IES MASTER

Institute for Engineers (IES/GATE/PSUs)

ESE 2021 Prelims Exam

Paper - II

CIVIL ENGINEERING

Detailed Solution

(SET-A)

Office Address

DELHI: F-126, Katwaria Sarai, New Delhi - 110 016

Ph: 011-41013406, Mobile: 8130909220, 9711853908

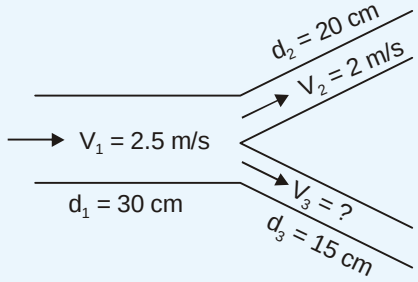
Web: www.iesmaster.org | E-mail: info@iesmaster.org

1. A network of pipes conveying water to a city has the following specifications. The diameter of a main pipe is 30 cm and it branches into two pipes of diameters 20 cm and 15 cm respectively. If the average velocity in the main pipe is 2.5 m/s and the average velocity in the 20 cm pipe is measured as 2 m/s, what is the velocity in the 15 cm pipe?

(a) 8.84 m/s (b) 7.44 m/s
(c) 5.84 m/s (d) 6.44 m/s

Ans. (d)

Sol.



From the continuity equation

$$\frac{\pi d_1^2}{4}V_1 = \frac{\pi d_2^2}{4}V_2 + \frac{\pi d_3^2}{4}V_3$$

$$\Rightarrow d_1^2V_1 = d_2^2V_2 + d_3^2V_3$$

$$\Rightarrow V_3 = \frac{d_1^2V_1 - d_2^2V_2}{d_3^2} = \left(\frac{d_1}{d_3}\right)^2 V_1 - \left(\frac{d_2}{d_3}\right)^2 V_2$$

$$\Rightarrow V_3 = \left(\frac{30}{15}\right)^2 \times 2.5 - \left(\frac{20}{15}\right)^2 \times 2$$

$$\Rightarrow V_3 = 4 \times 2.5 - \frac{4}{2.25} \times 2 = 6.44 \text{ m/s}$$

$$\boxed{V_3 = 6.44 \text{ m/s}}$$

2. A centrifugal pump delivers water against a net head of 14.5 m and a design speed of 1000 r.p.m. The vanes are curved back to an angle of 30° with the periphery. The impeller diameter is 300 mm and the outlet width is 50 mm. What is the tangential velocity of impeller at outlet?

(a) 15.7 m/s (b) 13.2 m/s
(c) 9.7 m/s (d) 11.2 m/s

Ans. (a)

Sol. Centrifugal pump

H_m = 14.5 m
N = 1000 rpm
β_2 = 30°
D_2 = 300 mm
B_2 = 50 mm
u_2 = ?

Tangential velocity of impeller at outlet (u_2)

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 300 \times 10^{-3} \times 1000}{60}$$

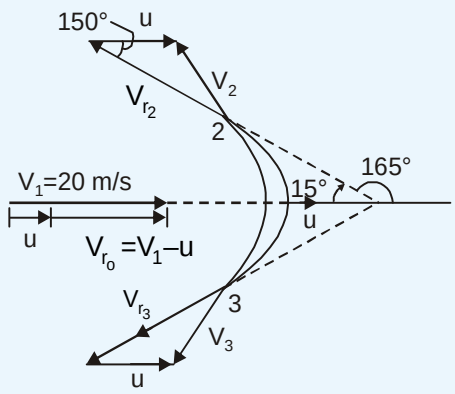
$$= 15.7 \text{ m/s}$$

3. A 7.5 cm diameter jet of water strikes a curved plate at its centre with a velocity of 20 m/s. The curved plate is moving with a velocity of 8 m/s in the direction of the jet. The jet is deflected through an angle of 165°. By assuming the plate as smooth, what is the angle made by the relative velocity at the outlet of the plate?

(a) 45° (b) 30°
(c) 15° (d) 0°

Ans. (c)

Sol.



Since the jet is deflected by 165°, the relative velocity at outlet will make an angle of 15° with the direction of plate movement. This is based on the assumption that for shockless exit, relative velocity should be tangential to plate at outlet.

4. A reservoir has a head of 40 m and a channel leading from the reservoir permits a flow rate of 34 m^3/s. If the rotational speed of the rotor is 150 r.p.m., what is the power of the turbine? (Take g = 9.81 m/s^2)

(a) 14.34 MW (b) 13.34 MW
(c) 12.34 MW (d) 11.34 MW

Ans. (b)

Sol. $H = 40$ m

$Q = 34\ m^3/s$

$N = 150$ rpm

$g = 9.81\ m/s^2$

Power output of turbine $= \eta_o \times \rho g Q H$

$= 1 \times 1000 \times 9.81 \times 34 \times 40$

$= 13.34$ MW

5. A stream function is given by $\psi = 3x^2 - y^3$. What is the magnitude of velocity components at the point (2, 1)?

(a) 8.52 (b) 9.17
(c) 10.81 (d) 12.37

Ans. (d)

Sol. $\psi = 3x^2 - y^3$

$\frac{\partial \psi}{\partial x} = v =$ y-component of velocity $= 6x$

$-\frac{\partial \psi}{\partial y} = u =$ x-component of velocity $= 3y^2$

$\Rightarrow \vec{V} = 3y^2\hat{i} + 6x\hat{j}$

$\vec{V}$ at point (2, 1) is $\vec{V} = 3\hat{i} + 12\hat{j}$

$\Rightarrow |\vec{V}| = \sqrt{(3)^2 + (12)^2} = 12.37$ m/s

6. Full load is supplied by the turbine shaft when the diameter of jet issuing from the nozzle is 150 mm. If the load suddenly drops to 36% of the full load, what diameter of the jet should be attained by regulating the spear rod?

(a) 15 mm (b) 45 mm
(c) 90 mm (d) 180 mm

Ans. (c)

Sol. Upon change in load: discharge is varied by varying the area of jet $Q_1 = Q$

Velocity of jet remains constant.

At full load; $d = d_1 = 150$ mm

$Q_2 = 0.36Q$

At 36% of full load; $d = d_2$

$$Q = A \times V_1 = \frac{\pi}{4} d^2 \times V_1$$

As V_1 = constant: $Q \propto d^2$

$$\frac{Q_2}{Q_1} = \left(\frac{d_2}{d_1}\right)^2 \Rightarrow 0.36 = \left(\frac{d_2}{150}\right)^2$$

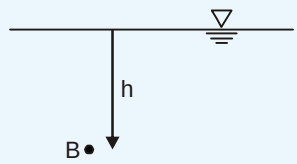
$$\frac{d_2}{150} = 0.6 \Rightarrow \boxed{d_2 = 90 \text{ mm}}$$

7. What is the depth of a point below water surface in sea, where pressure intensity is 1.006 MN/m²? (Specific gravity of sea water is 1.025)

(a) 60 m (b) 80 m
(c) 100 m (d) 120 m

Ans. (c)

Sol.



$$P_B = \gamma_{sea} \cdot h = 1.006 \times 10^6\ N/m^2$$

$$\Rightarrow h = \frac{1.006 \times 10^6}{\gamma_{sea}}$$

$$= \frac{1.006 \times 10^6\ N/m^2}{1.025 \times 9810\ N/m^3}$$

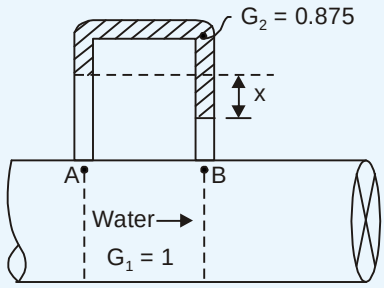
$= 100.047$ m ≈ 100 m

8. Two pressure points in a water pipe are connected to a manometer which has the form of an inverted U-tube. The space above the water in the two limbs of the manometer is filled with toluene (specific gravity is 0.875). If the difference of level of water columns in the two limbs reads 12.0 cm, what is the corresponding difference of pressure? (Take $g = 9.81\ m/s^2$)

(a) 110.49 N/m² (b) 128.12 N/m²
(c) 131.34 N/m² (d) 147.15 N/m²

Ans. (d)

Sol.



$$\frac{P_A - P_B}{\gamma_w} = \left(1 - \frac{G_2}{G_1}\right)x$$

$$\Rightarrow (P_A - P_B) = \left(1 - \frac{G_2}{G_1}\right)x \cdot \gamma_w$$

$$= \left(1 - \frac{0.875}{1}\right) \times 0.12 \times 9810$$

$$\Rightarrow (P_A - P_B) = 147.15 \text{ N/m}^2$$

9. What is the minimum size of glass tube that can be used to measure water level if the capillary rise in the tube is to be restricted to 2 mm? (Take surface tension of water in contact with air as 0.073575 N/m)

(a) 1.5 cm (b) 1.0 cm

(c) 2.5 cm (d) 2.0 cm

Ans. (a)

Sol. Capillary rise $= \dfrac{4\sigma\cos\theta}{\gamma \times d} = h$

If $h \le 2$ mm

$$\Rightarrow \frac{4\sigma\cos\theta}{\gamma_w d} \le 2 \text{ mm}$$

$$d \ge \frac{4\sigma\cos\theta}{\gamma_w \times 2 \text{ mm}}$$

$$d_{min} = \frac{4\sigma\cos\theta}{\gamma_w \times 2 \text{ mm}}$$

For water-glass contact, $\theta = 0$

$$\Rightarrow d_{min} = \frac{4\sigma}{\gamma_w \times 2 \text{ mm}}$$

$$= \frac{4 \times 0.073575 \text{ N/m}}{9810 \text{ N/m}^3 \times 2 \times 10^{-3} \text{ m}}$$

$d_{min} = 0.015$ m $= 15$ mm $= 1.5$ cm

10. A semi-tubular cylinder of 75 mm radius with concave side upstream (drag coefficient = 2.3) is submerged in flowing water of velocity 0.6 m/s. If the cylinder is 7.2 m long and density of water is 1000 kg/m^3, what is the drag?

(a) 150 N (b) 173 N

(c) 955 N (d) 223 N

Ans. (d)

Sol. Drag force $= \dfrac{1}{2} C_D \rho_w A V^2$

$$F_D = \frac{1}{2} \times 2.3 \times 1000[7.2 \times 0.075][0.6]^2$$

$$F_D = 223.56 \text{ N}$$

11. A double acting reciprocating pump having piston area 0.1 m^2 has a stroke length 0.30 m. The pump is discharging 2.4 m^3 of water per minute at 45 r.p.m. through a height of 10 m. What is the slip of the pump?

(a) 0.005 m^3/s (b) 0.015 m^3/s

(c) 0.025 m^3/s (d) 0.035 m^3/s

Ans. (a)

Sol. Double acting reciprocating pump

$A = 0.1$ m^2

$L = 0.30$ m

$Q = 2.4$ m^3/min.

$N = 45$ rpm

$H = 10$ m

Slip of pump = ?

$$\text{Slip} = Q_{th} - Q_{out}$$

$$Q_{th} = \frac{2ALN}{60} = \frac{2 \times 0.1 \times 0.30 \times 45}{60}$$

$$= 0.045 \text{ m}^3/\text{s} = 2.7 \text{ m}^3/\text{min}$$

$$\text{Slip} = Q_{th} - Q_{out}$$

$$= 2.7 - 2.4 = 0.3 \text{ m}^3/\text{min}$$

$$= 0.005 \text{ m}^3/\text{sec}$$

12. If pressure head of water is 100 m and specific gravity of kerosene is 0.81, what is the pressure head of kerosene?

(a) 123.5 m of kerosene
(b) 241.3 m of kerosene
(c) 75.1 m of kerosene
(d) 52.4 m of kerosene

Ans. (a)

Sol. For equal pressure,

$$100\gamma_w = h \cdot \gamma_{kerosene}$$

$$\Rightarrow h = \frac{100 \times \gamma_w}{\gamma_{kerosene}} = \frac{100}{0.81} = 123.46 \text{ m}$$

h = pressure head of kerosene

13. A lake has an area of 15 km^2. Observation of hydrological variables during a certain year has shown as follows:

Precipitation = 700 mm/year,

Average inflow Q_{in} = 1.4 m^3/s;

Average outflow Q_{out} = 1.6 m^3/s

Assume that there is no net water exchange between the lake and the groundwater. What is the evaporation during this year?

