



ESE 2026

Prelims Solutions

**Civil
Engineering**

SET-D

Exam held on 08-02-2026

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CIVIL ENGINEERING
Paper Analysis of ESE 2026
Preliminary Examination

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- Q.1** Which one of the following statements is not correct regarding soil sampling?
- (a) In open drive sampler, the most widely used sample tube has an internal diameter of 100 mm and a length of 450 mm. The area ratio is approximately 30%.
 - (b) In thin-walled sampler, the internal diameter may range from 35 to 100 mm. The area ratio is approximately 100%.
 - (c) In split-barrel sampler, the internal and external diameters are 35 and 50 mm, respectively. The area ratio is approximately 100%.
 - (d) Continuous sampler is highly specialized type of sampler which is capable of obtaining undisturbed samples up to 25 m in length. The sampler is used mainly in soft clays.

Ans. (b)

As thin walled-sampler (like the Shelby tube) is designed to minimize disturbance. Therefore, its area ratio is low, typically less than 10%.

End of Solution

- Q.2** Which one of the following statements is not correct regarding Taylor's stability number?
- (a) Taylor's stability number N is defined as $C_m/\gamma H$.
 - (b) The procedure is based on the Swedish method of slices.
 - (c) The results are embodied in Taylor's design charts which may be used for determining the factor of safety of a slope or for designing the height for a desired safety factor.
 - (d) It is an analytical approach.

Ans. (b)

Taylor's stability method is not based on the Swedish (Fellenius) method of slice. Method of slices are different class of slope stability.

End of Solution

- Q.3** A sample of sand, 5 cm in diameter and 15 cm long, was prepared at a porosity of 60% in a constant-head apparatus. The total head was kept constant at 30 cm and the amount of water collected in 5 seconds was 40 cm³. The test temperature was 20°C. What is the seepage velocity?

- (a) 0.21 cm/s
- (b) 0.98 cm/s
- (c) 0.67 cm/s
- (d) 0.45 cm/s

Ans. (c)

Given: $d = 5$ cm, $l = 15$ cm, $\eta = 0.60$

Discharge, $Q = vA$

$$\Rightarrow 8 \text{ cm}^3/\text{s} = v \times \frac{\pi}{4} \times 5^2$$

$$\text{Seepage velocity} = \frac{v}{n} = \frac{8}{\frac{\pi}{4} \times 5^2 \times 0.6} = 0.68 \text{ cm/s}$$

End of Solution

Q.4 A soil layer is partially saturated due to capillary action and the degree of saturation is 50%. The height of point 'x' under consideration measured from groundwater table is 0.25 m. Assume unit weight of water is 10 kN/m^3 . What is the approximate pore water pressure at point 'x'?

- (a) -2.5 kN/m^2 (b) -1.5 kN/m^2
(c) -1.25 kN/m^2 (d) -2.75 kN/m^2

Ans. (c)

For partially saturated soil under capillary action, the pore water pressure is approximated as

$$\begin{aligned} u &= -S_{\gamma_w} h \\ &= -0.5 \times 10 \times 0.25 \\ &= -1.25 \text{ kN/m}^2 \end{aligned}$$

End of Solution

Q.5 Which one of the following statements is not correct regarding clay minerals?

- (a) The typical range of shrinkage limit of Kaolinite is 8.5 - 15.
(b) The typical range of shrinkage limit of Illite is 15 - 17.
(c) The typical range of liquid limit of Montmorillonite is 100 - 900.
(d) The typical range of plastic limit of Montmorillonite is 50 - 100.

Ans. (a)

| Consistency limits based on clay minerals | | | |
|---|------------------|-------------------|---------------------|
| Mineral | Liquid limit (%) | Plastic limit (%) | Shrinkage limit (%) |
| Montmorillonite | 100 – 900 | 50 – 100 | 8.5 – 15 |
| Kaolinite | 30 – 110 | 25 – 40 | 25 – 29 |
| Illite | 60 – 120 | 35 – 60 | 15 – 17 |

End of Solution

Q.6 A dam has been constructed across a river over a permeable stratum of soil of limited thickness. The head of water on the upstream side is 18 m and on the downstream side is 8 m. The flow net constructed across the dam gives N_f as 6 and N_d as 12. If the equivalent coefficient of permeability is $1.28 \times 10^{-3} \text{ cm/s}$, what is the quantity of seepage per unit length of the section per cm length of dam?

- (a) $0.64 \times 10^{-3} \text{ cm}^3/\text{s}$ (b) $0.64 \text{ cm}^3/\text{s}$
(c) $2.56 \times 10^{-3} \text{ cm}^3/\text{s}$ (d) $2.56 \text{ cm}^3/\text{s}$

Ans. (b)

Given: $N_f = 6$, $N_d = 12$, $k = 1.28 \times 10^{-5} \text{ m/sec}$

Seepage per unit length of dam, $q = kH \frac{N_f}{N_d}$

$$\Rightarrow q = 1.28 \times 10^{-5} \times (18 - 8) \times \frac{6}{12}$$

Ans. (b)

- Bacteria → Salmonella typhosa
- Virus → Hepatovirus A
- Protozoa → Entamoeba histolytica
- Helminths → Ancylostoma

End of Solution

Q.9 What is the BOD₅ of a water sample for the given data?

Temperature of sample = 16°C; Initial dissolved oxygen corresponding temperature is 10 mg/L; Dilution is 1:30, with seeded dilution water; Final dissolved oxygen of seeded dilution water is 8 mg/L; Final dissolved oxygen bottle with sample and seeded dilution water is 2 mg/L; Volume of BOD bottle is 300 mL.

- (a) 183 mg/L (b) 153 mg/L
(c) 220 mg/L (d) 250 mg/L

Ans. (a)

Given:

$$T = 16^{\circ}\text{C}$$

$$\text{D.O} = 10 \text{ mg/l, D.F} = 1:30$$

$$(\text{D.O}_i) = 8 \text{ mg/l, (For seeded dilution water)}$$

$$(\text{D.O}_i) = 2 \text{ mg/l (For sample)}$$

DO drop from sample seeded water = 10 – 8 = 2 mg/l

DO drop from seed alone = 10 – 2 = 8 mg/l

$$\text{BOD} = \left(8 - (2) \times \frac{(290)}{300} \right) \times \frac{300}{10} = 183 \text{ mg/l}$$

End of Solution

Q.10 As per the Manual on Water Supply and Treatment, Ministry of Urban Development, GOI, the fire demand for 1 lakh population is:

- (a) 41,760 L/min (b) 35,050 L/min
(c) 31,625 L/min (d) 21,960 L/min

Ans. (a)

Given,

$$P = 1 \text{ lakh} = 100 \text{ thousand}$$

By national board of fire underwriter's formula,

$$\begin{aligned} \text{Fire demand (l/min)} &= 4637\sqrt{P}(1-0.01\sqrt{P}) \\ &= 4637 \times \sqrt{100}(1-0.01\sqrt{100}) \\ &= 41760 \text{ l/min} \end{aligned}$$

End of Solution

- Q.11** As per IS 10500:2012, the value of Nitrate in drinking water should be in the range of:
 (a) up to 45 mg/L (b) up to 60 mg/L
 (c) up to 30 mg/L (d) up to 15 mg/L

Ans. (a)

Refer IS 10500 : 2012 Table 2

Acceptable limit for nitrates in drinking water = 45 mg/l

If $\text{NO}_3 > 45$ mg/l it causes blue baby syndrome.

End of Solution

- Q.12** A confined aquifer is 6 m deep and the coefficient of permeability in the soil is $2 \text{ m}^3/\text{day}\cdot\text{m}^2$. The wells are 100 m apart, and the difference in the water elevation in the wells is 3.0 m. The superficial velocity through the aquifer is:
 (a) 0.09 m/day (b) 0.12 m/day
 (c) 0.03 m/day (d) 0.06 m/day

Ans. (d)

Given: $d = 100 \text{ m}$, $h = 3.0 \text{ m}$, $k = 2 \text{ m/day}$

$$\therefore i = \frac{h}{d} = \frac{3}{100} = 0.03 \text{ (hydraulic gradient)}$$

$$\therefore V = Ki \text{ (As per Darcy's law)}$$

$$V = 2 \times 0.03 \text{ m/day} = 0.06 \text{ m/day}$$

End of Solution

- Q.13** A wastewater is expected to have BOD_3^{27} of about 300 mg/L. The initial DO of dilution water is 8.5 mg/L. The minimum DO that should remain is 1.5 mg/L. The dilution requirement for BOD determination is:
 (a) 100 times dilution of the sample
 (b) 50 times dilution of the sample
 (c) 200 times dilution of the sample
 (d) 150 times dilution of the sample

Ans. (b)

Given, $(\text{BOD})_3^{27^\circ\text{C}} = 300 \text{ mg/l}$

$$300 \text{ mg/l} = (\text{DO}_i - 1.5) \times \text{Dilution ratio}$$

$$300 \text{ mg/l} = (8.5 - 1.5) \times \text{Dilution ratio}$$

$$\text{Dilution ratio} = \frac{300}{6} = 50$$

End of Solution

- Q.14** A sample of sludge has an SS concentration of 4000 mg/L. After settling for 30 minutes in a 1 L cylinder, the sludge occupies 400 mL. The Sludge Volume Index is:
 (a) 100 (b) 50
 (c) 200 (d) 150



Ans. (a)

Given: Suspended solid

Concentration = 4000 mg/l

Sludge volume = 400 mL in 1 litre

$$SVI = \frac{400\text{ml}}{4000\text{mg}} = 100 \text{ ml/g}$$

End of Solution

Q.15 Raw primary and waste activated sludge containing 4% solids is to be anaerobically digested at a loading of 3 kg/(m³ day). The total sludge produced in the plant is 1500 kg of dry solids per day. Assume 1 L of sludge weighs about 1 kg. The approximate hydraulic retention time required is:

(a) 13.5 days

(b) 15.5 days

(c) 10.5 days

(d) 12.5 days

Ans. (a)

Given: Total sludge solid = 1500 kg

$$\text{Total sludge} = \frac{1500}{0.04} = 37500\text{kg}$$

(Given: Solid = 4%)

$$\text{HRT} = \frac{V}{Q}$$

$$\text{Volume} = \frac{1500\text{kg/d}}{3 \text{ kg/m}^3/\text{day}} = 500\text{m}^3$$

$$\text{HRT} = \frac{500\text{m}^3}{37.5\text{m}^3/\text{day}} = 13.5\text{days}$$

End of Solution

Q.16 Which one of the following is not correct regarding measurement of horizontal distances?

(a) Absolute correction of chain or tape = True length – Nominal length.

(b) Steel Tape will give better result than invar tape.

(c) Tape or chain supported at the two ends will always sag.

(d) The correction due to 'chain or tape not horizontal' is always subtractive.

Ans. (b)

A steel tape cannot give better results than an invar tape as the invar tape has very low coefficient of thermal expansion. Hence, an invar tape is more precise.

End of Solution



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Q.17 In levelling, what is the combined correction (curvature and refraction) at a distance of 1 km?

- (a) 6.7×10^{-6} m (b) 0.067 m
(c) 167.5 m (d) 670 m

Ans. (b)

Given $d = 1$ km
Combined correction due to curvature and refraction is given as

$$C = C_C + C_R$$

$$\Rightarrow C = (-0.0785d^2) + (0.0112d^2)$$

$$\Rightarrow C = 0.0673 d^2$$

where C is in meters and d in kilometers.

Here, $C = -0.0673 \times 1^2 = -0.0673$ m

End of Solution

Q.18 For setting out a rectangular platform ABCD, a rotating construction laser was used. It gave a reading of 0.878 m on a temporary B.M., having a level 45.110 m. The lowest corner A has a level 45.30 m. The platform has a cross fall of 1 in 1000 longitudinally and 1 in 250 transversely. If the platform is 8 m longitudinally, i.e., along AD or BD, and 40 m transversely, i.e., along AB or DC, what is the offset from the laser beam to the corner C of the platform?

- (a) 0.688 m (b) 0.528 m
(c) 0.520 m (d) 0.680 m

Ans. (c)

$$\text{RL of laser} = \text{RL of BM} + \text{Sight reading}$$

$$\text{RL of laser} = 45.110 + 0.878 = 45.988 \text{ m}$$

$$\text{RL of D} = \text{RL of A} + \text{longitudinal cross fall @ D}$$

$$\text{RL of D} = 45.30 + 8 \times \frac{1}{1000} = 45.308 \text{ m}$$

$$\text{RL of C} = \text{RL of D} + \text{transverse crossfall @ C}$$

$$\text{RL of C} = 45.30 + 40 \times \frac{1}{250} = 45.468 \text{ m}$$

Offset from the laser of corner C,

$$= 45.988 - 45.468 = 0.520 \text{ m}$$

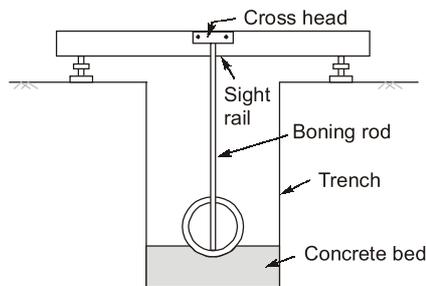
End of Solution

Q.19 Sight rails are used for setting out:

- (a) large buildings
(b) bridges
(c) the gradient of canal beds
(d) the gradient of trench or bottom or pipe inverts

Ans. (d)

Sight rails are specifically used in sewer, pipeline works. They are fixed at a known height and along with boning rods help to transfer and maintain the required longitudinal gradient of trench bottoms are pipe inverts during excavation.



End of Solution

Q.20 Location of points by resection requires pointings made on at least:

- (a) one known station (b) two known stations
(c) three known stations (d) four known stations

Ans. (b)

In resection, the instrument is at an unknown point, and we determine its position by observing directions to known control stations. Two known points, give unique intersections.

End of Solution

Q.21 Consider the length of the curve as L and radius of the curve as R . For a transition curve, the shift S of a circular curve is:

- (a) $R^2/12L$ (b) $L^2/24R$
(c) $L^2/24R^2$ (d) $L^2/12R$

Ans. (b)

$$\text{Shift of curve, } S = \frac{L^2}{24R}$$

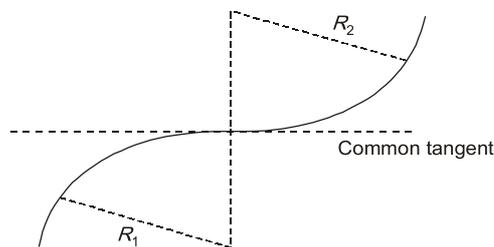
where, L = Length of curve
 R = Radius of curve

End of Solution

Q.22 A reverse curve consists of:

- (a) two circular arcs of different radii with their centres of curvature on the same side of the different tangents only.
- (b) two circular arcs of same radius with their centres of curvature on the same side of the common tangent only.
- (c) two circular arcs of different radii with their centres of curvature on the opposite side of the different tangents only.
- (d) two circular arcs of same or different radii with their centres of curvature on the opposite side of the common tangent.

