IES MASTER

Institute for Engineers (IES/GATE/PSUs)

ESE 2019

Prelims Exam

Paper - II

CIVIL ENGINEERING

Detailed Solution

(SET-C)

Office Address

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

Ph: 011-41013406, Mobile: 8130909220, 9711853908

NOIDA: B-23 A, 5th Floor, Gaurav Deep Heights, Near Fortis Hospital Sector 62, Noida- 201305 **Ph:** 0120 415 1100

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

SET - C

1. Which of the following statements are correct in respect of temperature effect on a long carrying three hinged arch?

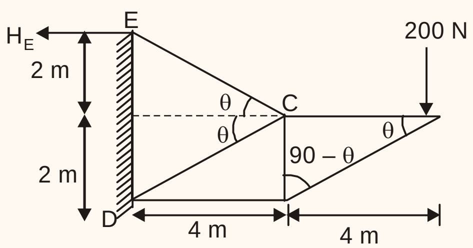
1. No stresses are produced in a three-hinged arch due to temperature change alone.
2. There is a decrease in horizontal thrust due to rise in temperature.
3. There is an increase in horizontal thrust due to rise temperature.

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

(c) 2 only (d) 3 only

Ans. (a)

2. Consider the frame as shown in the figure



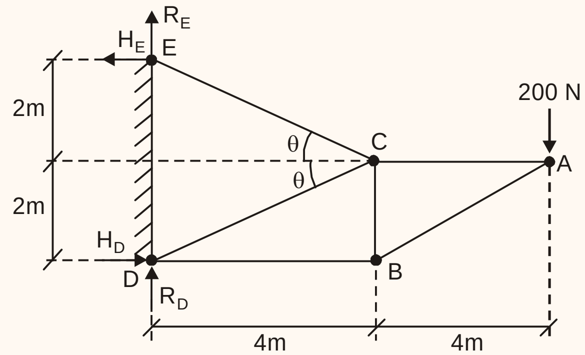
The magnitude of the horizontal support reaction at E is

(a) 400 kN (b) 300 kN

(c) 250 kN (d) 200 kN

Ans. (a)

Sol.

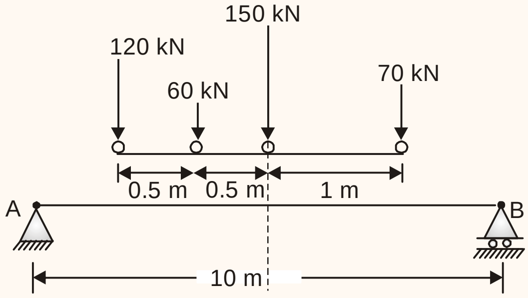


Taking moment about D

$200 \times 8 = H_E \times 4$

$$H_E = \frac{1600}{4} = 400 \text{ N}$$

3. The load system in the figure moves from left to right on a girder of span 10 m.



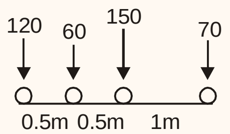
The maximum bending moment for the girder is nearly

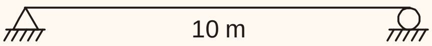
(a) 820 kNm (b) 847 kNm

(c) 874 kNm (d) 890 kNm

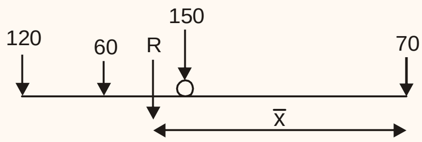
Ans. (d)

Sol.





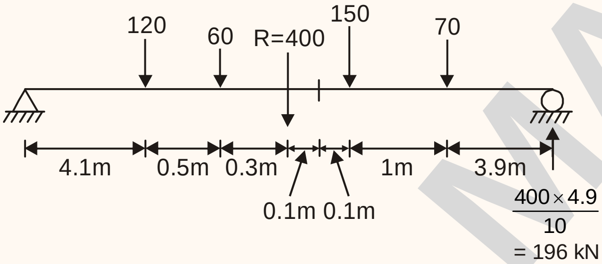
Resultant location of load is given by



$$\bar{x} = \frac{(70\times 0)+(150\times 1)+(60\times 1.5)+(120\times 2)}{400}$$

= 1.2 m

Max. BM will be taken as below 150 kN



BM below 150 kN is 196 × 4.9 – 70 ×1

= 890.4 kNm.