(a) 480 mm (b) 280 mm
(c) 380 mm (d) 180 mm

Ans. (b)

Sol. Precipitation (P) = 700 mm/yr

Avg inflow (Q_{in}) = 1.4 m^3/sec

Avg outflow (Q_{out}) = 1.6 m^3/sec

Lake area = 15 km^2

Assuming no change in storage in a year, we have

inflow-outflow = 0

inflow = outflow

$$700 \times 10^{-3} \times 15 \times 10^6 + 1.4 \times 365 \times 24 \times 60 \times 60$$

$$= 1.6 \times 365 \times 24 \times 60 \times 60 + E \times 10^{-3} \times 15 \times 10^6$$

(where E = evaporation in mm/yr)

solving we get

E = 279.52 mm/yr

≃ 280 mm/yr

14. A bridge has an expected life of 25 years and is designed for a flood magnitude of return period 100 years. What is the risk of this hydrologic design?

(a) $1-\left(\frac{100}{99}\right)^{25}$ (b) $\left(\frac{99}{100}\right)^{25}$

(c) $1-\left(\frac{99}{100}\right)^{25}$ (d) $\left(\frac{100}{99}\right)^{25}$

Ans. (c)

Sol. Design life (n) = 25 yr

Return period (T) = 100 yr

$$\text{Risk} = 1-(q)^n = 1-(1-p)^n = 1-\left(1-\frac{1}{T}\right)^n$$

$$= 1-\left(1-\frac{1}{100}\right)^{25}$$

$$= 1-\left(\frac{99}{100}\right)^{25}$$

15. In a groundwater field test, a tracer took 8 hours to travel between two observation wells which are 56 m apart. The difference in water table elevations in these wells was 0.70 m. The volume of the void of the aquifer is 30% of the total volume of the aquifer. What is the hydraulic conductivity of the aquifer, if the dynamic viscosity of water is 0.995 × 10^{-3} Ns/m^2?

(a) 4.664 cm/s (b) 3.664 cm/hr
(c) 2.664 mm/s (d) 1.664 cm/hr

Ans. (a)

Sol. The tracer records the actual velocity of water

$$(V_{act}) = \left[\frac{56 \times 100}{8 \times 60 \times 60}\right] = \frac{7}{36} \text{ cm/sec}$$

Discharge velocity, V = (n × V_{act}), where

$$n = \text{Porosity} = \left(\frac{\text{Volume of void}}{\text{Total volume}}\right)$$

= 0.30 (given)

$$\Rightarrow V = \left(0.3 \times \frac{7}{36}\right) = \left(\frac{7}{120}\right) \text{ cm/sec}$$

Hydraulic gradient (i) = $\left[\frac{0.7}{56}\right] = 1.25 \times 10^{-2}$

Coefficient of permeability or hydraulic conductivity of aquifer (k) = $\left(\frac{V}{i}\right)$

$$= \left(\frac{7}{120 \times 1.25 \times 10^{-2}}\right)$$

$$= \frac{14}{3} \text{ cm/sec} = 4.67 \text{ cm/sec.}$$

16. Consider the following statements regarding channel routing:

1. In channel routing, the flood hydrograph at various sections of the reach is predicted by considering a channel reach and an input hydrograph at the upstream end.
2. As the flood wave moves down the river, the shape of the wave does not change.
3. Flood waves passing down a river have their peaks attenuated due to friction.
4. The addition of lateral inflows can cause an increase of attenuation.

Which of the above statements are not correct?

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

Ans. (d)

Sol.

→ As the flood wave moves down the river, the shape of the waves gets modified due to various factors, such as channel storage, resistance, lateral addition or withdrawal of flow, etc.

→ When a flood wave passes through a reservoir, its peak is attenuated due to friction if there is no lateral inflow.

→ The addition of lateral inflows can cause a reduction of attenuation or even amplification of a flood wave.

→ In channel routing, the flood hydrograph at various sections of the reach is predicted by considering a channel reach and an input hydrograph at the upstream end.

17. Consider the following statements related to water logging control:

1. It is evident that water logging can be controlled only if the quantity of water into the soil below is checked and reduced.
2. Attempts should be made to reduce the seepage of water from the canals and water courses.
3. The entire irrigable land should receive canal water in all seasons.

Which of the above statements are correct?

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

Ans. (a)

Sol. To control water logging

→ Quantity of water into the soil below is checked and reduced

→ In such areas, seepage from canals should be minimum, hence these are generally lined canals.

→ In such areas only a small portion of irrigable land should be irrigated in one season and the remaining portion may be irrigated in the next seasons, by rotation.

→ Hence correct answer is option (a)

18. If wheat requires 7.5 cm of water after every 28 days and the base period for wheat is 140 days, what is the value of delta for wheat?

(a) 7.5 cm (b) 27.5 cm
(c) 37.5 cm (d) 17.5 cm

Ans. (c)

Sol. Delta for wheat = $\frac{140}{28} \times 7.5 = 37.5$ cm

19. A tile drainage system draining 12 hectares, flows at a design capacity for two days, following a storm. if the system is designed using a drainage coefficient of 1.25 cm, how much of water will be removed during this period?

(a) 1500 m^3 (b) 4500 m^3
(c) 3000 m^3 (d) 3500 m^3

Ans. **(c)**

Sol. Given: Area = 12 heaters = 12×10^4 m^2

D.C. = 1.25

→ From given drainage area, 1.25 cm depth of water is removed in 24 hrs.

→ Volume of water drained in two days = $2 \times 1.25 \times 10^{-2} \times 12 \times 10^4 = 3000$ m^3

Hence, option (c) is correct answer.

20. What is the hydraulic radius of a stable canal carrying a discharge of 27 m^3/s using Lacey's method? (Assume silt factor is 1.0)

(a) 1.44 m (b) 2.67 m

(c) 3.14 m (d) 4.28 m

Ans. **(a)**

Sol.
$$R = 0.47\left[\frac{Q}{f}\right]^{\frac{1}{3}}$$
$$R = 0.47\left[\frac{27}{1}\right]^{\frac{1}{3}}$$
$$R = 1.41 \text{ m}$$

Hence, closest option is (a).

21. Consider the following statements regarding loss of water in canals:

1. The water lost by evaporation is generally very small, as compared to the water lost by seepage in certain channels.
2. In percolation, there exists a zone of continuous saturation from the canal to the water-table and a direct flow is established.
3. In absorption, a small saturated soil zone exists around the canal section and is surrounded by a zone of decreasing saturation.

Which of the above statements are correct?

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

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

Ans. **(d)**

Sol. All the options are correct.

22. The chief aim of river training is

(a) to protect water from loss.

(b) bed scouring.

(c) to achieve ultimate stability of river with the aid of river training measures.

(d) pitching of banks and provision of launching aprons.

Ans. **(c)**

23. Which one of the following conditions is correct for a channel to behave in true regime?

(a) Discharge is non-uniform

(b) Flow is non-uniform

(c) Silt grade is varying

(d) Silt charge is constant

Ans. **(d)**

24. What is the delta for a crop when its duty is 864 hectares/cumec on the field and the base period of this crop is 120 days?

(a) 120 cm (b) 140 cm

(c) 160 cm (d) 172 cm

Ans. **(a)**

Sol. Duty × Delta = 8.64 B

$864 \times \Delta = 8.64 \times 120$

$\Rightarrow \Delta = 1.2$ m = 120 cm

Hence, option 'a' is correct answer.

25. Which one of the following is the merit of combined sewer system?

(a) Rain water dilutes the sewage, therefore, it can be easily and economically treated.

(b) Initial cost is high as compared with separate system.

(c) If the whole sewage is to be disposed off by pumping, it is uneconomical.

(d) During heavy rains, the overflowing of sewers will endanger the public health.

Ans. **(a)**

Sol. **Combined System**

This system consists of a single sewer line of large diameter through which the sewage and storm water are allowed to flow and are carried to the treatment plant.

The following are the advantages of this system:

(i) The storm water dilutes the sewage and hence its strength is reduced.

(ii) The self-cleansing velocity is easily acheived.

(iii) Due to larger diameter of sewer, it can be easily cleaned.

(iv) As the single sewer line serves the double function, it becomes economical.

The following are the disadvantages of this system:

(i) The treatment plant is unnecessarily loaded with the combined volume of sewage and storm water. It may exceed the normal capacity of the plant.

(ii) During a heavy storm, the combined sewer may be overflown and it may create trouble for the people at large.

(iii) It creates unnecessary pollution of storm water.

26. Which one of the following is a device used for measuring the velocity of flowing water in pipes of open channels?

(a) Pitot tube (b) Piezometer

(c) Venturimeter (d) Venturi tube

Ans. (a)

Sol. The basic principle used in this device is that if the velocity of flow at a particular point is reduced to zero, which is known as stagnation point, the pressure there is increased due to the conversion of the kinetic energy into pressure energy, and by measuring the increase in the pressure energy at this point the velocity of flow may be determined.

A single tube of this type may be used for measuring the velocity of flow in an open channel.

When a pitot tube is used for measuring the velocity of flow in a pipe or any other closed conduit then the pitot tube may be inserted in the pipe.

27. Which one of the following is the process in which ammonia is oxidised to nitrites and then to nitrates by aerobic bacteria?

(a) Nitrification (b) Denitrification

(c) Adsorption (d) Regeneration

Ans. (a)

Sol. Nitrification is the biological process in which ammonia is oxidized into nitrite, followed by a subsequent transformation of nitrites into nitrates by aerobic bacteria.

28. A tank into which raw or partly treated sewage is collected, left to stay, and discharged at such a rate as may be necessary for subsequent treatment, is called

(a) Dosing tank (b) Sedimentation tank

(c) Skimming tank (d) Settling tank

Ans. (a)

Sol. Dosing tank is a tank in which sewage is collected and later discharged at the rate required by subsequent treatment processes.

29. In the context of sludge conditioning, Elutriation is synonymous to

(a) Washing (b) Heating

(c) Compacting (d) Filtering

Ans. (a)

Sol. Elutriation is a process of sludge conditioning whereby a sludge is washed either by fresh water or plant effluent, to reduce the sludge alkalinity and fine particles, thus decreasing the amount of required coagulant in further treatment steps or in sludge dewatering.

30. Sludge thickening is commonly achieved by the following methods:

1. Gravity thickening
2. Air flotation
3. Centrifugation

Which of the above methods are correct?

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

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

Ans. (d)

Sol. Sludge thickening of sludge can be achieved by following methods:

- Gravity thickening
- Air floatation
- Centrifugation

31. Which one of the following is the process whereby chemicals are added to a wastewater resulting in a reduction of the forces tending to keep suspended particles apart?

(a) Coagulation (b) Flocculation

(c) Clarification (d) Sedimentation

Ans. (a)

Sol. Coagulation is defined as the addition of a chemical to a colloidal dispersion which results in particle destablishation by reducing the forces between colloidal particles which trying to keep then apart.

32. Which one of the following is a grit-removal unit which also removes silt as well as some organic matter along with grit?

(a) Detritus Tank (b) Skimming Tank

(c) Detention Tank (d) Suspension Tank

Ans. (a)

Sol. A detritus tank is a grit removal unit which removes silt and some organic matter along with grit.

33. The domestic sewage of a town was tested for total solids and the following results were obtained:

Weight of sample of sewage = 1000 gm

Weight of solids after evaporation of liquid = 0.952 gm

Weight of dry residue after ignition = 0.516 gm

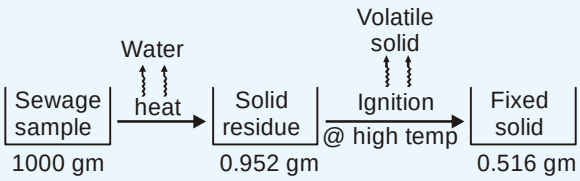
What is the value of volatile solids?

(a) 952 ppm (b) 516 ppm

(c) 436 ppm (d) 694 ppm

Ans. (c)

Sol.