Ans. (d)



End of Solution

Q.23 A parabola is preferred for vertical curves because:

- (a) The slope is constant throughout.
- (b) The rate of change of grade is constant throughout.
- (c) The rate of change of radial acceleration is constant throughout.
- (d) The rate of change of radial acceleration is zero.

Ans. (b)

This is the defining property of a parabolic vertical curve.

End of Solution

Q.24 Maximum ordinate on a Mass Haul Diagram occurs:

- (a) at the end of a cut.
- (b) at the end of an embankment.
- (c) when cut and fill are balanced.
- (d) at the midpoint of the cut.

Ans. (c)

In a mass haul diagram, the ordinate represents cumulative earthwork. The maximum ordinate happens at the point where, excavation cut to that point is exactly balanced by embankment (fill) beyond that point.

End of Solution

- Q.28** A footing $2.5 \text{ m} \times 2.5 \text{ m}$ carries a pressure of 400 kN/m^2 at a depth of 1 m in sand. The saturated unit weight of the sand is 20 kN/m^3 and the unit weight above the water table is 17 kN/m^3 . The design shear strength parameters are $c' = 0$ and $\phi = 40^\circ$ ($N_q = 64$; $N_\gamma = 95$). What is the factor of safety with respect to shear failure, if the water table is 5 m below ground level?
- (a) 1.5 (b) 6
(c) 7 (d) 3

Ans. (c)

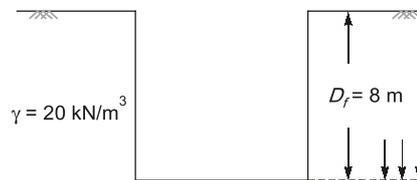
$$\begin{aligned} \text{Ultimate bearing capacity, } q_u &= qN_q + 0.4B\gamma N_\gamma \\ &= 17 \times 64 + 0.4 \times 17 \times 2.5 \times 95 = 2703 \text{ kN/m}^2 \end{aligned}$$

$$\text{FOS} = \frac{q_u}{q_{\text{applied}}} = \frac{2703}{400} = 6.76 \approx 7$$

End of Solution

- Q.29** A long braced excavation in soft clay is 4 m wide and 8 m deep. The saturated unit weight of the clay is 20 kN/m^3 and the undrained shear strength adjacent to the bottom of the excavation is given by $c_u = 40 \text{ kN/m}^2$ ($\phi_u = 0$). What is the factor of safety against base failure of the excavation? (Take $N_c = 7.1$)
- (a) 1.5 (b) 3.25
(c) 1.25 (d) 1.8

Ans. (d)



For base heave in soft clay, we compare:

$$\begin{aligned} \text{Resisting pressure} &= c_u N_c \\ \text{Driving pressure} &= \gamma D_f \end{aligned}$$

$$\text{FOS} = \frac{\text{Resisting pressure}}{\text{Driving pressure}} = \frac{40 \times 7.1}{20 \times 8} = 1.775 \approx 1.8$$

End of Solution

- Q.30** Which one of the following is not correct regarding the typical values of the coefficient of earth pressure at rest?
- (a) For dense sand: 0.35 (b) For loose sand: 0.6
(c) Normally consolidated clay: 0.55 (d) Overconsolidated clay: 0.25

Ans. (d)

$$(K_o)_{OCC} = (K_o)_{NCC} \sqrt{OCR}$$

As, $OCR > 1$

$$(K_o)_{OCC} > (K_o)_{NCC}$$

End of Solution



Q.31 Identify the correct sequence of treatment flow scheme for groundwater with low mineral content but presence of objectionable gases:

- (a) Raw Water - Aeration - Disinfectant - Disinfection Tank - Supply
- (b) Raw Water - Disinfection Tank - Disinfectant - Aeration - Supply
- (c) Raw Water - Disinfectant - Disinfection Tank - Sedimentation Tank - Aeration - Supply
- (d) Raw Water - Disinfection Tank - Aeration - Sedimentation Tank - Supply

Ans. (a)

End of Solution

Q.32 In solid waste management, compaction ratio is defined as:

- (a) the ratio of the as-compacted density to the as-discarded density.
- (b) the ratio of the as-discarded density to the as-compacted density.
- (c) the ratio of the as-deposited density to the as-compacted density.
- (d) the ratio of the as-compacted density to the as-deposited density.

Ans. (d)

$$\text{Compaction ratio} = \frac{\text{Compacted density at landfill}}{\text{Deposited density at landfill}}$$

End of Solution

Q.33 Which of the following statements are correct regarding sound in environmental engineering?

- 1. Sound Intensity can be defined as the time-weighted average sound power per unit area normal to the direction of propagation of the sound wave.
- 2. Sound Intensity can be defined as the time-weighted average sound power per unit area parallel to the direction of propagation of the sound wave.
- 3. Sound Pressure can be defined as the force on a unit surface area perpendicular to the direction of the sound.
- 4. Sound Pressure can be defined as the force on a unit surface area parallel to the direction of the sound.

Select the correct answer using the code given below:

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

Ans. (b)

End of Solution

Q.34 Match the following lists:

| List-I | | List-II | |
|--------|--------------|---------|--|
| P. | IS 4954:1968 | 1. | Measurement of noise emitted by moving vehicles |
| Q. | IS 3028:1998 | 2. | Code of practice for noise reduction in industrial buildings |
| R. | IS 4758:1968 | 3. | Recommendations for noise abatement in town planning |
| S. | IS 3483:1965 | 4. | Methods of measurement for noise emitted by machines |

| | P | Q | R | S |
|-----|---|---|---|---|
| (a) | 4 | 3 | 2 | 1 |
| (b) | 4 | 3 | 1 | 2 |
| (c) | 2 | 3 | 1 | 4 |
| (d) | 1 | 3 | 2 | 4 |

Ans. (c)

IS 4954 : 1968 – Recommendation for noise abatement for town planning.

IS 3028 : 1998 – Measurement of noise emitted by moving vehicle.

End of Solution

Q.35 Which of the following statements are correct regarding landfills?

1. The landfill must be proximate to wastewater treatment facilities.
2. Landfills are not compatible with airport siting.
3. The bottom of the landfill must be below the highest expected groundwater elevation.

Select the correct answer using the code given below:

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

Ans. (a)

The bottom of the landfill must be “above” the highest expected groundwater elevation to prevent the contamination.

End of Solution

Q.36 A 20 cm storm occurred for 6 hrs in a catchment having a CN of 50. What is the net rainfall using SCS method?

- | | |
|---------------|--------------|
| (a) 11.57 cm | (b) 15.70 cm |
| (c) 151.70 mm | (d) 17.51 cm |

Ans. (*)

Given, Storm rainfall, (P) = 20 cm

Duration = 6 hr

Curve number, CN = 50, $\lambda = 0.2$

$$\therefore \text{CN} = \frac{25400}{254 + S}$$

$$\text{Potential maximum retention, } S = 254 \left(\frac{100}{\text{CN}} - 1 \right) = 254 \left(\frac{100}{50} - 1 \right)$$

$$S = 254 \text{ mm}$$

$$S = 25.4 \text{ cm}$$

$$\text{SCS runoff equation, } Q = \frac{(P - \lambda S)^2}{P + (1 - \lambda)S} = \frac{(20 - 0.2 \times 25.4)^2}{20 + 0.8 \times 25.4}$$

Net annual rainfall, $Q = 5.52 \text{ cm}$

End of Solution

Q.37 The sliding factor of a gravity dam is defined as:

- | | |
|---|---|
| (a) $\frac{\text{The stabilizing moment}}{\text{The overturning moment}}$ | (b) $\frac{\text{The sum of the vertical forces}}{\text{The sum of the horizontal forces}}$ |
| (c) $\frac{\text{The overturning moment}}{\text{The stabilizing moment}}$ | (d) $\frac{\text{The sum of the horizontal forces}}{\text{The sum of the vertical forces}}$ |

Ans. (d)

Sliding factor of a gravity dam is defined as the ratio of the sum of horizontal forces to the sum of vertical forces.

$$SF = \frac{\Sigma H}{\Sigma V}$$

End of Solution

Q.38 The depths of penetrations along the length of a border strip at points 30 m apart were probed. The observed values are 2.0 m, 1.9 m, 1.8 m, 1.6 m and 1.5 m. The water distribution efficiency is:

- | | |
|-----------|-----------|
| (a) 0.905 | (b) 0.805 |
| (c) 0.725 | (d) 0.685 |

Ans. (a)

We know,

$$D = \frac{y_1 + y_2 + y_3 + y_4 + y_5}{5}$$

$$\Rightarrow D = \frac{2 + 1.9 + 1.8 + 1.6 + 1.5}{5} = 1.76 \text{ m}$$

Also,

$$d = \frac{|D - y_1| + |D - y_2| + \dots + |D - y_5|}{5}$$

$$\Rightarrow d = \frac{0.24 + 0.14 + 0.04 + 0.16 + 0.26}{5} = 0.168 \text{ m}$$

Water distribution efficiency,

$$\eta_d = \left(\frac{D - d}{D} \right) \times 100$$

$$\eta_d = \frac{1.76 - 0.168}{1.76} \times 100 = 90.45\% \approx 0.905$$

End of Solution

- Q.39** Which one of the following statements is correct regarding aqueducts?
1. The choice of a particular type of aqueduct does not depend upon its length.
 2. The selection of a type of aqueduct lies on the considerations of economy.
 3. On a very wide drainage, Type III aqueduct is most economical.
 4. In Type III aqueduct, the width of the aqueduct is minimum but the cost of bank connections is maximum.

Select the correct answer using the code given below:

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

Ans. (a)

The choice of a particular type of aqueduct depends on its length.

The type of aqueduct selected is based on economic consideration.

In type III aqueduct, the width of aqueduct is minimum but the cost of bank connections is maximum.

End of Solution

- Q.40** A storm with 12.0 cm precipitation produced a direct runoff of 6.8 cm. The time distribution of the storm is given in the following Table. What is the ϕ -index?
(Take duration of excess rainfall as 8 hrs)

| Time from start (hr) | Incremental rainfall in each hour (cm) |
|----------------------|--|
| 1 | 0.56 |
| 2 | 0.95 |
| 3 | 1.90 |
| 4 | 2.80 |
| 5 | 2.00 |
| 6 | 1.80 |
| 7 | 1.20 |
| 8 | 0.61 |

- (a) 0.55 cm/hr (b) 0.31 cm/hr
(c) 0.46 cm/hr (d) 0.65 cm/hr

Ans. (d)

| Time (hr) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------------------------|------|------|------|------|-----|-----|-----|------|
| Rainfall intensity (cm/hr) | 0.56 | 0.95 | 1.90 | 2.80 | 2.0 | 1.8 | 1.2 | 1.61 |

Total infiltration, $I = 12.0 - 6.8 = 5.2$ cm

$$W\text{-index} = \frac{\text{Infiltration}}{\text{Total time}} = \frac{5.2}{8} = 0.65 \text{ cm/hr}$$

As ϕ -index > w-index, so storm of intensity less than w-index will not produce rainfall excess.

$$\begin{aligned} \phi\text{-index} &= \frac{\text{Total infiltration in which rainfall excess occurs}}{\text{Time period in which rainfall excess occurs}} \\ &= \frac{5.2 - (0.56 + 0.61)}{6} = 0.6716 \text{ cm/hr} \end{aligned}$$

End of Solution



- Q.41** Consider the following statements regarding polluted water resources:
1. If the polluted water is discharged directly to the recipient (such as lakes and rivers) without treatment, it usually leads to serious deterioration of the ecological life in the water body.
 2. The polluted water is usually treated in a sewage treatment plant before it is led to the recipient.

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)

Polluted water must be treated before being discharged to the recipient otherwise it will cause deterioration of the ecological life.

End of Solution

- Q.42** In the context of clouds and raindrop formation, which one of the following give the minimum precipitation and are found at great heights (up to 12 kms) from the Earth's surface?

- (a) Cirrus (b) Nimbostratus
(c) Cumulus (d) Cumulonimbus

Ans. (a)

Circus clouds are high-altitude clouds, found at great heights upto 12 km from earth surface. Made mainly of ice crystals therefore minimum precipitation.

Nimbostratus clouds are low to middle level clouds.

Cumulus are low-level fair-weather clouds usually no rain.

Cumulonimbus are tall clouds reaching upto 12-14 mm produce maximum precipitation, thunderstorm, hail.

End of Solution

- Q.43** The annual evaporation from a lake with surface area of 1500 hectare is 240 cm. What is daily average evaporation rate in hectare-metre per day during the year?

- (a) 9.863 Ha.m (b) 3600 Ha.m
(c) 360 Ha.m (d) 986.3 Ha.m

Ans. (a)

$$\text{Total lake evaporation rate} = \frac{\text{Annual evaporation}}{\text{Time}}$$

$$= \frac{2.40\text{m} \times 150 \text{ Ha}}{365} = 9.863 \text{ Ha.m}$$

End of Solution



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Q.44 In the process of drainage of water through soil during rainfall, the excess water present is called:

- (a) Gravitational water (b) Hygroscopic water
(c) Capillary water (d) Saturation water

Ans. (a)

During the rainfall, soil pores will filled, the extra water that drains out from the soil under gravity which is called as gravitational water.

End of Solution

Q.45 A cyclone formed outside the tropical zone near the boundary between warm and cold air is called:

- (a) Extratropical Cyclone (b) Tropical Cyclone
(c) Anticyclone (d) Typhoon

Ans. (a)

Extratropical cyclones develops from outside the tropics along fronts between warm and cold air masses.