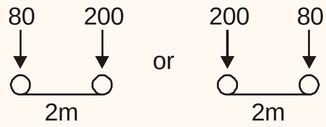
4. Two wheel loads 80 kN and 20 kN respectively spaced 2 m apart, move on a girder of span 16 m. Any wheel load can lead the other. The maximum negative shear force at a section 4 m from the left end will be

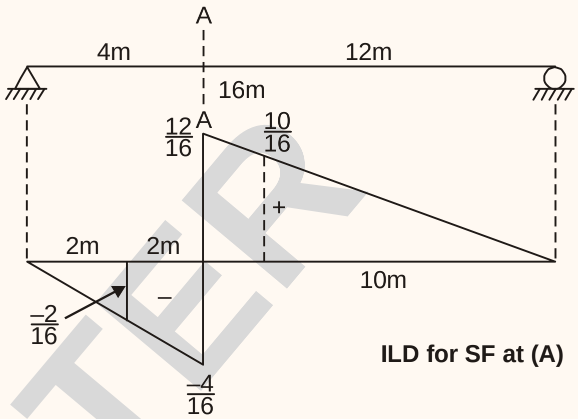
(a) –50 kN (b) –60 kN

(c) –70 (d) –80 kN

Ans. **(b)**

Sol.





ILD for SF at (A)

When 200 kN load is leading :

Max. (–)ve SF when 200 kN is just to the left of sec. (A)

$$V_A = 200\left(\frac{-4}{16}\right)+80\left(\frac{-2}{16}\right)$$

$$= \frac{-960}{16} = -60 \text{ kN}$$

When 80 kN load is leading :

Max. (–)ve SF when 80 kN is just to the left of (A)

$$V_A = 80\left(\frac{-4}{16}\right)+200\left(\frac{-2}{16}\right) = \frac{-720}{16} = -45 \text{ kN}$$

When 200 kN is just to the left of (A)

$$V_A = 200\left(\frac{-4}{16}\right)+80\left(\frac{10}{16}\right) = 0$$

5. The maximum possible span for a cable supported at the ends at the same level (assuming it to be in a parabolic profile) allowing a central dip of $\frac{1}{10}$ of the span with permissible stress of 150 N/mm^2 (where the steel weighs 78,000 N/m^3) will be nearly

(a) 1270 m (b) 1330 m

(c) 1388 m (d) 1450 m

Ans. (c)

Sol. Let the maximum horizontal span be ℓ metres.

Dip of the cable = h = $\frac{\ell}{10}$ metres

Length of the cable = L = $\ell + \frac{8}{3}\cdot\frac{h^2}{\ell}$

$$= \ell\left[1+\frac{8}{3}\left(\frac{h}{\ell}\right)^2\right] = L$$

$$= \ell\left[1+\frac{8}{3}\cdot\frac{1}{100}\right] = \frac{308}{300}\ell$$

Let the area of the cable be A mm^2

Weight of the cable = W

$$= \frac{308}{300}\ell\cdot\frac{A}{1000^2}\times 78000\ \text{N};$$

W = 0.08008 Aℓ N

Each vertical reaction

$$= V = \frac{W}{2};$$

Horizontal reaction = H = $\frac{W\ell}{8h}$

$$= \frac{W}{8}(10) = \frac{5}{4}W$$

$\therefore$ Max. tension = T_{max} = $\sqrt{V^2+H^2}$

$$= \sqrt{\left(\frac{W}{2}\right)^2+\left(\frac{5W}{4}\right)^2} = 1.35\ W$$

= 1.35 × 0.08008 Aℓ N

Maximum stress = $\frac{T_{max}}{A}$ = f_{max}

$\therefore$ $1.35\times 0.08008\ell$ = 150

$\therefore$ ℓ = 1387.5 m

6. A three-hinged arch has a span of 30 m and a rise of 10 m. The arch carries UDL of 60 kN/m on the left half of its span. It also carries two concentrated loads of 160 kN and 100 kN at 5 m and 10 m from the right end.

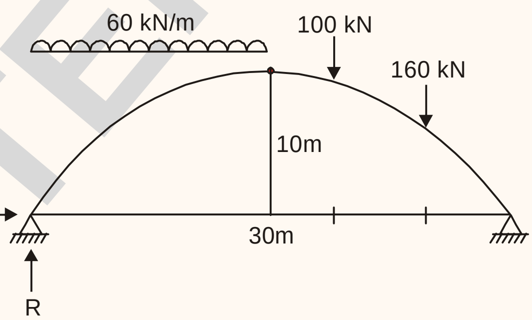
The horizontal thrust will be nearly

(a) 446 kN (b) 436 kN

(c) 428 kN (d) 418 kN

Ans. (c)

Sol.