Weight of water

$= 1000 - 0.952$

$= 999.048$ gm

$= 999.048\ cm^3$

$= 0.99$ lit $\simeq 1$ lit

Weight of volatile solids

$= 0.952 - 0.516$

$= 0.436$ cm

$= 436$ mg

Concentration of volatile solids

$= \frac{436\ mg}{1\ lit}$

$= 436$ mg/lit

$= 436$ ppm

34. The quantity of nitrogen present in wastewater before the decomposition of organic matter has started, is indicated by

(a) Albuminoid Nitrogen

(b) Free Ammonia

(c) Organic Nitrogen

(d) Nitrate Nitrogen

Ans. (a)

Sol. Organic ammonia (Albuminoid) indicates quanity of nitrogen before decomposition of organic matter has started.

35. Which one of the following is that (low) water content of the soil at which plants can no longer extract sufficient water for their growth?

(a) Wilting point (b) Tail water

(c) Irrigating head (d) Capillary water

Ans. (a)

Sol. Wilting point is water content of the soil at which plants can no longer extract sufficient water for their growth.

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36. Which one of the following is the advantage of using activated carbon for water treatment?

(a) When used in powdered form after coagulation, it does not aid in coagulation.

(b) It increases the chlorine demand of treated water.

(c) It removes organic matter present in water.

(d) Its overdose is harmful.

Ans. (c)

Sol. Because of adsorption property of activated carbon, it is used to remove organic matter, and color produced by phenols, H_2S, Fe and Mn.

37. A soil has bulk density of 20.1 kN/m^3 and water content 15%. What is the water content if the soil partially dries to a density of 19.4 kN/m^3 and the void ratio remains unchanged?

(a) 10.86% (b) 10.76%

(c) 10.68% (d) 10.66%

Ans. (a)

Sol. Since the void ratio remains unchanged or partial drying, the volume of soil remains unchanged because

$$V_{soil} = V_{solid}(1+e)$$

$\Rightarrow$ dry unit wt remains unchanged since

$$\gamma_d = \frac{W_{solid}}{V_{soil}}$$

Since, $\gamma_d = \dfrac{\gamma_{bulk}}{1+w}$

Hence, $\dfrac{\gamma_{bulk1}}{1+w_1} = \dfrac{\gamma_{bulk\,2}}{1+w_2}$

$$\Rightarrow \frac{20.1}{1.15} = \frac{19.4}{1+w_2}$$

$\Rightarrow w_2 = 0.1099$

$\Rightarrow$ Moisture content of partially died soil is 10.99%

Answer can be aproximately taken as (a).

38. A fine grained soil is found to have a liquid limit of 90% and a plasticity index of 50. The natural water content is 28%. What is the liquidity index?

(a) –0.34 (b) –0.14

(c) –0.24 (d) –2.40

Ans. (c)

Sol. Given:

$$W_L = 90\%$$
$$I_P = 50$$
$$W_N = 28\%$$

Liquidity index, $I_L = \dfrac{W_N - W_P}{W_L - W_P}$

$$I_P = W_L - W_P$$
$$50 = 90 - W_P$$
$$W_P = 90 - 50 = 40\%$$

$$I_L = \frac{28-40}{50} = -0.24$$

39. A concentrated load of 2000 kN is applied at the ground surface. What is the vertical stress at a point 6 m directly below the load?

(a) 16.42 kN/m^2 (b) 26.53 kN/m^2

(c) 36.12 kN/m^2 (d) 40.51 kN/m^2

Ans. (b)

Sol. Q = 2000 kN

The intensity of vertical stress just below the load point is

$$\sigma_{z=6} = \frac{3Q}{2\pi z^2} = 0.4775\frac{Q}{z^2}$$

$$= \frac{0.4775 \times 2000}{6^2}$$

$$= 26.53 \text{ kN/m}^2$$

40. Which one of the following is a characteristic of local shear failure?

(a) Failure pattern is not clearly defined.

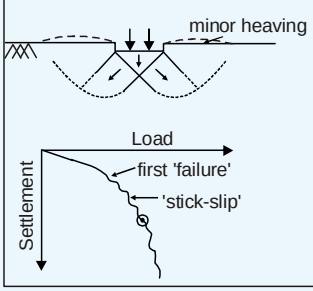
(b) Failure surfaces reach ground surfaces

(c) There is no bulging of soil around the footing

(d) Failure is not sudden and there is no tilting of footing.

Ans. (d)

Sol.

Modes of failure	Characteristics
Local shear (Transition) 	• Well-defined slip surface only below the foundation, discontinuous either side. • Large vertical displacement required before slip surface appear at ground level. • Some heaving occurs on both sides with no tilting and no catastrophic failure • No peak value, ultimate value not defined

41. A sample of silty clay has a volume of 14.88 cm^3, a total mass of 28.81 gm, a dry mass of 24.83 gm and a specific gravity of solids 2.7. What is the void ratio?

(a) 0.412 (b) 0.521

(c) 0.618 (d) 0.663

Ans. (c)

Sol. Given:

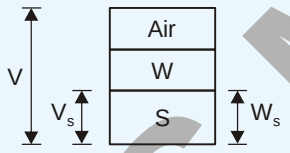
$V = 14.88\ cm^3$

$W = 28.81\ gm$

$W_s = 24.83\ gm$

$G_s = 2.7$

$e = ?$



$$V_s = \frac{W_s}{G_s\rho_w} = \frac{24.83}{2.7\times 1} = 9.196\ cm^3$$

$$e = \frac{V_v}{V_s} = \frac{V - V_s}{V_s} = \frac{V}{V_s} - 1$$

$$= \frac{14.88}{9.196} - 1 = 0.618$$

42. A constant head permeability test is carried out on a cylindrical sample of sand 10 cm diameter and 15 cm height. 160 cm^3 of water is collected in 1.75 minutes, under a head of 30 cm. What is the coefficient of permeability in m/year?

(a) 1257 m/year (b) 2111 m/year

(c) 3060 m/year (d) 3382 m/year

Ans. (c)

Sol. Given: Dia, d = 10 cm, Length, L = 15 cm

Volume of water = 160 cm^3, Time, t = 1.75 min

Head, h = 30 cm

q = Discharge measured

$$= \frac{160}{1.75\times 60}\ cm^3/sec$$

$= 1.524\ cm^3/sec$

A = Cross-sectional area

$$= \frac{\pi}{4}d^2 = \frac{\pi}{4}\times 10^2$$

$= 78.54\ cm^2$

We know $q = KiA = K\frac{h}{L}A$

Coefficient of permeability,

$$K = \frac{qL}{Ah} = \frac{1.524\times 15}{78.54\times 30}$$

$= 9.702 \times 10^{-3}$ cm/sec

$= 9.702 \times 10^{-5}$ m/sec

$= (9.702 \times 10^{-5}) \times 60 \times 60 \times 24 \times 365$ m/year

$= 3059.64$ m/year

$\simeq 3060$ m/year

43. Which one of the following is the correct assumption of Rankine's theory?

(a) The soil mass is infinite

(b) The soil mass is non homogeneous

(c) The soil mass is cohesive

(d) The ground surface is a plane which may be horizontal or inclined

Ans. (d)

Sol. Assumption of Rankine's theory:

- The soil is semi-infinite, homogeneous, isotropic, dry and cohesionless.
- The ground surface is a plane (although it does not necessarily need to be level).

44. If retaining wall 5 m high is restrained from yielding, what is the at-rest earth pressure per

meter length of wall? (Consider the backfill is cohesionless soil having $\phi = 30°$ and $\gamma = 18 kN/m^3$)

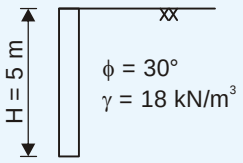
(a) 108 kN/m (b) 112.5 kN/m

(c) 115 kN/m (d) 124 kN/m

Ans. (b)

Sol. We know,

$$K_0 = 1 - \sin\phi = 1 - \sin 30° = \frac{1}{2} = 0.5$$



At rest earth pressure per meter length of wall

$$P_0 = \frac{1}{2}K_0\gamma H^2 = \frac{1}{2} \times 0.5 \times 18 \times 5^2 = 112.5 \text{ kN/m}$$

45. Consider the following steps related to construction with the use of geotextiles :

1. Start with an adequate working surface and staging area.
2. Lay a geotextile sheet of proper width on the ground surface.
3. Construction equipment must work from the soil backfill and be kept off the unprotected geotextile.

Which of the above steps are correct?

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

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

Ans. (d)

46. The void ratio of a clay sample is 0.5 and the degree of saturation is 70%. What is the bulk unit weight of the soil?

(Assume G = 2.7)

(a) 10.46 kN/m³ (b) 14.32 kN/m³

(c) 17.77 kN/m³ (d) 19.95 kN/m³

Ans. (d)

Sol. Given: e = 0.5, S = 70% = 0.7, G = 2.7

We know

$$eS = wG$$

$$w = \frac{eS}{G} = \frac{0.5 \times 0.7}{2.7} = 0.13$$

$$\gamma_t = \gamma_d(1+w) = \left(\frac{G\gamma_w}{1+e}\right)(1+w)$$

$$= \frac{2.7 \times 9.81}{1+0.5} \times (1+0.13)$$

$$= 19.95 \text{ kN/m}^3$$

47. What is the coefficient of volume change (using change in void ratio method) for pressure range $100 kN/m^2$ to $200 kN/m^2$?

(Consider $\sigma'_0 = 100 kN/m^2$, $e_0 = 1.121$, $\sigma' = 200 kN/m^2$, $e_0 = 0.964$, $\Delta\sigma = 100 kN/m^2$ and $\Delta e = -0.157$)

(a) 0.25 m²/MN (b) 0.48 m²/MN

(c) 0.69 m²/MN (d) 0.74 m²/MN

Ans. (d)

Sol. Given:

$$\Delta e = -0.157$$

$$\Delta\sigma = 100 \text{ kN/m}^2 = 0.1 \text{ MN/m}^2$$

$$e_0 = 1.121$$

Coefficient of volume change or coefficient of volume compressibility

$$m_v = \frac{a_v}{1+e_0} = \frac{\Delta e}{\Delta\bar{\sigma}}\left(\frac{1}{1+e_0}\right)$$

$$= \frac{0.157}{0.1}\left(\frac{1}{1+1.121}\right) \text{m}^2/\text{MN}$$

$$= 0.74 \text{ m}^2/\text{MN}$$

48. Which one of the following problems is required to be studied in the design of earth dams?

(a) The prediction of the position of the line of seepage in the longitudinal section

(b) The computation of seepage loss

(c) The seepage line should cut the down-stream slope

(d) The seepage loss through the dam should be maximum.

Ans. (b)

49. Which one of the following is ***not*** an instrument for setting out right angles?

(a) Cross staff (b) Site square

(c) Prism square (d) Optical staff

Ans. (d)

Sol. Instrument used for setting out right angles

- Cross-staff
- Site square
- Prism square/optical square

Optical staff is a levelling staff that helps to determine the height difference between two points on a survey.

50. Which one of the following is correct for Prismatic Compass?

(a) The graduated ring rotates with line of sight.

(b) Instrument cannot be used without tripod

(c) The graduations are engraved inverted

(d) The readings can directly be taken by setting through the top of the glass.

Ans. (c)

Sol. Prismatic compass

- The graduated ring is attached with the needle and does not rotate with line of sight.
- The instrument can be held in hand also while making the observations.
- Graduations are engraved inverted since the graduated ring is read through the prism.
- The readings are taken with the help of a prism, provided at the eye vane.

51. Magnetic declination at a place is the horizontal angle between

(a) the true meridian and the arbitrary meridian

(b) the magnetic meridian and the arbitrary meridian

(c) the true bearing and the magnetic bearing

(d) the true meridian and the magnetic meridian.

Ans. (d)

Sol. Magnetic declination at a place is the horizontal angle between the true meridian and the magnetic meridian.

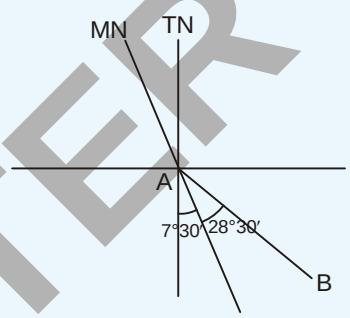
52. The magnetic bearing of a line AB is S28°30'E. What is the true bearing of line AB if the magnetic declination is 7°30' towards west?

(a) S36°E (b) N21°W

(c) S21°E (d) N36°W

Ans. (a)

Sol.



