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Institute for Engineers (IES/GATE/PSUs)

ESE 2018

Prelims Exam Paper - II

CIVIL ENGINEERING

DETAILED SOLUTION (SET-B)

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Explanation of Civil Engg. Prelims Paper-II (ESE - 2018)

SET - B

1. In a 90° triangular notch, the error in the estimated discharge for a given head due to an error of 1% in cutting the vertex angle is

(a) Zero (b) 1%

(c) $\frac{\pi}{2}\%$ (d) $\pi\%$

Ans. (c)

Sol.

$$Q = \frac{8}{15}C_d\sqrt{2g}\tan\frac{\theta}{2}H^{5/2}$$

$$dQ = \frac{8}{15}C_d\sqrt{2g}\sec^2\frac{\theta}{2}\frac{d\theta}{2}H^{5/2}$$

$$\frac{dQ}{Q} = \frac{\sec^2\theta/2}{\tan\theta/2}.\frac{d\theta}{\theta}.\frac{\theta}{2}$$

$$\frac{dQ}{Q} = 1\%\times\frac{2}{1}\times\frac{\pi}{2}\times\frac{1}{2} = \boxed{\frac{\pi}{2}\%}$$

2. Consider the following statements :

1. All soils can be identified in the field by visual examination
2. Fine-grained soils can be identified in the field by visual examination and touch
3. Fine grained soils can be identified in the field by dilatancy test
4. By visual examination, only coarse-grained soils can be identified

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 3 and 4 only (d) 1 and 4 only

Ans. (c)

Sol. Visual examination should establish the colour, grain size, grain shapes of the coarse grained part of soil.

Dilatancy test is one of the test used in field to identify fine grained soil. In this test, a wet pat of soil is taken and shaken vigorously in the palm. Silt exhibits quick response and water appears on surface, where as clay shows no or slow response.

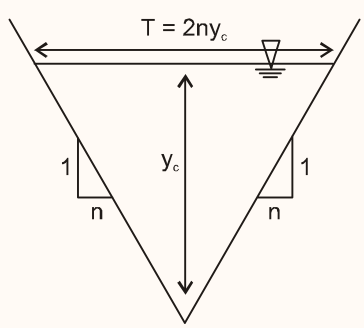
3. An open channel is of isosceles triangle shape, with side slopes 1 vertical and n horizontal. The ratio of the critical depth to specific energy at critical depth will be

(a) $\frac{2}{3}$ (b) $\frac{3}{4}$

(c) $\frac{4}{5}$ (d) $\frac{5}{6}$

Ans. (c)

Sol.



$$E_C = y_C + \frac{A}{2T}$$

Area (A) $= \frac{1}{2}\times 2ny_C \times y_C = ny_C^2$

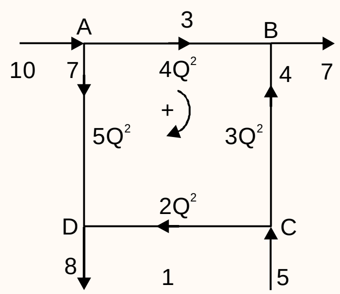
Top width (T) $= 2ny_C$

$\therefore\ E_C = y_C + \frac{ny_C^2}{2\times 2ny_C}$

$\Rightarrow\ E_C = \frac{5}{4}y_C$

$\therefore\ \boxed{\frac{y_C}{E_C} = \frac{4}{5}}$

4.



A pipe network is shown with all needful input data to compute the first iteration improved magnitudes of the initially assumed flows in the branches. What will be the such improved flow magnitudes in branches AB and CD? Consider to first decimal accuracy

(a) A to B : 5.1; C to D : 3.1

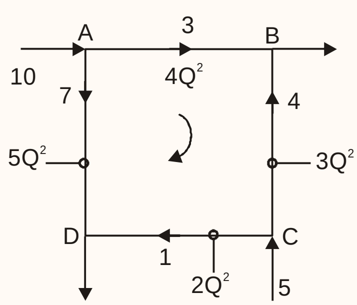
(b) A to B : 5.7; C to D : 2.8

(c) A to B : 4.9; C to D : 3.4

(d) A to B : 5.5; C to D : 3.8

Ans. **(a)**

Sol.



	rQ^n	$\lvert rnQ^{n-1}\rvert$
AB	$4Q^2 = 4\times3^2 = 36$	$\lvert 4\times2\times Q\rvert = 24$
BC	$3Q^2 = -3\times4^2 = -48$	$\lvert 3\times2\times Q\rvert = 24$
CD	$2Q^2 = 2\times1^2 = 2$	$\lvert 2\times2\times Q\rvert = 4$
DA	$5Q^2 = -5\times7^2 = -245$	$\lvert 5\times2\times Q\rvert = 70$
	$\Sigma\ rQ^2 = -255$	122

$$\Delta Q = \frac{-\sum rQ^n}{\sum \lvert rnQ^{n-1}\rvert} = \frac{-(-255)}{122} = 2.09$$

$Q_{AB} = 3+2.09 = 5.09 = 5.1$

$Q_{CD} = 1+2.09 = 3.09 = 3.1$

5. A 2 m wide rectangular channel carries a discharge of 10 m^3/s. What would be the depth of fow if the Froude number of the flow is 2.0?

(a) 1.72 m (b) 1.36

(c) 0.86 m (d) 0.68 m

Ans. **(c)**

Sol. We know,

$$F_r^2 = \frac{q^2}{gy^3}$$

$Q = 10$ m^3/sec, $B = 2$ m

$\therefore\ q = \frac{Q}{B} = \frac{10}{2} = 5$ m^2/s-m

$F_r = 2.0$, $g = 9.81$ m/sec^2

$$\Rightarrow\ 2^2 = \frac{5^2}{9.81\times y^3}$$

$$y = \left(\frac{25}{4\times 9.81}\right)^{1/3} = \boxed{0.86\text{ m}}$$

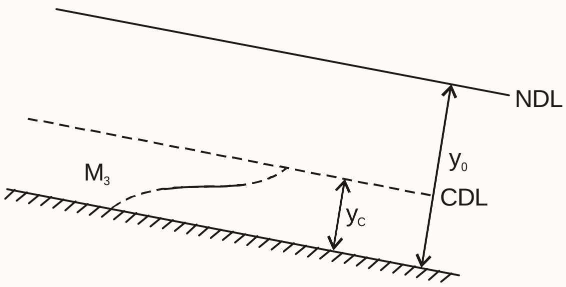
6. M_3 profile is indicated by which of the following conditions?

(a) $y_0 > y_c > y$ (b) $y > y_0 > y_c$

(c) $y_c > y_0 > y$ (d) $y > y_c > y_0$

Ans. (a)

Sol.



$\therefore\ y < y_C < y_0$

7. Floating logs of wood tend to move to the mid-river reach on the water surface. This is due to

(a) Least obstruction from the banks

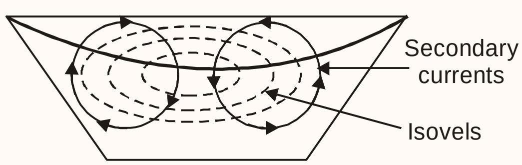
(b) 2-cell transverse circulation in the flow

(c) Faster velocity along the mid-river reach

(d) Near-symmetry of the isovels across the section is conductive to principle of least work

Ans. (b)

Sol.



Due to 2- cell transverse circulation in the flow, the logs of wood tend to move to the mid-river reach on the water surface. This is mainly due to effect of secondary currents.

8. The sequent depth ratio in a rectangular channel is 14. The froude number of the supercritcal flow will be

(a) 6.62 (b) 7.55

(c) 8.45 (d) 10.25

Ans. (d)

Sol. $\dfrac{y_2}{y_1} = \dfrac{-1+\sqrt{1+8Fr_1^2}}{2}$

$y_1 \rightarrow$ depth of supercritical flow

$y_2 \rightarrow$ depth of subcritical flow

$F_{r1} \rightarrow$ Froude's no. for supercritical flow

$14 = \dfrac{-1+\sqrt{1+8Fr_1^2}}{2}$

$F_{r1} = \boxed{10.25}$

9. In a hydraulic jump, the depths on the two sides are 0.4 m and 1.4 m. The head loss in the jump is nearly

(a) 0.45 (b) 0.65 m

(c) 0.80 m (d) 0.90 m

Ans. (a)

Sol. $h_L = \dfrac{(y_2-y_1)^3}{4y_2y_1} = \dfrac{(1.4-0.4)^3}{4\times1.4\times0.4} = \boxed{0.45\text{m}}$

10. A 20 cm centrifugal pump runs at 1400 rpm delivering 0.09 m^3/sec against a head of 45 m with an efficiency of 87%. What is its non-dimensional specific speed using rps as the relevant data component?

(a) 0.482 (b) 0.474

(c) 0.466 (d) 0.458

Ans. (d)

Sol. N = 1400 rpm

D = 20 m

Q = 0.09 m^3/s

H = 45 m

$\eta = 0.87$

For pump, $N_s = \dfrac{N\sqrt{Q}}{(gH)^{3/4}}$

$$\text{N in rps} = \frac{1400 \times 2\pi}{60} = 146.61 \text{ rps}$$

$$N_s = \frac{146.61 \times \sqrt{0.09}}{(9.81 \times 45)^{3/4}} = 0.457$$

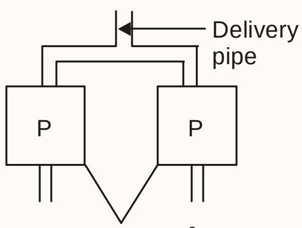
11. Two identical centrifugal pumps are connected in parallel to a common delivery pipe of a system. The discharge performance curve of each of the pumps is represented by H = 30 – 80Q^2. The discharge-head equation of the parallel duplex pump set is

(a) H = 30 – 80Q^2 (b) H = 15 – 20Q^2

(c) H = 30 – 20Q^2 (d) H = 15 – 80Q^2

Ans. **(c)**

Sol.



When two pumps are arranged in parallel, their resulting performance curve is obtained by adding the pump flow rates at the same head (h_1)

So, $h_1 = 30 - 80Q_1^2$ (For pump 1)

$h_1 = 30 - 80Q_2^2$ (For pump 2)

For pump 1

$$Q_1 = \sqrt{\frac{30 - h_1}{80}}$$

For pump 2

$$Q_2 = \sqrt{\frac{30 - h_1}{80}}$$

So, Q = Q_1 + Q_2 (at same head h1 for combined system)

$$Q = 2 \times \sqrt{\frac{30 - h_1}{80}}$$

$$Q^2 = 4 \times \frac{(30 - h_1)}{80}$$

$$h_1 = 30 - 20Q^2$$

12. Consider the following data relating to performance of a centrifugal pump : speed = 1200 rpm, flow rate = 30 l/s, head = 20 m, and power = 5 kW. If the speed of the pump is increased to 1500 rpm, assuming the efficiency is unaltered, the new flow rate and head, respectively, will be

(a) 46.9 l/s and 25.0 m

(b) 37.5 l/s and 25.0 m

(c) 46.9 l/s and 31.3

(d) 37.5 l/s and 31.3 m

Ans. **(d)**

Sol.

$$N = 1200 \text{ rpm}$$
$$Q = 30 \text{ l/s}$$
$$H = 20 \text{ m}$$
$$P = 5 \text{ kw}$$

If N_2 = 1500 rpm

$$\frac{N_1}{\sqrt{H_1}} = \frac{N_2}{\sqrt{H_2}}$$

$$\Rightarrow \frac{1200}{\sqrt{20}} = \frac{1500}{\sqrt{H_2}}$$

$$\Rightarrow H_2 = \left(\frac{1500}{1200}\right)^2 \times 20$$

$$= 31.25 \approx 31.3 \text{ m}$$

$$\frac{Q_1}{\sqrt{H_1}} = \frac{Q_2}{\sqrt{H_2}}$$

$$\frac{30}{\sqrt{20}} = \frac{Q_2}{\sqrt{31.25}}$$

$$\boxed{Q_2 = 37.5 \text{ l/sec}}$$

13. The work done by a kN of water jet moving with a velocity of 60 m/sec. when it impinges on a series of vanes moving in the same direction with a velocity of 9 m/sec is

(a) 60.2 kN m (b) 55.6 kN m

(c) 46.8 kN m (d) 45.0 kN m

Ans. **(c)**

Sol. Mass of water = $\frac{1\text{kN}}{g} = \frac{1000}{9.81}$

Mass of water (m) = 101.94 kg

Velocity of jet (V) = 60 m/sec

Velocity of vane (u) = 9 m/sec

Work done by jet = $mv_r \cdot u$ $[V_r = V - u]$

= m(V – u) u

= 101.94 × (60 – 9) × 9

= 46789 N

Work done by jet = 46.8 kN

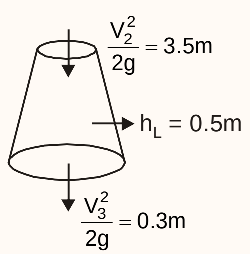
14. The velocity heads of water at the inlet and outlet sections of a draft tube are 3.5 and 0.3 m, respectively. The frictional and other losses in the draft tube can be taken as 0.5 m. What is the efficiency of the draft tube?

(a) 84.4% (b) 80.0%

(c) 77.1% (d) 74.4%

Ans. **(c)**

Sol.



$$\eta\% = \left[\frac{\left(\frac{V_2^2}{2g} - \frac{V_3^2}{2g}\right) - h_L}{\frac{V_2^2}{2g}}\right] \times 100$$

$$= \frac{3.5 - 0.3 - 0.5}{3.5} \times 100 = 77.14\%$$

15. Which of the following situations can be attributed to sustained excessive groundwater pumping in a basin?

1. Drying up of small lakes and streams over a period in spite of normal rainfall.
2. Deterioration of groundwater quality in certain aquifers
3. Land subsidence in the basin
4. Increase in seismic activity
5. Increased cost of groundwater extraction

(a) 2 and 4 only (b) 1, 2, 3 and 5 only

(c) 3 and 4 only (d) 1 and 5 only

Ans. **(b)**

Sol. Negative effects of groundwater depletion are:

1. Dryingup of wells
2. Reduction of water in streams and lakes
3. Deterioration of water quality
4. Increased pumping costs
5. Land subsidence

16. Horton's infiltration equation was fitted to data from an infiltration test. It was found that the initial infiltration capacity was 20 mm/h, final infiltration capacity was 5 mm/h and the exponential decay constant was 0.5 h^{-1}. If the infiltration was at capacity rates, the total depth for a uniform storm of 10 h duration would be

(a) 80 mm (b) 50 mm

(c) 30 mm (d) 20 mm

SCROLL DOWN

Ans. **(a)**

Sol. f_0 = Initial infiltration capacity = 20 mm/h

f_c = Final infiltration capacity = 5 mm/h

k_h = Horton decay coefficient = $0.5h^{-1}$

Horton equation

$$f = f_c + (f_0 - f_c)\, e^{-k_h t}$$

$$\Rightarrow f = 5 + 15\, e^{-0.5t}$$

Total infiltration depth

$$F = \int f dt = 5t + 15\left(\frac{e^{-0.5t}}{-0.5}\right)$$

$$= \left[5t - 30e^{-0.5t}\right]_0^{10}$$

$F = [5 \times 10 - 30e^{-5} + 30]$

F = 80 mm

17. Consider the following statements regarding turbines :

1. The main function of a governor is to maintain a constant speed even as the load on the turbine fluctuates
2. In the case of pelton turbines, the governor closes or oepns the wicket gates
3. In the case of Francis turbines, the governor opens or closes the needle valve
4. In the case of a Kaplan turbine, the governor swings the runner blades appropriately in a ddition to further closing or further opening of the wicket gates

Which of the above statements are correct?