End of Solution

Q.46 While taking the stopping sight distance into consideration, when $L > SSD$, then the general equation for length L of the parabolic curve is:

- (a) $L = \frac{NS^2}{\sqrt{2H} + \sqrt{2h}^2}$ (b) $L = \frac{2NS^2}{\sqrt{2H} + \sqrt{2h}}$
(c) $L = \frac{NS^2}{\sqrt{H} + \sqrt{h}^2}$ (d) $L = \frac{NS^2}{2\sqrt{H} + \sqrt{h}^2}$

Ans. (a or d)

When $L > S$ (Curve longer than sight distance)

$$L = \frac{NS^2}{(\sqrt{2H} + \sqrt{2h})^2} = \frac{NS^2}{2(\sqrt{H} + \sqrt{h})^2}$$

When, $L < S$ (Curve shorter than sight distance)

$$L = 2S - \frac{(\sqrt{2H} + \sqrt{2h})^2}{N}$$

End of Solution

Q.47 For a street having 15 m width, what is the spacing between lighting units to produce average lux of 6.0? (Take lamp size as 6000 lumen, coefficient of utilization as 0.5, and maintenance factor as 0.9)

- (a) 30 m (b) 15 m
(c) 45 m (d) 60 m

Ans. (a)

$$\text{Spacing between lighting} = \frac{\text{Lamp size} \times \text{Utilization coefficient} \times \text{Maintenance factor}}{\text{Average lux} \times \text{width}}$$

$$= \frac{6000 \times 0.5 \times 0.9}{6 \times 15} = 30 \text{ m}$$

End of Solution

Q.48 Match the following lists:

List-I

- P. Cut and Cover
- Q. Shield Driven
- R. Sequential Excavation

List-II

- 1. Circular Tunnel
- 2. Horseshoe Tunnel
- 3. Rectangular Tunnel

| | P | Q | R |
|--|---|---|---|
|--|---|---|---|

- | | | | |
|-----|---|---|---|
| (a) | 1 | 2 | 3 |
| (b) | 3 | 1 | 2 |
| (c) | 1 | 3 | 2 |
| (d) | 3 | 2 | 1 |

Ans. (b)

- | | | |
|------------------------------|---|---|
| Cut and Cover | → | Box type so used for Rectangular Tunnel |
| Shield Driven | → | Circular Tunnel |
| Sequential Excavation (NATM) | → | Horseshoe Tunnel |

End of Solution

Q.49 Select the correct order of steps in travel demand modelling:

- (a) Trip Generation - Mode Choice - Trip Distribution - Traffic Assignment
- (b) Trip Generation - Trip Distribution - Mode Choice - Traffic Assignment
- (c) Traffic Assignment - Trip Generation - Trip Distribution - Mode Choice
- (d) Mode Choice - Trip Generation - Trip Distribution - Traffic Assignment

Ans. (b)

- Trip generation – Trip Distribution – Mode Choice – Traffic Assignment
- 1. Know how many trip exist – Trip Generation
 - 2. Know where they go – Trip distribution
 - 3. Know how they travel – Mode choice
 - 4. Know which roads they use – Traffic assignment

End of Solution

Q.50 Match the following lists with corresponding acceptability limits of physical properties of aggregates for Bituminous Macadam construction, that is recommended by the Ministry of Road Transport and Highways specifications for Road and Bridge works: (as per MoRTH specifications)

List-I

- P. Los Angeles abrasion value
Q. Aggregate impact value
R. Soundness loss with sodium sulphate test
S. Aggregate stripping value

List-II

1. 12% maximum
2. 25% maximum
3. 30% maximum
4. 40% maximum

- | | P | Q | R | S |
|-----|---|---|---|---|
| (a) | 1 | 2 | 3 | 4 |
| (b) | 4 | 3 | 1 | 2 |
| (c) | 3 | 1 | 2 | 4 |
| (d) | 2 | 1 | 3 | 4 |

Ans. (b)

As per MoRTH specifications for bituminous Macadam:

| Property | Correct limit |
|--|---------------|
| Los Angeles abrasion value | 40% maximum |
| Aggregate impact value | 30% maximum |
| Soundness loss with sodium sulphate test | 12% maximum |
| Aggregate stripping value | 25% maximum |

End of Solution

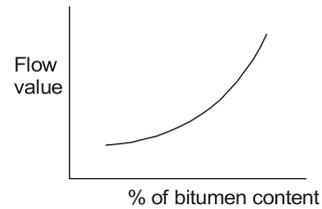
Q.51 Which one of the following statements is correct regarding Marshall test?

- (a) With increase in bitumen content, flow value increases, air voids decrease and voids filled with bitumen increase.
(b) With increase in bitumen content, flow value increases, air voids decrease and voids filled with bitumen decrease.
(c) With increase in bitumen content, flow value decreases, air voids increase and voids filled with bitumen decrease.
(d) With increase in bitumen content, flow value decreases, air voids decrease and voids filled with bitumen decrease.

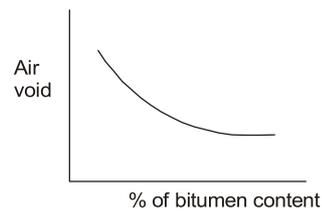
Ans. (a)

As per Marshall test of bitumen content.

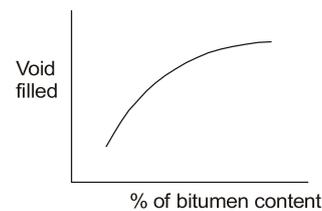
1. Flow values vs % of bitumen content.



2. Air voids vs % of bitumen content.



3. Void filled vs % of bitumen content.



End of Solution

Q.52 In Indian Railways, the field survey normally covers a width of:

- 100 m on either side of the track.
- 200 m on either side of the track.
- 300 m on either side of the track.
- 500 m on either side of the track.

Ans. (a)

As per Indian Railways:

| Type of survey | Width covered |
|-----------------------|----------------------------|
| Reconnaissance survey | Very wide (no fixed limit) |
| Preliminary survey | 500 m on either side |
| Final location survey | 150 - 300 m on either side |
| Field survey | 100 m on either side |

End of Solution

Select the correct answer using the code given below:

| | P | Q | R | S |
|-----|---|---|---|---|
| (a) | 4 | 3 | 1 | 2 |
| (b) | 3 | 4 | 1 | 2 |
| (c) | 3 | 4 | 2 | 1 |
| (d) | 4 | 3 | 2 | 1 |

Ans. (a)

Refer IRC : 93 – 1985 Cl. 22.1 and Cl. 22.6

- i. Initial walking time for pedestrians : 7 seconds
- ii. Green time required for first vehicle to cross the stop bar : 6 seconds.
- iii. Reaction time for overtaking sight distance : 2 seconds
- iv. Reaction time for stopping : 2.5 seconds sight distance.

End of Solution

Q.56 What is the capacity of the road section, if speed (V) – density (K) study has resulted in a linear relationship $V = 60 - 0.5K$?

- | | |
|----------|----------|
| (a) 1800 | (b) 7200 |
| (c) 900 | (d) 3600 |

Ans. (a)

Given: $v = 60 - 0.5 k$

$$\Rightarrow v = 60 \times \left(1 - \frac{k}{(60/0.5)}\right)$$

On comparing it with $V = V_f \left(1 - \frac{k}{k_j}\right)$

We get, $V_f = 60 \text{ kmph}$ and $k_j = 120 \text{ veh/km}$

Now, $q_{\max} = \frac{1}{4} V_f k_j$

$$\Rightarrow q_{\max} = \frac{1}{4} \times 60 \times 120 = 1800 \text{ vph}$$

End of Solution

Q.57 For the spot speed study distribution, $x: N[55, 49]$, what is the speed of the next vehicle with a probability of 97.5%?

(Take equivalent static on the standard normal distribution (z) = 1.96)

- | | |
|-------------|-------------|
| (a) 64 km/h | (b) 68 km/h |
| (c) 72 km/h | (d) 76 km/h |

Ans. (b)

A spot speed study determines the distribution of vehicle speeds at a specific location producing a normal curve.

For a normal distribution, $x : N[55, 49]$ represents that mean, $\bar{x} = 55$ and variance, $\sigma^2 = 49$.

$$\therefore \sigma = 7$$

Now, for probability of 97.5%, $z = 1.96$

Using relation, $x = \bar{x} + z\sigma$

We get, $x = 55 + 1.96 \times 7$

$$\Rightarrow x = 68.72 \text{ kmph} \simeq 68 \text{ kmph}$$

End of Solution

Q.58 A line AB between the stations A and B was measured as 348 m using a 20 m tape, too short by 0.05 m. What is the correct length of AB ?

- (a) 347.41 m (b) 349.15 m
(c) 347.13 m (d) 348.87 m

Ans. (c)

Given: $L = 20 \text{ m}$
 $L' = (20 - 0.05) \text{ m}$
 $l' = 348 \text{ m}$

We know, $l = \frac{L'}{L} \times l'$

$$l = \left(\frac{20 - 0.05}{20} \times 348 \right) = 347.13 \text{ m}$$

End of Solution

Q.59 A tape of standard length 20 m at 85°F was used to measure a base line. The measured distance was 882.50 m. What is the true length of the line, if the mean temperature during measurement was 63°F and the coefficient of thermal expansion of the tape material is 6.5×10^{-6} per °F?

- (a) 872.982 m (b) 879.282 m
(c) 882.374 m (d) 882.626 m

Ans. (c)

Given: $T_o = 85^\circ\text{F}$
 $T_m = 63^\circ\text{F}$
 $\alpha = 6.5 \times 10^{-6}/^\circ\text{F}$
 $l_o = 882.5 \text{ m}$

$$C_{\text{Temperature}} = l_o \alpha (T_m - T_o)$$

$$C_{\text{Temperature}} = 882.5 \times 6.5 \times 10^{-6} (63 - 85) = -0.1262 \text{ m}$$

Now,

$$l = MV + C_{\text{Temperature}}$$

$$l = 882.5 + (-0.1262) = 882.374 \text{ m}$$

End of Solution

Q.60 With what accuracy must a difference in elevation between two ends of a 30 m tape be known if the difference in the elevation is 3 m and the accuracy ratio is to be at least 1 in 600000?

- (a) 0.0005 m (b) 0.0157 m
(c) 0.0003 m (d) 0.0006 m

Ans. (*)

$$\text{Accuracy ratio} = \frac{\text{True value}}{\text{Permissible error}}$$

$$\begin{aligned}\text{Permissible error} &= \frac{3}{600000} \\ &= 5 \times 10^{-6} \text{ m} = 0.000005 \text{ m}\end{aligned}$$

End of Solution

Q.61 Soil materials which have the property to store water due to good number of pores in them, but passage of water through them is not possible, are called :

- (a) Aquifuge (b) Aquiclude
(c) Aquitard (d) Aquifer

Ans. (b)

Formation of ground that contains water and may transmit water in usable quantity is called aquifer.

A geological formation that may contain water because of high porosity but cannot transmit it is called aquiclude.

A geological formation that has poor permeability, but through which seepage is possible and is insignificant as compared to an aquifer is called aquitard. A geological formation that neither contains nor transmits water is called aquifuge.

End of Solution

Q.62 Which one of the following is not a type of groyne ?

- (a) Repelling groyne (b) Attracting groyne
(c) Perpendicular groyne (d) Straight groyne

Ans. (d)

Types of groynes are as follows:

- i. Attracting Groyne
- ii. Repelling Groyne
- iii. Deflecting/Perpendicular Groyne

End of Solution

- Q.63** A wooden block of rectangular section 1.25 m wide, 2 m deep, 4 m long floats horizontally in sea water. The specific gravity of wood is 0.64 and water weighs 1000 kg(f)/m³. Under this situation, the position of centre of buoyancy of wood is at :
- (a) 1.28 m above the base (b) 0.64 m above the base
(c) 0.32 m above the base (d) 0.96 m above the base

Ans. (b)

Given:

$$G_{\text{wood}} = 0.64$$

$$\rho_{\text{wood}} = 640 \text{ kg/m}^3$$

Now, weight of wooden block = F_B

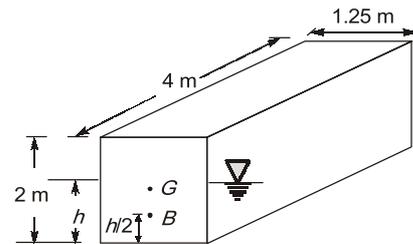
$$\Rightarrow \rho_{\text{wood}} Vg = \rho_w \nabla g$$

$$\Rightarrow 640 \times (1.25 \times 4 \times 2) = 10^3 \times (1.25 \times 4 \times h)$$

$$\Rightarrow h = 1.28 \text{ m}$$

$$\text{Position of centre of buoyancy} = \frac{h}{2} = \frac{1.28}{2}$$

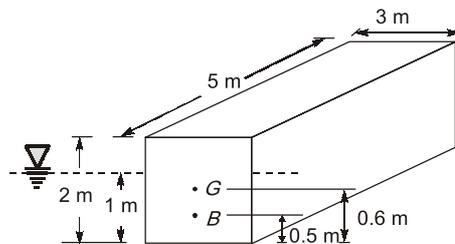
$$= 0.64 \text{ m (above the base of block)}$$



End of Solution

- Q.64** A rectangular pontoon is 5 m long, 3 m wide and 1.20 m high. The depth of immersion of the pontoon is 1.0 m in sea water. If the centre of gravity is 0.6 m above the bottom of the pontoon, what is the metacentric height of the same ? (Take the density of sea water as 1000 kg/m³)
- (a) 0.65 m (b) 0.85 m
(c) 0.75 m (d) 0.50 m

Ans. (a)



$$\text{Metacentric height, } GM = \frac{I}{\nabla} - BG$$

$$\Rightarrow GM = \frac{(5 \times 3^3)}{(5 \times 3 \times 1)} - (0.6 - 0.5)$$

$$\Rightarrow GM = \frac{9}{12} - 0.1$$

$$GM = 0.65 \text{ m}$$

End of Solution

Q.65 What are the vorticity components at a point (1, 1, 1) for the following flow field ?

$$u = 2x^2 + 3y, \quad v = -2xy + 3y^2 + 3zy,$$

$$w = -1.5z^2 + 2xz - 9y^2z$$

(a) $\Omega_x = -21$ units, $\Omega_y = -2$ units, $\Omega_z = -5$ units

(b) $\Omega_x = -2$ units, $\Omega_y = -12$ units, $\Omega_z = -5$ units

(c) $\Omega_x = -2$ units, $\Omega_y = -21$ units, $\Omega_z = -5$ units

(d) $\Omega_x = -5$ units, $\Omega_y = -2$ units, $\Omega_z = -21$ units

Ans. (a)

Given: $u = 2x^2 + 3y, \quad v = -2xy + 3y^2 + 3zy$
 $w = -1.5z^2 + 2xz - 9y^2z$

Now, $\Omega_x = \frac{\partial w}{\partial y} - \frac{\partial v}{\partial z} = -18yz - 3y$

$$\Omega_y = \frac{\partial u}{\partial z} - \frac{\partial w}{\partial x} = 0 - 2y$$

$$\Omega_z = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} = -2y - 3$$

At point (1, 1, 1)

$$\Omega_x = -21 \text{ unit}, \quad \Omega_y = -2 \text{ units}, \quad \Omega_z = -5 \text{ units}$$

End of Solution

Q.66 Which of the following correctly depicts the continuity equation in its integral form ?

(a) $\frac{\partial \rho}{\partial x} + \nabla \cdot (\rho \vec{V}) = 0$

(b) $\frac{\partial V}{\partial t} - \nabla \cdot (\rho \vec{V}) = 0$

(c) $\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{V}) = 0$

(d) $\frac{\partial \rho}{\partial t} - \nabla \cdot (\rho \vec{V}) = 0$

Ans. (c)

End of Solution

Q.67 Which of the following sets of equations represent(s) possible two-dimensional incompressible flows ?

1. $u = x + y; \quad v = x - y$

2. $u = x + 2y; \quad v = x^2 - y^2$

3. $u = 4x + y; \quad v = x - y^2$

4. $u = xt + 2y; \quad v = x^2 - yt^2$

5. $u = xt^2; \quad v = xyt - y^2$

Select the correct answer using the code given below :

(a) 1 only

(b) 1 and 2 only

(c) 1, 2 and 3 only

(d) 2, 3, 4 and 5



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Ans. (a)

For two dimensional incompressible flow

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

Only

$u = x + y, v = x - y$ satisfy this condition.