True bearing of line AB = $28°30' + 7°30'$

$= 36°$ or S36°E

53. The Zeniths is/are

(a) the point on the upper portion of the celestial sphere marked by plumb line above the observer

(b) the point on the lower portion of the celestial sphere marked by plumb line below the observer

(c) the two points in which the Earth's axis of rotation meets the Earth's sphere

(d) the great circle of the Earth, the plane of which is at right angles to the axis of rotation.

Ans. (a)

Sol. The point on celestial sphere vertically above the observer's station is called zenith and the point vertically below is called Nadir.

54. Which one of the statements is ***not*** correct for remote sensing?

(a) It requires energy source

(b) It requires propagation of energy through atmosphere

(c) It requires energy interaction with the Earth's surface features

(d) It requires absorption of energy by the Earth's surface

Ans. (d)

55. Energy in remote sensing deals with which region of electromagnetic spectrum?

(a) Ultraviolet (b) Infrared

(c) X-Ray (d) Gamma Ray

Ans. (b)

56. Consider the following statements related to the classification based upon the object of survey?

1. Archeological surveys for unearthing relics of antiquity.
2. Geological surveys for determining different strata in the Earth's crust.
3. Mine surveys for exploring mineral wealth such as gold, coal, etc.

Which of the above statements are correct?

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

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

Ans. (d)

Sol. All statements are correct.

57. In setting up of plane table at a station P, the corresponding point on the plan was not accurately centered above P. If the displacement of P was 30 cm in a direction at right angles to the ray and scale is 1 cm = 2 m, how much on the plan would be the consequent displacement of point from its true position?

(a) 0.15 mm (b) 6.0 mm

(c) 1.5 mm (d) 0.3 mm

Ans. (c)

Sol. $r = \frac{1}{200}$

We know,

$$aa' = r \times e$$

In this case,

$$e = 30 \text{ cm} = 300 \text{ mm}$$

$$aa' = \frac{1}{200} \times 300 = 1.5 \text{ mm}$$

58. A photographic survey is carried out to a scale of 1:20000. A camera with a wide angle lens of f = 170 mm was used with 25 cm × 25 cm plate size for a net 65% overlap along the line of flight. What is the error in height given by an error of 0.15 mm in measuring the parallax of the point?

(a) 5.15 m (b) 5.27 m

(c) 5.83 m (d) 6.45 m

Ans. (c)

Sol.

$$S = \frac{f}{H} = \frac{1}{20000} = \frac{170 \times 10^{-3}}{H}$$

$$H = 3400 \text{ m}$$

The length of air base

$$B = (1 - P_\ell)\ell s$$

$$= (1 - 0.65) \times 25 \times 10^{-2} \times 2 \times 10^4$$

$$= 1750 \text{ m}$$

We know $dh = \frac{(H-h)^2}{Bf} dp$

$$= \frac{3400^2}{1750 \times 170} \times 0.15$$

$$= 5.83 \text{ m}$$

59. What is the aeroplane flying height to obtain the average scale of the photograph equal to 1/7200? (Ground surface elevations vary from 160 m to 430 m and the focal length of the camera lens is 153 mm).

(a) 1021 m (b) 1145 m

(c) 1284 m (d) 1397 m

Ans. (d)

Sol. Given:

$$S_{avg} = \frac{1}{7200}$$

$$h_{avg} = \frac{160+430}{2} = 295 \text{ m}$$

$$f = 153 \text{ mm}$$

$$S_{avg} = \frac{f}{H - h_{avg}} \Rightarrow \frac{1}{7200} = \frac{153 \times 10^{-3}}{H - 295}$$

$$\Rightarrow \quad H = 1396.6 \text{ m} \simeq 1397 \text{ m}$$

60. Which one of the following conditions shall be fulfilled when a transition curve is inserted between the tangent and circular curve?

(a) It should not meet the original straight tangentially.

(b) It should not meet the circular curve tangentially

(c) Its radius at the junction with the circular curve should be the same as that of the circular curve.

(d) The rate of decrease of curvature along the transition curve should be same as that of increase in superelevation.

Ans. (c)

Sol.
- It should meet the original straight tangentially.
- It should meet the circular curve tangentially.
- Its radius at the junction with the circular curve should be the same as that of the circular curve.
- The rate of increase of curvature along the transition curve should be same as that of increase in superelevation.

61. Consider the following statements related to road pavements :

1. Deflections measured near cracks are normally much lower than the measurements in non-distressed areas.
2. Deflection measurements near longitudinal joints, transverse joints or corners are higher than those measured at mid-slab concrete pavements.
3. Thermal and moisture gradient in the vertical direction of concrete slabs does not have an influence on deflection measurements.
4. Measurements taken at right or in the early morning are considerably different from those obtained in the afternoon.

Which of the above statements are ***not*** correct ?

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

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

Ans. (b)

Sol.
- Statement 1: Deflection measured near cracks are normally much higher than the measurements in non-distressed areas.
- Statement 3: Thermal and moisture gradient in the vertical direction of concrete slabs influence the deflection measurements.

Hence, statement 1 and 3 are not correct.

62. Which one of the following tunneling methods is adopted for the situations where the metro alignment passes under residential buildings or a canal?

(a) Earth pressure balance tunneling machine method

(b) Tunnel boring machine method

(c) Tube tunnelling method

(d) Driven shield tunneling method

Ans. (b)

Sol. Tunnel boring machine method is used where the metro alignment passes under residential buildings or canal.

63. Consider the following statements related to the advantages of concrete sleepers :

1. Concrete sleepers can generally be mass produced using local resources.
2. Concrete sleepers are not suitable for beater packing
3. Concrete sleepers have a very long life-span.
4. Concrete sleepers have no scrap value.

Which of the above statements is/are correct ?

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

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

Ans. (b)

Sol.
- Concrete sleepers can generally be mass produced using local resources.
- Concrete sleepers have a very long life span.

64. Which one of the following is ***not*** the method of tunneling in hard rock?

(a) Full-face heading method

(b) Heading and bench method

(c) Drift method

(d) Shaft method

Ans. (d)

Sol. Shaft method is not used for tunneling in hard rock.

65. Consider the following statements related to the advantages of uniformity of rail gauges :

1. As trans shipping is not required, there is breakage of goods.
2. Large sheds to store goods are not required.
3. Labour strikes, etc. do not affect the service and operation of trains.

Which of the above statements are correct?

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

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

Ans. (b)

Sol. Advantages of uniformity of rail gauges are:
- As trans shipping is not required, there is no breakage of goods.
- Large sheds to store goods are not required.
- Labour strikes, etc. do not affect the service and operation of trains.

66. Which one of the followings are provided to give access to properties along an important highway with controlled access to expressway or freeway?

(a) Lay-bys (b) Frontage roads

(c) Driveways (d) Cycle tracks

Ans. (b)

Sol. A frontage road (also known as an access road, "outer road", service road, feeder road, or parallel road) is a local road running parallel to a higher speed, limited-access road. A frontage road is often used to provide access to private driveways, shops, houses, industries or farms.

67. When properly designed traffic signals are used, which one of the following is the advantage of traffic signals?

(a) The signals allow crossing of the heavy traffic flow with safety.

(b) The rear-end collision may increase

(c) Improper design and location of signals may lead to violation of the control system.

(d) Failure of the signal due to electric power failure may cause confusion to the road users.

Ans. (a)

Sol. One of the advantages of properly designed traffic signal is that heavy vehicles traffic flow can cross the intersection safely.

68. If the ruling gradient is 1 in 150 on a particular section of broad gauge and at the same time a curve of 4 degree is situated on this ruling gradient, what is the allowable ruling gradient ?

(a) 1 in 10 (b) 1 in 72

(c) 1 in 196 (d) 1 in 245

Ans. (c)

Sol. Grade compensation on broad gauge track = 0.04% per degree

Degree of curve = 4

Grade compensation = 4 × 0.04% = 0.0016

Allowable ruling gradient

$$= \frac{1}{150} - 0.0016$$

$$= \frac{1}{197.36} \approx \frac{1}{196}$$

69. What is the value of headlight sight distance for a highway with a design speed of 65 kmphs? [Take f = 0.36 and t = 2.5 sec.]

(a) 66.5 m (b) 81.3 m

(c) 91.4 m (d) 182.8 m

Ans. (c)

Sol. HSD = 0.278 × V × t_R + $\frac{V^2}{254f}$ $(\because \text{HSD} = \text{SSD})$

V = 65 kmph ; t_R = 2.5 sec ; f = 0.36

$\Rightarrow$ HSD = 91.4 m

70. What is the minimum stopping sight distance on a –3.5% grade for a design speed of 110 kmph?

(Consider friction coefficient f = 0.28, t = 2.5 sec and G = 0.035).

(a) 76.4 m (b) 194.4 m

(c) 214.6 m (d) 270.8 m

Ans. (d)

Sol. SSD = 0.278 × V × t_R + $\frac{V^2}{254(f+n\%)}$

V = 110 kmph; t_R = 2.5 sec; f = 0.28

n = slope% = –3.5%

$$\text{SSD} = 0.278 \times 110 \times 2.5 + \frac{(110)^2}{254(0.28-0.035)}$$

= 270.8 m

71. The free mean speed on a roadway is found to be 80 kmphs. Under stopped condition, the average spacing between the vehicles is 6.9 m. What is the capacity flow?

(a) 5800 Vehicles/hour (per lane)

(b) 7200 Vehicles/hour (per lane)

(c) 1450 Vehicles/hour (per lane)

(d) 2900 Vehicles/hour (per lane)

Ans. (d)

Sol. Free mean speed (V_f) = 80 km/hr

jam density (K_j) = $\frac{1000}{6.9} \simeq 145$ veh / km

(As one vehicle under stopped condition occupies 6.9 m)

Capacity flow (C) = $\frac{V_f K_j}{4} = 2900$ veh / hr

72. For a steel lighting system, having the following conditions :

Street width = 15 m

Mounting height = 7.5 m

Lamp size = 6000 lumen

Luminaire type = II

Coefficient of utilization = 0.44

Maintenance factor = 0.8

What is the spacing between lighting units to produce average Lux = 6?

(a) 18 m (b) 20 m

(c) 23 m (d) 27 m

Ans. (c)

Sol. Spacing between lighting units

$$\text{Spacing} = \frac{\text{Lamp lumen} \times \text{Coefficient of utilization} \times \text{maintenance factor}}{\text{Average lux} \times \text{Width of road}}$$

$$\Rightarrow \text{Spacing} = \frac{6000 \times 0.44 \times 0.8}{6 \times 15}$$

= 23.47 m ≈ 23 m

73. Consider the following for the objects of seasoning wood :

1. Reduce the shrinkage and warping after placement in structure.
2. Increase its tendency to split and decay
3. Decrease workability
4. Reduce its weight

Which of the above objects are correct?

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

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

Ans. (b)

Sol. Objectives of seasoing of wood are:

- Reduce the shrinkage and warping after placement in structure.
- Decrease its tendency to split and decay.
- Increase workability, strength and durability.
- Reduce its weight.

74. The hardness of aggregate is tested by

(a) Impact test

(b) Crushing strength test

(c) Abrasion test

(d) Soundness test

Ans. (c)

Sol. Hardness of aggregate is tested by Abrasion test.

75. Which one of the following statements is correct in respect of mild steel?

(a) It has high carbon content

(b) It is tougher than hard steel

(c) It is more elastic than hard steel

(d) It can be forged and welded easily

Ans. (d)

Sol.
- Mild steel is low carbon steel, whereas hard steel is high carbon steel.
- Mild steel has low carbon content.
- High carbon steel is tougher than mild steel.
- High carbon steel is more elastic than mild steel since initial slope of stress-strain curve of high steel is more than that of mild steel.
- Mild steel can be forged and welded easily.

76. The chemical composition 'Silicates of iron and alumina' is found in which one of the following minerals?

(a) Garnet (b) Serpentine

(c) Olivine (d) Calcite

Ans. (a)

Sol. Garnets are niosilicates having general formula $X_3Y_2(SiO_4)_3$

where X site is usually occupied by divalent cations (Ca^{+2}, Mg^{+2}, Fe^{+2}, Mn^{+2})

and the Y site is occupied by trivalent cations (Al^{+3}, Fe^{+3}, Cr^{+3}) in an octahedral/tetrahedral framework with $(SiO_4)^{-4}$ occupying the tetrahedra. So, silicates of iron and alumina is found in Garnet minerals.