R × 15 – H × 10 – 60 × 15 × 7.5 = 0

1.5R – H – 675 = 0 ...(1)

R × 30 – 60 × 15 × 22.5 – 100 × 10 – 160 × 5 = 0

R = 735 kN

$\Rightarrow$ H = 427.5 kN

7. An unstable vibratory motion due to combined bending and torsion which occurs in flexible plate like structures is called

(a) Galloping (b) Ovalling

(c) Flutter (d) Oscillation

Ans. (c)

Sol. Flutter is a oscillatory motion that results from the coupling of aerodynamic forces with the elastic deformation of a structre. It is often the results of combined bending and torsion and effects plate like structures.

Examples: sign boards and suspension bridges decks.

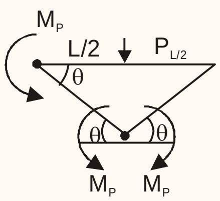
8. A propped cantilever beam of span l and constant plastic moment capacity M_p carries a concentrated load at mid-span. The load at collapse will be

(a) $\frac{2\,M_p}{l}$ (b) $\frac{4\,M_p}{l}$

(c) $\frac{6\,M_p}{l}$ (d) $\frac{8\,M_p}{l}$

Ans. (c)

Sol.



$$P\frac{L}{2}\theta = 3M_P\theta$$

$$P = \frac{6M_P}{L}$$

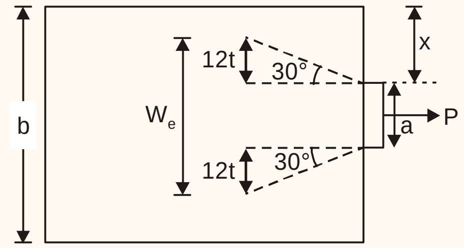
9. A steel plate is subjected to tension. The tensile force is applied over a width 'a' whereas the gross width of the plate 'b'. The dispersion of the force from the point of application is at about 30° with the axis and extends to a maximum width of 12 times the thickness t of the plate. The effective width which into action will be

(a) 2a + 12t (b) a + 12t

(c) a + 24t (d) 2a + 24t

Ans. (c)

Sol.



Effective width (W_e) = a + 24t (If, x > 12t)

Effective width (W_e) = b (If, x < 12t)

10. A wind brace is to be provided between two columns spaced at 5m, at an inclination of 30° with the horizontal, to resist a tension of 320 kN developed by a wind force. The effective area required will be nearly (considering 150 N/m^2 as a relevant factor)

(a) 1670 mm^2 (b) 1640 mm^2

(c) 1600 mm^2 (d) 1570 mm^2

Ans. (c)

11. A beam column for non-sway column in a building frame is subjected to a factored axial load of 50 kN, factored moment at bottom of column of 45 kNm. For ISHB 200, the values are A = 4750 mm^2, $\gamma_y = 45.1$, h = 200 mm, b = 200 mm, b_f = 9 mm and the effective length is 0.8 L. Its buckling load will be

(a) 910 kN (b) 930 kN

(c) 950 kN (d) 980 kN

Ans. (c)

Sol. P_e = equivalent axial load

$$P_e = P + \frac{2M_z}{d}, \text{ where } d = \text{depth of beam}$$

$$= 500 + 2 \times \frac{45000}{200} = 950 \text{ kN}$$

12. Which of the following assumptions are correct for ideal beam behaviour?

1. The compression flange of the beam is restrained from moving laterally

2. The tension flange of the beam is restrained from moving laterally.

3. Any form of local buckling is prevented.

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

(c) 1 only (d) 3 only

Ans. **(b)**

Sol. Two important assumptions are made for ideal beam behaviour.

(i) Compression flange of beam is restrained laterally.

(ii) Local buckling of elements is prevented.

13. In which one of the following industrial roofing contexts, is the loading carried by the combination of pure flexure and flexure due to shear induced by the relative deformation between the ends of the top and bottom chord members?

(a) Vierendeel girders

(b) Scissors girders

(c) Lenticular girders

(d) Mansard girders

Ans. **(a)**

Sol. **Mansard truss :** When straight members are used for top chords, they are called **Mansard trusses**. Any web system may be used, since the web stresses are normally small. If, for example, a parabolic upper chord is used and the truss is subjected to a uniform load, there will be no stress in the web members, uniform tension throughout the lower chord, and compression in the upper chord (forces in upper chord members will be slightly higher than the lower chord members due to their slope). In other words, the behaviour will be similar to that of a tied arch of the same rib form. The diagonals, though carrying zero forces, are provided for stability under varying loading conditions, if the joints are pin-connected. Both bowstring and mansard trusses are used for longer spans.