End of Solution

Q.68 A venturimeter having area of $700 \text{ cm}^2 \times 150 \text{ cm}^2$ is inserted in a vertical pipe carrying water, flowing in the upward direction. A differential manometer connected to the inlet and throat gives a reading of 20 cm. What is the approximate discharge by assuming $C_d = 1.0$ and $g = 1000 \text{ cm/s}^2$?

- (a) 110 L/s (b) 100 L/s
(c) 125 L/s (d) 95 L/s

Ans. (a)

In this problem, manometric fluid is not given

Given, $C_d = 1, g = 1000 \text{ cm/sec}^2, x = 20 \text{ cm}$
 $A_1 = 700 \text{ cm}^2, A_2 = 150 \text{ cm}^2$

Assume: manometric fluid Hg

$$h = x \left(\frac{G_{\text{Hg}}}{G_{\text{water}}} - 1 \right) = 20 \left(\frac{13.6}{1} - 1 \right) = 252 \text{ cm}$$

$$\text{Discharge, } Q = \frac{C_d A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2gh}$$

$$\Rightarrow Q = \frac{1 \times 700 \times 150}{\sqrt{700^2 - 150^2}} \sqrt{2 \times 1000 \times 252}$$

$$Q = 109.021 \times 10^3 \text{ cm}^3/\text{sec}$$

$$Q \approx 110 \text{ l/sec}$$

End of Solution

Q.69 The flow of incompressible fluid is defined by $u = 2, v = 8x$. What is the stream function? (where C = constant)

- (a) $\phi = -2x^2 + y + C$
(b) $\phi = -4x^2 + 2y + C$
(c) $\phi = -4x + 2y^2 + C$
(d) $\phi = -4x - 2y^2 + C$

Ans. (b)

Given: $u = 2, v = 8x$

$$\frac{\partial \psi}{\partial y} = u$$

$$\frac{\partial \psi}{\partial x} = v$$

$$\begin{aligned} \Rightarrow &= \frac{-1}{2\mu} \left(\frac{\partial P}{\partial x} \right) \left(\frac{H^3}{2} - \frac{H^3}{3} \right) + \left(V.H - \frac{V}{H} \cdot \frac{H^2}{2} \right) \\ &= \frac{-1}{2\mu} \left(\frac{\partial P}{\partial x} \right) \frac{H^3}{6} + \frac{V.H}{2} \end{aligned}$$

For net flow is zero

$$Q = 0$$

$$0 = \frac{-1}{2\mu} \left(\frac{\partial P}{\partial x} \right) \frac{H^3}{6} + \frac{V.H}{2}$$

$$\Rightarrow \frac{\partial P}{\partial x} = \frac{6\mu V}{H^2}$$

$$\Rightarrow \frac{\partial P}{\partial x} = \frac{6(5 \times 10^{-4})(-0.3)}{(0.003)^2}$$

$$\frac{\partial P}{\partial x} = -100 \text{ N/m}^2 \cdot \text{m}$$

End of Solution

Q.71 Without velocity of approach, the discharge through a Cipolletti weir is:

- (a) $Q = \frac{2}{3} C_d L \sqrt{2g} H^{3/2}$ (b) $Q = \frac{1}{2} C_d L \sqrt{5g} H^{2/3}$
 (c) $Q = \frac{2}{3} C_d L \sqrt{g} H^{2/3}$ (d) $Q = \frac{1}{2} C_d L \sqrt{5g} H^{3/2}$

Ans. (a)
The discharge through a cipollettic weir is

$$Q = \frac{2}{3} C_d L \sqrt{2d} (H)^{3/2}$$

End of Solution

Q.72 The rate of flow of water through a horizontal pipe is 0.25 m³/s. The diameter of the pipe which is 200 mm is suddenly enlarged to 400 mm. The pressure intensity in the smaller pipe is 11.772 N/cm². The approximate power lost due to enlargement is:

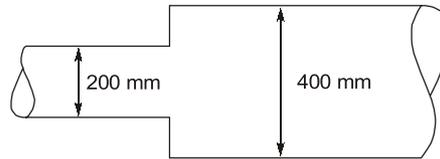
(Take $g = 10 \text{ m/s}^2$)

- (a) 4.50 kW (b) 9.00 kW
 (c) 2.25 kW (d) 1.80 kW

Ans. (a)

Given:

$$Q = 0.25 \text{ m}^3/\text{sec}$$



$$V_1 = \frac{Q}{A_1} = \frac{0.25}{\frac{\pi(0.2)^2}{4}} = 7.95 \text{ m/sec}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.25}{\frac{\pi(0.4)^2}{4}} = 1.99 \text{ m/sec}$$

head loss due to sudden extension

$$h_f = \frac{(V_1 - V_2)^2}{2g} = \frac{(7.96 - 1.99)^2}{2 \times 10}$$

$$h_f = 1.78 \text{ m}$$

$$\text{Power lost} = \rho Q g h_f$$

$$= 10^3 \times 0.25 \times 10 \times 1.78 = 4.45 \text{ kW}$$

End of Solution

Q.73 Water is flowing with a velocity of 1.5 m/s in a pipe of length 2500 m and of diameter 500 mm. At the end of the pipe, a valve is provided. What is the rise in pressure, if the valve is closed in 25 seconds?

(Take the value of C as 1460 m/s)

(a) 15 N/cm²

(b) 150 N/cm²

(c) 7.5 N/cm²

(d) 75 N/cm²

Ans. (a)

Time taken to close the valve (T) = 25 sec

$$\frac{2L}{C} = \frac{2(2500)}{1460} = 3.425$$

Since, $T > \frac{2L}{C}$ so gradual closure of valve

So, pressure rise = $\rho \frac{LV}{T}$

$$= (10^3)(2500) \frac{(1.5)}{25}$$

$$= 150 \text{ kN/m}^2 \text{ or } 15 \text{ N/cm}^2$$

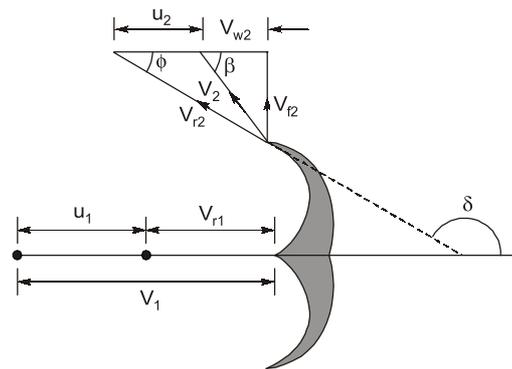
End of Solution

Q.74 A Pelton wheel is having a mean bucket speed of 10 m/s with a jet of water flowing at the rate of 700 litre/s under a head of 31.25 m. The buckets deflect the jet through an angle of 150° . Assuming co-efficient of velocity as unity, g as 10 m/s^2 , and the density of water as 1000 kg/m^3 , the approximate power given by water to the runner of the turbine is:

- (a) 196 kW (b) 98 kW
(c) 49 kW (d) 294 kW

Ans. (a)
Given:

$$\begin{aligned} u_1 &= u_2 = 10 \text{ m/s} \\ Q &= 0.7 \text{ m}^3/\text{s} \\ H &= 31.25 \text{ m} \\ \delta &= 150^\circ \\ \phi &= 30^\circ \\ C_v &= 1 \\ g &= 10 \text{ m/s}^2 \\ \rho &= 10^3 \text{ kg/m}^3 \end{aligned}$$



$$V_1 = \sqrt{2gH} = \sqrt{2(10)(31.25)} = 25 \text{ m/s}$$

$$V_{r1} = V_1 - u_1 \quad (\because V_1 = V_{w1}) \\ = 25 - 10 = 15 \text{ m/s}$$

$$V_{r2} = V_{r1} = 15 \text{ m/s}$$

$$V_{w2} = V_{r2} \cos \phi - u_2 = 15 \cos 30^\circ - 10 = 2.99 \text{ m/s}$$

Now,

$$\text{R.P.} = \dot{m}(V_{w1} + V_{w2})u$$

$$= \rho Q(V_{w1} + V_{w2})u$$

$$= (10^3)(0.7)(25 + 2.99)(10)$$

$$\text{R.P.} = 195.93 \text{ kW} \approx 196 \text{ kW}$$

End of Solution

Q.75 Consider the following statements regarding the operating characteristic curves of centrifugal pumps :

- The input power curve will pass through the origin.
- The head curve will have maximum value of head when the discharge is maximum.
- The output power curve will start from origin.
- The efficiency curve will start from origin.

Which of the above statements are correct?

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

Ans. (b)

End of Solution

Q.76 Water absorption for burnt clay heavy duty bricks should not be more than:

- (a) 10 percent (b) 20 percent
(c) 5 percent (d) 15 percent

Ans. (a)

Refer IS:2180-1988 Cl.6.2

The bricks when tested after immersion in water for 24 hours, the water absorption by mass shall not be more than 10%.

End of Solution

Q.77 The decomposition of felspar is represented as $K_2Al_2O_3 \cdot 6H_2O + CO_2 + nH_2O =$

- (a) $K_2CO_3 + Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O + 4SiO_2 \cdot nH_2O$
(b) $K_2CO_3 + Al_2O_3 \cdot SiO_2 \cdot 2H_2O + 4SiO_2 \cdot nH_2O$
(c) $K_2CO_3 + Al_2O_3 \cdot 2SiO_2 \cdot H_2O + 4SiO_2 \cdot nH_2O$
(d) $K_2CO_3 + Al_2O_3 \cdot SiO_2 \cdot H_2O + 4SiO_2 \cdot nH_2O$

Ans. (a)



End of Solution

Q.78 The metal oxide used to make emerald green glass is:

- (a) MnO_2 (b) Cr_2O_7
(c) Cobalt oxide (d) Iron oxide

Ans. (b)

Coloured glass is produced by adding metal oxides to molten glass. Some examples are:

- (i) Black glass: Oxides of Cobalt and Manganese
(ii) Violet glass: MnO_2
(iii) Emerald green glass : Oxides of chromium (Cr_2O_7)

End of Solution

Q.79 Match the following lists:

List-I

P. Cupping

Q. Bowing

R. Checks

S. Knots

List-II

1. Caused by wood limbs encased by wood of the tree trunk

2. Caused by grain irregularities in the board

3. Small cracks appearing at the ends of boards due to rapid drying

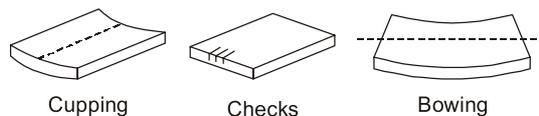
4. Unequal shrinking in the radial and tangential direction

Select the correct answer using the code given below:

| | P | Q | R | S |
|-----|---|---|---|---|
| (a) | 2 | 4 | 1 | 3 |
| (b) | 4 | 2 | 3 | 1 |
| (c) | 1 | 2 | 4 | 3 |
| (d) | 3 | 1 | 2 | 4 |

Ans. (b)

Checks: These are small cracks usually running lengthwise that separate wood fibres of a timber piece.



Cupping: It appears in the form of a curve along the face of a board across the width of the board.

Bowing: It appears in the form of a curve along the face of a timber board that usually runs from end to end.

Knots: These are the portions of branches that get enclosed within the trunk as the tree grows.

End of Solution

Q.80 Which one of the following statements is not correct regarding the fineness of cement?

- Fine cement is more liable to suffer from shrinkage cracking than a coarse cement.
- Fine cement shows faster rate of heat evolution and total quantity of heat evolved is much larger than coarse cement.
- Fine cement will show faster rate of hardening than coarse cement.
- Fine cement shows the same setting time as coarse cement.

Ans. (b, d)

- Total quantity of heat evolved is same for both fine as well as coarse cement.
- Fine cement sets faster than coarse cement.

End of Solution

Q.81 Match the following lists:

List-I (Types of cement)

P. Rapid hardening

Q. Quick-setting

R. High alumina

S. Low-heat

List-II (Uses)

1. Repair of bridges

2. Dams

3. Concrete under water

4. Refractory concrete in industries

Select the correct answer using the code given below:

- | | P | Q | R | S |
|-----|----------|----------|----------|----------|
| (a) | 2 | 4 | 1 | 3 |
| (b) | 4 | 2 | 3 | 1 |
| (c) | 3 | 1 | 2 | 4 |
| (d) | 1 | 3 | 4 | 2 |

Ans. (d)

- (i) Rapid hardening cement – Repair of bridges
- (ii) Quick setting cement – Concrete under water
- (iii) High alumina – Refractory concrete in industries
- (iv) Low heat – Dams

End of Solution

Q.82 The approximate composition of CaO in Portland cement is in the range of:

- (a) 60% - 65%
- (b) 50% - 55%
- (c) 65% - 70%
- (d) 55% - 60%

Ans. (a)

Chemical composition of portland cement:

| Oxides | Composition (%) | Function |
|--------------------------------|-----------------|------------------------------------|
| CaO | 60 - 65 | Controls strength and soundness |
| SiO ₂ | 17 - 25 | Imparts strength |
| Al ₂ O ₃ | 3 - 8 | Imparts quick setting |
| Fe ₂ O ₃ | 0.5 - 6 | Imparts colour and helps in fusion |
| MgO | 0.5 - 4 | Imparts colour and hardness |
| SO ₃ | 1 - 2 | Makes cement sound |

End of Solution

- Q.83** The percentage of MgO in cement is calculated using:
- (a) Weight of residue \times 32.4 (b) Weight of residue \times 27.4
(c) Weight of residue \times 42.7 (d) Weight of residue \times 72.4

Ans. (d)

Refer IS:4032-1985 Cl.4.8.1

As per gravimetric method,

Percentage of MgO = Weight of residue (in gram) \times 72.4

where 72.4 is the molecular ratio of 2 MgO to $Mg_2P_2O_7$ (0.362) divided by weight of sample used (0.5 g) and multiplied by 100.