77. The drawback of electric seasoning of timber is

(a) Checks (b) Splitting

(c) Cracks (d) Reduced Strength

Ans. (b)

Sol. The drawback of electric seasoning is that wood may split.

78. Which one of the following is a product obtained by distilling tar and is used largely as an effective preservative for wood?

(a) Creosote (b) Solignum

(c) Coal tar (d) Wax polish

Ans. (a)

Sol. Creosote oil is prepared by the distillation of tar. It is used for preservation of timber.

79. Pozzolanas are

(a) argillaceous materials

(b) calcareous materials

(c) accelerators

(d) siliceous materials

Ans. (d)

Sol. Pozzolanas consist of very fine siliceous and aluminous materials.

80. For better chemical resistance, proportion of which one of the following compounds in cement clinker shall be increased?

(a) Tricalcium Silicate

(b) Dicalcium Silicate

(c) Tetracalcium Aluminate

(d) Tetracalcium Aluminoferrite

Ans. (b)

Sol. For better chemical resistance, the tricalcium aluminate component in cement is minimised and a high percentage of dicalcium silicate is added.

81. The finishing coat in X-ray room walls is done preferably with

(a) Barium plaster (b) Cement plaster

(c) Gypsum (d) Plaster of Paris

Ans. (a)

Sol. Barium plaster is used as a final coat for surfaces of X-ray room so as to protect the person working in and around X-ray rooms.

82. The most suitable type of cement for mass concreting works is

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(c) Low Heat Portland Cement
(d) Quick Setting Cement

Ans. (c)

Sol. Low heat portland cement is most suitable for mass concrete works.

83. Which one of the non-destructive tests can be performed on fresh concrete?

(a) Ultrasonic test (b) Penetration test
(c) Core test (d) Hammer test

Ans. (a)

Sol. Ultrasonic test and maturity test are the two non destructive tests, which are conducted on fresh concrete.

84. In a concrete mix, for given cement content and workability, higher proportion of fine aggregate will be required if

(a) maximum size of aggregate is large
(b) maximum size of aggregate is small.
(c) rounded aggregate is used.
(d) all in aggregate is used

Ans. (a)

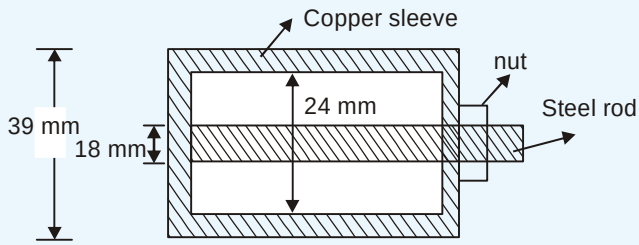
Sol. When maximum size of aggregate is large, higher proportion fine aggregates should be used to minimise the voids created due to large size of maximum size aggregates.

85. A central steel rod 18 mm diameter passes through a copper sleeve with 24 mm inside and 39 mm outside diameter. It is provided with nuts and washers at each end and the nuts are tightened until a stress of 10 N/mm^2 is set up in the steel. Then, the stress developed in copper tube is

(a) 29.1 N/mm^2, Compressive
(b) 3.4 N/mm^2, Compressive
(c) 3.4 N/mm^2, Tensile
(d) 29.1 N/mm^2, Tensile

Ans. (b)

Sol.



→ Due to tightening of nuts, tensile force will be developed in the steel rod whereas compressive force will get developed in the copper sleeve.

Tensile force in steel = Compressive force in copper

$$\Rightarrow \quad \sigma_s.A_s = \sigma_c.A_c$$

$$\Rightarrow \quad \sigma_c = \frac{A_s}{A_c} \times \sigma_s$$

$$\Rightarrow \quad \sigma_c = \frac{\frac{\pi}{4} \times 18^2}{\frac{\pi}{4}(39^2 - 24^2)} \times 10$$

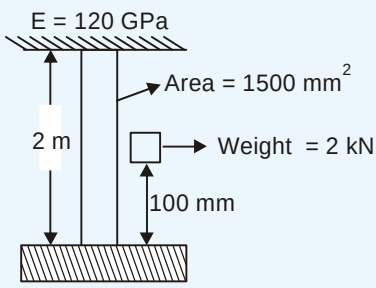
$$\sigma_c = 3.42 \text{ N/mm}^2 \text{ (compressive)}$$

86. A 2m long alloy bar of 1500 mm^2 cross-sectional area hangs vertically and has a collar securely fixed at its lower end. What is the stress induced in the bar when a weight of 2 kN falls from a height of 100 mm on the collar? (Take E = 120 GPa)

(a) 126.5 MPa (b) 158.3 MPa
(c) 161.2 MPa (d) 181.3 MPa

Ans. (a)

Sol.



Case of impact loading

$$\delta_{static} = \frac{w.\ell}{AE} = \frac{(2 \times 10^3) \times (2000)}{1500 \times (120 \times 10^3)}$$

$$= \frac{1}{45} \text{mm}$$

$$\text{Impact factor (I.F)} = 1+\sqrt{1+\frac{2h}{\delta_{st}}}$$

$$\text{I.F} = 1+\sqrt{1+\frac{2\times 100}{\frac{1}{45}}} = 95.87$$

$$\rightarrow \quad \sigma_{max} = \text{I.F}\,(\sigma_{static})$$

$$\sigma_{max} = 95.87\times\left(\frac{2\times 10^3}{1500}\right) = 127.83 \text{ MPa}$$

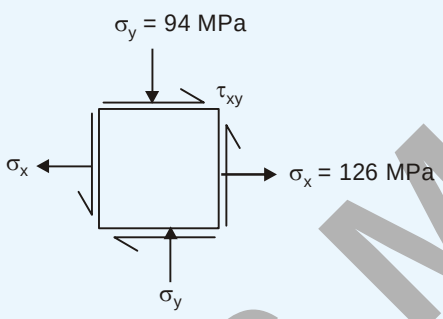
87. Normal stresses of 126 MN/m^2 (Tensile) and 94 MN/m^2 (Compressive) are acting at a point in an elastic material at right angles to each other. If the maximum principal stress is limited to 146 MN/m^2, the shear stress that may be allowed at that point in the same plane is

(a) 170 MN/m^2 (b) 89 MN/m^2

(c) 69 MN/m^2 (d) 96 MN/m^2

Ans. (c)

Sol.



$$\sigma_x = 126 \text{ MPa}, \sigma_y = -94 \text{ MPa}$$

Given, $\sigma_{major} = 146$ MPa

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

$$\Rightarrow \quad 146 = \frac{126-94}{2}+\sqrt{\left(\frac{126+94}{2}\right)^2+\tau_{xy}^2}$$

$$\Rightarrow \quad \tau_{xy} = 69.28 \text{ MPa}$$

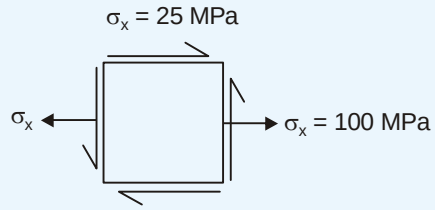
88. A plane element in a body is subjected to a tensile stress of 100 MPa and shear stress of 25 MPa. What is the normal stress on a plane inclined at 15° with the tensile stress?

(a) – 5.8 MPa (b) – 4.8 MPa

(c) – 3.8 MPa (d) – 2.8 MPa

Ans. (a)

Sol.



$\sigma'_x \rightarrow$ normal stress on the plane inclined at 15° with the tensile stress, hence normal is inclined at angle 75°.

Case-I: When rotation is in anticlockwise direction i.e., θ is positive.

$$\sigma'_x = \left(\frac{\sigma_x+\sigma_y}{2}\right)+\left(\frac{\sigma_x-\sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\sigma'_x = \frac{100}{2}+\frac{100}{2}\cos(2\times 15) + 25\sin(2\times 75)$$

$$\sigma'_x = 19.19 \text{ MPa}$$

Case-II: When rotation is in clockwise direction i.e., θ is negative.

$$\sigma'_x = \frac{100}{2}+\frac{100}{2}\cos(-150) + 25\sin(-150)$$

$$\sigma'_x = -5.8 \text{ MPa}$$

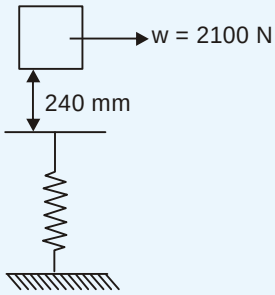
89. A load of 2100 N is dropped axially on a closed-coiled helical spring from a height of 240 mm. The spring has 22 coils each of mean diameter 180 mm and wire diameter is 25 mm. If modulus of rigidity C = 84000 N/mm^2 and amount of compression $\delta = 255$ mm, what is the maximum shear stress produced in the spring?

(a) 156 N/mm^2 (b) 346 N/mm^2

(c) 239 N/mm^2 (d) 123 N/mm^2

Ans. (c)

Sol.



Given $n = 22,\ d = 25$ mm, $R = 90$ mm

$c = 84000$ MPa

$\delta_{max} = 255$ mm

$$\delta_{static} = \frac{64\,PR^3.n}{Gd^4} = \frac{64\times2100\times90^3\times22}{8400\times(25)^4}$$

$\delta_{static} = 65.69$ mm

$$I.F = \frac{\delta_{max}}{\delta_{st}} = \frac{255}{65.69} = 3.88$$

$$\tau_{static} = \frac{16\,PR}{\pi d^3} = \frac{16\times2100\times90}{\pi\times25^3}$$

$= 61.6$ MPa

$\tau_{max} = I.F\times\tau_{static}$

$= 3.88 \times 61.6$

$\Rightarrow \tau_{max} = 239.02$ MPa

90. An I-section purlin of span 4 m is subjected to a total uniformly distributed load of 5 kN. The purlin will be designed for maximum bending moment of

(a) 2000 Nm (b) 20 kNm

(c) 2500 Nm (d) 25 kNm

Ans. (a)

Sol. The maximum bending moment for purlin

$$M = \frac{P\ell}{10}$$

P = Total load acting on the purlin

ℓ = Span of the purlin

$$\Rightarrow M = \frac{5\times4}{10} = 2 \text{ kNm} = 2000 \text{ Nm}$$

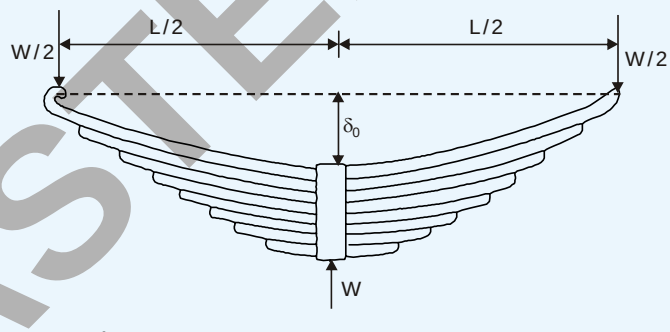
91. A 1.4 m long laminated carriage spring has leaves of 100 mm width and 10 mm thickness. The spring has to absorb 125 N-m energy when straightened, without exceeding the bending stress of 160 MPa. What is the number of leaves? (Take the elastic modulus of material of spring as 200 GPa)

(a) 11 (b) 9

(c) 7 (d) 5

Ans. (b)

Sol.



Given :

$b = 100$ mm, $t = 10$ mm, $L = 1.4$ m

$E = 200$ GPa, $\sigma_{max} = 160$ MPa

$U = 125$ N-m $= 125 \times 10^3$ N-mm

$$U = \frac{f^2}{6E}\left(\frac{nb}{2}.Lt\right)$$

$$\Rightarrow 125\times10^3 = \frac{160^2}{6\times200\times10^3}\times\left(n\times\frac{100}{2}\times1400\times10\right)$$

$\Rightarrow n = 8.37,$

Hence number of leaves = 9

92. A wooden floor is required to carry a load of 12 kN/m^2 and is to be supported by wooden joists of 120 mm × 250 mm in section over a span of 4 m. If the bending stress in these wooden joists is not to exceed 8 MPa, what is the spacing of the joists?