(a) 1 and 3 only (b) 2 and 4 only

(c) 2 and 3 only (d) 1 and 4 only

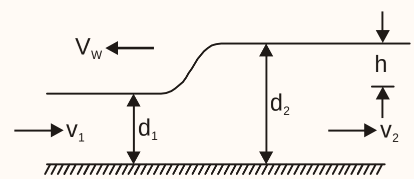
Ans. **(d)**

Sol. In pelton turbine governing action is through regulation of needle valve. In case of reduced load needle in the nozzle start moving forwards along with reduction in the area of openings and when loads increases, needle in the nozzle is pulled back to cause increase in the area of opening.

In francis turbine, governing is done through the regulation of guide vane by closing and opening the wicket gate, the area of flow is decreased or increased correspondingly.

In Kaplan turbine we have double control guide vane which controls flow and inlet angle and individual blades can also be rotated about their respective axis.

18.



Consider the occurance of a surge at the water surface of a wide rectangular channel flow, as in the figure, where th eone-dimensionally considered velocities are v_1 and v_2 and the depths are d_1 and d_2, with the surge height h, whereby $d_2 - d_1 = h$, moving at a speed of V_w over depth d_1. Joint application of continuity and momentum principles will indicate the surge front speed V_w, to be

(a) $V_w = \sqrt{gd_1}\left(1 + \frac{3}{2}\frac{h}{d_1}\right)^{\frac{1}{2}}$

(b) $V_w = \sqrt{gd_1}\left(1 + \frac{3}{2}\frac{h}{d_1} + \frac{1}{2}\left(\frac{h}{d_1}\right)^2\right)^{\frac{1}{2}}$

(c) $V_w = \sqrt{gd_1}\left(1 + \frac{h}{2}\right)^{\frac{1}{2}}$

(d) $V_w = \sqrt{gd_1}\left(1 + \left(\frac{h}{d_1}\right)^2\right)^{\frac{1}{2}}$

Ans. **(b)**

Sol. As celerity is given by

$$C = \sqrt{\frac{1}{2} g \frac{y_2}{y_1}(y_1 + y_2)}$$

where $y_2 = d_1 + h$ and $y_1 = d_1$

$$\Rightarrow \text{Celerity} = \sqrt{\frac{1}{2} g \left(\frac{d_1 + h}{d_1}\right)(2d_1 + h)}$$

$$= \sqrt{\frac{1}{2} g \left(1 + \frac{h}{d_1}\right)\left(2 + \frac{h}{d_1}\right) d_1}$$

$$C = \sqrt{\frac{1}{2} g \left(2 + \frac{h}{d_1} + \frac{2h}{d_1} + \left(\frac{h}{d_1}\right)^2\right) d_1}$$

Assuming V_w as celerity

$$V_w = \sqrt{g\left(1 + \frac{3}{2}\left(\frac{h}{d_1}\right) + \frac{1}{2}\left(\frac{h}{d_1}\right)^2\right) d_1}$$

19. Which of the following will pose difficulties in adopting u.h.g. principles and processes in evaluating flood hydrographs of basins?

1. Non-uniform areal distribution within a storm
2. Intensity variation within a storm.
3. The centre of the storm varying from storm to storm in case of large catchments
4. Dividing into a number of sub-basins and routing the individual DRHs through their respective channels to obtain the composite DRH at the basin outlet.
5. Large storages within the catchment

(a) 1, 3 and 4 only (b) 2, 3 and 4 only

(c) 1, 2 and 5 only (d) 1, 2, 3 and 5 only

Ans. **(d)**

Sol. For adoption of unit hydrograph principle:

1. Uniform areal distribution within a storm
2. Intensity does not vary within a storm
3. Catchment does not have large storage
4. In case of large storms when centre of storm is varying we can not use unit hydrograph theory

20. Rainfall of magnitude 4.3 cm, followed by 3.7 cm, occurred on two consecutive 4 h durations on a catchment area of 25 km^2, and there resulted a DRH (after isolation of base flow in the flood flow hydrograph) with the following ordinates starting from the beginning of the rainfall. (Adopt trapezoidal formula)

Time (hours)	0	4	8	12	16	20	24	28	32	36	40	44
DRH (ordinate m^3 / sec)	0	9	16	20	20	17.8	13.4	9.4	6.2	3.7	1.8	0

What is the ϕ index value?

(a) 0.149 cm/h (b) 0.155 cm/h

(c) 0.161 cm/h (d) 0.167 cm/h

Ans. **(b)**

Sol. **Runoff calculation:**

Total direct runoff = Area of DRH

$$= \frac{1}{2}(0 + 9 + 9 + 16 + 16 + 20 + 20 + 17.8 + 17.8 + 13.4 + 13.4 + 9.4 + 9.4 + 6.2 + 6.2 + 3.7 + 3.7 + 1.8 + 1.8 + 0) \times 4 \times 3600$$

$= 117.3 \times 4 \times 3600 = 1689120$ m^3

$$\text{Runoff depth} = \frac{1689120}{25 \times 10^4}\text{cm} = 6.76 \text{ cm}$$

$$\phi\text{-index} = \frac{4.3 + 3.7 - 6.76}{8} = 0.155 \text{ cm/h}$$

21. Groundwater flows through an aquifer with a cross-sectional area of 1.0 × 10^4 m^2 and a length of 1500 m. Hydraulic heads are 300 m and 250 m at the groundwater entry and exit points in the aquifer, respectively. Groundwater discharges into a stream at the rate of 750 m^3/day. Then the hydraulic conductivity of the aquifer is

(a) 1.50 m/day (b) 2.25 m/day

(c) 3.50 m/day (d) 4.25 m/day

Ans. **(b)**

Sol. Aquifer cross-section = 10^4 m^2

Length of aquifer = 1500 m

Head drop between entry and exit points = 50 m

Groundwater discharge = 750 m^3/day

By Darcy law

$Q = kiA$

$$\Rightarrow 750 = k \times \frac{50}{1500} \times 10^4$$

$$\Rightarrow k = \frac{750 \times 1500}{50 \times 10^4} = 2.25 \text{ m/day}$$

22. A hydraulic turbine develops 5000 kW under a head of 30 m when running at 100 rpm. This turbine belongs to the category of

(a) Pelton wheel (b) Francis Turbine

(c) Kaplan Turbine (d) Propeller Turbine

Ans. **(b)**

Sol. $$N_s = \frac{N\sqrt{P}}{H^{5/4}} = \frac{100\sqrt{5000}}{30^{5/4}} = 100.71$$

For francis turbine, N_s = 60 to 300.

23. The rate of rainfall for the successive 30 min periods of a 3-hour storm are : 1.6, 3.6, 5.0, 2.8, 2.2 and 1.0 cm/hour. The corresponding surface runoff is estimated to be 3.2 cm. Then, the ϕ index is

(a) 1.5 cm/h (b) 1.8 cm/h

(c) 2.1 cm/h (d) 2.4 cm/h

Ans. **(b)**

Sol. Assume ϕ-index greater than 1 cm/hr because no option is less than 1 cm/hr.

Iteration 1:

$$\text{Total precipitation} = \frac{1}{2}\times(1.6)+\frac{1}{2}\times 3.6 + \frac{1}{2}\times 5.0+\frac{1}{2}\times 2.8+\frac{1}{2}\times 2.2$$

= 7.6 cm

[$\because$ 1cm/hr will not be considered as value is less than ϕ-index assumed]

Runoff = 3.2 cm

$$\phi\text{-index} = \frac{7.6-3.2}{2.5} = 1.76 \text{ cm/h} > 1.6 \text{ cm/h}$$

It implies 1.6 cm/h rainfall ineffective. So, exclude 1 cm/h and 1.6 cm/h both.

Iteration 2:

Similarly, total precipitation = 1.8 + 2.5 + 1.4 + 1.1 = 6.8 cm

Runoff = 3.2 cm

$$\phi\text{-index} = \frac{6.8-3.2}{2} = 1.8 \text{ cm/h}$$

so, $\boxed{\phi\text{-index} = 1.8 \text{ cm/h}}$

24. For stability analysis of slopes of purely cohesive soils, the critical centre is taken to lie at the intersection of

(a) The perpendicular bisector of the slope and the locus of the centre

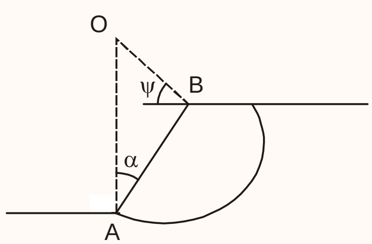
(b) The perpendicular drawn at the one-third slope from the toe and the locus of the centre

(c) The perpendicular drawn at the two-third slope from the toe and the locus of the centre

(d) Directional angles

Ans. **(d)**

Sol. Fellenius proposed on empirical procedure to find the centre of the most critical circle in a purely cohesive soil. The centre 'O' for the toe failure case can be located at the intersection of the two lines drawn from the ends A & B of the slope at angles 'α' and 'ψ' (directional angles.)



25. Consider the following statements regarding water logging :

1. Water logging is the rise of groundwater table leading to possible increase in salinity resulting in a reduction in the yield of crops
2. Water logging cannot be eliminated in certain areas but can be controlled only if the quantity of water percolating into that soil is checked and reduced.

Which of the above statement is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neithr 1 nor 2

Ans. **(c)**

Sol.

Water logging can be controlled by provision of efficient drainage to drain away the storm water and excess irrigation water. by use of sub-surface drainage, water logging can be controlled by checking and removing percolating water.

26. Annual rainfall values at station A in mm for the years 2001 to 2010 are given in the table below. If simple central 3-year moving mean of this rainfall record is calculated, the maximum and minimum values in the moving mean list would be

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Annual Rainfall P at station A (mm)	586	621	618	639	689	610	591	604	621	650

(a) 689 mm and 602 mm

(b) 649 mm and 602 mm

(c) 689 mm and 586 mm

(d) 649 mm and 586 mm

Ans. **(b)**

Sol.

Year	Annual rainfall at A (mm)	3-year moving mean
2001	586	
2002	621	608
2003	618	626
2004	639	649
2005	689	646
2006	610	630
2007	591	602
2008	604	605
2009	621	625
2010	650	

Max. 3 year moving mean = 649 mm

Minimum 3 year moving mean = 602 mm

27. Khosla's formulae for assessing pressure distribution under weir floors are based on

(a) Potential flow in permeable layers just beneath the floors

(b) Boundary layer flow with pressure drop longitudinally

(c) Conformal transformation of potential flow into the w plane

(d) Simplification of 3-D flow

Ans. **(a)**

Sol.

Khosla's theory of independent variables is based an assumption that the potential flow theory can be applied to sub-soil flow.

28. In a siphon aqueduct, the worst condition of uplift on the floor occurs when

(a) The canal is full and the drainage is empty, with water table at drainage bed level

(b) The canal is empty and the drainage is full, with water table at drainage bed level

(c) Both the canal and the drainage are full

(d) The canal is empty and the drainage is full, with water table below the floor.

Ans. **(a)**

Sol.

In case of Siphon aqueduct drain flows below the canal under syphonic action.

The maximum uplift under the worst condition would occur when there is no water flowing in the drain and the water table has risen upto drainage bed. The maximum net uplift in such a case would be equal to the difference in level between drainage bed and bottom of floor.

29. Zero hardness of water is achieved by

(a) Lime-soda process

(b) Ion exchange treatment

(c) Excess lime treatment

(d) Excess alum dosage

Ans. **(b)**

Sol.

→ In ion exchange method we use zeolites which are hydrated silicates of sodium and aluminium. Which reacts as following:

$$\text{Naz} + \begin{matrix}\text{Ca}\\\text{Mg}\end{matrix}\left\{\begin{matrix}HCO_3^-\\SO_4^{2-}\\Cl^-\end{matrix}\right. \longrightarrow \text{Na}\left\{\begin{matrix}HCO_3^-\\SO_4^{2-}\\Cl^-\end{matrix}\right. + \left.\begin{matrix}\text{Ca}\\\text{Mg}\end{matrix}\right\}\text{Z}$$

→ Ion exchange method produces water with zero hardness.

30. Five-days BOD of a 10% diluted sample having D_O = 6.7 mg/l, D_S = 2 mg/l and consumption of oxygen in blank = 0.5 mg/l, will be

(a) 22 mg/l (b) 42 mg/l

(c) 62 mg/l (d) 82 mg/l

Ans. **(b)**

Sol.

D_0 = Initial D.O. of mix = 6.7 mg/l

D_s = Final D.O of mix = 2 mg/L

Consumption of oxygen inblank sample = 0.5 mg/L

Dilution ratio (P) = 0.1

As the mixture uses seeded water

$$BOD_5 = \frac{(D_0 - D_s) - (D_{ob} - D_{Sb}) \times (1-P)}{P}$$

$$= \frac{(6.7-2) - 0.5 \times 0.9}{0.1}$$

= 42.5 mg/l

So, nearest option will be (b)

31. Which one of the following statements related to testing of water for municipal use is correctly applicable?

(a) Pseudo-hardness is due to presence of fluoride in water

(b) When alkalinity $\geq$ total hardness, Carbonate hardness in mg/l = Total hardness in mg/l

(c) Bicarbonate alkalinity = total alkalinity – (carbonate alkalinity – hydroxide alkalinity)

(d) Hydroxide alkalinity = Carbonate alkalinity + Bicarbonate alkalinity

Ans. (b)

Sol. $\rightarrow$ If non-carbonate hardness is absent in water

- Total hardness = minimum (carbonate hardness, alkalinity)

Thus, Alkanlinity > Total hardness

then total hardness = carbonate hardness.

$\rightarrow$ Pseduo hardness is due to pressure of Na^+ (sodium) ion in water.

$\rightarrow$ Bicarbonate alkalinity = Total alikalnity – [carbond alkalnity + hydroxide alkalnity]

32. The capacity of a service reservoir in a campus should cater to

(a) Sum total of balancing storage, breakdown storage and fire reserve

(b) Sum total of balancing storage and fire reserve

(c) Sum total of breakdown storage and fire reserve

(d) Balancing storage only

Ans. (a)

Sol.

- Capacity of a service reservoir in any community should cater to sum total balancing storage breakdown stroage and fire reserve.
- The storage capacity of balancing reservoirs is worked out with the help of hydrograph of inflow and outflow by mass curve method.

33. Consider the following statements regarding groundwater pollutants:

1. Most of the groundwaters are generally non-alkaline
2. A moderate amount of fluoride, about 0.6 mg/l to 1.5 mg/l, in drinking water, would help in good development of teeth
3. Natural waters do not have dissolved mineral matter in them

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) 3 only (d) 1, 2 and 3

Ans. (b)

Sol.

1. Most of the ground waters are alkaline in nature.
2. natural waters contain dissolved minor matter in them.
3. A moderate amount of fluoride helps in good development of teeth.

Thus, only statement (2) is correct.

34. Consider the following statements regarding anchorage of pipelines conveying water:

1. At bends, pipes tend to pull apart
2. At bends, forces exerted on the joints due to longitudinal shearing stresses are enormous and the joints may get loosened

3. To avoid problems by hydrodynamic effects, pipes are anchored using concrete blocks which absorb side thrusts at bends
4. Pipes are also anchored on steep slopes

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 1, 3 and 4 only (d) 1, 2, 3 and 4

Ans. (d)

Sol. Pipelines on pipe bend and those designed an steep slope (> 20%) require concrete anchor blocks.