End of Solution

- Q.84** The minimum value of Modulus of Rupture for Class A lime should be:
- (a) 1.15 N/mm² (b) 1.05 N/mm²
(c) 1.50 N/mm² (d) 1.25 N/mm²

Ans. (b)

Minimum value of modulus of rupture:

- (i) Class-A lime – 1.05 N/mm²
(ii) Class-B lime – 0.7 N/mm²

End of Solution

- Q.85** Match the following lists:

List-I (Cement mortar for different works)

- P.** Normal brickwork
Q. Plastering work
R. Grouting cavernous rocks
S. Guniting

List-II (Proportion of cement: Sand in mortar)

- 1.** 1 : 4
2. 1 : 3
3. 1 : 6
4. 1 : 1.5

Select the correct answer using the code given below:

- | | P | Q | R | S |
|-----|---|---|---|---|
| (a) | 2 | 4 | 1 | 3 |
| (b) | 3 | 1 | 4 | 2 |
| (c) | 1 | 2 | 4 | 3 |
| (d) | 3 | 2 | 1 | 4 |

Ans. (b)

| Type of work | Mix proportion |
|--|----------------|
| Stone masonry with ordinary stones, normal brickwork, foundations etc... | 1 : 6 |
| Plastering work | 1 : 4 |
| Guniting | 1 : 3 |
| Grouting Cavernous rocks | 1 : 1.5 |

End of Solution



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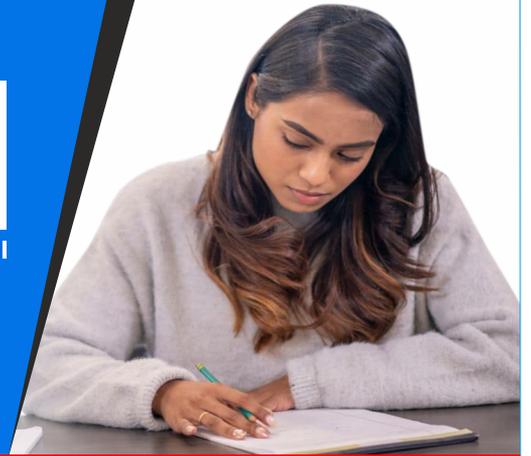


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Q.86 Which one of the following statements is correct regarding the factors influencing strength of concrete?

- (a) If the size of cube is decreased, the compressive strength tends to increase and modulus of elasticity decreases.
- (b) If the size of cube is decreased, the compressive strength tends to decrease and modulus of elasticity increases.
- (c) If the size of cube is decreased, the compressive strength tends to increase and modulus of elasticity also increases.
- (d) If the size of cube is decreased, the compressive strength tends to decrease and modulus of elasticity also decreases.

Ans. (c)

As the size of cube decreases, its compressive strength tends to increase.

Also,

$$\therefore E = 5000\sqrt{f_{ck}}$$

$$\therefore E \propto \sqrt{f_{ck}}$$

Hence, modulus of elasticity also increases.

End of Solution

Q.87 The cement content in a mix design is 378 kg/m³, water content 170 kg, sand is 30% of total aggregate, entrapped air is 1%, specific gravity of cement, coarse aggregate and fine aggregate are, respectively 3.15, 2.70 and 2.60.

The fine aggregate is approximately:

- (a) 510 kg
- (b) 600 kg
- (c) 550 kg
- (d) 450 kg

Ans. (c)

Given:

$$M_c = 378 \text{ kg}$$

$$V_{air} = 1\%$$

$$M_w = 170 \text{ kg}$$

$$M_{FA} = 0.3 M_{Agg}; M_{CA} = 0.7 M_{Agg}$$

$$G_C = 3.15; G_{FA} = 2.6; G_{CA} = 2.7$$

We know,

$$V_{concrete} = V_{air} + V_w + V_c + V_{FA} + V_{CA}$$

$$1 = \frac{1 \times 1}{100} + \frac{170}{1000} + \frac{378}{3.15 \times 1000} + \frac{0.3 M_{Agg}}{2.6 \times 1000} + \frac{0.7 M_{Agg}}{2.7 \times 1000}$$

$$\Rightarrow \frac{M_{Agg}}{1000} \left[\frac{3}{26} + \frac{7}{27} \right] = 1 - 0.01 - 0.17 - 0.12$$

$$\Rightarrow M_{Agg} \left[\frac{81+182}{702} \right] = 0.7 \times 1000$$

$$\Rightarrow M_{Agg} = \frac{700 \times 702}{263} = \frac{491400}{263} \text{ kg}$$

Now,
$$\epsilon_{\text{ext}} = \frac{\Delta l_{\text{ext}}}{l_o} = \frac{l_e - l_o}{l_o} = \frac{4 - 2}{2} = 1$$

and,
$$\epsilon_{\text{comp}} = \frac{\Delta l_{\text{comp}}}{l_e} = \frac{l_c - l_e}{l_e} = \frac{2 - 4}{4} = -0.5$$

End of Solution

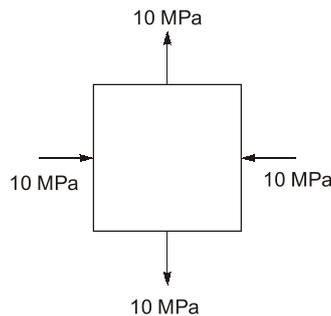
Q.90 A rectangular block is subjected to two perpendicular stresses of 10 MPa tension and 10 MPa compression. What are the stresses on planes inclined at 45° with the horizontal plane?

- (a) Normal Stress = 10 MPa and Shear Stress = 20 MPa
 (b) Normal Stress = 0 MPa and Shear Stress = -10 MPa (counter clockwise direction)
 (c) Normal Stress = 5 MPa and Shear Stress = -20 MPa (counter clockwise direction)
 (d) Normal Stress = 10 MPa and Shear Stress = 5 MPa

Ans. (b)

Given:

$$\sigma_y = 10 \text{ MPa}; \sigma_x = -10 \text{ MPa}$$



Stress at plane inclined at 45° ,

Normal stress,

$$\sigma_n = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta \quad [\because \tau_{xy} = 0]$$

$$\Rightarrow \sigma_n = -10 \cos^2 45^\circ + 10 \sin^2 45^\circ = 0$$

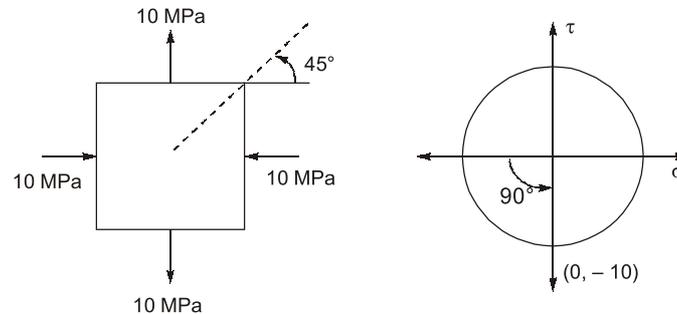
Shear stress,

$$\tau_{x'y'} = (\sigma_y - \sigma_x) \sin\theta \cos\theta \quad [\because \tau_{xy} = 0]$$

$$\Rightarrow \tau_{x'y'} = (10 - (-10)) \sin 45^\circ \cos 45^\circ$$

$$\Rightarrow \tau_{x'y'} = 20 \times \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = 10 \text{ MPa}$$

Alternate solution:



End of Solution

Q.91 The angle made by the resultant stress with the normal of the oblique plane is known as obliquity (ϕ) and is expressed as:

(a) $\tan \phi = \frac{\text{Shear Stress}}{\text{Normal Stress}}$

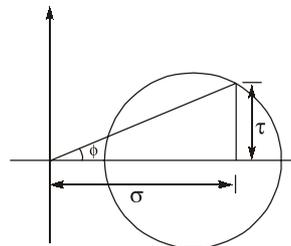
(b) $\cos \phi = \frac{\text{Shear Stress}}{\text{Normal Stress}}$

(c) $\tan \phi = \frac{\text{Normal Stress}}{\text{Tangential Stress}}$

(d) $\cos \phi = \frac{\text{Normal Stress}}{\text{Tangential Stress}}$

Ans. (a)

For Mohr's circle for normal stress σ and shear stress τ ,



$$\therefore \tan \phi = \frac{\tau}{\sigma} = \frac{\text{Shear stress}}{\text{Normal stress}}$$

End of Solution

Q.92 A central load of 2500 N is acting on a leaf spring. The leaf spring is to be made of 12 steel plates of 6 cm width and 5 mm thickness. If the bending stress is limited to 200 N/mm², then the length and deflection at the centre of the spring are, respectively: (Assume Modulus of elasticity as 2×10^5 N/mm²)

(a) 660 mm; 16.08 mm

(b) 760 mm; 26.08 mm

(c) 860 mm; 36.08 mm

(d) 960 mm; 46.08 mm

Ans. (d)

For leaf spring,

$$\delta_{\max} = \frac{3PL^3}{8nbt^3}$$

and

$$\sigma_{\max} = \frac{3PL}{2nbt^2}$$

Here,

$$\sigma_{\max} = 200 \text{ N/mm}^2; P = 2500 \text{ N}; n = 12; b = 6 \text{ cm}; t = 5 \text{ mm}$$

\therefore

$$200 = \frac{3 \times 2500 \times L}{2 \times 12 \times 6 \times 10 \times 5^2}$$

\Rightarrow

$$L = 960 \text{ mm}$$

Now,

$$\delta_{\max} = \frac{3 \times 2500 \times 960^3}{8 \times 12 \times 6 \times 10 \times 5^3} = 46.08 \text{ mm}$$

End of Solution

Q.93 A 150 N load is acting on a close coiled helical spring. The mean coil diameter has to be 12 times that of the wire diameter. If the maximum shear stress is not to exceed 150 N/mm², what is the diameter of the coil?

- (a) 57.64 mm
(c) 77.64 mm

- (b) 67.64 mm
(d) 87.64 mm

Ans. (b)

Given:

$$P = 150 \text{ N}; \tau_{\max} = 150 \text{ N/mm}^2$$

$$D = 12 d, \quad C = \frac{D}{d} = 12$$

\therefore

$$R = 6 d$$

For a close coiled helical spring,

$$\tau_{\max} = \frac{16PR}{\pi d^3} \left[1 + \frac{1}{2C} \right]$$

\Rightarrow

$$150 = \frac{16 \times 150 \times 6d}{\pi d^3} \left(1 + \frac{1}{2 \times 12} \right)$$

\Rightarrow

$$d^2 = 31.831$$

\Rightarrow

$$d = 5.64 \text{ mm}$$

Diameter of coil,

$$D = 12 \times 5.64 = 67.68 \text{ mm}$$

End of Solution

Q.94 A circular rod of 20 mm diameter and 400 mm length is subjected to a tensile force of 50 kN. What is the volumetric strain, if Poisson's ratio = 0.25 and Young's modulus $E = 2 \times 10^5 \text{ N/mm}^2$?

- (a) 79.57×10^{-5}
(c) 79.57×10^{-3}

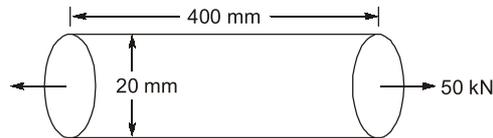
- (b) 39.75×10^{-5}
(d) 39.75×10^{-3}

Ans. (b)

Given:

$$d = 20 \text{ mm}, l = 400 \text{ mm}, P = 50 \text{ kN}, \mu = 0.25$$

$$E = 2 \times 10^5 \text{ N/mm}^2$$



$$\sigma_x = \frac{P}{A} = \frac{50 \times 10^3}{\frac{\pi}{4}(20)^2} = 159.15 \text{ N/mm}^2$$

Volumetric strain,

$$\epsilon_v = \frac{\sigma_x + \sigma_y + \sigma_z}{E} (1 - 2\mu)$$

⇒

$$\epsilon_v = \frac{159.15}{2 \times 10^5} (1 - 2 \times 0.25)$$

$$\epsilon_v = 39.78 \times 10^{-5}$$

End of Solution

Q.95 A rod which tapers uniformly from 30 mm diameter to 15 mm diameter in a length of 300 mm is subjected to an axial load of 6 kN. If Young's modulus is $2 \times 10^5 \text{ N/mm}^2$, what is the elongation of the rod?

(a) $\frac{0.06}{\pi}$ mm

(b) $\frac{0.08}{\pi}$ mm

(c) $\frac{0.6}{\pi}$ mm

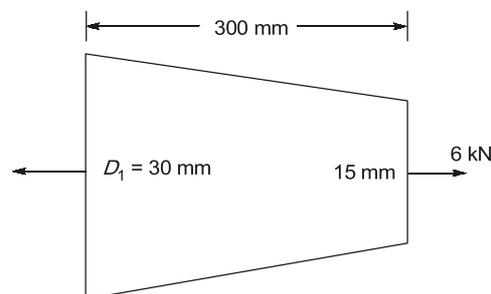
(d) $\frac{0.8}{\pi}$ mm

Ans. (b)

Given:

$$D_1 = 30 \text{ mm}, D_2 = 15 \text{ mm}, l = 300 \text{ mm}$$

$$P = 6 \text{ kN}, E = 2 \times 10^5 \text{ N/mm}^2$$



Elongation of the rod is given by

$$\Delta l = \frac{4Pl}{\pi D_1 D_2 E}$$

$$\Rightarrow \Delta l = \frac{4 \times 6 \times 10^3 \times 300}{\pi \times 30 \times 15 \times 2 \times 10^5}$$

$$\Rightarrow \Delta l = \frac{0.08}{\pi} \text{ mm}$$

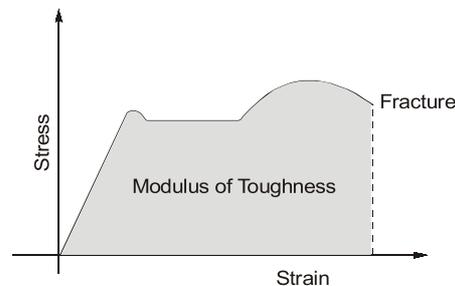
End of Solution

Q.96 Which one of the following is a measure of the ability of a material to absorb energy before fracture?

- (a) Resilience (b) Strain Energy Density
(c) Resilience Modulus (d) Modulus of Toughness

Ans. (d)

Modulus of toughness is a measure of ability of a material to absorb energy before fracture.



End of Solution

Q.97 A 10 coils 120 mm mean diameter closely coiled helical spring is made up of a 12 mm steel wire. If the spring is carrying an axial load of 150 N, what is the maximum shear stress?

(Take modulus of rigidity $C = 8.16 \times 10^4 \text{ N/mm}^2$)

- (a) 16.52 N/mm² (b) 20.52 N/mm²
(c) 26.52 N/mm² (d) 32.52 N/mm²

Ans. (c)

Given: $n = 10$, $D = 120 \text{ mm}$, $d = 12 \text{ mm}$,

$$P = 150 \text{ N}, C = \frac{120}{12} = 10$$

$$\tau_{\max} = ?$$

Maximum shear stress,

$$\tau_{\max} = \frac{16PR}{\pi d^3} \left(1 + \frac{1}{2C} \right)$$

$$\Rightarrow \tau_{\max} = \frac{16 \times 150 \times 60}{\pi (12)^3} \left(1 + \frac{1}{2 \times 10} \right)$$

$$\Rightarrow \tau_{\max} = 27.85 \text{ MPa}$$

But no answer is matching, so neglect direct shear stress

$$\begin{aligned} \therefore \tau_{\max} &= \frac{16PR}{\pi d^3} = \frac{16 \times 150 \times 60}{\pi (12)^3} \\ \Rightarrow &= 26.52 \text{ MPa} \end{aligned}$$

End of Solution

Q.98 The optimistic time estimate is defined as:

- The best guess of the minimum time that would be required to complete the activity.
- The best guess of the maximum time that would be required to complete the activity.
- The shortest possible time in which an activity can be completed, under ideal conditions.
- The longest possible time in which an activity can be completed, under any conditions.