(a) 356 mm (b) 318 mm

(c) 432 mm (d) 417 mm

Ans. (d)

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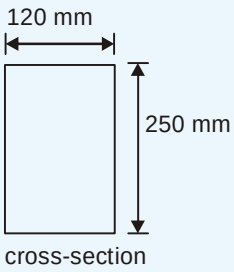
Sol.



Load from wooden floor = 12 kN/m^2

Assuming spacing between joist = s meter

$\Rightarrow$ Load on wooden joist (w) = 12 × s kN/m^2

Maximum bending moment = $\frac{w\ell^2}{8} = \frac{125 \times 4^2}{8}$

M_{max} = 24 S kN-m

$$\sigma_{max} = \frac{M_{max}}{z} = \frac{M_{max}}{bd^2/\sigma}$$

$$\Rightarrow \quad 8 = \frac{24 \times s \times 10^6}{120 \times \frac{(250)^2}{6}}$$

$\Rightarrow$ S = 0.41667 meter = 416.67 mm

93. A motor driving a solid circular shaft transmits 30 kW at 500 r.p.m. What is the torque activity on the shaft, if allowable shear stress is 42 MPa?

(a) 427 MPa (b) 573 Nm

(c) 180 Nm (d) 219 Nm

Ans. (b)

Sol.

Power = 30 kW

N = 500 rpm

τ_{per} = 42 MPa

$\Rightarrow$ Power = $T.w = 30 \times 10^3$

$\Rightarrow$ $T.\frac{2\pi N}{60} = 30 \times 10^3$

$\Rightarrow$ $T.\frac{2\pi \times 500}{60} = 30 \times 10^3$

$\Rightarrow$ T = 572.95 N-m

→ As diameter of shaft is not given, thus, torque can't be calculated from allowable shear stress.

→ Hence most appropriate answer is option (b)

94. An open-coiled helical spring of wire diameter 12 mm, mean coil radius 84 mm, helix angle 60° carries an axial load of 480 N. What is the twisting moment?

(a) 10.22 Nm (b) 20.16 Nm

(c) 14.24 Nm (d) 24.11 Nm

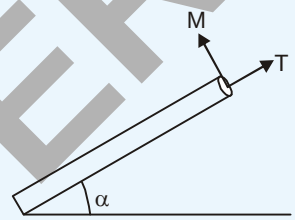
Ans. (b)

Sol. Given:

d = 12 mm, R = 84 mm

α = 60°, P = 480 N

For open-coiled helical spring with mean radius R subjected to axial load P



Torque (T) = $PR\cos\alpha$

Bending moment (M) = $PR\sin\alpha$

T = $PR\cos\alpha$

$\Rightarrow$ T = 480 × 84 × cos 60°

$\Rightarrow$ T = 20.16 N-m

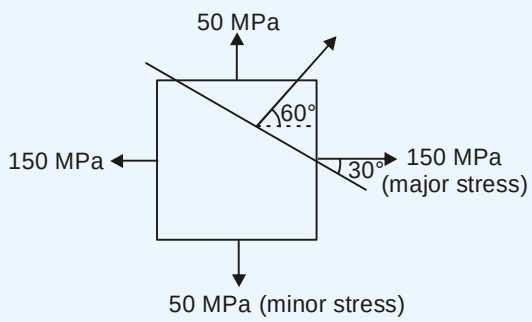
95. The stresses at a point of a machine component are 150 MPa and 50 MPa, both tensile. What is the intensity of normal stress on a plane inclined at an angle of 30° with the axis of major tensile stress?

(a) 25 MPa (b) 50 MPa

(c) 75 Mpa (d) 100 MPa

Ans. (c)

Sol.



$\sigma_{x'} \rightarrow$ normal stress on the plane inclined at an angle 30° with the major axis.

$$\sigma'_x = \frac{\sigma_x + \sigma_y}{2} + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\sigma'_x = \frac{150+50}{2} + \left(\frac{150-50}{2}\right)\cos(2\times 60°)$$

$$\sigma'_x = 75 \text{ MPa}$$

96. In case of lintel design, the load enclosed in an equilateral triangle is fully transferred to the lintel provided the height of wall above lintel is

(a) not less than 1.25 times the height of the equilateral triangle.

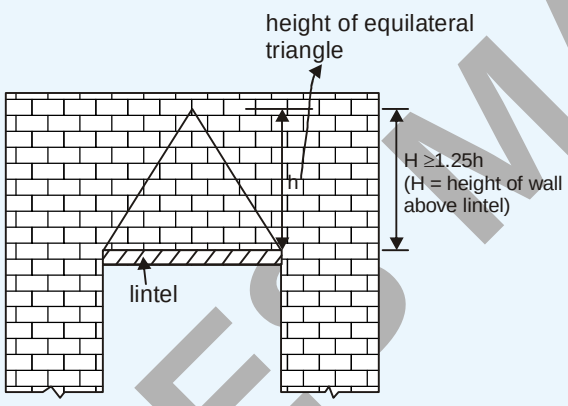
(b) less than twice the height of the equilateral triangle.

(c) less than 1.25 times the height of the equilateral triangle.

(d) greater than twice the height of the equilateral triangle.

Ans. (a)

Sol.



97. Consider the following statements for Euler's equation to find critical load of a column:

1. Critical load of a column is proportional to the flexural rigidity.
2. Critical load of a column depends upon yield stress.
3. Critical load of a column is inversely proportional to the length of column.
4. Critical load of a column is inversely proportional to the square of the length of column.

Which of the above statements are correct?

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

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

Ans. (b)

Sol.

$$P_{cr} = \frac{\pi^2 EI}{\ell^2}$$

Correct statement are 1 and 4.

98. A steel plate 120 mm wide and 20 mm thick is bent into a circular arc of radius 10 m. What is the maximum stress produced and the bending moment which can produce this stress respectively? (Take E = 200 GPa)

(a) 100 MPa, 32 kN-m

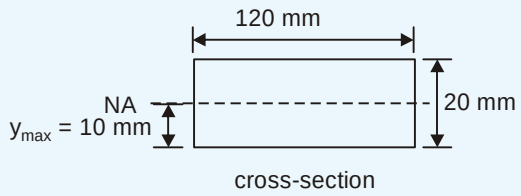
(b) 200 MPa, 160 N-mm

(c) 200 MPa, 1600 N-m

(d) 20 MPa, 160 kN-m

Ans. (c)

Sol.



Radius of curvature = 10 m, E = 200 GPa

For bending :

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

$$f_{max} = \left(\frac{E}{R}\right)y_{max} = \frac{200\times 10^3}{10\times 1000}\times 10$$

$$f_{max} = 200 \text{ MPa}$$

$$\Rightarrow \quad M_{max} = \frac{f_{max}}{y_{max}}\times I$$

$$M_{max} = \frac{200}{10}\times\frac{120\times 20^3}{12}$$

$$M_{max} = 1600000 \text{ N-mm} = 1600 \text{ N-m}$$

99. Consider the following statements regarding shearing force and bending moment:

1. Point of contraflexure is the point where bending moment changes its sign.
2. Shear force is the rate of change of bending moment.
3. For bending moment to be the maximum or minimum, shear force should change its sign.
4. Rate of change of loading is equal to shear force.

Which of the above statements are correct?

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

Ans. (d)

Sol. Statement 1, 2 and 3 are correct

Statement 4 incorrect, because

Loading intensity = Rate of change of shear force

i.e $w = \frac{dV}{dx}$

100. Consider the following statements:

Moment Area Method proves advantageous in analyzing

1. cantilever beams.
2. symmetrically loaded simply supported beams.
3. fixed beams.
4. continuous beams.

Which of the above statements are correct?

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

Ans. (c)

Sol.

Method area moment prove advantageous for

(1) Cantilever beam $\rightarrow$ Slope at fixed end is zero
(2) Symmetrically simply supported beams
$\rightarrow$ slope at mid point is zero
(3) Fixed beam $\rightarrow$ slopes at fixed support are zero

101. Consider the following statements regarding continuous beam:

1. A beam is said to be a continuous beam if it is supported on more than two supports.
2. A continuous beam is a statically indeterminate structure.
3. The degree of indeterminacy depends upon the number of supports and also on the nature of the supports.

Which of the above statements are correct?

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

Ans. (c)

Sol. All the statements are correct,

Hence, option c is the correct answer.

102. In case of flexural tension or flexural compression, the minimum length of the bar which must be embedded in concrete beyond any section to develop its full strength is termed as

(a) Twisted length (b) Flexural length
(c) Bond length (d) Development length

Ans. (d)

103. It is observed experimentally that the amplitude of free vibration of a certain structure modelled as a single degree of freedom system, decreases from 1.0 to 0.4 in 10 cycles. What is the percentage of critical damping?

(Take ln 2 = 0.693 and ln 10 = 2.303)

(a) 5.21% (b) 1.46%
(c) 2.37% (d) 3.22%

Ans. (b)

Sol. Damping ratio,

$$\xi = \frac{1}{2\pi j}\ln\left[\frac{u_i}{u_{i+j}}\right]$$

$$= \frac{1}{2\pi\times 10}\ln\left[\frac{1}{0.4}\right]$$

$$= \frac{1}{20\pi}\ln\left[\frac{10}{4}\right]$$

$$= \frac{1}{20\pi}[\ln 10 - 2\ln 2]$$

$$= \frac{1}{20\pi}[2.303 - 2\times 0.693] = 0.0146$$

$\Rightarrow$ Percentage of critical damping

$= 0.0146 \times 100 = 1.46\%$

104. The ultimate tensile strain in steel is in the range of

(a) 0.012 – 0.020 (b) 0.0012 – 0.0020

(c) 0.12 – 0.20 (d) 0.00012 – 0.00020

Ans. (c)

Sol. For mild steel,

Strain at ultimate stress $\rightarrow$ 10 to 15%

$\rightarrow$ 0.1 to 0.15

Strain at fracture point $\rightarrow$ 20 to 30%

$\rightarrow$ 0.2 to 0.3

Hence, most appropriate answer is option (c).

105. Consider the following statements regarding statically determinate structures:

1. Conditions of equilibrium are sufficient to fully analyse the structure.
2. The bending moment at a section or the force in any member is independent of the material of the components of the structure.
3. The bending moment at a section or the force in any member is independent of the cross-sectional areas of the components.

Which of the above statements are correct?

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

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

Ans. (c)

Sol. Since in statically determinate structures, equilibrium eq. is sufficient for analysis of structure, hence material & X-sectional properties are not required for analysis i.e. for determining member forces.

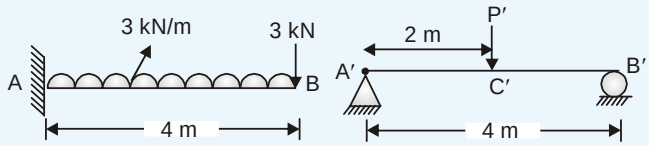
106. A cantilever beam of 4 m span carries a UDL of 3 kN/m over its entire span and a point load of 3 kN at the free end. If the same beam is simply supported at two ends, what point load at the centre should it carry to have same deflection as the cantilever?

(a) 60 kN (b) 120 kN

(c) 160 kN (d) 210 kN

Ans. (b)

Sol.



$$\delta_B = \delta'_c$$

$$\Rightarrow \frac{w\ell^4}{8EI} + \frac{P\ell^3}{3EI} = \frac{P'\ell^3}{48EI}$$

$$\frac{3\times 4^4}{8} + \frac{3\times 4^3}{3} = \frac{P'\times 4^3}{48}$$

$\Rightarrow$ $P' = 120$ kN

Hence option (b) is correct answer.