35. Consider the following statements with reference to bioenergy as a renewable energy source:

1. Plants ensure continuous supply of gas due to their continuous growth
2. Cost of obtaining energy from biogas is less than that from fossil fuels
3. Digestion of sludge may produce H_2S and NO_X which are injurious to human health
4. 'Floating dome' installation is the preferred option as it supplies gas at constant pressure irrespective of quantity of gas produced

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 2, 3 and 4 only (d) 1, 3 and 4 only

Ans. (d)

Sol.

Cost of obtaining energy from fossil fuel is less as compared to that from biogas:

Thus, statement (2) is incorrect.

36. Consider the following statements regarding waste stabilization ponds:

1. The pond has a symbiotic process of waste stabilization through algae on one hand and bacteria on the other
2. The oxygen in the pond is provided by algae through photosynthesis
3. The detention period is of the order of two to three days
4. The bacteria which develop in the pond are aerobic bacteria

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 3 and 4 only (d) 1 and 4 only

Ans. (a)

Sol.

→ Stabilization pond has symboisis between algae and bacteria.

In which algae produces oxgyen by photosynthesis and aerobic bacteria consumes that

→ Stabilization pond used for domestic sewage are mostly facultative in nature

→ Stabilization pond has detention period around 15 –30 days

37. The purpose of re-carbonation after water softening by the lime-soda process is the

(a) Removal of excess soda from the water
(b) Removal of non-carbonate hardness in the water
(c) Recovery of lime from the water
(d) Conversion of precipitates to soluble forms in the water

Ans. (d)

Sol. → Complete removal of hardness cannot be accomplished by chemical precipitation. These remains will precipitate slowly and hence will get accumulated inside the pipe and clog the pipe with time. Hence it is necessary to make it soluble.

And this is done by adding 'CO_2' in water.

38. Environmental flow of a river refers to the quantity, quality and timing of the flow

(a) Required in the river to sustain the river ecosystem

(b) Required to maintain healthy ecological conditions in the command area of a river development project

(c) Generated by the ecosystem of the catchment of the river

(d) As the minimum requirement to support the cultural practices of the community living on the banks of the river

Ans. (a)

Sol.

Environmental flows describe the quantity, timing and quality of water flows required to sustain freshwater and river ecosystem.

39. The moisture content of a certain Municipal Solid Waste with the following composition will be

	Wet, % weight	Dry, % weight
Food waste	10	03
Paper	35	30
Yard waste	20	10
Others	35	20

(a) 100% (b) 63%

(c) 37% (d) 13%

Ans. (c)

Sol.

Total weight = (10+ 35 + 20 + 35)

= 100 units

Dry weight = (63 + 30 + 10 + 20)

= 63 units

Thus, moisture = (100 – 63) = 37 units.

$$\% \text{ moisuture content } = \frac{37}{100} \times 100\%$$

$$= 37\%$$

40. Consider the following statements:

1. When a soil sample is dried beyond its shrinkage limt, the volume of the soil slowly decreases.
2. Plastic limit is always lower than the liquid limit for any type of soil
3. At the liquid limit, the soil behaves like a liquid and possesses no shear strength at all
4. When subjected to drying, the volume of the soil remains unchanged once the water content of the soil goes below its shrinkage limit.

Which of the above statements are correct?

(a) 1 and 3 only (b) 1 and 4 only

(c) 2 and 3 only (d) 2 and 4 only

Ans. (d)

Sol. Shear strength of soils at liquid limit is approximately 2.7 kN/m^2

The volume of soil do not change, when subjected to drying at water content below shrinkage limit.

Plastic limit is always lower than the liquid limits for any type of soil.

41. Consider the following statements in respect of the troposphere:

1. The gaseous content constantly churns by turbulence and mixing.
2. Its behaviour makes the weather
3. The ultimate energy source for producing any weather change is the sun
4. The height of the troposhere is nearly 11 km at the equatorial belt and is 5 km at the poles.

Which of these are true of the troposphere?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 1, 3 and 4 only (d) 2, 3 and 4 only

Ans. **(a)**

Sol.

The height of troposphere ranges from 9 km at the poles to 17 km at the equator.

Thus, statement (4) is incorrect.

42. A sand sample has a porosity of 30% and specific gravity of solids as 2.6. What is its degree of saturation at moisture content of 4.94%?

(a) 40% (b) 3.5%
(c) 30% (d) 25%

Ans. **(c)**

Sol. n = 0.3

G_s = 2.6

w = 4.94%

$$e = \frac{n}{1-n} = \frac{0.3}{1-0.3} = \frac{3}{7}$$

So, es = wG_s

$$\frac{3}{7} \times s = \frac{4.94}{100} \times 2.6$$

$\Rightarrow$ S = 0.299

$S \approx 30\%$

43. What will be the unit weight of a fully saturated soil sample having water content of 38% and grain specific gravity of 2.65?

(a) 19.88 kN/m^3 (b) 17.88 kN/m^3
(c) 16.52 kN/m^3 (d) 14.65 kN/m^3

Ans. **(b)**

Sol. w = 0.38

G_s = 2.65

S = 1

es = wG_s

1.e = 0.38 × 2.65 $\Rightarrow$ e = 1.007

$$\gamma_{sat} = \frac{(G_s + Se)\gamma_w}{1+e} = \left(\frac{(2.65 + 1 \times 1.007}{1+1.007}\right) \times 9.81$$

= 17.88 kN/m^3

44. How many cubic metres of soil having void ratio of 0.7 can be made from 30m^3 of soil with void ratio of 1.2?

(a) 36.6m^3 (b) 30.0m^3
(c) 25.9m^3 (d) 23.2m^3

Ans. **(d)**

Sol.

$V_1 = (1 + e_1)\, V_s$

$V_2 = (1 + e_2)\, V_s$

$$\frac{V_2}{V_1} = \frac{1+e_2}{1+e_1}$$

$$V_2 = \frac{1.7}{2.2} \times 30$$

$$V_2 = 23.18 \simeq 23.2\, m^3$$

45. A dry sand specimen is put through a tri-axial test. The cell pressure is 50 kPa and the deviator stress at failure is 100 kPa. The angle of internal friction for the sand specimen is

(a) 15º (b) 30º
(c) 45º (d) 55º

Ans. (b)

Sol. $\sigma_3 = 50$ kPa

$\sigma_d = \sigma_1 - \sigma_3 = 100\,\text{kPa}$

$\Rightarrow \sigma_1 = 100 + 50 = 150$ kPa

$$\sigma_3 = \sigma_1 \tan^2\left(45 - \frac{\phi}{2}\right) \quad [C = 0]$$

$$\Rightarrow 50 = 150 \tan^2\left(45 - \frac{\phi}{2}\right)$$

$$\Rightarrow \tan\left(45 - \frac{\phi}{2}\right) = \frac{1}{\sqrt{3}}$$

$$45 - \frac{\phi}{2} = 30°$$

$$\frac{\phi}{2} = 15°$$

$$\Rightarrow \phi = 30°$$

46. The theory of consolidation predicts settlement due to primary consolidation; it cannot include settlement due to initial compression nor due to secondary consolidation. This happens because of the following assumptions made in developing the theory:

1. Soil grains and water are incompressible.
2. Soil is fully saturated
3. Compression takes place in the vertical direction only
4. Time lag in consolidation is entirely due to low permeability of soil

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 3 and 4 only (d) 1, 2, 3 and 4

Ans. (b)

Sol. Soil grains and water are incompressible and soil is fully saturated are assumption which makes sure that initial compression is not taken in account.

Time lag in consolidation is entirely due to low permeability of soil which is reason that secondary consolidation can be neglected.

Compression in vertical direction only do not have any relation with primary and seconary compression

47. Consider the following statements:

1. Secondary consolidation results due to prolonged dissipation of excess hydrostatic pressure.
2. Primary consolidation happens under expulsion of both air and water from voids in early stages.
3. Initial consolidation in the case of fully saturated soils is mainly due to compression of solid particlels
4. Primary consolidation happens more quickly in coarse-grained soils than in fine-grained soils

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 3 and 4 only (d) 1 and 4 only

Ans. (c)

Sol.
- Initial consolidation for fully saturated soil is due to compression of soil solids.
- Primary consolidation occurs due to expulsion of excess pore water. Since permeability of coarse grained is greater. Hence it happens more quickly in coarse grained.

- Secondary consolidation occurs due to gradual, readjustment of clay particles into a more stable configuration.

48. Consider the following statements with regard to Soil testing:

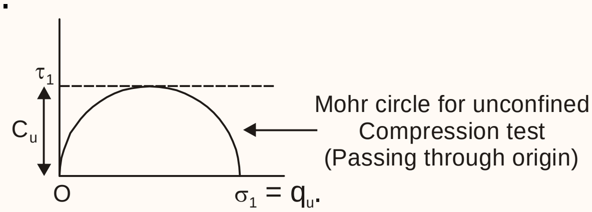
1. The origin and pole are at the same point in a Mohr's circle
2. The shear stress is maximum on the failure plane
3. Mohr's circle drawn with data from an unconfined compression test passes through the origin
4. Maximum shear stress occurs on a plane inclined at 45º to the principal plane

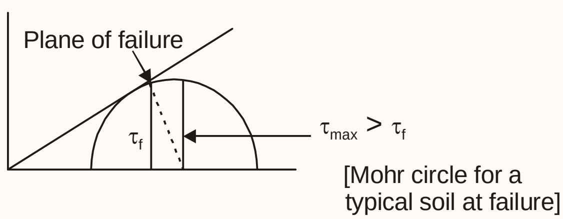
Which of the abvoe statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 3 and 4 only (d) 1 and 4 only

Ans. (c)

Sol.





49. A soil yielded a maximum dry unit weight of 18 kN/m^3 at a moisture content of 16% during a Standard Proctor Test. What is the degree of saturation of the soil if its specific gravity is 2.65?

(a) 98.42% (b) 95.50%
(c) 84.32% (d) 75.71%

Ans. (b)

Sol. $\gamma_d = 18 \text{ kN/m}^3$

$w = 0.16$

$G_s = 2.65$

$$\gamma_d = \frac{G_s\gamma_w}{1+e}$$

$$\Rightarrow 18 = \frac{2.65\times 9.81}{1+e}$$

$\Rightarrow e = 0.444$

$e \times s = wG_s$

$\Rightarrow 0.444 \times s = 0.16 \times 2.65$

$\Rightarrow s = 0.9547$

$s = 95.5\%$

50. Consider the following assumptions regarding Coulomb's Wedge Theory:

1. There is equilibrium of every element within the soil mass of the material
2. There is equilibrium of the whole of the material
3. Backfill is wet, cohesive and ideally elastic
4. The wall surface is rough

Which of the above assumptions are correct?

(a) 1 and 3 only (b) 1 and 4 only
(c) 2 and 3 only (d) 2 and 4 only

Ans. (d)

Sol.
- Friction is assumed betwen soil and wall
- Backfill is dry, cohesionless, isotropic
- Equilibrium of soil wedge is considered.

51. In a clayey soil having 50 kN/m^2 as unit cohesion and 18 kN/m^3 as unit weight, an excavation is made with a vertical face. Taking Taylor's stability number as 0.261, what is the maximum depth of excavation so that the vertical face remains stable?

(a) 5.30m (b) 7.06m

(c) 10.6m (d) 12.4m

Ans. **(c)**

Sol. S_n = Stability number

H = Maximum depth of stable excavation

$$S_n = \frac{C}{F_c \gamma H}$$

$$\Rightarrow 0.261 = \frac{50}{18 \times H} \qquad (\text{Take } F_c = 1)$$

$$\Rightarrow H = \frac{50}{18 \times 0.261} = 10.64 \text{ m}$$

52. What is the Boussinesq's vertical stress at a point 6m directly below a concentrated load of 2000 kN applied at the ground surface?

(a) 53.1 kN/m^2 (b) 26.5 kN/m^2

(c) 11.8 kN/m^2 (d) 8.8 kN/m^2

Ans. **(b)**

Sol.
$$\sigma_z = \frac{3Q}{2\pi z^2} \times \left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2}$$

$$= \frac{3 \times 2000}{2 \times \pi \times 6^2} \times \left(\frac{1}{1}\right)^{5/2} = 26.53 \text{ kN/m}^2$$

53. Consider the following statements:

1. In a reinforced concrete member subjected to flexure, the externally applied moments is resisted by an internal couple formed by steel and concrete and their magnitudes vary with the applied moment, while the lever arm of the internal couple remains constant

2. In a prestressed concrete member, the external moment is resisted by an internal couple, but it is the lever arm that changes with the loading conditions and the stress in steel remains practically constant.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

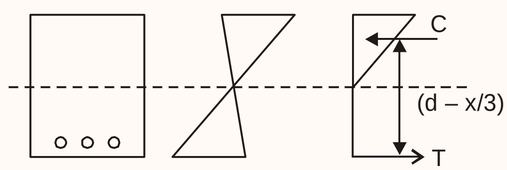
(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. **(c)**

Sol. A change in the external moments in the elastic range of a pre-stressed concrete beam results in a shift of the pressure line rather than in an increase in the resultant force in the beam.

In R.C.C. design principle of lever arm practically remains constant.

This is in contrast to a reinforced concrete beam section where an increase in the external moment results in a corresponding increase in the tensile force and the compressive force but the lever arm of internal couple remains constant.



54. Consider the following statements with regard to Global Positioning Systems (GPS):

1. The position of an object can be exactly determined by a single satellite

2. The position of the observer (moving person or vehicel) on ground is determined by an oribiting satellite

3. Atomic clocks are fixed in satellites to calculate the positioning of the satellite to aid in determining travel times.

4. Absolute positioning, where accuracy of 1 cm to 5cm is needed, depends upon the health of the satellite.

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only

(c) 1, 3 and 4 only (d) 2, 3 and 4 only

Ans. **(d)**

Sol. Minimum 4 satellite are required to determine exact position of an object.

55. A temporary bench mark has been established at the soffit of a chejja on a window opening, and its known elevation is 102.405 m abvoe mean sea level. The backsight used to establish the height of the instrument is by an inverted staff reading of 1.80m. A foresight reading with the same staff, held normally, is 1.215m on a recently constructed plinth. The elevation of the plinth is

(a) 95.42 m O.D (b) 99.39 m O.D

(c) 102.42 m O.D (d) 105.99 m O.D

Ans. **(b)**

Sol. R.L. of T.B.M = 102.405 m (elevation of soffit of chejja).

B.S. = –1.8m (inverted)

F.S. = 1.215 m

H.I. = R.L. of T.B.M. + B.S.

H.I. = 102.405 – 1.8 = 100.605 m

R.L. of plinth = 100.605 – 1.215 = 99.39 m

56. A transition curve is to be provided for a circular railway curve of 300m radius, the gauge being 1.5m with the maximum superelevation restricted to 15 cm. What is the length of the transition curve for balancing the centrifugal force?

(a) 72.3m (b) 78.1m

(c) 84.2m (d) 88.3m

Ans. **(a)**

Sol. Correct option is (a)

here,

$$V_{max} = 4.35\sqrt{R-67}$$

$$= (4.35\sqrt{300-67})\text{ km/hr}$$

$$= 66.39 \text{ km/hr}$$

Thus,

Length of transition curve

$= 0.073 \times e \times V_{max}$

$= (0.073 \times 15 \times 66.39)$m

$= 72.6 \text{ m} \simeq 72.3 \text{ m}$

57. Consider the following statements regarding remote sensing survey:

1. Information transfer is accomplished by use of electromagnetic radiation
2. Remote sensing from space is done by satellites
3. Remote sensing has no application in earthquake prediction

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol. Remote sensing from space is done by space shuttle i.e. space craft or satellites.

Remote sensing is detecting and measuring electromagnetic energy emanating or reflected from distant objects made up of various materials, so that we can identify and categorize these objects.