Ans. (c)

Optimistic time : It is the minimum time in which any activity is expected to be completed when condition is/are most favourable i.e. ideal.

End of Solution

Q.99 What is the expected time of completion of an activity, if the optimistic time (t_o) is 4 days, most likely time (t_l) is 6 days and pessimistic time (t_p) is 11 days?

- 6.5 days
- 9.5 days
- 3.25 days
- 4.25 days

Ans. (a)

Given:

$$t_o = 4 \text{ days}$$

$$t_m = 6 \text{ days}$$

$$t_p = 11 \text{ days}$$

$$\therefore t_e = \frac{t_o + 4t_m + t_p}{6} = \frac{4 + 4 \times 6 + 11}{6} = \frac{39}{6}$$

$$t_e = 6.5 \text{ days}$$

End of Solution

Q.100 Independent float is defined as:

- Maximum amount of time by which an activity can be delayed from early start without delaying the project.
- Maximum amount of time by which an activity can be delayed without delaying the early start of any following activity.
- Maximum amount of time by which an activity can be delayed without delaying the project but will cause delay to the early start of some following activity.
- Maximum amount of time by which an activity can be delayed without delaying the project; even if all predecessors are at late start and all successors at early start.

Ans. (d)

Independent float: It gives idea about excess time over an activity duration when proceeding activity will complete as late as possible and succeeding activity will start as early as possible without affecting total project duration.

End of Solution

Q.101 The details of marks of the technical and the financial bids of four bidders, who bid for a project having an estimated cost of Rs.1,00,000 are given as follows:

| Contractor | Score of technical Bid | Financial Bid (INR) |
|------------|------------------------|---------------------|
| A | 80 | 1,35,000 |
| B | 75 | 1,25,000 |
| C | 45 | 1,01,000 |
| D | 60 | 1,15,000 |

To whom can the contract be awarded with the following conditions:

1. Technical score must be more than 50.
2. Job is awarded to the bidder with highest composite score evaluated considering equal weightage for financial and technical bid.
3. The call may be cancelled if the award price deviates more than 20% of the estimated cost.

Choose the correct answer from the options given below:

- (a) Cancel the call, though contractor B is technically qualified but quoted more than 20% of the estimated cost.
- (b) Cancel the call, though contractor A is technically qualified but quoted more than 20% of the estimated cost.
- (c) Cancel the call, though contractor D is technically qualified but quoted more than 20% of the estimated cost.
- (d) Contractor C

Ans. (a)

Given: Estimated cost = 1,00,000/-

Condition:

- (i) Since technical score > 50, therefore contractor C will disqualify
- (ii) Composite score with equal weightage of financial and technical bid:

Highest technical score = 80

∴ Composite score:

$$\text{Contractor A} = \frac{80}{80} \times 50 = 50$$

$$B = \frac{75}{80} \times 50 = 46.88$$

$$D = \frac{60}{80} \times 50 = 37.50$$

(iii) Financial score = $\frac{\text{lowest bid}}{\text{bid}} \times 50$

$\therefore A \rightarrow \frac{1,15,000}{1,35,000} \times 50 = 42.50$

$B \rightarrow \frac{1,15,000}{1,25,000} \times 50 = 46.00$

$D \rightarrow \frac{1,15,000}{1,15,000} \times 50 = 50$

\therefore Composite score = Technical + Financing

$A \rightarrow 50 + 42.59 = 92.59$

$B \rightarrow 46.8 + 46 = 92.8$

$C \rightarrow 37.5 + 50 = 87.5$

It shows highest composite score of *B*.

(iv) For cancellation of call,

Award price deviates more than 20% of the estimated cost.

$\therefore 20\% \text{ of } 100000 = 20,000$

\therefore Acceptable range = 80000 to 120000 /-

Note: However, no contractor is matching all the condition

But, contractor *B* quotes 125000 and also satisfies (ii) condition.

So, option (a) is most appropriate.

End of Solution

Q.102 A construction firm is considering to execute a structural modification project in a running manufacturing mill. Due to technical reasons, the work is to be executed slowly and carefully. It is expected that only 20 tons of fabrication is possible in each month. The firm of has an estimated fixed cost (equipment, supervision, overhead deployment) Rs.1,50,000 per month, variable cost (labour and material) of Rs.30,000 per month and Rs.35,000 for normal cost of fabrication. What is the rate that should be quoted by the firm to achieve at least 10% profit?

- (a) Rs.35,000 (b) Rs.41,000
(c) Rs.45,000 (d) Rs.49,000

Ans. (b)

Given: Estimated fixed cost per month = 150000

Variable cost = 30000 /month

Normal cost of fabrication = 35000/-

\Rightarrow Fixed cost per tonne = $\frac{150000}{20} = \text{Rs. } 7500/\text{tonne}$

Total cost per tonne = 30000 + 7500 = Rs. 37500/ tonne

For 10% profit, total cost per tonne = 37500 \times 1.1 = Rs.41250/tonne

Note: Normal cost of fabrication will depend on working condition so it will not be added in total cost.

End of Solution



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Q.103 A preliminary survey indicates that 20% of the time of a gang of workers is spent idly. What is the total number of observations required to determine the proportion of idle time within $\pm 5\%$ with 95% confidence limit?

(Take Z values as 2.0)

- (a) 256 (b) 128
(c) 512 (d) 1024

Ans. (a)

Preliminary estimate of idle time.

Idle time proportion, $p = 0.250$

Complementary proportion, $q = 1 - p = 0.8$

Allowable error, $e = \pm 5\% = 0.05$

Standard normal vertical $z = 2.0$

$$\text{Proportion of idle time, } n = \frac{Z^2 pq}{e^2} = \frac{2^2 \times 0.2 \times 0.8}{(0.05)^2}$$

$$n = 256$$

End of Solution

Q.104 Construction of a military helipad at an altitude of 2400 m involves 88000 m³ (loose) of excavation area in soft soil. This task needs to be completed in 200 working hours. The company entrusted two dozers, each with an output of 220 m³/h under job conditions for task execution. It also holds wheel loaders and 22 m³ dump trucks. One loader can load in trucks, about 120 m³ of excavated soil per hour. The dump truck cycle time for disposal of excavated materials is 40 minutes. This includes 8 minutes of loading time by a loader team that consists of 2 loaders. In this case, the total number of dumpers required to complete the task on time is:

- (a) 6 (b) 12
(c) 18 (d) 24

Ans. (*)

Given:

$$\text{Hourly output required } \frac{88000}{200} = 440 \text{ m}^3/\text{hr}$$

Two dozers each have capacity = 220 m³/hr

$$\therefore \text{Total output by dozers} = 2 \times 220 = 440 \text{ m}^3/\text{hr}$$

$$\text{Truck capacity} = 22 \text{ m}^3$$

$$\text{Cycle time} = 40 \text{ minutes}$$

$$\therefore \text{Number of cycle per hour} = \frac{60}{40} = 1.5 \text{ cycle/hr}$$

$$\text{So, one truck carries per hour} = 22 \times 1.5 = 33 \text{ m}^3/\text{hr}$$

$$\therefore \text{Number of dumpers required} = \frac{440}{33} = 13.38$$

$$\approx 14 \text{ truck required}$$

End of Solution

$$\sigma'_x = 120 \cos^2(-45^\circ) + 45 \sin^2(-45^\circ) + 2 \times 30 \cos(-45^\circ) \sin(-45^\circ)$$

$$\Rightarrow \sigma'_x = 52.5 \text{ MPa}$$

Note: In this question direction of rotation of plane is not given. Generally we take it as anticlockwise.

End of Solution

Q.107 At a point in an elastic material, a direct tensile stress of 70 N/mm² and a direct compressive stress of 50 N/mm² are applied on planes at right angles to each other. If the maximum principal stress in the material is limited to 75 N/mm² what is the maximum shear stress?

- (a) 65 N/mm² (b) 55 N/mm²
(c) 75 N/mm² (d) 25 N/mm²

Ans. (a)

Given: $\sigma_x = 70 \text{ N/mm}^2$, $\sigma_y = -50 \text{ MPa}$
 $\sigma_1 = 75 \text{ N/mm}^2$, $\tau_{\max} = ?$

Principal stresses

$$\sigma_1/\sigma_2 = \frac{\sigma_x + \sigma_y}{2} \pm \frac{1}{2} \sqrt{(\sigma_y - \sigma_x)^2 + 4\tau_{xy}^2}$$

$$\Rightarrow 75 = \frac{70 - 50}{2} + \frac{1}{2} \sqrt{(-50 - 70)^2 + 4\tau_{xy}^2}$$

$$\Rightarrow \tau_{xy} = 25 \text{ MPa}$$

Now,

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \frac{1}{2} \sqrt{(\sigma_y - \sigma_x)^2 + 4\tau_{xy}^2}$$

$$\Rightarrow 75 = \frac{70 - 50}{2} - \frac{1}{2} \sqrt{(-50 - 70)^2 + 4(25)^2}$$

$$\Rightarrow \sigma_2 = -55 \text{ MPa}$$

Maximum shear stress, $\tau_{\max} = \frac{\sigma_1 - \sigma_2}{2}$

$$\Rightarrow \tau_{\max} = \frac{75 - (-55)}{2} = 65 \text{ MPa}$$

Alternate solution

We know that,

$$\sigma_1 + \sigma_2 = \sigma_x + \sigma_y$$

$$75 + \sigma_2 = 70 + (-50)$$

Maximum shear stress, $\sigma_2 = -55 \text{ MPa}$

$$\tau_{\max} = \frac{75 - (-55)}{2} = 65 \text{ MPa}$$

End of Solution

Q.108 A material has strength in tension, compression and shear as 30 N/mm², 90 N/mm² and 25 N/mm² respectively. If a specimen of diameter 25 mm is tested in compression, then identify the failure load and failure plane.

- (a) Failure load is 14726 N and failure plane is 30° to the plane of axial compression
- (b) Failure load is 24543 N and failure plane is 45° to the plane axial compression
- (c) Failure load is 36574 N and failure plane is 60° to the plane of axial compression
- (d) Failure load is 18745 N and failure plane is 90° to the plane of axial compression

Ans. (b)

Given: $d = 25 \text{ mm}$
 $\sigma_t = 30 \text{ MPa}$, $\sigma_c = 90 \text{ MPa}$, $\sigma_s = 25 \text{ MPa}$

Normal stress, $\sigma_n = \frac{P}{A} = \sigma_1$

Maximum shear stress,

$$\tau_{\max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{\frac{P}{A} - 0}{2}$$

$$\Rightarrow \tau_{\max} = \frac{P}{2A}$$

$$\Rightarrow 25 = \frac{P}{2 \times \frac{\pi}{4} (25)^2}$$

$P = 24543.6 \text{ N}$, 45° to the line of action of compressive load.

End of Solution

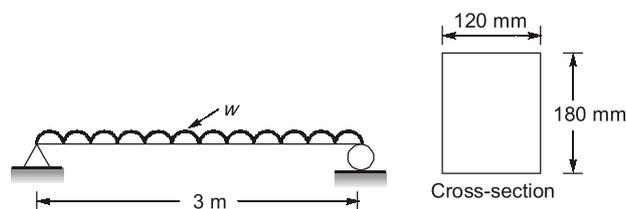
Q.109 A simply supported beam of span 3.0 m has a cross-section 120 mm × 180 mm. If the permissible stress in the material of the beam is 10 N/mm², what is the maximum uniformly distributed load (UDL) that it can carry? (Ignore the moment due to self-weight)

- (a) 9.72 kN/m
- (b) 4.52 kN/m
- (c) 5.76 kN/m
- (d) 8.80 kN/m

Ans. (c)

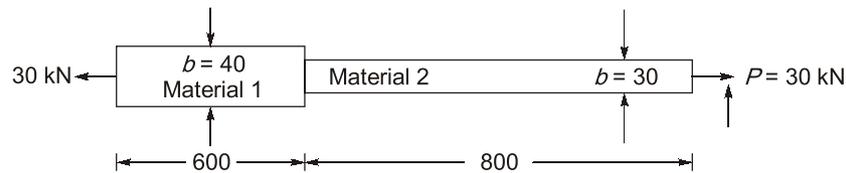
Given:

$$\sigma_{\text{per}} = 10 \text{ N/mm}^2$$



Maximum bending stress.

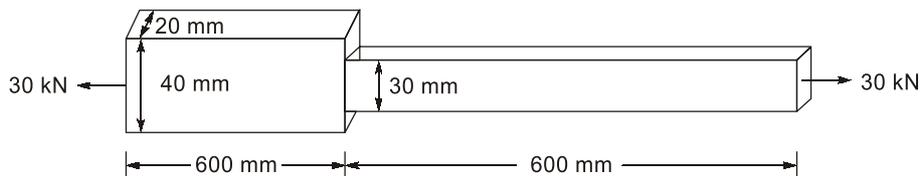
Q.111 The stepped bar shown in the figure is made up of two different materials. Material 1 has Young's modulus = 2×10^5 N/mm² while that of Material 2 is 1×10^5 N/mm². What is the extension of the bar under a pull of 30 kN if both the portions are 20 mm in thickness? (The dimensions shown below are in mm)



- (a) 0.5125 mm (b) 0.4000 mm
(e) 0.1125 mm (d) 0.2875 mm

Ans. (a)

Given: $E_1 = 2 \times 10^5$ MPa
 $E_2 = 1 \times 10^5$ MPa



Total extension of the bar

$$\Delta l = \Sigma \left(\frac{Pl}{AE} \right)$$

$$\Rightarrow \Delta l = \frac{30 \times 10^3 \times 600}{40 \times 20 \times (2 \times 10^5)} + \frac{30 \times 10^3 \times 800}{30 \times 20 \times (1 \times 10^5)}$$

$$\Rightarrow \Delta l = 0.1125 + 0.4$$

$$\Rightarrow \Delta l = 0.5125 \text{ mm}$$

End of Solution

Q.112 Two parallel walls, 8 m apart, are stayed together by a steel rod of 20 mm diameter passing through metal plates and nuts at each end. The nuts are screwed up to the plates while the bar is at a temperature of 400 K. What is the pull exerted by the bar after it has cooled to 300 K, if the total yielding at the two ends is 5 mm?

