complex. the relationship depends on a large number of factors.

- **Maximum Flood discharge Method :**

As already mentioned, a flood is high flow in a river with a high stage when water usually overflows the banks. However, overflowing of the banks is not an essential characteristics. If the river is flowing in a deep gorge.

- **Empirical Methods :**

Dicken's formula  $\Rightarrow Q = C A^{3/4}$

Ryve's Formula  $\Rightarrow Q = C A^{2/3}$

Inglis formula  $\Rightarrow Q = \frac{124A}{\sqrt{A+10.4}}$

Meyer's formula  $\Rightarrow Q = 176p\sqrt{A}$

Ali nawaz jung bahadur formula  $\Rightarrow Q = C(0.386 A)^n$

Fuller's formula  $\Rightarrow Q = \bar{Q} (1 + 0.8 \log_{10} T_r)$