Remote sensing is used in disaster management services such as flood and drought warning and monitoring, damage assesment in case of natural calamities like volcanic erruptions, earthquake, tsunami etc. But it has no application in earthquake prediction.

58. The rate of equilibrium superelevation on a road is

1. Directly proporitonal to the square of vehicel velocity
2. Inversely proportional to the radius of the horizontal curve
3. Directly proportional to the square of the radius of the horizontal curve

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

Sol.

Correct option is (a)

Rate of equilibrium superelevation.

$$\boxed{e = \frac{v^2}{gR}}$$

Thus, statement (3) is incorrect.

59. As per IRC 37: 2012, the fatigue life of a flexible pavement consisting of granular base and sub-base depends upon

1. Resilient Modulus of bituminous layers
2. Horizontal tensile strain at the the bottom of bituminous layer
3. Mix design of birumen
4. Vertical subgrade strain

Which of the above statments are correct?

(a) 1, 2 and 4 only (b) 1, 3 and 4 only

(c) 1, 2 and 3 only (d) 2, 3 and 4 only

Ans. (c)

Sol.

Does not depend on vertical subgrade strain

60. Which one of the following types of steel is used in the manufacturing of metro and mono rails?

(a) Mild steel (b) Cast steel

(c) Manganese steel (d) Bessemer steel

Ans. (c)

Sol. Correct option is (c)

Maganese steel is used in the manufacturing of metro and mono rails.

61. Consider the following statements for selecting building stones:

1. Seasoning of stones is essential and is done by soaking in water
2. Specific gravity of stone is to be more than 2.7
3. Porosity of stone affects its durability
4. Climatic conditions decide the type of stone to be used in construction

Which of the above statements are correct?

(a) 1, 2 and 3 only
(b) 1, 2 and 4 only
(c) 1, 3 and 4 only
(d) 2, 3 and 4 only

Ans. (d)

Sol. For good building material specific gravity of stone should be more than 2.7.

Stones with high porosity are less durable.

Suitability of stones depends on its characteristics also on local environmental and climatic conditions.

62. Consider the following statements:

1. Hydrophobic cement grains possesses low wetting ability
2. Rapid-hardening cement is useful in concreting under static, or running water
3. Quick-setting cement helps concrete to attain high strength in the initial period
4. White cement is just a variety of ordinary cement free of colouring oxides.

Which of the above statements are correct?

(a) 1 and 4 only (b) 1 and 3 only
(c) 2 and 4 only (d) 2 and 3 only

Ans. (a)

Sol.
- Hydrophobic cement contains admixtures which decreases the wetting ability of cement grains.
- Rapid hardening cement is similar to OPC, except it has more C_3S (upto 50%) and less C_2S and it is ground more finely. It helps in attainment of early strength and used where early removal of formwork is required.
- Quick setting cement has low gypsum content which gives the quick setting property but it doesnot affect the strength gain.
- White cement are free from iron oxides.

63. Consider the following statements:

1, Rich mixes are less prone to bleeding than lean ones
2. Bleeding can be reduced by increasing the fineness of cement

Which of the above statements is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (c)

Sol. Bleeding can be reduced by the use of uniformly graded aggregates, pozzolana-by breaking the continuous water channel, or by using-entraining agents, finer cement, alkali cement and rich mix.

64. The yield of concrete per bag of cement for a concrete mix proportional of 1 : 1.5 : 3 (with adopting $\frac{2}{3}$ as the coefficient) is

(a) 0.090 m^3 (b) 0.128 m^3
(c) 0.135 m^3 (d) 0.146 m^3

Ans. (b)

Sol. Volume of one bag of cement = 0.035m^3

Cement: sand : Aggregate :: 1 : 1.5 : 3 (by volume)

$\therefore$ Volume of dry mix = 0.035 + 1.5 × 0.035 + 3 × 0.035 = 0.1925 m^3

$\therefore$ For wet mix yield of concrete

$$= \frac{2}{3} \times 0.1925 = \boxed{0.128\ m^3}$$

65. Consider the following statements:

1. Workability of concrete increases with the increase in the proportion of water content
2. Concrete having small-sized aggregates is more workable than that containing large-sized aggregate
3. For the same quantity of water, rounded aggregates produce a more workable concrete mix as compared to angular and flaky aggregates

4. A concrete mix with no slump shown in the slump cone test indicates its very poor workability

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only

(c) 1, 3 and 4 only (d) 2, 3 and 4 only

Ans. **(c)**

Sol.
- Workability of concrete is the ease with which a concrete can be transported, placed and 100% compacted without excessive bleeding or segregation.
- Concrete having large sized aggregate has high workability due to less surface area of large aggregates which requires less paste.
- Slump value of zero is an indication of extremely low workability of mixture.

66. A steel wire of 20 mm diameter is bent into a circular shape of 10 m radius. If E, the modulus of elasticity, is 2×10^6 kg/cm^2, then the maximum tensile stress induced in the wire is, nearly

(a) 2×10^3 kg/cm^2 (b) 4×10^3 kg/cm^2

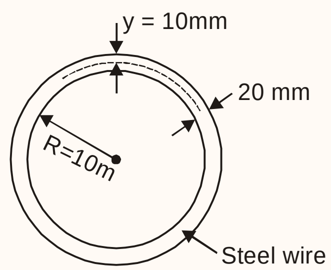
(c) 2×10^4 kg/cm^2 (d) 4×10^4 kg/cm^2

Ans. **(a)**

Sol. Dia of steel wire = 20 mm

Radius of circular shape = 10 m

Modulus of elasticity, E = 2×10^6 kg/cm^2



$\therefore$ From bending formula

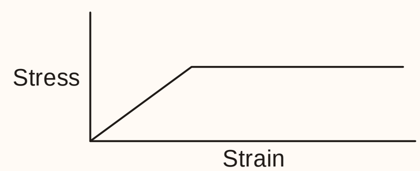
$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

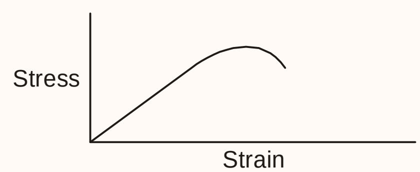
$$\frac{f}{y} = \frac{E}{R} \Rightarrow f = \frac{E}{R} \times y$$

$$f = \frac{2 \times 10^6}{10} \times \frac{20}{2} \times 10^{-3} \text{ kg/cm}^2$$

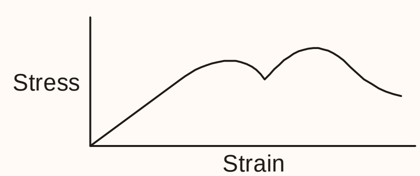
$$\boxed{f = 2 \times 10^3 \text{ kg/cm}^2}$$

67. The stress-strain curve for an ideally plastic material is

(a) 

(b) 

(c) 

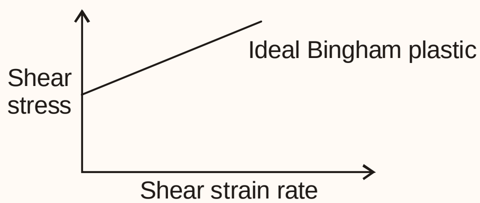
(d) 

Ans. **(c)**

Sol. Stress-strain curve for perfectly plastic material

Curve will not have any elastic component. So most appropriate answer is ‘c’.

Note : shear stress-strain rate curve for ideal Bingham Plastic.



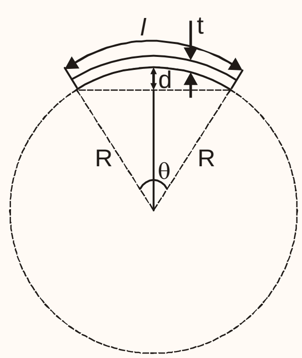
68. A long rod of uniform rectangular section with thickness t, originally straight, is bent into the form of a circular arch with displacement d at the mid-point of span l. The displacement d may be regarded as small as compared to the length l. The longitudinal surface strain is

(a) $\frac{2td}{l^2}$ (b) $\frac{4td}{l^2}$

(c) $\frac{8td}{l^2}$ (d) $\frac{16td}{l^2}$

Ans. **(b)**

Sol.



$\therefore$ From property of circle

$$(2R - d) \times d = \left(\frac{l}{2}\right)\cdot\left(\frac{l}{2}\right)$$

$\therefore$ for small 'θ' arch length and chord length are same

$$\boxed{d = \frac{l^2}{8R}} \quad \text{or} \quad \boxed{R = \frac{l^2}{8d}}$$

From bending formula

$$\frac{\sigma}{y} = \frac{E}{R} \Rightarrow \frac{\sigma}{t/2} = \frac{E}{\frac{l^2}{8d}}$$

$$\boxed{\frac{\sigma}{E} = \varepsilon = \frac{y}{R} = \frac{4dt}{l^2}}$$

69. If strains on a piece of metal are ε_x = –120 μm/m, ε_y = – 30 μm/m, and γ = 120 μm/m, what is the maximum principal strain?

(a) 0 (b) 50 μm/m

(c) 75 μm/m (d) 150 μm/m

Ans. **(d)**

Sol. Given :

ε_x = –120 μm/m

ε_y = –30 μm/m

γ = 120 μm/m

$$\therefore \quad \varepsilon_{max} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$= \frac{-120-30}{2} \pm \sqrt{\left(\frac{-120+30}{2}\right)^2 + \left(\frac{120}{2}\right)^2}$$

$$= -75 \pm \sqrt{45^2 + 60^2}$$

$$\boxed{\varepsilon_{max} = -150\ \mu m/m} \quad \text{or} \quad \boxed{\varepsilon_{min} = 0}$$

Maximum magnitude of strain will be considered.

70. The state of stress at a point is given by : $\sigma_x = 80\text{ MPa}, \sigma_y = 100\text{ MPa}$ and τ_{xy} = 60 MPa. If the yield strength for the material is 150 MPa, as determined in a uniaxial test, then the maximum shear stress is, nearly

(a) 150.8 MPa (b) 127.4 MPa
(c) 119.3 MPa (d) 104.0 MPa

Ans. **(*)**

Sol. Given,

σ_x = 80 MPa

σ_y = 100 NPa

τ_{xy} = 60 MPa

f_y = 150 MPa

$$\sigma_{1/2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_1 = \frac{80+100}{2} + \sqrt{\left(\frac{80-100}{2}\right)^2 + 60^2} = 150.83\text{MPa}$$

$$\sigma_2 = \frac{80+100}{2} - \sqrt{\left(\frac{80-100}{2}\right)^2 + 60^2} = 29.17\text{MPa}$$

$$\tau_{max} = \max\left\{\left|\frac{\sigma_1 - \sigma_2}{2}\right|, \left|\frac{\sigma_1}{2}\right|, \left|\frac{\sigma_2}{2}\right|\right\}$$

$$\tau_{max} = 75.41\text{MPa}$$

71. Principal stress at a point in an elastic material are 1.5σ (tensile), σ (tensile) and 0.5σ (compressive). The elastic limit in tension is 210 MPa and μ = 0.3. The value of σ at failure when computed by maximum principal strain theory is, nearly

(a) 140.5 MPa (b) 145.5 MPa
(c) 150.5 MPa (d) 155.5 MPa

Ans. **(d)**

Sol. $\sigma_1 = 1.5\sigma(T)$, E = 210 MPa

$\sigma_2 = \sigma(T)$

$\sigma_3 = 0.5\sigma(c)$

μ = 0.3

From maximum principal strain theory

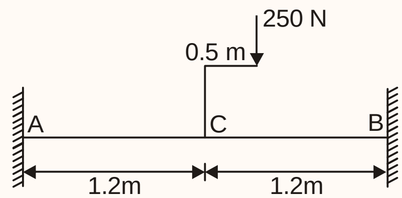
$$\frac{\sigma_1}{E} - \frac{\mu\sigma_2}{E} - \frac{\mu\sigma_3}{E} \le \frac{f_y}{E}$$

$$\frac{1.5\sigma}{E} - \frac{0.3\times\sigma}{E} - 0.3\times\left(\frac{-0.5\sigma}{E}\right) \le \frac{f_y}{E}$$

$\therefore f_y$ = 210 MPa

$$\boxed{\sigma = 155.5\text{ MPa}}$$

72.

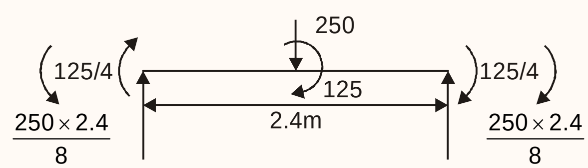


A horizontal bar of 40 mm diameter solid section is 2.40 m long and is rigidly held at both ends so that no angular rotation occurs axially or circumferentially at the ends (as shown in figure). The maximum tensile stress in the bar is nearly

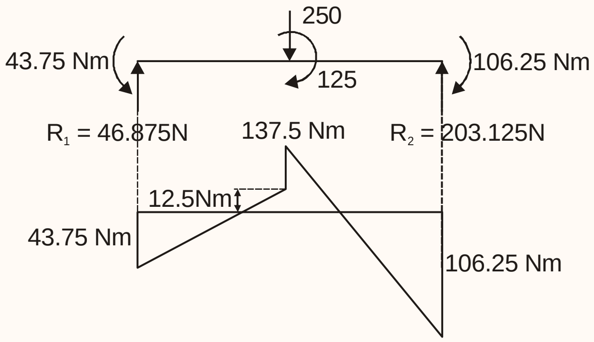
(a) 12.2 N/mm^2 (b) 13.7 N/mm^2
(c) 15.2 N/mm^2 (d) 16.7 N/mm^2

Ans. **(d)**

Sol.



$$R_1 = \frac{250}{2} - \frac{125}{2.4} - \frac{62.5}{2.4} \qquad R_2 = \frac{250}{2} + \frac{125}{2.4} + \frac{62.5}{2.4}$$



$\Rightarrow$ Maximum bending stress occur at the point of maximum bending moment

$$\sigma_{max} \text{ (at mid span)} = \frac{32M}{\pi d^3}$$

$$= \frac{32 \times 137.5 \times 1000}{\pi \times 40^3}$$

$= 21.88$ MPa

$$\sigma_{max} \text{ (at end B)} = \frac{32M}{\pi d^3}$$

$$= \frac{32 \times 106.25 \times 1000}{\pi d^2} \approx 16.9 \text{ MPa}$$

73. A slid shaft A of diameter D and length L is subjected to a torque T; another shaft B of the same material and of the same length, but half the diameter, is also subjected to the same torque T. The ratio between the angles of twist of shaft B to that of shaft A is

(a) 32 (b) 16

(c) 8 (d) 4

Ans. **(b)**

Sol. Shaft A | Shaft B

Diameter, $d_1 = D$ | $d = \frac{D}{2}$

Length, $l = L$ | $l = L$

Torque $= T$ | Torque $= T$

$$\therefore \frac{T}{J} = \frac{\tau}{r} = \frac{C\theta}{L}$$

$$\theta = \frac{TL}{CJ} \Rightarrow \theta \propto \frac{1}{J}$$

$$\therefore J = \frac{\pi d^4}{32}$$

$$\frac{\theta_1}{\theta_2} = \frac{d_2^4}{d_1^4} \Rightarrow \frac{\theta_A}{\theta_B} = \frac{1}{16}$$

$$\boxed{\frac{\theta_B}{\theta_A} = 16}$$

74. The required diameter for a solid shaft to transmit 400 kW at 150 rpm, with the working shear stress not to exceed 80 MN/m^2, is nearly

(a) 125 mm (b) 121 mm

(c) 117 mm (d) 113 mm

Ans. **(c)**

Sol. Power = 400 kW

N = 150 rpm

Shear stress = 80 MPa

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

$$T = \frac{400 \times 10^3 \times 60}{2\pi \times 150}$$

$T = 25464.79$ N.m

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

$$\frac{25464.79 \times 10^3}{\frac{\pi}{32} \times d^4} = \frac{80}{\frac{d}{2}}$$

$$d^3 = \left(\frac{25464.79 \times 16 \times 10^3}{\pi \times 80}\right)$$

$$\boxed{d = 117.4 \text{ mm}}$$

75. An RCC column of 4 m length is rigidly connected to the slab and to the foundation. Its cross-section is (400 × 400) mm^2. The column will behave is a/an

(a) Long column

(b) Short column

(c) Intermediate column

(d) Linkage

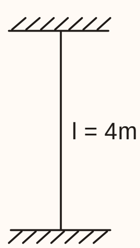
Ans. (b)

Sol. As the connection is rigid, both rotation and translation is not allowed at both the ends and have l_{eff} = 0.65l.