107. A beam AB of span 5 m fixed at both ends carries a UDL of 12 kN/m over the whole span. If the right end B settles down by 12 mm, what are the end moments for the beam? (Take EI = 15000 kN/m^2)

(a) M_a = 68.2 kNm (hogging) and M_b = 18.2 kNm (sagging)

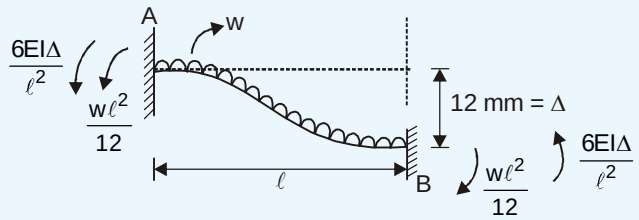
(b) M_a = 18.2 kNm (hogging) and M_b = 68.2 kNm (sagging)

(c) M_a = 68.2 kNm (hogging) and M_b = 68.2 kNm (sagging)

(d) M_a = 18.2 kNm (hogging) and M_b = 18.2 kNm (sagging)

Ans. (a)

Sol. w = 12 kN/m and ℓ = 5 m



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AIR 20 CE — BHAVYA PARASHAR

AIR 3 ME — SURAJ KUMAR SHAW

AIR 4 ME — SHUBHAM BOTHRA

AIR 5 ME — KAMLESH PARWAR

AIR 6 ME — MOHAMMAD ZUHAIB

AIR 8 ME — VUYYURU SAIKRISHNA REDDY

AIR 9 ME — GANESH KUMAR ADIGAUR

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$$M_A = \frac{w\ell^2}{12} + \frac{6EI\Delta}{\ell^2}$$

$$M_A = \frac{12\times5^2}{12} + \frac{6\times15000\times12\times10^{-3}}{5^2}$$

M_A = 68.2 kN-m (hogging)

$$M_B = \frac{w\ell^2}{12} - \frac{6EI\Delta}{\ell^2}$$

M_B = 25 – 43.2 = –18.2

M_B = 18.2 kN-m (sagging)

Hence, correct answer is option (a).

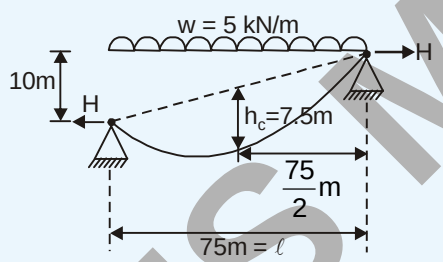
108. A cable is suspended between two points, 75 m apart horizontally with its left end lower than the right end by 10 m. The cable supports a UDL of 5 kN/m along the horizontal span. What is the horizontal tension in the cable if central sag is 7.5 m?

(a) 385.13 kN (b) 468.75 kN

(c) 145.2 kN (d) 528.62 kN

Ans. (b)

Sol.



$$\text{Horizontal tension (H)} = \frac{w\ell^2}{8h_c}$$

$$= \frac{5(75)^2}{8\times(7.5)} = 468.75 \text{ kN}$$

109. Consider the following statements related to merits of construction in structural steel:

1. Structural steel has high strength per unit weight as compared to RCC.
2. The steel members are slender or small in size as compared to RCC.
3. The steel structures are useful in construction of tall buildings, long-span bridges and airplane hangars.

Which of the above statements are correct?

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

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

Ans. (d)

Sol. Advantages of steel as construction materials:

- **High strength-to weight ratio:** The high strength-to-weight ratio of steel results in smaller section and smaller weight of structures.

  This fact is of great importance for long-span bridges, tall buildings and structures situated on soil with relatively low bearing capacity.
- **Invariability of properties:** Unlike reinforced concrete, the properties of steel do not change substantially with time in normal service.
- **Elasticity:** Steel behaves closer to design assumptions than most other materials because it follows Hooke's law up to high stresses
- **Long service life:** A properly constructed and maintained steel structure can last indefinitely.
- **Weldability:** The structural steels are perfectly weldable with welding materials having specified yield streingth, ultimate tensile strength and elongation at failure.
- **High toughness:** The toughness of structural steels enables the steel members to be subjected to large deformations when they are bent, hammered and sheared, and holes are punched during fabrication and erection without fracture.

Disadvantages of steel as construction material:

- **High maintenance cost**
- **High fire proofing cost**
- **Susceptibility to buckling:** With an increase in the length or slenderness of a compression member, possibility of buckling rapidly increases, this may require additional steel for enhancing the stiffness of member (impacting economy).

110. For a laced column, the minimum width of the lacing bars when using 20 mm nominal diameter rivets is

(a) 65 mm (b) 60 mm

(c) 55 mm (d) 50 mm

Ans. (b)

Sol. "For a laced column, the minimum flat width of lacing bar should not be less than three times the nominal diameter of end connector".

$\therefore$ Width of lacing bar = 3 × 20 mm = 60 mm

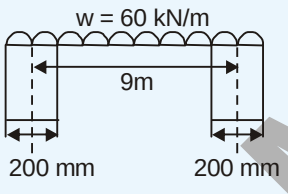
111. A beam simply supported over an effective span of 9m, carries a uniformly distributed load of 60 kN/m, inclusive of its own weight. What is the section modulus of the beam, if f_y = 250 N/mm^2 and E = 2 × 10^5 N/mm^2? (Assume width of support is 200 mm)

(a) 2612 ×10^3 mm^3 (b) 3682 ×10^3 mm^3

(c) 4682 ×10^3 mm^3 (d) 5124 ×10^3 mm^3

Ans. (b)

Sol.



L_{eff} = 9 m

Maximum perimissible bending stress in compression (σ_{bc}) = 0.66 f_y

$\therefore$ σ_{bc} = 0.66 × 250 = 165 N/mm^2

Maximum BM = $\frac{w\ell^2}{8} = \frac{60\times 9^2}{8}$ = 607.5 kNm

= 607.5 × 10^6 Nmm

Section modulus (Z) = $\frac{M}{\sigma_{bc}} = \frac{607.5\times 10^6}{165}$

= 3681.8 × 10^3 mm^3

≃ 3682.2 × 10^3 mm^3

112. Consider the following statements related to batten plates:

1. These normally consist of flat plates, connecting the components of the built-up columns in two parallel planes.
2. These are used fro triaxial loading.
3. The design of battened columns and the design of battens are usually governed by IS code requirements.

Which of the above statements are correct?

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

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

Ans. (a)

Sol.

- Battens are plates or any other rolled sections used to connect the main components of compression members.
- Battens should be placed opposite to each other on two parallel faces of the compression member.

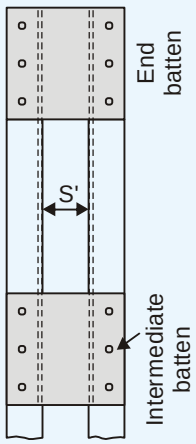


Fig.Batten

- IS 800:2007, clause 7.7.2 deals with the design of battens.
- Batten are not used for triaxial loading.
- Battens are not recommended for a column subjected to an eccentric load is plane of connecting system.
- Batten plates are designed to carry the bending moment and shear arising from the transverse shear, which is equal to 2.5% of total axial force on the whole compression member.

113. Consider the following statements related to design of tension member with single structural shapes and plates:

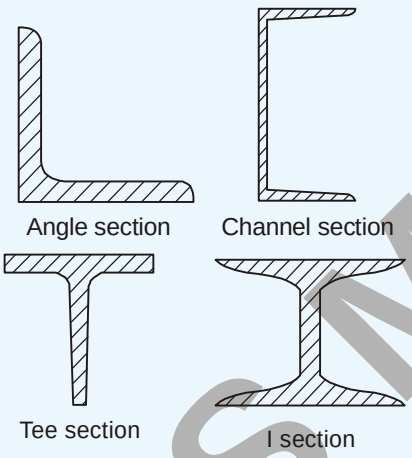
1. The common single structural shapes are angle sections, tee sections and channel sections.
2. Single angles are not used for bracing for light truss tension members.
3. Occasionally, I sections are also used as tension members as they have more rigidity.

Which of the above statements are correct?

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

Ans. (a)

Sol.
- The common single structural shapes are angle sections, tee sections and channel sections.



- Angle sections are mainly used for bracing, for light truss tension members.
- Angle sections can also resist small compression if reversal of stress takes place.
- Occassionally, I sections are also used as tension members as they have more rigidity. I sections are used as tension members in heavier building or bridge trusses with double plane construction.
- When the member is required to take heavy tensile load, built up section consisting of two or more plates are used.

114. Consider the following statements regarding the advantages of a good organization:

1. It increases cooperation and a feeling of freedom.
2. It prevents duplication of work.
3. It makes communication easier.
4. It increases the likelihood of run-arounds.

Which of the above statements are correct?

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

Ans. (a)

115. For design of a roof truss, if the design wind velocity is 20 m/s, what is the design wind pressure?

(a) 400 N/m^2 (b) 40 N/m^2
(c) 240 N/m^2 (d) 200 N/m^2

Ans. (c)

Sol. Design wind pressure $(P_z) = 0.6\ V_z^2$

P_z = Design wind pressure in N/m^2 at height Z.

$\therefore\ P_z = 0.6 \times 20^2 = 240$ N/m^2

116. Consider the following statements:

1. The working stress design is based on explicit consideration of the various conditions under which the structure may cease to fulfil its intended function.
2. In case of working stress design, structure will directly take into consideration the various relevant modes of failure.
3. In working stress method, regulatory bodies or classification societies usually specify the value of the allowable stress as some fraction of the mechanical properties of materials.

Which of the above statements is/are correct?

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

Ans. (d)

Sol.
- Limit state design is based on the explicit consideration of the various conditions under which the structure may cease to fulfill its intended function.

- Structure can not directly take into considerations the relevant modes of failure. For example, increase in stress near the openings of a steel plate can not be accounted for directly in working stress method.
- In working stress method, regulatory bodies or classification societies usually specify the value of the allowable stress as some fraction of the mechanical properties of materials that is usually based on similar past experience.

117. Consider the following statements regarding the working stress design method:

1. Working stress design is based on the elastic theory.
2. The working stress in the member should be less than the permissible stress.
3. The permissible stress is the ratio of the factor of safety to the yield stress.
4. The permissible stresses for fasteners are usually based on the ultimate strength of the connection.

Which of the above statements is/are **not** correct?

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

Ans. (b)

Sol.
- Working stress design method (WSDM) is based on elastic theory.
- Attainment of initial yielding forms the design criteria for the members in this method.
- The working stress should be less than permissible stress.
- Permissible stress is defined as the ratio of yield stress to the factor of safety.
- The permissible stresses for fasteners are usually based on the ultimate strength of the connection using Factor of safety values of about 2 and 3 for various fasteners.

Note:
- When the yield point is well defined,

$$\text{FOS} = \frac{\text{Yield stress}}{\text{Maximum expected stress}}$$

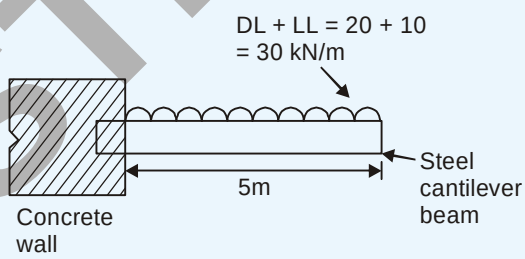
- Factor of safety (FOS) may also be defined as the ratio of strength of member to the expected force.

118. A steel cantilever beam is proposed to build into a concrete wall at one end and other end is free. It supports a dead load of 20 kN/m and a live load of 10 kN/m. The length of the beam is 5 m. What are the shear force and bending moment respectively? (Take yield strength of steel as 250 N/mm^2)

(a) 225 kN and 562.5 kNm
(b) 22.5 kN and 56.25 kNm
(c) 225 kN and 56.25 kNm
(d) 22.5 kN and 562.5 kNm

Ans. (a)

Sol.



Span of beam (L) = 5m

Ultmate load (w_u) = (30 × 1.5) kN/m

Shear force (V_u) = $w_u \times L$
= 30 × 1.5 × 5
= 225 kN

Bending moment (M_u) = $30 \times 1.5 \times 5 \times \frac{5}{2}$
= 562.5 kNm.

119. Consider the following for local capacity of section:

1. Local section failure is usually encountered in the case of short stocky beam-columns with relatively smaller axial compression ratio and beam-columns bent in reverse curvature.
2. The strength of end section reached under combined axial force and bending, governs the failure.
3. The strength of the section may be governed by plastic buckling of plate elements in the

case of plastic, compact and semi-compact and semi-compact sections.

Which of the above statements are correct?

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

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

Ans. (c)

Sol. Check for local capacity of section:

- The local section failure is usually encountered in the case of short stocky beam column with relatively smaller axial compression ratio and beam-column bent in reverse curvature.
- The strength of end section reached under combined axial force and bending, governs the failure.
- The strength of the section may be governed by plastic buckling of plate elements in the case of plastic, compact and semi compact sections or by the elastic buckling of plate elements of slender sections.