(Take coefficient of thermal expansion for steel as 12×10^{-6} per K and Young's modulus of steel as 2×10^5 N/mm²)

- (a) 75.398 kN (b) 240 kN
(c) 115 kN (d) 36.128 kN

Ans. (d)

Given: $L = 8$ m, $\alpha = 12 \times 10^{-6}$ per K, $E = 2 \times 10^5$ N/mm²
 $d = 20$ mm, yielding = 5 mm
 $\Delta T = 400 - 300 = 100$ K

$$\begin{aligned}\text{Free contraction} &= L \alpha \Delta T \\ &= 8 \times 10^3 \times 12 \times 10^{-6} \times 100 \\ &= 9.6 \text{ mm} \\ \text{Expansion prevented} &= 9.6 - 5 \\ &= 4.6 \text{ mm}\end{aligned}$$

Now

$$\begin{aligned}\frac{PL}{AE} &= 4.6 \text{ mm} \\ \Rightarrow \frac{P \times (8 \times 10^3)}{\frac{\pi}{4} (20)^2 \times 2 \times 10^5} &= 4.6 \\ \Rightarrow P &= 36.128 \text{ kN}\end{aligned}$$

End of Solution

Q.113 Which one of the following statements is not correct regarding principal stresses and planes?

- The planes on which shearing stresses are zero are called principal planes and the stresses normal to principal planes are known as principal stresses.
- The principal planes are the planes of maximum or minimum normal stresses.
- The planes of extreme shearing stresses are at 90° to the principal planes.
- The sum of normal stresses in any two mutually perpendicular directions is general constant in case of a two-dimensional stress.

Ans. (c)

τ_{\max} plane lies at 45° to the principle planes.

End of Solution

Q.114 What is the maximum torque T_E that can be applied to a solid steel cylindrical shaft 8 cm in diameter, if the shaft is to remain elastic? (Take the elastic limit in shear and the shear modulus as $\tau_0 = 145 \text{ MPa}$ and $G = 76 \text{ GPa}$ respectively)

- 14,580 N-m
- 7,290 N-m
- 3,645 N-m
- 29,160 N-m

Ans. (a)

Given: $D = 8 \text{ cm} = 0.08 \text{ m}$
 $\tau_{\max} = 145 \text{ N/mm}^2 = 145 \times 10^6 \text{ N/m}^2$

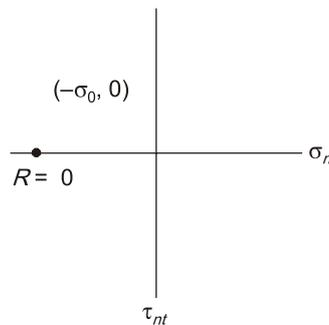
We know, $\tau_{\max} = \frac{16T}{\pi D^3}$

$$\Rightarrow 145 \times 10^6 = \frac{16T}{\pi (0.08)^3}$$

$$\Rightarrow T = 14576.98 \text{ N-m} \approx 14580 \text{ N-m}$$

End of Solution

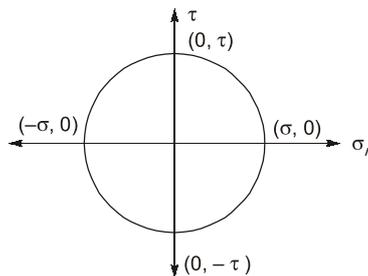
Q.115 Given the state of stress $\sigma_x = \sigma_y = -\sigma_0$ (where $\sigma_0 > 0$) and $\tau_{xy} = 0$ as shown in the figure, which one of the following statements is not correct?



- (a) The radius of the Mohr circle $R = 0$
- (b) No shear stress exists on any plane passing through this point.
- (c) The state of stress shown here is called a state of 'Pure Shear'.
- (d) The normal stress is same for all planes passing through this point.

Ans. (c)

For pure shear condition,



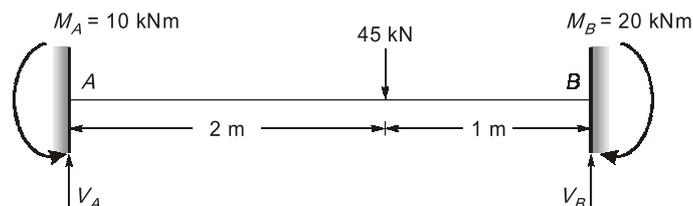
For hydrostatic stress condition, the Mohr's circle is a point.

End of Solution

Q.116 A fixed-fixed beam 'AB' of length 3 m is subjected to a point load of 45 kN at a distance 2 m from left support 'A'. What are the vertical reaction forces at both the supports 'A' and 'B'?

- (a) $R_A = 15$ kN and $R_B = 30$ kN
- (b) $R_A = 15$ kN and $R_B = 11.67$ kN
- (c) $R_A = 33.33$ kN and $R_B = 30$ kN
- (d) $R_A = 11.67$ kN and $R_B = 33.33$ kN

Ans. (d)



$$M_A = \frac{Pab^2}{l^2} = \frac{45 \times 2 \times 1^2}{3^2} = 10 \text{ kN-m } (\curvearrowright)$$

$$M_B = \frac{Pa^2b}{l^2} = \frac{45 \times 2^2 \times 1}{3^2} = 20 \text{ kN-m } (\curvearrowleft)$$

Taking moment about A,

$$\Sigma M_A = 0$$

$$\Rightarrow 20 + 45 \times 2 - V_B \times 3 - 10 = 0$$

$$\Rightarrow V_B = 33.33 \text{ kN } (\uparrow)$$

$$\therefore V_A + V_B = 45 \text{ kN}$$

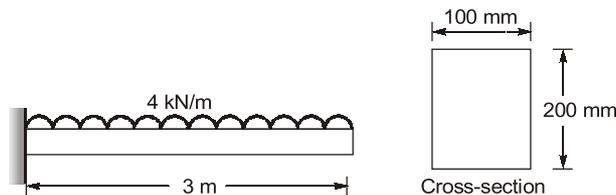
$$\therefore V_A = 11.67 \text{ kN } (\uparrow)$$

End of Solution

Q.117 A cantilever wooden beam is 3 m long and carries a UDL of 4 kN/m. The cross-section of the beam is 100 mm width and 200 mm depth. What is the maximum bending stress for this section?

- (a) 2.7 MPa (b) 27 MPa
(c) 270 MPa (d) 0.27 MPa

Ans. (b)



$$M = \frac{wL^2}{2} = \frac{4 \times 3^2}{2} = 18 \text{ kN-m} = 18 \times 10^6 \text{ N-mm}$$

$$y = \frac{D}{2} = \frac{200}{2} = 100 \text{ mm}$$

$$I = \frac{BD^3}{12} = \frac{100 \times 200^3}{12} = \frac{8 \times 10^8}{12} \text{ mm}^4$$

By flexural equation,

$$\frac{M}{I} = \frac{\sigma_{\max}}{y}$$

$$\Rightarrow \sigma_{\max} = \frac{18 \times 10^6 \times 100}{\frac{8 \times 10^8}{12}} = 27 \text{ N/mm}^2$$

End of Solution

Q.118 In the context of measures of surfaces, which one of the following is not correct?

- (a) 1 Sq. mile = 2.590 Sq. kilometres (b) 1 Sq. mile = 259 Hectares
(c) 1 Sq. mile = 640 Acres (d) 1 Sq. mile = 10^9 Sq. centimetres

Ans. (d)

$$\begin{aligned} 1 \text{ mile} &= 1.609 \text{ km} = 1.609 \times 10^5 \text{ cm} \\ 1 \text{ sq. mile} &= (1.609)^2 = 2.59 \text{ km}^2 \\ 1 \text{ km}^2 &= 100 \text{ ha} \\ 2.59 \text{ km}^2 &= 259 \text{ ha} \\ 1 \text{ sq. mile} &= 640 \text{ Acres} \end{aligned}$$

End of Solution

Q.119 A hollow steel column carrying an axial load of 2.1 MN has an ultimate stress of 510 N/mm². The internal diameter of the column is 150 mm. Consider the factor of safety as 4. What is the external diameter of the column?

- (a) 201.49 mm (b) 208.49 mm
(c) 214.49 mm (d) 218.49 mm

Ans. (b)

Given: $P = 2.1 \times 10^6 \text{ N}$, $\sigma_{\text{ultimate}} = 510 \text{ N/mm}^2$
 $d_i = 150 \text{ mm}$, $\text{FOS} = 4$, $d_o = ?$

$$\sigma_n \leq \frac{\sigma_{\text{ultimate}}}{\text{FOS}}$$

$$\Rightarrow \frac{2.1 \times 10^6}{\frac{\pi}{4}(d_o^2 - 150^2)} = \frac{510}{4}$$

$$\Rightarrow d_o^2 = 150^2 = 20971.00$$

$$\Rightarrow d_o = 208.49 \text{ mm}$$

End of Solution

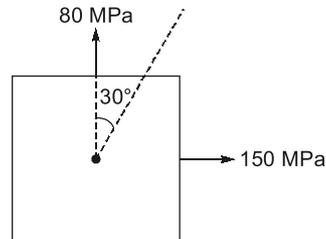
Q.120 The tensile stresses at a point across two mutually perpendicular planes are 150 N/mm² and 80 N/mm². What are the tangential and normal stresses, respectively, on a plane inclined at 30° to the axis of the minor stress?

- (a) 112.5 N/mm²; 10.31 N/mm² (b) 122.5 N/mm²; 20.31 N/mm²
(c) 132.5 N/mm²; 30.31 N/mm² (d) 142.5 N/mm²; 40.31 N/mm²

Ans. (c)

$$\sigma_x = 150 \text{ N/mm}^2, \quad \sigma_y = 80 \text{ N/mm}^2$$

$$\tau_{xy} = 0, \quad \theta = 30^\circ$$



Normal stress,

$$\sigma'_x = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta$$

$$\Rightarrow \sigma'_x = 150 \cos^2 30^\circ + 80 \sin^2 30^\circ$$

$$\Rightarrow \sigma'_x = 132.5 \text{ MPa}$$

Shear stress,

$$\tau'_{xy} = (\sigma_y - \sigma_x) \sin\theta \cos\theta$$

$$\Rightarrow \tau'_{xy} = (80 - 150) \sin 30^\circ \cos 30^\circ$$

$$\Rightarrow \tau'_{xy} = -30.31 \text{ MPa}$$

End of Solution

Q.121 As per IS 1893:2016, what is the percentage of imposed load to be considered in the calculation of seismic weight, if the imposed uniformly distributed floor load is 4 kN/m²?

- (a) 25 (b) 50
(c) 40 (d) 75

Ans. (b)

As per IS 1893 (part 1): 2016, clause 7.3.1

Imposed loads for Seismic Weight calculation,

For floors with uniformly distributed imposed load $\leq 3 \text{ kN-m}^2$, 25% of imposed load shall be considered.

For floors with UDL $> 3 \text{ kN/m}^2$, 50% of imposed load shall be considered.

End of Solution

Q.122 Which one of the following statements is not correct regarding the response reduction factor?

- (a) It accounts for inherent system ductility.
(b) It accounts for redundancy.
(c) It influences the non-linear behaviour of building during strong earthquake shaking.
(d) It accounts for the importance of the building.

Ans. (d)

IS 1893 (Part I): 2016 clause 6.4.2

Response reduction factor (R) depends on:

1. Ductility
2. Redundancy
3. Overstrength
4. Energy dissipation capacity of the lateral load-resisting system.

Importance of building is not included in R as per clause 6.4.3.

End of Solution

Q.123 Which one of the following statements is not correct regarding the working stress method?

- (a) Stress-strain relation is considered linear till yield stress.
- (b) To take care of uncertainties in the design, permissible stress is kept as a fraction of yield stress.
- (c) Increase of permissible stresses by 25% is permitted when dead load, live load and wind load are considered.
- (d) Working stress method gives the uneconomical sections.

Ans. (c)

As per IS 800: 2007 Clause 4.1.1

Permissible stresses may be increased by $33\frac{1}{3}\%$, when wind or earthquake loads are included in combination with dead and imposed load.

End of Solution

Q.124 As per IS 800:2007, the maximum effective slenderness ratio for 'members always in tension (other than pre-tensioned members) is:

- | | |
|---------|---------|
| (a) 180 | (b) 250 |
| (c) 350 | (d) 400 |

Ans. (d)

As per IS 800 : 2007

| Member | λ |
|--|-----------|
| A tension member in which reversal of direct stress due to load other than wind or seismic force occur | 180 |
| Members always under tension | 400 |

End of Solution

Ans. (b)

Given:

$$A_{eff} = 7500 \text{ mm}^2$$

$$f_{cd} = 300 \text{ MPa}, \quad \text{FoS} = 1.5$$

$$\text{Factored load, } P_c = \frac{7500 \times 300}{1000} \text{ kN} = 2250 \text{ kN}$$

$$\text{Safe load, } P_s = \frac{2250}{1.5} = 1500 \text{ kN}$$

End of Solution

Q.130 Which one of the following statements related to a design of laced columns as per IS 800:2007 is not correct?

- (a) The slenderness ratio for lacing bars should not exceed 145.
- (b) In bolted/riveted construction, the minimum width of lacing bars shall be four times the nominal diameter of the bolt/rivet.
- (c) Lacing bars should be inclined at 40° to 70° to the axis of built up member.
- (d) The effective slenderness ratio of laced columns shall be taken as 1.05 times the actual maximum slenderness ratio, in order to account for shear deformation effects.

Ans. (b)

For a laced column

(i) $\lambda < 145$

(ii) B (width) = $3d$ (where d : nominal diameter of bolt)

(iii) $40^\circ < \theta < 70^\circ$

(iv) For laced column λ is taken 5% extra of actual slenderness ratio λ actual i.e.

$$\lambda = 1.05 \lambda_{\text{actual}}$$

End of Solution

Q.131 A roof of a hall measuring 8 m × 12 m consists of 100 mm thick reinforced concrete slab supported on I-beams spaced 3 m apart. The steel beam is designed considering finishing load of 1.5 kN/m² and live load of 1.5 kN/m². What is the permissible deflection for this beam as per IS 800:2007, by considering effective length of beam as 9 m?

- (a) 27.67 mm
- (b) 14.5 mm
- (c) 30 mm
- (d) 35 mm

Ans. (c)

Given: Effective length = 9 m = 9000 mm
for brittle cladding simply supported beam.

$$\text{Permissible deflection} = \frac{\text{Span}}{300} = \frac{9000}{300} = 30$$

End of Solution

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| | | | | | | | | | |
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| 2 AIR IN S. Bhattacharya Test Series | 2 AIR ES Jitesh Choudhary Classroom Course | 2 AIR ES Tarun Yadav Classroom Course | 3 AIR CE Pankaj Meena Classroom Course | 3 AIR ME Nimesh Chandra Classroom Course | 3 AIR PI Aditya Kr. Prasad Classroom Course | 3 AIR XE Rohan Kr. Biswal Test Series | 5 AIR CE Kartik Pokhriyal Classroom Course | | |
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| 9 AIR XE Apar Harsh Chandra Classroom Course | 10 AIR CE Adnan Quasain Classroom Course | 10 AIR CE Rahul Singh Online Course | 10 AIR ME Ashutosh Kumar Classroom Course | 10 AIR ME Jetti Ganateja Test Series | 10 AIR ME Muhammed Sinan K Test Series | 10 AIR ME Pitchika Kr. Vasu Online Course | 10 AIR PI M Gopu Ganesh Test Series | 10 AIR EE Neelava Mukherjee Postal Package & Test Series | |

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Q.132 A simply supported beam of effective span 1.5 m is carrying a factored concentrated load of 360 kN at mid span. What is the section modulus of the beam?