Slenderness Ratio :

$$\frac{l_{eff}}{b} = \frac{0.65 \times 4000}{400} = 6.5$$

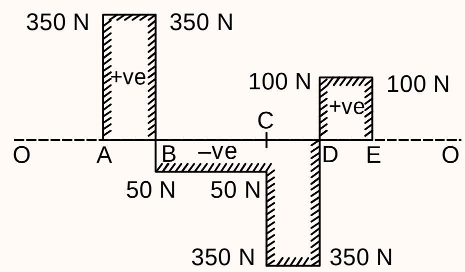
$$\Rightarrow \text{ Short column } \left(3 < \frac{l_{eff}}{b} < 12\right)$$



Note : Slenderness Ratio < 3 $\Rightarrow$ Pedestal

3 $\leq$ Slenderness Ratio $\leq$ 12 $\Rightarrow$ Short column

76.



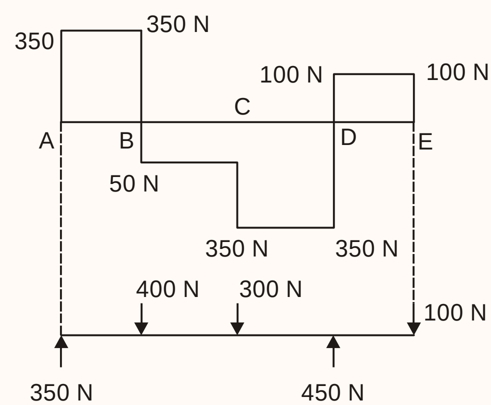
The shear force diagram of a single overhanging beam is shown in figure. One simple support is at end A. The 'total' downward load acting on the beam is

(a) 800 N (b) 600 N

(c) 400 N (d) 200 N

Ans. (a)

Sol.



Total downword SF. = 400 + 300 100

= 800 N

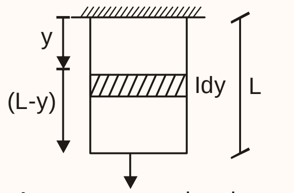
77. The deformation of a vertically held bar of length L and cross-section A is due to its self-weight only. If Young's modulus is E and the unit weight of the bar is γ, the elongation dL is

(a) $\dfrac{\gamma L^3}{2E}$ (b) $\dfrac{EL^2}{2\gamma}$

(c) $\dfrac{\gamma L^2}{2E}$ (d) $\dfrac{\gamma L^2}{2AE}$

Ans. (c)

Sol.



A = cross – sectional area

s = unit wt of bar

E = Young's modulus of elasticity.

Total elongation, $dL = \dfrac{PL}{AE}$

$\Rightarrow \; dL = \displaystyle\int_0^L \frac{\gamma A(L-y)dy}{AE}$

Integrating we get,

$$\boxed{dL = \frac{\gamma L^2}{2E}}$$

78. For material, the modulus of rigidity is 100 GPa and the modulus of elasticity is 250 GPa. The value of the Poisson's ratio is

(a) 0.20 (b) 0.25

(c) 0.30 (d) 0.35

Ans. (b)

Sol. $E = 2G(1+\mu)$, E = 250 GPa, G = 100 GPa

$$\mu = \frac{E}{2G} - 1 = \frac{250}{2\times 100} - 1$$

$$\boxed{\mu = 0.25}$$

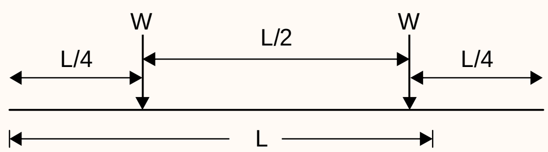
79. Two persons weighing W each are sitting on a plank of length L floating on water, at $\dfrac{L}{4}$ from either end. Neglecting the weight of the plank, the bending moment at the middle point of the plank is

(a) $\dfrac{WL}{16}$ (b) $\dfrac{WL}{64}$

(c) $\dfrac{WL}{8}$ (d) Zero

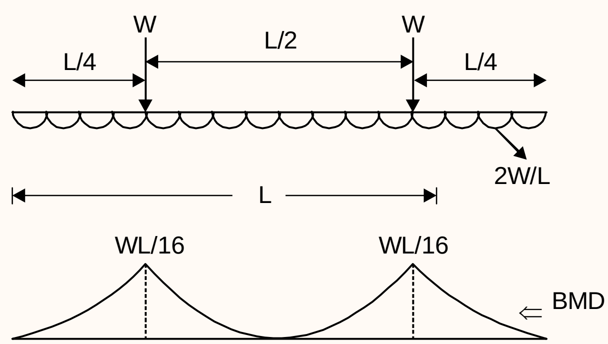
Ans. (d)

Sol.



Reaction will be in the form of udl acting upward.

i.e.,



Mass, bending moment at middle point of plank = zero.

80. In the case of a rectangular beam subjected to a transverse shearing force, the ratio of maximum shear stress to average shear stress is

(a) 0.75 (b) 1.00

(c) 1.25 (d) 1.50

Ans. (d)

Sol. Average shear stress for a beam of cross section area (b × d) = $\frac{V}{bd}$

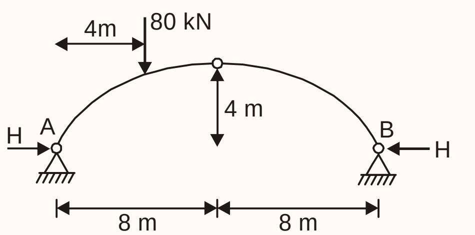
Shear stress distribution for rectangular cross-section = $\frac{V}{2I}\left(\frac{d^2}{4}-y^2\right)$

Maximum will be at y = 0 (at N.A.)

$$\tau_{max} = \frac{V}{\frac{2bd^3}{12}} \times \frac{d^2}{4} = \frac{3}{2}\left(\frac{V}{bd}\right)$$

So, $\frac{\tau_{max}}{\tau_{avg.}} = \frac{3}{2} = 1.5$

81.



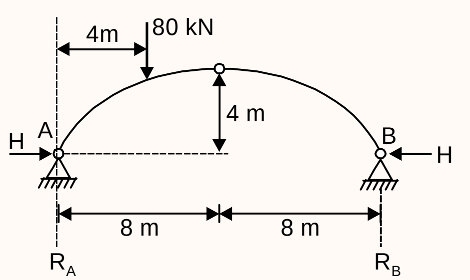
The horizontal thrust of the three-hinged arch loaded as shown in the figure is

(a) 20 kN (b) 30 kN

(c) 40 kN (d) 50 kN

Ans. (c)

Sol.



Moment about B will be zero

$$\sum M_B = 0 \Rightarrow -R_A \times 16 + 80 \times 12 = 0$$

$\Rightarrow$ R_A = 12 × 5 = 60 kN; R_B = 20 kN

$\Rightarrow$ Moment of forces on right of hinge about the hinge will be zero so,

20 × 8 = H × 4 $\Rightarrow$ H = 40 kN

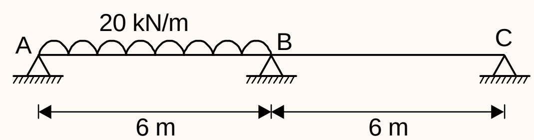
82. Each span of a two-span continuous beam of uniform flexural rigidity is 6 m. All three supports are simple supports. It carries a uniformly distributed load of 20 kN/m over the left span only. The moment at the middle support is

(a) 90 kNm Sagging (b) 45 kNm Hogging

(c) 90 kNm Hogging (d) 45 kNm Sagging

Ans. (b)

Sol.



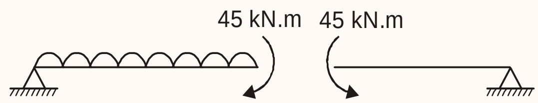
By moment distribution method

Distribution factor at B and C will be 0.5

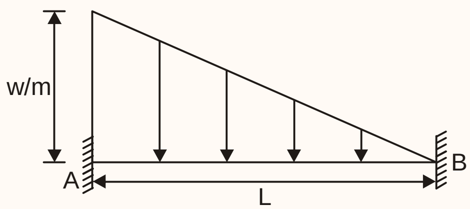
FEM at A = $-\frac{20 \times 6^2}{12} = -60$ kN-m

FEM_B = 60 kN-m

Joint	A	B		C
Member	AB	BA	BC	CB
DF		0.5	0.5	
FEM	–60 +60	60 30 –45	 –45	
Final moment	0	45	–45	0



83.



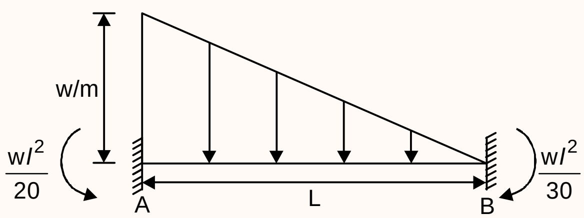
A fixed beam is loaded as in figure. The fixed end moment at support A

(a) $\frac{wL^2}{30}$ (b) $\frac{wL^2}{20}$

(c) $\frac{wL^2}{10}$ (d) $\frac{wL^2}{8}$

Ans. (b)

Sol. Fixed end moment for beam loaded with uniformly varying load.



84. For a plane truss member, the length is 2 m, E = 200 GPa and area of cross-section is 200 mm^2. The stiffness matrix coefficient K_{11} with reference to its local axis is

(a) 200 N/m (b) 2 × 10^7 N/m

(c) 4 × 10^7 N/m (d) 400 N/m

Ans. (b)

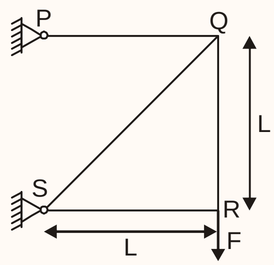
Sol. For truss local stiffness matrix is

$$= \begin{bmatrix} \frac{AE}{L} & -\frac{AE}{L} \\ -\frac{AE}{L} & \frac{AE}{L} \end{bmatrix}$$

$$k_{11} = \frac{AE}{L} = \frac{200 \times 200 \times 10^3}{2}$$

$= 2 \times 10^7$ N/m

85.



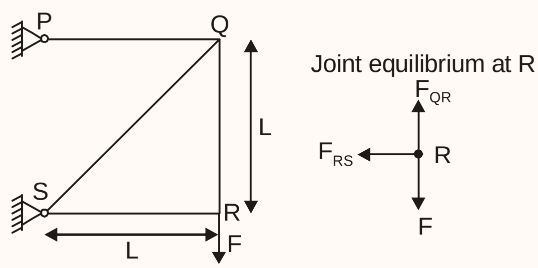
For the truss shown in the figure, the force in the member PQ is

(a) F (b) $\frac{F}{\sqrt{2}}$

(c) $\sqrt{2}$ F (d) 2F

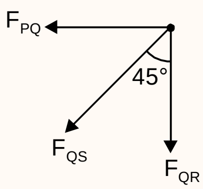
Ans. (a)

Sol.



So, FQR = F and FRS = 0

Joint equilibrium of Q



$\Rightarrow \sum F_x = 0 \quad \Rightarrow \quad F_{PQ} + F_{QS}\sin 45 = 0$

$\Rightarrow \quad F_{PQ} = -F_{QS}\sin 45° \qquad \ldots(i)$

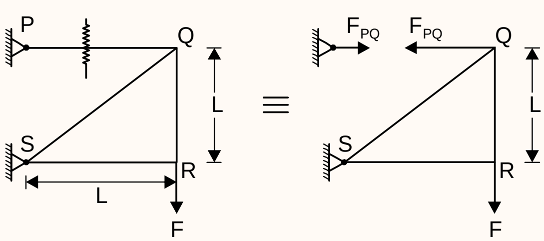
$\Rightarrow \sum F_y = 0 \quad \Rightarrow \quad F_{QR} + F_{QS}\cos 45 = 0$

$\Rightarrow \quad F_{QS} = -\sqrt{2}\,F \qquad \ldots(ii)$

by eq. (i)

$\boxed{F_{PQ} = F}$

Alternative solution:



Method of section

$+\circlearrowleft \quad \sum M_s = 0$

$\Rightarrow H_P \times L = F \times P$

$\Rightarrow$ So, $\boxed{F_{PQ} = H_P = F}$

86. An important building is located in earthquake zone V in India. The seismic weight of the building is 10000 kN and it is designed by ductility considerations. The spectral acceleration factor for this structure is 2.5. The base shear for this structure is

(a) 1350 kN (b) 5000 kN

(c) 10000 kN (d) 25000 kN

Ans. **(a)**

Sol. Seismic base shear $V_B = A_h W$

A_h = Horizontal earthquake force

W = Seismic weight

$$A_h = \frac{ZISa}{2Rg} = \frac{0.36 \times 1.5 \times 2.5}{2 \times 5} = 0.135$$

z = 0.36 for zone V

I = 1.5 for important building

$\frac{Sa}{g} = 2.5$ (given)

R = 5 (for building designed with ductile consideration)

Thus,

Base shear = 0.135 × 10000 kN = 1350 kN

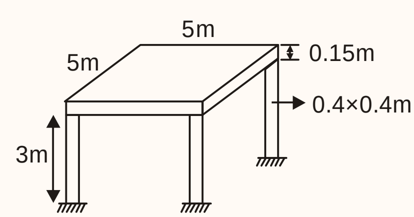
87. An RCC slab (M 25 grade) of dimensions 5 m × 5 m × 0.15 m, is supported on four square columns (M 25 grade) of side 400 mm, the clear height of each column being 3 m. Assuming rigid connections, the fundamental time period of vibration of the slab along the horizontal direction is nearly

(a) 4.12 s (b) 2.80 s

(c) 0.50 s (d) 0.07 s

Ans. **(d)**

Sol.