120. A tension member of a roof truss carries a factored load of 430 kN. By considering the strength in yield, what is the gross area required to carry this load? (Consider Fe 250 grade steel)

(a) 1892 mm^2 (b) 1978 mm^2

(c) 1903 mm^2 (d) 2150 mm^2

Ans. (a)

Sol.

Factored load (F_u) = 430 kN

Grade of steel = 250

Tensile strength due to gross section yeilding

$$(T_{dg}) = \frac{A_g f_y}{\gamma_{m_0}}$$

Putting, $T_{dg} = F_u$ and $\gamma_{m_0} = 1.1$

$$\therefore A_g = \frac{430\times10^3}{\frac{250}{1.1}} = 1892 \text{ mm}^2$$

121. Stirrup area in excess of that required for shear and torsion is provided along each terminated bar over a distance from the cut-off point equal to

(a) three-fourth the effective depth of the member.

(b) one-third the effective depth of the member.

(c) two-third the effective depth of the member.

(d) one-fourth the effective depth of the member.

Ans. (a)

Sol. Per IS 456:2000, clause no 26.2.3.2 (b), the correct option shall be (a)

122. Which one of the following is **not** a type of mortar?

(a) Lime surkhi mortar

(b) Cement sand mortar

(c) Cement stone chips mortar

(d) Cement lime mortar

Ans. (c)

Sol. Cement stone chips mortar is not a type of mortar

123. The grade of concrete and reinforcement are M-20 and Fe-250 respectively. Consider 25 mm diameter bars and τ_{bd} is 1.2. What is the development length at support for a simply supported beam of a rectangular section?

(a) 1133 mm (b) 1033 mm

(c) 1321 mm (d) 1232 mm

Ans. (a)

Sol. The development length $L_d = \dfrac{0.87 f_y \phi}{4\tau_{bd}}$

$$= \frac{0.87\times250\times25}{4\times1.20} = 1132.81 \text{ mm} \cong 1133 \text{ mm}$$

124. In a singly reinforced beam, for given grade of concrete, permissible bond stress in deformed bars

(a) is lesser than that of plain bars.

(b) is equal to that of plain bars.

(c) may be greater than or smaller than that of plain bars.

(d) is greater than that of plain bars.

Ans. (d)

Sol. As per IS 456:2000, clause no 26.2.1.1, permissible bond stress in deformed bars shall be increased by 60% of permissible bond stress of plain bars.

125. The safe load carried by the helically reinforced column is

(a) 1.05 times the load carried by the similar column with ties.

(b) 2.15 times the load carried by the similar column with ties.

(c) 1.15 times the load carried by the similar column with ties.

(d) 2.05 times the load carried by the similar column with ties.

Ans. (a)

Sol. As per IS 456 : 2000, clause no 39.4, the strength of compression members with helical reinforcement shall be taken as 1.05 times the strength of similar member with lateral ties.

126. Nominal cover to reinforcement is provided to

(1) protect reinforcement against corrosion.

(2) provide shear resistance.

(3) protect reinforcement against fire.

(4) develop sufficient bond strength along surface area of reinforcement bars.

Which of the above statements are correct?

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

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

Ans. (c)

127. In slab design, ratio of maximum diameter of reinforcing bars to the total thickness of slab should not be more than

(a) 1/12 (b) 1/6

(c) 1/8 (d) 1/7

Ans. (c)

Sol. As per IS 456:2000, clause no 26.5.2.2, the diameter of reinforcing bar shall not exceed one eight of the total thickness of the slab.

128. To prevent cracking of edges, the corners in two way slab are provided with

(a) shear reinforcement

(b) torsion reinforcement

(c) tensile reinforcement

(d) compression reinforcement

Ans. (b)

129. Critical section for two way shear in case of isolated footing design is at

(a) the face of column.

(b) effective depth from the face of column.

(c) half of the effective depth from the face of column.

(d) two-third of the effective depth from the face of column.

Ans. (c)

Sol. As per IS 456:2000, clause no. 34.2.4.1 (b), the correct option shall be option (c).

130. Accepted relationship between tread and riser in case of staircase design is

(a) Riser × Tread = 60,000 mm^2

(b) 2 × Riser + Tread = 600 mm

(c) Riser + Tread = 600 mm

(d) 2 × Tread + Riser = 600 mm

Ans. (b)

Sol. In general, 2 × Riser + Tread = 580 mm to 600 mm.

131. Loss of pre-stress is not directly related to

(a) creep of concrete.

(b) shrinkage of concrete.

(c) grade of concrete.

(d) slipping of steel tendons from concrete.

Ans. (d)

Sol. Slipping of steel tendons from concrete is not considered as it is assumed that there will be perfect bond between steel and concrete.

132. Which one of the following statements is the disadvantage of post-tensioning method?

(a) The loss of pre-stress is less as compared to pre-tensioning system.

(b) Post-tensioning method is costly as compared to pre-tensioning method.

(c) Post-tensioning can be done in factories and at the site also.

(d) Post-tensioning method is used for large spans and heavily loaded structures.

Ans. (b)

133. What is the main limitation of bar chart?

(a) It does not help in material and labour planning.

(b) It does not show all the activities of a project.

(c) It does not indicate critical activities of a project.

(d) Project duration cannot be estimated.

Ans. (c)

134. Graders are not suitable for

(a) levelling of earthwork.

(b) cutting ditches.

(c) working on steeper slopes.

(d) heavy excavation.

Ans. (d)

Sol.

→ Graders are multipurpose machines and used for finishing, shaping, bank sloping and ditching.

→ They are also used for mixing, spreading, side casting, leveling and crowning, light stripping operations, general construction, and direct road maintenance.

→ A grader's primary purpose in cutting and moving mateial with the moldboard.

Note: Graders are restricted to making shallow cuts in medium-hard materials; they should not be used for heavy excavation.

135. Line of Balance technique is

(a) modified bar chart.

(b) planning of repetitive activities of a project.

(c) modified form of PERT.

(d) used for planning milestones of a project.

Ans. (b)

136. Which one of the following statements is not correct in respect of drawing network?

(a) No activity can start until its tail event has occurred.

(b) An event cannot occur twice.

(c) Length of arrow should be in proportion to the time consumed by that activity.

(d) The number of arrows should be equal to the number of activities in the project.

Ans. (c)

Sol. Arrows in a network diagram are not vectors. They are never used to indicate duration (or time) through its length. All arrows should be of nearly equalsize wherever possibley i.e., wide variation in length of arrows should be avoided.

137. A-O-N system of network

(a) completely eliminates the use of dummy activities.

(b) requires judicious use of dummy activities.

(c) does not distinctly show pre-operation and post-operation of the activities.

(d) is not suitable for projects with large number of activities.

Ans. (a)

Sol. A-O-N system of network completely eliminates the use of dummy activities as it is self sufficient to fulfill the grammatical and logical purpose regarding the project.

138. Which one of the following types of cost-plus contracts allows the amount of the re-imbursement to increase if the contractor's cost increases

(a) Cost-plus award fee contract

(b) Cost-plus incentive fee contract

(c) Cost-plus fixed fee contract

(d) Cost-plus percentage fee contract

Ans. (d)

Sol. Cost-plus percentage fee contract:

→ Contractor gets profit as percentage of total cost incurred by him.

→ Profit increases with an increase in total cost.

139. Number of bricks required for 15 cu.m of brickwork is approximately

(a) 6750 (b) 7200

(c) 7500 (d) 6000

Ans. (c)

Sol. We know that,

Nominal size of brick = 20cm × 10cm × 10cm

∴ For 1 m^3 brick work,

Number of bricks required = $\left(\frac{1\times10^6}{20\times20\times10}\right)$

= 500

∴ For 15 m^3 of brick work,

Number of bricks required = (15 × 500) = 7500

140. The plinth area of a building does not include area of

(a) the walls at the floor levels.

(b) internal shaft for sanitary installations upto 2 sq.m area.

(c) lifts.

(d) cantilevered porches.

Ans. (d)

Sol. Plinth area is the built up covered area of a building measured at floor level of any storey.

The following shall be included in the plinth area:

(i) All floors, area of walls at the floor level excluding plinth offsets, if any.

(ii) Internal shaft for sanitory installations provided that these do not exceed 2 m^2 in area.

(iii) Air condition ducts, lifts, etc.

(iv) The area of barsati and the area of at terrace level.

(v) Area of porches other than cantilevered.

Note: Court-yard, open areas, balconies and cantilever projections are not included in the plinth area.

141. Which one of the following statements is not correct?

(a) The circulation area of any floor includes entrance halls.

(b) Floor area of a building includes area of sills of doors and other openings.

(c) Cube rate estimate of a building is more accurate as compared to plinth area estimate.

(d) The preliminary estimate for water supply and sewerage project can be prepared on the basis of per head of population served.

Ans. (b)

Sol. Floor area of a building is the total area of floor in between walls and consists of floor of all rooms, verandals, passages, corridors, staircase rooms, entrance hall, kitchen, stores, bath and latrine (W.Cs), etc.

Notes: Sills of doors and other openings are not included in the floor area.

142. Consider the following statements regarding the advantages in Line or Military Organization of management technique:

(1) The command and control is very effective.

(2) It is simple to work and easily understood by the employees.

(3) Responsibilities in all levels are definite and fixed.

(4) The organization is rigid.

Which of the above statements are correct?

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

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

Ans. (a)

143. Project management audit consists of which of the following?

(1) Project work-breakdown structure verification and the relevance.

(2) Risk identification, cost, levels and security.

(3) Measurements of risk impacts.

Select the correct answer using the code given below:

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

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

Ans. (c)

144. Consider the following statements regarding inspection and quality control:

(1) Coefficient of variation is a relative measure of dispersion.

(2) Standard deviation is the root mean square of the deviation of all the results.

(3) Standard deviation is relative measure of dispersion.

(4) Lower value of standard deviation indicates low degree of uniformity of observations.

Which of the above statements are correct?

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

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

Ans. (c)

Directions: Each of the next six (06) items consists of two statements, one labelled as the 'Statement (I)' and the other as 'Statement (II)'. You are to 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

145. **Statement (I):** The theoretical strength of concrete as per Gel-Space ratio theory is less than the actual strength of concrete.

Statement (II): In the Gel-Space ratio theory, it has been assumed that the concrete is perfectly homogeneous and flawless.

Ans. (d)

Sol. The limitation of Gel-space ratio theory is that the theoretical strength of concrete is much more than the actual strength of concrete.

146. **Statement (I):** Spur length is kept longer than 1.5 to 2 times the depth of flow.

Statement (II): Shorter spur length in deeper rivers induces swirling motion on both the upstream and downstream sides of the spur.

Ans. (d)

Sol. No general rule is formulated for selection of spur length. It depends on the position of existing bank line and the desired position of bank line after the training works.

Hence Statement I is wrong, thus correct answer is option (d).

147. **Statement (I):** Both the Empirical formulae given by American Insurance Association and Buston for the determination of fire demand of water are not suitable for Indian conditions.

Statement (II): Kuichling's formula estimates lesser value of fire water demand.

Ans. (b)

Sol.
- Freeman's formula nation board of fire under writer's formula (now known as American Insurance Association and Buston's formula give higher values of fire demand which are not suitable as for as Indian conditions are concerned.
- Kuichling's formula estimates lesser value of fire water demand.

148. **Statement (I):** For the design of slender column, additional moments are required to be considered.

Statement (II): Lateral deflection of slender columns, under axial load, is substantial and causes additional moments.

Ans. (a)

149. **Statement (I):** To achieve maximum value for minimum radius of gyration of compression members, without increasing the area of the section, a number of elements are placed away from the principal axis using suitable lateral systems.

Statement (II): Batten shall be placed at 40° to 70° to the axis of built-up members.

Ans. **(c)**

Sol. In order to increase the radius of gyration, we need to increase the moment of inertia of the built up section and this can be done by placing the elements away from the principal axis.

Lacing shall be placed at 40° to 70° to the axis of built up members and batten shall be placed in the transverse direction. So this statement is incorrect.

150. **Statement (I):** Chain surveying is that type of surveying in which only linear measurements are made in the field.

Statement (II): Traversing is that type of survey in which a number of connected survey lines from the framework and the directions and lengths of the survey lines are measured with the help of an angle measuring instrument and a tape respectively.

Ans. **(b)**