(Take $f_y = 250 \text{ N/mm}^2$ and $\gamma_{m0} = 1.1$)

- (a) $594 \times 10^3 \text{ mm}^3$ (b) $651 \times 10^3 \text{ mm}^3$
(c) $768 \times 10^3 \text{ mm}^3$ (d) $256 \times 10^3 \text{ mm}^3$

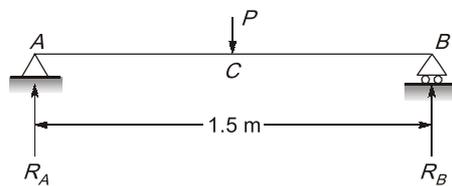
Ans. (a)

Given:

$$L = 1.5 \text{ m}$$

$$P = 360 \text{ kN}$$

$$R_A = R_B = \frac{360}{2} = 180 \text{ kN}$$



Bending moment at mid point.

$$\therefore M_c = \frac{PL}{4} = \frac{360 \times 1.5}{4} = 135 \text{ kN-m}$$

$$M = \beta \times Z_p \frac{f_y}{\gamma_{m0}} = Z_e \times \frac{f_y}{\gamma_{m0}} \quad \left(\because \beta = \frac{Z_e}{Z_p} \right)$$

$$135 \times 10^6 = Z_e \times \frac{250}{1.1}$$

$$Z_e = 594 \times 10^3 \text{ mm}^3$$

End of Solution

Q.133 What is the effective length of a simply supported beam of span length 7 m for the following restraint conditions at the support under normal loading conditions?

Torsional restraint: Fully restrained;

Warping restraint: Both the flanges fully restrained

- (a) 5.25 m (b) 5.95 m
(c) 4.90 m (d) 6.30 m

Ans. (c)

Torsional restraint: Full restrained (prevent rotation about the longitudinal axis)

Warping restraint: Prevent lateral bending of the flange at support

Under these condition: Effective length factor = 0.7

$$\therefore l_o = 0.7 L = 0.7 \times 7 = 4.90 \text{ m}$$

End of Solution

Q.134 What is the bending moment in case of continuous purlins?

(Take the effective length of the purlin as L and load intensity as w)

- (a) $wL^2/8$ (b) $wL^2/10$
(c) $wL^2/32$ (d) $wL^2/24$

Ans. (b)

The maximum bending moment for design in Purlins is Computed by $\frac{wl^2}{10}$ or $\frac{Wl}{10}$

Where,
 w = unfactored uniformly distributed load
 W = unfactored concentrated load at centroid
 l = span of purlin

End of Solution

Q.135 In the case of stiffened seated connection, to avoid local buckling, typically the ratio of outstanding leg length to its thickness should be:

- (a) greater than 8 (b) less than 8
(c) less than 16 (d) greater than 16

Ans. (c)

Outstanding leg length = L_o
thickness = t

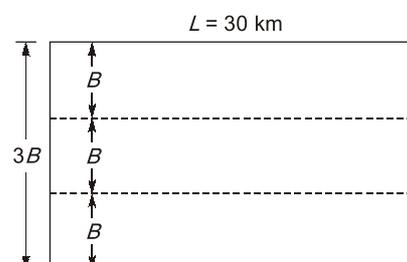
$$\frac{l_o}{t} < 16 \text{ to avoid local buckling}$$

End of Solution

Q.136 What is the time required to grade and finish 30 km of road formation with width equal to thrice the width of the motor grader, using six passes of the motor grader with speed for each of the successive two passes as 6 km/h 8 km/h and 10 km/h, respectively? (Take machine efficiency based on operator's skill, machine characteristics and working conditions as 75%)

- (a) 45 hours (b) 15 hours
(c) 90 hours (d) 60 hours

Ans. (c)



As given, width of formation = $3 \times$ width of motor grader.

Therefore, to cover full width, 3 parallel strips are needed. Each strip requires 6 passes of the grader.

Speed for each of the successive two passes means
 1st and 2nd pass : 6 km/h; Length cover = $2 \times 30 = 60$ km
 3rd and 4th pass : 8 km/h; Length cover = $2 \times 30 = 60$ km
 5th and 6th pass : 10 km/h; Length cover = $2 \times 30 = 60$ km

$$\text{Time to cover one strip} = \frac{60}{6} + \frac{60}{8} + \frac{60}{10}$$

$$= 23.5 \text{ hr}$$

$$\text{Total time to cover all three strips} = 3 \times 23.5 = 70.5 \text{ hr}$$

$$\text{Total required} = \frac{\text{Total time}}{\text{Efficiency}} = \frac{70.5}{0.75}$$

$$= 94 \text{ hr}$$

End of Solution

Q.137 Match the following lists:

List-I

- P. ISO 9001:2015
- Q. ISO 9004:2018
- R. ISO 10005:2018
- S. ISO 10006:2017

List-II

- 1. Guidelines for Quality Plans
- 2. Requirements for Quality Management Systems
- 3. Guidelines for Quality Management in Projects
- 4. Guidelines to achieve Sustained Success

Select the correct answer using the code given below:

| | P | Q | R | S |
|-----|---|---|---|---|
| (a) | 2 | 4 | 1 | 3 |
| (b) | 4 | 2 | 1 | 3 |
| (c) | 1 | 2 | 4 | 3 |
| (d) | 3 | 1 | 2 | 4 |

Ans. (a)

- 1. ISO 9001:2015 - Requirements for Quality Management Systems
- 2. ISO 9004:2018 - Guidelines to achieve Sustained Success
- 3. ISO 10005:2018 - Guidelines for Quality Plans
- 4. ISO 10006:2017 - Guidelines for Quality Management in Projects

End of Solution

Q.138 For the following data, what is the rate of crashing?

Crash cost = INR 10,000

Normal cost = INR 5,000

Normal time = 10 days

Crash time = 5 days

- (a) INR 1000/day
- (b) INR 5000/day
- (c) INR 10000/day
- (d) INR 500/day

Ans. (a)

Given: $C_C = \text{Rs.}10000$, $C_N = \text{Rs.}5000$
 $t_c = 5$ days, $t_n = 10$ days

$$\text{Cost slope} = \frac{C_C - C_n}{t_n - t_c} = \frac{10000 - 5000}{10 - 5}$$

$$= \text{INR } 1000/\text{ day}$$

End of Solution

Q.139 Under time-related financial incentive schemes, the employee is paid:

- according to the overtime worked in proportion to the basic hourly wages and regulatory measures
- according to the measurable completed job
- for completing the fixed quantity of a specified job
- as bonus after a pre-determined time

Ans. (a)

End of Solution

Q.140 Considering A and B as two activities of a project, what are the standard deviation of Activity A and B?

| Activity A | Activity B |
|---|---|
| Optimistic time (t_o) = 4 days | Optimistic time (t_o) = 4 days |
| Most likely time (t_l) = 7 days | Most likely time (t_l) = 6 days |
| Pessimistic time (t_p) = 16 days | Pessimistic time (t_p) = 22 days |

- Standard deviation of Activity A = 2 and B = 3
- Standard deviation of Activity A = 6 and B = 9
- Standard deviation of Activity A = 4 and B = 6
- Standard deviation of Activity A = 4.5 and B = 3

Ans. (a)

Activity (A)

$$\Rightarrow t_o = 4 \text{ days, } t_p = 16 \text{ days}$$

$$\therefore \sigma_A = \frac{t_p - t_o}{6} = \frac{16 - 4}{6} = 2 \text{ day}$$

Activity (B) $t_o = 4$ days, $t_p = 22$ days

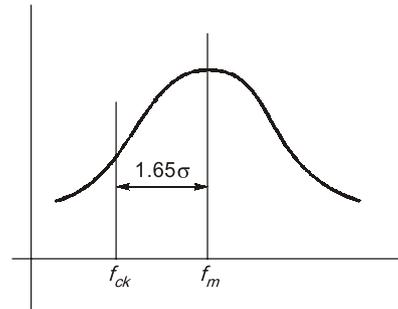
$$\therefore \sigma_B = \frac{22 - 4}{6} = 3 \text{ day}$$

End of Solution

Q.141 If the standard deviation is 4 N/mm² and the desired characteristic strength is 20 N/mm², what is the mean strength of concrete?

- (a) 26.4 N/mm² (b) 14.6 N/mm²
(c) 28 N/mm² (d) 16 N/mm²

Ans. (a)



As per IS 456;

$$f_m = f_{ck} + 1.65 \sigma$$

$$= 20 \text{ MPa} + 1.65 \times 4$$

$$f_m = 26.6 \text{ MPa}$$

End of Solution

Q.142 As per IS 456:2000, what is the creep coefficient of concrete at the age of 28 days of loading?

- (a) 2.2 (b) 1.1
(c) 1.6 (d) 2.8

Ans. (c)

As per IS 456:2000, clause 6.2.5.1 creep of concrete

| Age of concrete loading | Creep coefficient |
|-------------------------|-------------------|
| 7 day | 2.2 |
| 28 day | 1.6 |
| 1 year | 1.1 |

End of Solution

Q.143 As per IS 875 (Part 2) – 1987, what is the minimum imposed load that needs to be considered for living rooms?

- (a) udl = 3 kN/m²; concentrated load = 4.5 kN
(b) udl = 4 kN/m²; concentrated load = 2.7 kN
(c) udl = 2.5 kN/m²; concentrated load = 2.7 kN
(d) udl = 2 kN/m²; concentrated load = 1.8 kN

Ans. (d)

As per IS 875 (Part 2): 1987, Clause 3.1, Table 1

Living room design for 2 kN/m² for uniformly distributed load and 1.8 kN for concentrated load.

End of Solution



Q.144 What is the typical unit weight of brick masonry used by designers?

- (a) 24 kN/m³ (b) 20 kN/m³
(c) 0.130 kN/m³ (d) 25 kN/m³

Ans. (b)

As per IS 875 (part 1): 1987, clause 7.3, Table 1.

Brick masonry is (in cement mortar) unit weight = 20 kN/m³.

End of Solution

Q.145 Which one of the following statements related to IS 875 (Part 3) –1987 is not correct?

- (a) The design wind velocity depends on terrain, height and structure size.
(b) The design wind depends on topography.
(c) The design wind pressure is $0.6 \times (\text{design wind velocity})^2$.
(d) Up to a height of 50 m, the wind pressure is considered to act uniformly.

Ans. (d)

As per IS 875 (part 3): 1987, Clause 5.3.2 clearly states that wind speed depends on:

- Terrain category
- Height above ground
- Structure size

As per clause 5.3.3, the design wind speed depends on topography

As per clause 5.4, design wind pressure, $p_z = 0.6 V_z^2$

Where P_z = Design wind pressure (N/m²)

V_z = Design wind speed (m/s)

IS 875.1987, does not permit uniform pressure upto 50 m. i.e. wind speed varies with height above ground level.

End of Solution

Q.146 As per IS 875 (Part 2) – 1987, what is the reduction in total distributed imposed load (in percent) for design of supporting structural elements in a structure with 10 floors?

- (a) 10% (b) 20%
(c) 30% (d) 40%

Ans. (d)

As per IS 875 (part 2): 1987, clause 3.2.1

Number of floors to be carried
by member under consideration

Reduction in Total distributed imposed load
on all floors to be carried by member under
considerations.

| | | |
|----------|---|----|
| 1 | → | 0 |
| 2 | → | 10 |
| 3 | → | 20 |
| 4 | → | 30 |
| 5-10 | → | 40 |
| above 10 | → | 50 |

End of Solution



Q.147 A one-way slab has effective span of 3.6 m and is 150 mm thick. The live load expected on it is 3 kN/m².

What is the load for checking serviceability?

- (a) 14.4 kN (b) 6.75 kN
(c) 0.75 kN (d) 16.40 kN

Ans. (b)

Dead load due to self weight of slab = depth of slab $\times \gamma_c$
 $= 0.15 \times 25 = 3.75 \text{ kN/m}^2$

Live load = 3.0 kN/m²

For serviceability,

Total load = 1.0 DL + 1.0 LL
 $= 3.75 + 3.0 = 6.75 \text{ kN}$

End of Solution

Q.148 As per IS 456:2000, the strength of concrete achieved in structure is taken as:

- (a) (2/3)rd times the strength of the cube cast at laboratories.
(b) (1/3)rd times the strength of the cube cast at laboratories.
(c) (1/6)th times the strength of the cube cast at laboratories.
(d) (1/4)th times the strength of the cube cast at laboratories.

Ans. (a)

As per IS 456:2000, clause 38.1.

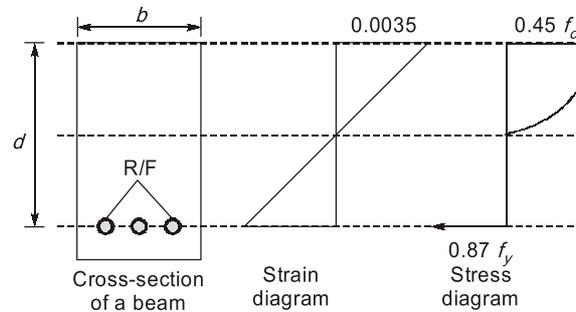
Compressive strength of concrete in structure = $\frac{2}{3}$ of cube strength.

End of Solution

Q.149 As per IS 456:2000, which one of the following statements is **not** correct?

- (a) The strain diagram across the depth of the cross-section is linear.
(b) The tensile strength of concrete is ignored.
(c) The stress in steel shall correspond to strain in steel.
(d) If a partial safety factor of 1.15 is used for design purpose, then the maximum stress in steel is limited to $0.45 f_y$
(where f_y = characteristic strength steel)

Ans. (d)



As per IS 456 : 2000 clause 36.2.1, design strength of steel = $0.87f_y$ (using $\gamma_m = 1.15$)

End of Solution

Q.150 As per IS 1893:2016, what is the value of constant 'A' in the equation mentioned below for determining cyclic stress ratio (CSR)?

$$CSR = A \left(\frac{a_{\max}}{g} \right) \left(\frac{\sigma_{v0}}{\sigma'_{v0}} \right) r_d$$

where, a_{\max} = Peak ground acceleration (PGA) preferably in terms of g .

g = acceleration due to gravity,

r_d = stress reduction factor.

(a) 0.5

(b) 0.15

(c) 0.36

(d) 0.65

Ans. (d)

As per IS 1893 (part 1): 2016, Annex D (Liquefaction analysis)

The cyclic stress ratio (CSR) expression is based on the Seed and Idriss (1971) simplified procedure

$$CSR = 0.65 \left(\frac{a_{\max}}{g} \right) \left(\frac{\sigma_{p0}}{\sigma'_{v0}} \right) r_d$$

$$A = 0.65$$

End of Solution

■■■■