Stiffness of each column = $\frac{12EI}{L^3}$

$$= \frac{12 \times 5000\sqrt{25} \times 400 \times 400^3}{12 \times 3000^3} = 23703 \text{ N/mm}$$

where $E = 5000\sqrt{fck}$ N/mm^2

$$I = \frac{bd^3}{12}$$

Stiffness of four column = 4K

= 4 × 23703 = 94812 × 10^3 N/m

Using lumped mass technique, mass of the single degree of freedom system

= Mass of slab + mass of 50% column height

= [5 × 5 × 0.15 + 4 × 1.5 × 0.4 × 0.4] × 25

= 117.75 kN

$$\text{Mass} = \frac{\text{weight}}{g} = \frac{117.75}{9.81} \times 10^3 = 12003.05 \text{ kg}$$

Fundamental natural time period

$$T_n = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{12003.05}{94812 \times 10^3}} = 0.0706 \text{ sec}$$

88. Consider the following statements regarding suspension cables :

1. The horizontal component of the cable tension in a suspension bridge is constant at every point along the length of the cable.
2. Stiffening girders in a suspension bridge carry only the live load

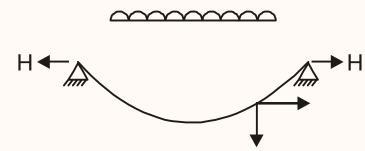
Which of the above statement is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

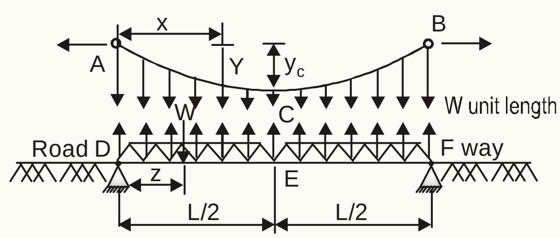
Ans. **(c)**

Sol. Correct option is (c)



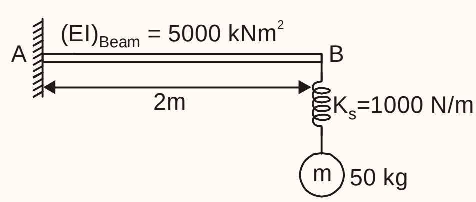
1. Horizontal component of cable tension at each section is the same and it is equal to the horizontal reaction at support.

2. The uniformly distributed dead load of the roadway and the stiffening girders is transmitted to the cables through hanger cables and is taken up entirely by the tension in the cables. The stiffnening girders do not suffer any S.F or B.M under dead load as the girders are supported by closely spaced hanger cables throughtout. Any live load on the bridge will be transmitted to the girders as point loads. The stiffening girders transmit the live load to the cable as uniformly distributed load. While doing so the stiffening girders will be subjected to S.F. and B.M throughout their length.



Three hinged stiffening girder

89.



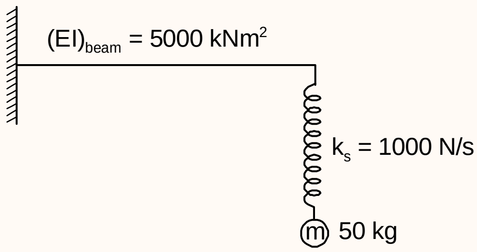
The fundamental time period of vibration of the system shown in the figure, by neglecting the self weight of the beam, is nearly

(a) 0.2 sec (b) 0.8 sec

(c) 1.4 sec (d) 2.8 sec

Ans. (c)

Sol.



$$k_{eq} = \frac{k_1 k_s}{k_1 + k_s}$$

$$k_1 = \frac{3EI}{l^3} = \frac{3 \times 5000 \times 10^3}{2^3} = 1875000 \text{ N/m}$$

$$k_{eq} = \frac{1875000 \times 1000}{1875000 + 1000} = 999.47 \text{ N/m}$$

$$\text{Time period} = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{50}{999.47}} = 1.4 \text{ sec}$$

90. Consider the following statements with reference to the design of welded tension members:

1. The entire cross-sectional area of the connected leg is assumed to contribute to the effective area in the case of angles.
2. Two angles, back-to-back and tack-welded as per the codal requirements, may be assumed to behave as a tee-section.
3. A check on slenderness ratio may be necessary in some cases.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

Sol.
1. In case of welded tension members, entire cross-sectional area of connected leg is condiered in effective area calculation, whereas for bolted connection, deduction for holes is made for connected leg.
2. As per IS 800 : 2007, two angles placed back-to-back and tack welded area assumed to behave as tee section.
3. As per IS 800 : 2007, check for slenderness ratio of tension members may be necessary to provide adequate rigidity to prevent accidental eccentricity of load or excessive vibration.

Thus, statement 1, 2 and 3 all are correct.

91. A sample of dry soil is coated with a thin layer of paraffin and has a mass of 460 g. It displaced 300 cc of water when immersed in it. The paraffin is peeled off and its mass was found to be 9 g. If the specific gravity of soil solids and paraffin are 2.65 and 0.9 respectively, the voids ratio of soil is nearly

(a) 0.92 (b) 0.71

(c) 0.59 (d) 0.48

Ans. (b)

Sol. Mass of soil + paraffin = 460 g

Mass of paraffin = 9g

Mass of soil = 451 g

Volume of soil + volume of paraffin = 300cc

$$\text{Volume of soil} + \frac{9g}{0.9 \times 1} = 300$$

Volume of soil = 290 cc

$$\text{dry density of soil } (\gamma_d) = \frac{451}{290} = 1.555 \text{ g/cc}$$

$$\gamma_d = \frac{G_s V_w}{1+e}$$

$$1.555 = \frac{2.65 \times 1}{1+e}$$

$$e = 0.704$$

92. Marshalling yard in railway system provides facilities for

(a) Maintenance of rolling stock

(b) Safe movements of passengers and coaches

(c) Receiving, breaking up, re-forming and dispatching onwards – of trains

(d) Receiving, loading, unloading and delivery of goods and vehicles, and scheduling their further functioning

Ans. **(c)**

Sol. Correct option is (c)

Marshalling yard is a yard with facilities for receiving, classfying and despatching rolling stock to their destinations.

93. 'Composite Sleeper Index' is relevant in determining:

1. Required and adoptable sleeper density
2. Durability of sleeper units
3. Mechanical strength of the stock of wooden sleepers

Which of the above statements is/are correct?

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 only (d) 3 only

Ans. **(d)**

Sol.

'Composte sleeper index' is employed to determine mechanical strength of wooden sleepers.

94. The normal flows on two approach roads at an intersection are respectively 500 pcu/h and 300 pcu/h. The corresponding saturation flow is 1600 pcu/h on each road. The total lost time per single cycle is 16 s. The optimum cycle time by Webster's method is

(a) 72.5 s (b) 58.0 s

(c) 48.0 s (d) 19.3 s

Ans. **(b)**

Sol.

By Webster's method optimum cycle time,

$$C = \frac{1.5L + 5}{1 - \sum \frac{q}{s}}$$

where,

L = Total lost time = 16 sec

S = Saturation flow = 1600 pcu/n.

$$\sum \frac{q}{s} = \frac{500}{1600} + \frac{300}{1600} = \frac{1}{2}$$

$$\therefore \quad C = \frac{(1.5 \times 16) + 5}{1 - 0.5} \text{ sec}$$

$$= 58 \text{ sec}$$

95. In the offshore region at a particular harbour facility, an oscillatory wave train approaches with wavelength of 80 m where the mean sea depth is 30 m. What would be the velocity of the individual waves?

(a) 17.15 m/s (b) 16.05 m/s

(c) 15.15 m/s (d) 14.05 m/s

Ans. **(a)**

Sol. L = 80 m (wavelength)

h = 30 m (mean see depth)

$$V = \sqrt{\frac{gL}{2\pi}} \tanh \frac{2\pi h}{L}$$

$$= \sqrt{\frac{9.81 \times 80}{2\pi}} \frac{e^{\frac{2\pi\times30}{80}} - e^{-\frac{2\pi\times30}{80}}}{e^{\frac{2\pi\times30}{80}} + e^{-\frac{2\pi\times30}{80}}} = 10.98 \text{ m/s}$$

$\because$ The same ans do not match with any option.

We will find wave velocity by equation.

$V = \sqrt{gh}$

This expression is generally used in shallow water waves where h <<< L (generally $h \approx 0.05L$)

$V = \sqrt{9.81 \times 30} = 17.15 \text{ m/s}$

96. For proper planning of harbours oscillatory waves in the relevant off-shore region must be taken into account. If the sea depth is 30 m and an oscillatory waves train is observed to have wavelength of 50 m, what would be the velocity of the individual waves?

(a) 9.43 m/s (b) 9.21 m/s

(c) 9.08 m/s (d) 8.83 m/s

Ans. (d)

Sol. L = 50 m (wavelength)

h = 30 m (mean sea depth)

$$V = \sqrt{\frac{gL}{2\pi} \tanh\frac{2\pi h}{L}}$$

$$\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

$$V = \sqrt{\frac{9.81 \times 50}{2 \times \pi} \times \frac{e^{\frac{2\pi\times30}{50}} - e^{\frac{2\pi\times30}{50}}}{e^{\frac{2\pi\times30}{50}} + e^{-\frac{2\pi\times30}{50}}}}$$

= 8.83 m/s

Directions: Each of the next Twenty Four (24) items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)

(c) Statement (I) is true but Statement (II) is false

(d) Statement (I) is false but statement (II) is true

97. **Statement (I) :** Glass, used as sheets in buildings, is a crystalline solid and is transparent.

Statement (II) : Glass is obtained by the fusion of silicates of sodium and calcium, both of which are crystalline in structure.

Ans. (d)

Sol. Correct option is (d)

I– Glass is a non-crystalline amorphous solid

II– Glass is manufactured by using some of the cystalline solids like silicates of sodium, calcium etc.

Thus, statement I is incorrect.

98. **Statement (I) :** Lime-surkhi mortar is used in construction of Anicuts (dams) since the 19th century.

Statement (II) : Portland cement is a recent material compared to surkhi-mortar which is best suited for hydraulic structures.

Ans. (b)

Sol. Statement I and II both are correct

Cement mortar has better quality as compare to lime-surkhi mortar.

99. **Statement (I) :** Rapid method of concrete mix-design will take 3 days for trials.

Statement (II) : This rapid method depends on curing the concrete in warm water at or above 55°C.

Ans. (a)

Sol.

Rapid method of concrete mix-design takes only 3 days for trials.

The procedure is based on the use of accelerated curing (using warm water).

100. **Statement (I) :** R.M.C. is preferably used in construction of large projects.

Statement (II) : R.M.C. is adoptable to achieve any desired strength of concrete, with simultaneous quality control.

Ans. (a)

Sol. Ready mix concrete (RMC) is preferably used in large project as it possess the following major properties:

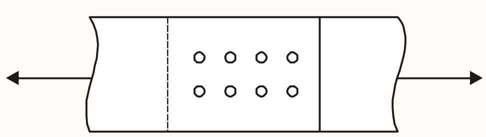
(i) Better quality concrete is produced.

(ii) Elimination of storage space for basic materials at site.

(iii) It can achieve any desired strength of concrete.

Thus helps in easy completion of large projects.

101. **Statement (I) :** In a bolted joint, all similarly placed bolts share the load equally.



Statement (II) : Bolts are placed in holes having slightly larger diameters.

Ans. (b)

Sol. Statement (I) and (II) both are correct.

102. **Statement (I) :** In a RC beam, bond stress developed is due to pure adhesion, and frictional and mechanical resistance.

Statement (II) : Inadequacy of bond strength can be compensated by providing end anchorage in the reinforcing bars.

Ans. (b)

Sol. Statement I is correct as the bond stress developed is due to pure adhesion (due to gum like property in the products of hydration), frictional resistance (due to the surface roughness of the reinforcement and the grip exerted by the concrete shrinkage) and mechanical resistance (due to the deformed bars).

Statement II is correct, as the inadequacy of bond strength can be compensated by providing development length/end anchorage in the reinforcing bars. However, statement II is not the reason of statement I.

103. **Statement (I) :** A Dummy is an activity in the network.

Statement (II) : A Dummy is a representation in the network requiring neither time nor resources.

Ans. (d)

Sol. Dummy is not an activity in the network diagram, it is only used to show inter-relationship which neither consumes resources nor time.

104. **Statement (I) :** In areas where extreme cold conditions are a regular feature, and more so particularly in winter, it is necessary to use lighter oil for automobiles than in summer.

Statement (II) : 'Lighter' in Statement (I) refers to the oil density, which may be adjusted by admixtures.

Ans. **(c)**

Sol. Oil is thin when heated and thickens as it is cooled even to the point that at very cold temperature, oil would thicken such that, it no longer lubricate the engine. Therefore lighter viscosity motor oils is essential when season changes from summer to winter to prevent catastrophic engine failure.

105. **Statement (I) :** Bernoulli's equation is applicable to any point in the flow field provided the flow is steady and irrotational.

Statement (II) : The integration of Euler's equation of motion to derive Bernoulli's equation involves the assumptions that velocity potential exists and that the flow conditions do not change with time at any point.

Ans. **(a)**

Sol. The integration of Euler's equation of motion to derive Bernoulli's equation involves the assumptions that velocity potential exists.

If velocity potential exist, flow is irrotational.

106. **Statement (I) :** A sloping glacis is always preferred over a horizontal bed for locating a hydraulic jump.

Statement (II) : The hydraulic jump is the best dissipator of energy of the flowing water.

Ans. **(d)**

Sol. Sloping glacis is not preferred because length of hydraulic jump increases and energy loss decreases on this.

Hydraulic jump is the best dissipator of energy so statement (II) is only correct.

107. **Statement (I) :** Anaerobic sludge digester, by itself, is considered to be the better method than other methods of sludge treatment.

Statement (II) : During Anaerobic sludge digestion, CH_4 is produced; also rodents and other pests are attracted when digester sludge is dried.

Ans. **(b)**

Sol. During anaerobic sludge degistain CH_4 is produced and rodents and pests are attracted when degistor sludge is dried.

108. **Statement (I) :** A nomogram is a ready reckoner to compute any two hydraulic parameters like discharge, pipe diameter, pipe slope and flow velocity in the pipe if the other two are known.

Statement (II) : Hydraulic parameters can be determined by using Mannings or Chezy's formulae; and a Nomogram is an organized compilation of a number of such, varied computations.

Ans. **(a)**

Sol. Nomogram is a diagram representing the relation between three or more variables quantities by means of a number of scale, so that value of variable can be found by simple geometric construction.

Chezy's equation

$$Q = C\times A\sqrt{R\times S} \qquad \left(\text{where } A = \frac{\pi}{4}D^2\right)$$

Manning's equation $Q = \dfrac{1}{n}A\times R^{2/3}S^{1/2}$

109. **Statement (I) :** The field capacity of Municipal solid waste is the total moisture that can be retained in a waste sample against gravity.

Statement (II) : The field capacity of Municipal solid waste is of critical importance in determining the volume of leachate in landfills.

Ans. **(b)**

Sol.

I. Field capacity of municipal solid waste is the moisture retained against the force of gravity.

II. Field capacity (i.e., mositure retained) is of prime importance while finding out volume of leachate.

110. **Statement (I) :** Proximate analysis of MSW is carried out to determine moisture content, volatile matter, and fixed carbon.

Statement (II) : Ultimate analysis of MSW is carried out to determine the full range of chemical composition and the energy value.

Ans. **(b)**

Sol. Correct option is (b)

I. Proximate analysis of 'municipal solid waste' is carried out to determine.

(i) Moisture

(ii) Volatile matter

(iii) Ash

(iv) Fixed carbon

II. Ultimate analysis of solid waste is used to characterize the chemical composition of organic matter. They are also used to define the proper mix of solid waste materials to achieve suitable C/N ratios for bio-conversion processes.

111. **Statement (I) :** The impact of Green House Gas emission on the environment may comprise accelerated increase in global warming as well as a significant rise in mean sea levels.

Statement (II) : Green House Gas emission is responsible for decreased land masses, increased population densities and food shortages.

Ans. **(b)**

Sol.

- Green house effect increase the temperature of earth and due to which the polar ice caps will melt and it will increase the ocean level.
- Inundation of coastal land decreases land mass, consequently increases population density and creates food shortages.

112. **Statement (I) :** The fundamental principle of surveying is 'to work from the whole to the part'.

Statement (II) : Working from the whole to the part ensures prevention of accumulation of possible errors in survey work over large areas.

Ans. **(a)**

Sol. Fundamental principal of surveying is from working from whole to part which ensures localisation of error.

Whereas working from part to whole maximises error.

113. **Statement (I) :** Compass survey is still used by Geologists to locate the magnetic ores.

Statement (II) : Local attraction causes errors in compass survey due to terrestrial features either natural or man made.

Ans. **(b)**

Sol. Compass survey is used by geologist to locate the magnetic ores because north or south end of the needle is drawn downards, according to the polarity of the ore.

Local attraction causes error in magnetic bearing due to terrestrial features either natural or man-made which create errors in compass survey.

114. **Statement (I) :** PCA is a preferred raw material for construction of Bituminous pavements in areas of heavy rainfall.

Statement (II) : In PCA, no stripping is needed as there is improved binding: and thereby stability is also improved.

Ans. **(a)**

Sol. 'Plastic coated aggregates' and also they protect bitumen from aggregate moisture are water resistant thus gives proper bond strength and durability in areas of heavy rainfall.

115. **Statement (I) :** Bituminous roads disintegrate even with light traffic, but such failures are not exclusively attributable to wrong surface treatment.

Statement (II) : Improper preparation of the subgrade and the foundation is often responsible for this disintegration.

Ans. **(c)**

Sol.

- Some defects which is not rectified immediately, result in the disintegration of the pavement into small, loose fragment.

  Examples of such defects are

  (1) Stripping

  (2) Loss of aggregates

  (3) Ravelling

  (4) Edge breaking

- Improper prepartion of subgrade is not a cuase of disintegration.

116. **Statement (I) :** Cermet, as a refractory material (Clay 80% + Aluminium 20%), is used in the construction of rockets and jets.

Statement (II) : Cermet containing metals, which are stable at temperatures as high as 600ºC, resists sudden shocks.

Ans. **(a)**

Sol.

- The composition of most cermets: 80% cermaic (clay) and 20% metals (Al, Ni, Fe etc). These cermets are mainly used as high refractories where high temp as well as shock resistant. Thus cermets are used in rockets and jet engine port.

117. **Statement (I) :** Aluminium alloy with less than 6% copper is used in making automobile pistons.

Statement (II) : Duraluminium containing 4% copper has a high tensile strength and is well usable wherever alkaline environment is not present.

Ans. **(b)**

Sol.

- Y-alloy consist of Al (92%) and Cu around 4–5% is generally used is piston of IC engine
- Composition of duralium is as follows

Cu	Mn	He	Mg	Al
$3.5-4.5\%$	$0.4-0.7\%$	$<0.7\%$	$0.4-0.7$	Rest

118. **Statement (I) :** There is no practical method of concrete mix design based on the specific surface of aggregates.

Statement (II) : Surface area of aggregates plays a vital role in achieving the right mix desired for a desired strength.

Ans. **(b)**

Sol. Desired strength of concrete depends on workability which is in-turn depended on surface area of aggregates.

119. **Statement (I) :** Air seasoning of structural timber renders it more durable, tough and elastic.

Statement (II) : Air seasoning of timber is the most economical and eco-friendly method of treatment when time is not a constraining criterion.

Ans. **(b)**

Sol.
- Seasoning is the process of reducing the moisture content of timber which increases the durability, toughness and elasticity of timber.
- Air seasoning is very economical, but it requires large time for seasoning.
- Both statements are correct but statement (II) does not explain the statement (I).

120. **Statement (I) :** Lining of nuclear plants with specially heavy concrete is needed for shielding and protecting against several dangerous conditions.

Statement (II) : Limonite is one special type of aggregate possessing a high density.

Ans. **(b)**

Sol. Limonite is one special type of aggregate having density 2.7 – 4.3 g/cc.

121. A steel column is pinned at both ends and has a buckling load of 200 kN. If the column is restrained against lateral movement at its mid-height, its buckling load will be

(a) 100 kN (b) 200 kN

(c) 400 kN (d) 800 kN

Ans. **(d)**

Sol.

$$P_{cr_1} = \frac{\pi^2 EI}{l_{eff1}^2}$$

$$P_{cr_2} = \frac{\pi^2 EI}{l_{eff2}^2}$$

$$\frac{200}{P_{cr_2}} = \left(\frac{l_{eff2}}{l_{eff1}}\right)^2 = \frac{1}{4}$$

$$P_{cr_2} = 800 \text{ kN}$$

122. Consider the following statements in respect of column splicing :

1. Splices should be provided close to the point of inflection in a member
2. Splices should be located near to the point of lateral restraint in a member
3. Machined columns for perfect bearing would need splices to be designed for axial force only

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(a)**

Sol. In case of column splicing:

1. Splicing should be provided close to point of inflection and point of contraflexure.
2. Splices should be located near to point of lateral restraint.
3. Machined columns need splices to be designed for axial force and bending moment.

Hence, statement (1) and (2) are correct.

123. Buckling of the compression flange of a girder, without transverse stiffeners, can be avoided if (with standard notations)

(a) $\frac{d}{t_w} \le 345\varepsilon_f^2$ (b) $\frac{d}{t_w} \le 270\varepsilon_f^2$

(c) $\frac{d}{t_w} \le 270\varepsilon_w$ (d) $\frac{d}{t_w} \le 250\varepsilon_w$

Ans. **(a)**

Sol. To avoid buckling of compression flange, IS-800: 2007 specifies following web thickness requirements

(I) when transverse stiffeners are not provided $\frac{d}{t_w} \le 345\,\varepsilon_f^2$.

(II) When only transverse stiffeners are provided

(i) $\frac{d}{t_w} \le 345\,\varepsilon_f^2$ for $c \ge 1.5\,d$

(ii) $\frac{d}{t_w} \le 345\,\varepsilon_f$ for $c < 1.5\,d$

where,

d = depth of the web

t_w = thickness of the web

$$\varepsilon_f = \sqrt{\frac{250}{f_{yf}}}$$

f_{yf} = yield stress of the compression flange

c = clean distance between transverse stiffener.

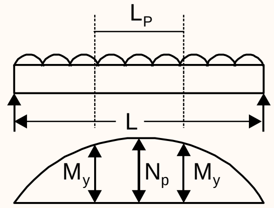
124. A simply supported steel beam of rectangular section and of span L is subjected to a uniformly distributed load. The length of the plastic hinge by considering moment ratio of 1.5 will be nearly

(a) 0.27 L (b) 0.39 L

(c) 0.45 L (d) 0.58 L

Ans. **(d)**

Sol. For simply supported beam subjected to uniformly distributed load.



Length of plastic hinge,

$$L_P = L\sqrt{1-\frac{1}{S.F.}}$$

where, S.F. = Shape factor = Moment ratio = 1.5 (given)

Thus,

$$L_P = \sqrt{1-\frac{1}{1.5}} = (0.577)\,L \simeq 0.58\,L$$

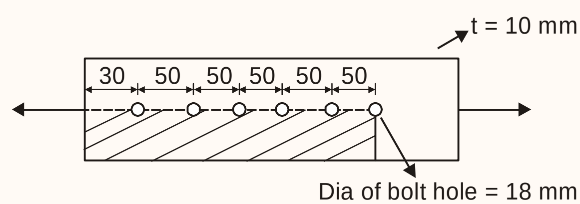
125. A single angle of thickness 10 mm is connected to a gusset by 6 numbers of 18 mm diameter bolts, with pitch of 50 mm and with edge distance of 30 mm. The net area in block shear along the line of the transmitted force is

(a) 1810 mm^2 (b) 1840 mm^2

(c) 1920 mm^2 (d) 1940 mm^2

Ans. **(a)**

Sol. * Assuming diameter of bolt hole = 18 mm



Net area in block shear along the line of force [(30 + 5 × 50) – 5.5 × 18] × 10

= 1810 mm^2

126. Consider the following statements for the design of a laced column :

1. In a bolted construction, the minimum width of the lacing bar shall be three times the nominal diameter of the end bolt.
2. The thickness of the flat of a single lacing system shall be not less than one-fortieth of its effective length.
3. The angle of inclination of the lacing bar should be less than 40° with the axis of the built-up column
4. The lacing shall be designed for a transverse shear of 2.5% of the axial load on the column

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only

(c) 1, 3 and 4 only (d) 1, 2, 3 and 4

Ans. (b)

Sol. Angle of lacing with built-up column, should be $40° < \theta < 70°$.

127. The permissible bending compressive strength for M 25 grade of concrete is 8.5 N/mm². Its short-term and long-term modular ratios are, nearly

(a) 8 and 11 (b) 8 and 8

(c) 11 and 11 (d) 11 and 6

Ans. (a)

Sol. Short term modular ratio

$$= \frac{E_S}{E_C}$$

$$= \frac{2\times10^5 \text{ MPa}}{5000\sqrt{f_{ck}} \text{ MPa}}$$

$$= \frac{2\times10^5}{5000\sqrt{25}} = 8$$

Long term modular ratio (including effect of creep) $= \dfrac{280}{3\sigma_{cbc}}$

σ_{cbc} for M 25 = 8.5

Long term modular ratio $= \dfrac{280}{3\times8.5}$

$= 10.98 \approx 11$

128. The ultimate load carrying capacity of a short circular column of 300 mm diameter with 1% helical reinforcement of Fe 415 grade steel and concrete of M 20 grade, is nearly

(a) 451 kN (b) 500 kN

(c) 756 kN (d) 794 kN

Ans. (d)

Sol. Ultimate load carrying capacity of circular column with helical reinforcement = $P_{u\text{-helical}}$

$P_{u\text{-helical}} = 1.05(0.4\, f_{ck}A_c + 0.67 f_y A_{sc})$

$f_{ck} = 20 \text{ N/mm}^2$

$$A_C = 0.99\times\frac{\pi}{4}\times300^2 \text{ mm}^2$$

$f_y = 415 \text{ N/mm}^2$

$$A_{SC} = 0.01\times\frac{\pi}{4}\times300^2 \text{ mm}^2$$

$P_{u\text{-helical}} =$

$$1.05\left(0.4\times20\times\frac{\pi}{4}\times300^2\times0.99+0.67\times415\times0.01\times\frac{\pi}{4}\times300^2\right)$$

$= 794192.46$ N

$\approx \boxed{794 \text{ kN}}$

129. In a cantilever retaining wall, the main steel reinforcement is provided

(a) On the backfill side, in the vertical direction

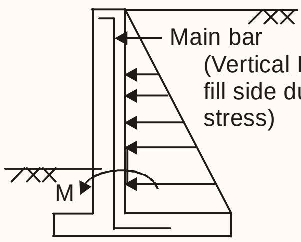
(b) On both, inner and outer, faces

(c) In horizontal as well as in vertical directions

(d) To counteract shear stresses

Ans. (a)

Sol.



Due to lateral pressure of backfills, the wall is designed as a cantilever and main reinforcement is provided on the rear side or backfill side in the vertical direction.

130. Design strength for M25 concrete in direct compression, bending compression and flexural tension are, respectively

(a) 10 MPa, 11.15 MPa and 3.5 MPa

(b) 25 MPa, 11.15 MPa and 3 MPa

(c) 10 MPa, 12.5 MPa and 3.5 MPa

(d) 25 MPa, 11.15 MPa and 2.57 MPa

Ans. (a)

Sol. Direct compression = 0.4 fck = 0.4×25 = 10 MPa.

(In case of cloumn, in axial compression the value of direct compression strength of concrete is assumed as 0.4 fck).

Bending compression strength = 0.446 fck = 11.15 MPa.

Flexure tension strength = $0.7\sqrt{fck}$ = 3.5 MPa.

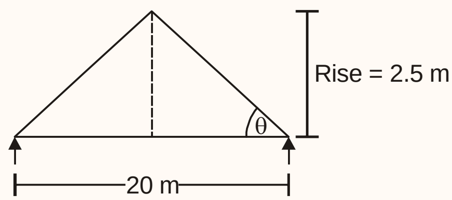
131. Double pitched roof trusses of span 20m and rise 2.5m are placed at 8m spacing. The maximum live load reaction at the supports is nearly

(a) 36 kN (b) 40 kN

(c) 46 kN (d) 60 kN

Ans. (d)

Sol.



spacing = 8 m

$$\tan\theta = \left(\frac{2.5}{10}\right)$$

$$\Rightarrow \boxed{\theta \approx 14°}$$

For θ = 14°, (> 10°)

Live load on roof tress

[0.75 – (14 – 10) × 0.02] kN/m^2

= 0.67 kN/m^2

Hence,

Maximum live load reaction

$$= \frac{0.67 \times \text{Floor area}}{2}$$

$$= \frac{0.67 \times 20 \times 8}{2}\text{kN} = 53.6\text{ kN}$$

But since this is not given in option,

⇒ Let us take maximum live load = 0.75 kN/m^2

Thus,

Maximum live load reaction at support

$$= \frac{0.75 \times 20 \times 8}{2}\text{kN} = 60\text{ kN}$$

132. Ground motion during earthquak e is random in nature. For the purpose of analysis, it can be converted into different harmonic excitations through

(a) Fourier series

(b) Newton's second law

(c) Duhamel's integral

(d) Time series analysis

Ans. **(a)**

133. An RCC structure with fundamental time period of 1.2 sec vibrates at a forcing frequency of 10 rad/sec. The maximum dynamic displacement is X% of static displacement. The value of X is

(a) 10.1 (b) 28.9

(c) 37.7 (d) 50.2

Ans. **(c)**

Sol. $T_n = 1.25$

$\omega = 10$ rad/sec

$$\frac{\text{Dynamic displacement}}{\text{Static displacement}} = R_d = \frac{u_0}{(u_{st})_0} = \frac{1}{|1-\beta^2|}$$

where,

R_d = Magnification factor/amplification factor

$$\beta = \text{Frequency ratio} = \frac{\omega}{\omega_n}$$

$$T_n = \frac{2\pi}{\omega_n} \Rightarrow \omega_n = \frac{2\pi}{1.2}$$

$$\Rightarrow \beta = \frac{10\times 1.2}{2\pi} = 1.91$$

$$\Rightarrow v_0 = R_d(u_{st})_0 = \frac{1}{|1-1.91^2|}(u_{st})_0$$

$$= 0.377(u_{st})_0 = 37.7\%(u_{st})_0$$

134. A steel building has plan dimensions of 50m × 50m and it is 120 m tall. It is provided with brick infill panels. The approximate fundamental time period of the building is

(a) 1.53 sec (b) 2.72 sec

(c) 3.08 sec (d) 4.15 sec

Ans. **(a)**

Sol. The approximate fundamental natural period of building with brick in fill pannel is

$$T_a = \frac{0.09\,h}{\sqrt{d}} = \frac{0.09\times 120}{\sqrt{50}} = 1.53 \text{ sec}$$

135. A masonry structure has a prism strength of 10 N/mm^2 with $\mu = 0.25$. The modulus of elasticity and the shear modulus of the masonry arer respectively.

(a) 5500 MPa and 2200 MPa

(b) 2000 MPa and 200 MPa

(c) 5500 MPa and 1000 MPa

(d) 2000 MPa and 1000 MPa

Ans. **(a)**

Sol. Elastic modulus of brick modulus = 550 f_m

Where f_m = presim strength

$E_{masonry}$ = 550×10 = 5500 N/mm^2.

$$\text{Shear modulus} = \frac{E}{2(1+\mu)}$$

$$= \frac{5500}{2(1+0.25)} = 2200\,\text{N/mm}^2$$

136. The surface tension in a soap bubble of 20 mm diameter, when the inside pressure is 2.0 N/m^2 above atmospheric pressure, is

(a) 0.025 N/m (b) 0.0125 N/m

(c) 5 × 10^{-3} N/m (d) 4.25 × 10^{-3} N/m

Ans. **(c)**

Sol. $\Delta P = \dfrac{8\sigma}{D}$

$2N/m^2 = \dfrac{8\sigma}{0.02}$

$\Rightarrow \sigma = 5 \times 10^{-3}$ N/m

137. Consider the following statements regarding labour welfare:

1. Work prompted by mere sympathy and kindness may degenerate and may injure the worker's sense of self-respect.
2. Rapid industrialization on a large scale poses problems in respect of labour and its welfare
3. Construction labour is still largely unorganized, and hence lacks in welfare measures

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 1, 2 and 3 (d) 2 and 3 only

Ans. **(c)**

Sol. All statements are correct and self explanatory.

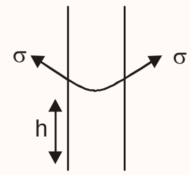
138. A soil sample has an average grain diameter as 0.03 mm. The size of interstices is one eight of the mean grain diameter. Considering σ of water as 0.075 g/cm, the water will rise in the clay to a height of

(a) 2.4 m (b) 3.0 m

(c) 3.6 m (d) 4.0 m

Ans. **(d)**

Sol.



Size of interstices $= \dfrac{1}{8}D_m = \dfrac{0.003}{8}$cm

Size of interstices is assumed as radius of interstices.

$$\sigma\cos\theta \times \pi D = \frac{\pi}{4}D^2 \times h \times \gamma_w$$

$$\frac{4\sigma\cos\theta}{D\gamma_w} = h \qquad (\theta = 0)$$

$$h = \frac{4\times\sigma}{\gamma\times D} = \frac{4\times 0.075}{1\text{ g/cc}\times\dfrac{0.003}{8}\times 2}$$

$= 400$ cm

$= 4$ m

139. A jet of water has a diameter of 0.3 cm. The absolute surface tension of water is 0.072 N/m and atmospheric pressure is 101.2 kN/m^2 The absolute pressure within the jet of water will be

(a) 101.104 kN/m^2 (b) 101.152 kN/m^2

(c) 101.248 kN/m^2 (d) 101.296 kN/m^2

Ans. **(c)**

Sol. $d_j = 0.3$cm

$\sigma_{water} = 0.072$ N/m

$P_{atm} = 101.2 N/m^2$

$\Delta P = \dfrac{2\sigma}{D}(\text{for jet})$

$P_{jet} - P_{atm} = \dfrac{2\times 0.072 N/m}{0.3\times 10^{-2}} = 48 N/m^2 = 0.048 KN/m^2$

$P_{jet} = 101.2 + 0.048 = 101.248$ KN/m^2.

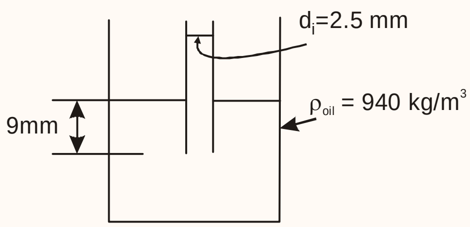
140. A glass tube of 2.5 mm internal diameter is immersed in oil of mass density 940 kg/m^3 to a depth of 9 mm. If a pressure of 148 N/m^2 is needed to from a bubble which is just released. What is the surface tension of the oil?

(a) 0.041 N/m (b) 0.043 N/m

(c) 0.046 N/m (d) 0.050 N/m

Ans. **(a)**

Sol.



$$(P_i - P_0) = \frac{4\sigma}{D}$$

Now $P_0 = 940 \times 9.81 \times 9 \times 10^{-3} = 82.99$ N/m^2

$$\Rightarrow \ 148 - 82.99 = \frac{4 \times \sigma}{2.5 \times 10^{-3}}$$

$$\Rightarrow \ \sigma = \frac{65.01 \times 2.5 \times 10^{-3}}{4} \approx 0.041 \text{N/m}$$

141. In a rectangular open channel, 2.0 m wide, water flows at a depth of 0.8 m. It discharges over an aerated sharp crested weir over the full width, with depth over weir crest being 0.25 m/ C_c = 0.61. Adjusting for velocity head of approach, what would be the discharge through the channel? $\sqrt{2g}$ = 4.43 units

(a) 0.439 m^3/sec (b) 0.445 m^3/sec

(c) 0.453 m^3/sec (d) 0.461 m^3/sec

Ans. **(c)**

Sol. B = 2m (L)

Y_{oc} = 0.8m

C_C = 0.61

$\sqrt{2g}$ = 4.43

$Y_{\text{weir crest}}$ = H = 0.25 m

$$Q = \frac{2}{3} Cd\sqrt{2g} L H^{3/2} \quad (\text{take } Cd = C_C = 0.61)$$

$$= \frac{2}{3} \times 0.61 \times 4.43 \times 2 \times 0.25^{3/2}$$

= 0.45 m^3/s

Discharge through open channel = Discharge through weir = 0.45 m^3/s.

142. A steady, two dimensional, incompressible flow field is represented by u = x + 3y + 3 and v = 2x - y - 8 In this flow field, the stagnation point is

(a) (3, 2) (b) (–3, 2)

(c) (–3, –2) (d) (3, –2)

Ans. **(d)**

Sol. u = x + 3y + 3

v = 2x – y – 8

for stagnation point, u = 0 & v = 0

$\Rightarrow x + 3y + 3 = 0$ ... (i)

$3(2x - y - 8) = 0$

$\Rightarrow 6x - 3y - 24 = 0$

$x + 3y + 3 = 0$

$7x = 21$

$x = 3$

Put x = 3 in ...(i)

$3 + 3y + 3 = 0$

$\Rightarrow \boxed{y = -2}$ so, x = 3, y = –2

143. If the energy present in a jet of water of 20 cm diameter and having a velocity of 25 m/s could be extracted by a device with 90% efficiency, the power extracted would be nearly.

(taking $\frac{1}{2g}$ = 0.051 $\frac{\sec^2}{m}$)

(a) 180 kW (b) 225 kW

(c) 260 kW (d) 300 kW

Ans. **(b)**

Sol. D = 20 cm

V = 25 m/s

$\eta = 90\%$

$$P = \frac{1}{2}mv^2 \times \eta = \frac{1}{2}(\rho \times Q) \times v^2 \times \eta$$

$$= \frac{1}{2} \times 1000 \times \frac{\pi}{4} \times 0.2^2 \times 25^3 \times 0.9$$

= 220.89 kW

144. In a siphon, the summit is 5m above the water level in the tank from which the flow is being discharged. If the head loss from the inlet to the summit is 2.5m and the velocityhead at the summit is 0.5 m, (taking γ = 10 appropriate units) the pressure head at the summit is

(a) –80 kPa

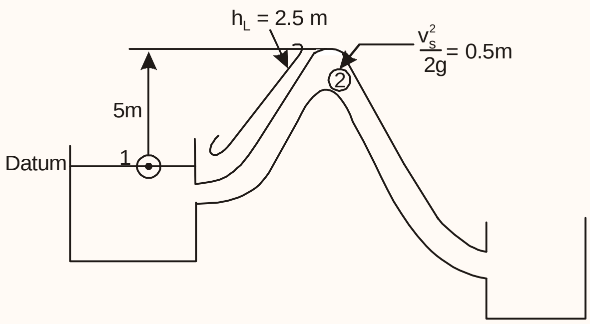
(b) –3 m of water (abs)

(c) 5 m of water (abs)

(d) 18 m of water (abs)

Ans. **(a)**

Sol.



Applying bernoulli's equation between (1) & (2)

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_s^2}{2g} + Z_2 + h_L$$

$$\left(\frac{P_1}{\gamma} = \frac{V_1^2}{2g} = Z_1 = 0\right)$$

$$\Rightarrow \frac{P_2}{\gamma} + 0.5 + 2.5 + 5 = 0$$

Pressure head = –8m

P_2 = –8×10 = –80 kPa.

145. The stream function of a doublet with horizontal axis and of strength μ is

(a) $\frac{\mu}{2\pi}r$ (b) $\frac{\mu}{2\pi r}\cos\theta$

(c) $\frac{\mu}{2\pi}r\sin\theta$ (d) $\frac{\mu}{2\pi}\frac{\sin\theta}{r}$

Ans. **(d)**

Sol. For doublet $\psi = \frac{-\mu}{2\pi}\frac{\sin\theta}{r}$ & $\phi = \frac{\mu}{2\pi}\frac{\cos\theta}{r}$

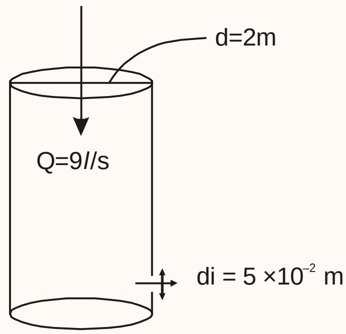
146. A vertical cylindrical tank, 2m diameter has at the bottom, a 5 cm diameter, sharp-edged orifice, for which C_d = 0.6. Water enters the tank at a constant rate of 9*l*/sec. At what depth above the orifice will the level in the tank become steady?

(a) 2.95 m (b) 2.75 m

(c) 2.60 m (d) 2.50 m

Ans. **(a)**

Sol.



$$Q_{in} - Q_{out} = \frac{dV}{dt} \quad \left[Q_{out} = Cd \times \frac{\pi}{4} \times d_i^2 \times \sqrt{2gH}\right]$$

(V = volume of water in tank)

$\Rightarrow 9\times10^{-3} m^3/s$ –

$$\frac{\pi}{4}\times(5\times10^{-2})^2\left(\sqrt{2\times9.81}\times\sqrt{h}\times0.6\right) = \frac{d\frac{\pi}{4}d^2\times h}{dt}$$

(for h to be constant)

Therefore, $\frac{dh}{dt} = 0$

So, $9\times10^{-3} = \frac{\pi}{4}\times(5\times10^{-2})^2\sqrt{2\times9.81}\times0.6\sqrt{h}$

$\Rightarrow \sqrt{h} = 1.725$

h = 2.975 m $\simeq$ 2.95m

147. A transmitter antenna is of a vertical pipe, 20 cm diameter and 25 m height, on top of a tall structure. It is subjected to wind speed of 20 m/sec. Density of air is 1.22 kg/m^3; its viscosity is 1.8 × 10^{-5} Ns/m^2. Drag coefficient of a (tall) circular cylinder is tabulated as

R_e	10^2	10^3	1.3×10^3	10^4	1.5×10^4	1.06×10^5	1.2×10^5	4.5×10^5
C_D	1.6	1.05	0.95	1.0	1.08	1.0	0.89	0.26

What is the drag experienced?

(a) 737 N (b) 700 N

(c) 670 N (d) 63 N

Ans. (a)

Sol. D = 20m

h = 25m

V_w = 20m/s

ρ_a = 1.22 Kg/m^3;

μ = 1.8×10^{-5} Ns/m^2

$$R_e = \frac{\rho VD}{\mu} = \frac{1.22\times20\times0.2}{1.8\times10^{-5}} = 2.71\times10^5$$

Re	C_D
1.2×10^5	0.89
4.5×10^5	0.26

$C_{D\,\text{for}\,Re=2.7\times10^5}$ =

$$= 0.89 - \frac{0.89-0.26}{(4.5-1.2)\times10^5}\times(2.71-1.2)\times10^5$$

= 0.601

$$F_D = \frac{1}{2}C_D\,\rho\,AV^2$$

A_D = D × h (projected area)

$$F_D = \frac{1}{2}\times0.6\times1.22\times0.2\times25\times20^2 = 733.22N.$$

148. A smooth flat plate with a sharp leading edge is placed along a free steam of water flowing at 2.5 m/sec. At what distance from the leading edge will the boundary layer transition from laminar to turbulent flow? Take density of water as 1000 kg/m^3 and its viscosity as 1 centipoise. Also, what will be the boundary layer thickness at that distance?

(a) 12.8 cm and 0.113 cm

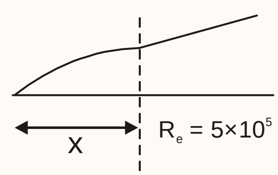
(b) 14.2 cm and 0.113 cm

(c) 12.8 cm and 0.125 cm

(d) 14.2 cm and 0.125 cm

Ans. (a)

Sol.



V_o = 2.5m/s

ρ = 1000 Kg/m^3;

$\mu = 1\times10^{-2}$ poise $\approx 1\times10^{-2}\times0.1\,\text{N.S/m}^2$

$= 1\times10^{-3}\,\text{N.S/m}^2$

At transition $\dfrac{\rho V_0 x}{\mu} = 5\times10^5$

$$= \frac{1000\times2.5\times x}{10^{-3}\,\text{NS/m}^2} = 5\times10^5$$

$x = 0.2\text{m} = 20\text{cm}$

$$\frac{\delta}{x} = \frac{5}{\sqrt{R_{ex}}}$$

$$\Rightarrow \frac{\delta}{0.2} = \frac{5}{\sqrt{5\times10^5}} \Rightarrow \delta = 0.141\text{cm}$$

However, sometime transition occurs at different Re between $2\times10^5 - 3\times10^6$, depending on the roughness of plate and turbulence in approaching stream.

Taking Re = 3.2×10^5

$$\frac{\rho V_0 x}{\mu} = 3.2\times10^5$$

$$\Rightarrow x = \frac{3.2\times10^5\times10^{-3}}{10^3\times2.5} = 0.128\text{m} = 12.8\text{cm.}$$

$$\frac{\delta}{x} = \frac{5}{\sqrt{\text{Re}\,x}}$$

$$\Rightarrow \delta = \frac{5\times12.8}{\sqrt{3.2\times10^5}} = 0.113\text{cm.}$$

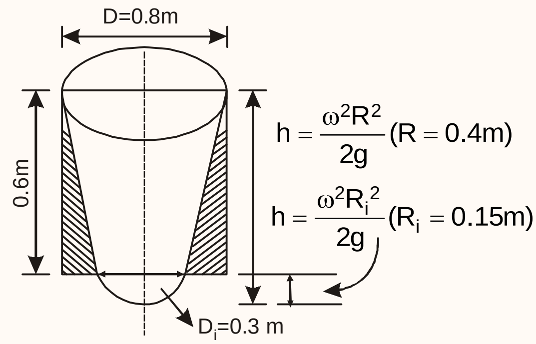
149. What is the rotational speed in rpm of a 0.8 m diameter cylindrical container, held with axis vertical, if the fluid contained in it rises to 0.6 m height at the sides and leaves a circular space 0.3 m diameter on the bottom uncovered?

(a) 90.2 rpm (b) 88.4 rpm

(c) 86.0 rpm (d) 83.7 rpm

Ans. **(b)**

Sol.



D = 0.8 m

$$\omega = \frac{2\pi N}{60}$$

$$\frac{\omega^2R^2}{2g} - \frac{\omega^2R_i^2}{2g} = 0.6$$

$$= \frac{\omega^2\times0.4^2}{2\times9.81} - \frac{\omega^2\times0.15^2}{2\times9.81} = 0.6$$

$\Rightarrow$ ω = 9.253 rad/s

$$\Rightarrow \frac{2\pi N}{60} = 9.253$$

N = $\boxed{88.4}$

150. If δ_1 and δ_2 are the laminar boundary layer thickness at a point M distant x from the leading edge when the reynolds number of the flow are 100 and 484, respectively, then the ratio $\dfrac{\delta_1}{\delta_2}$ will be

(a) 2.2 (b) 4.84

(c) 23.43 (d) 45.45

Ans. **(a)**

Sol. $\dfrac{\delta_1}{x} = \dfrac{5}{\sqrt{R_{ex1}}}$ so $\delta_1 = \dfrac{5x}{\sqrt{100}}$

Similarly $\delta_2 = \dfrac{5x}{\sqrt{484}}$

$$\frac{\delta_1}{\delta_2} = \sqrt{\frac{484}{100}} = \frac{22}{10} = 2.2$$