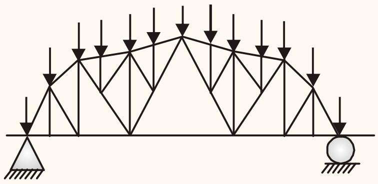


Fig. (a)

Vierendeel girders : When the chords are parallel as shown in figure below, they are called as Vierendeel girders. In a Vierendeel girder, the loading is carried by a combination of pure flexure and flexure due to shear induced by the relative deformation between the ends of the top and bottom chord members, similar to that found in castellated beams.

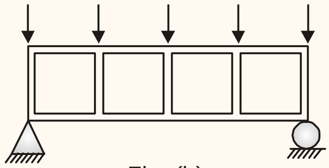


Fig. (b)

Lenticular truss : The lens shaped truss is called as lenticular truss, as shown in figure below has been used in some bridges in USA. Here again the web members will carry zero forces and hence may be removed and the joints may be made rigid as shown in figure below.

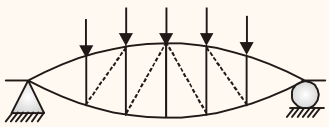


Fig. (c)

Scissors truss : The scissors truss is shown below, is used infrequently in steel construction but is included to show as efficient form for use in short spans. In these types of trusses, both the chords are sloped.

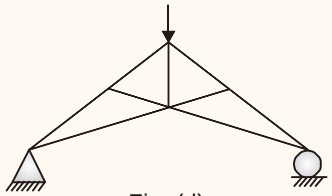


Fig. (d)

14. Bearing stiffeners are provided

(a) At the ends of plate girders

(b) At the ends of plate girder and on both faces of the wen

(c) At the ends of plate girder and only on one face of the web

(d) At the points of concentrated loads, to protect the web from the direct compressive loads.

Ans. **(d)**

Sol. Bearing stiffners are provided at joints of concentrated loads, to protect the web from the direct compressive loads.

15. If the cost of purlins/unit area is p and the cost of roof covering/unit area is r, then cost of trusses/unit area l for an economical spacing

(a) p + r (b) 2p + r

(c) p + 2r (d) 2p + 2r

Ans. **(b)**

Sol. Cost of truss is inversely proportional to the spacing of truss,

$\therefore l = k_1/s$

Cost of purlins is directly proportional to the square of spacing of trusses

$\therefore$ $P = k_2s^2$

Cost of roof covering is directly proportional to the spacing of trusses

$\therefore$ $r = k_3s$

$\therefore$ Total cost = $l + p + r$

$C = k_1/s + k_2s^2 + k_3s$

For minimum cost, $\frac{dc}{ds} = 0$

$\therefore$ $-k_1/s^2 + 2k_2s + k_3 = 0$

$\Rightarrow$ $k_1/s + 2k_2s^2 + k_3s = 0$

$\Rightarrow$ $-l + 2p + r = 0$

$\therefore$ $l = 2p + r$

16. A welded plate girder of span 25 m is laterally restrained throughout its length. It has to carry a load of 80 kN/m over the whole span besides its weight. If K = 200 and f_y = 250 MPa, the thickness of web will be nearly

(a) 10 mm (b) 14 mm

(c) 16 mm (d) 20 mm

Ans. **(a)**

Sol. Span (l) = 25 m

Factored applied udl = 1.5 × 80 = 120 kN/m

Total factored applied load (W) = 120 × 25

= 3000 kN

Let self weight of the girder = $\frac{W}{200}$ kNm

$= \frac{3000}{200} = 15$ kNm

$\therefore$ Total uniform factored load = 120 + 15

= 135 kNm

Maximum bending moment (M) = $\frac{135 \times 25^2}{8}$

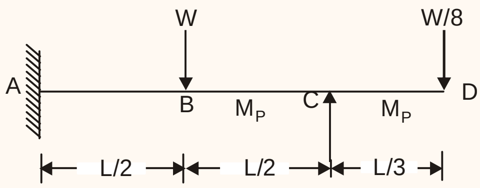
= 105.46.875 kNm

Optimum thickness of web,

$$t_w = \left(\frac{M}{f_y k^2}\right)^{1/3} = \left(\frac{10546.875 \times 10^6}{250 \times 200^2}\right)$$

= 10.17 mm $\simeq$ 10 mm

17. A proper cantilever ABCD is loaded as shown in figure. If it is of uniform cross-section, the collapse load of the beam will be nearly

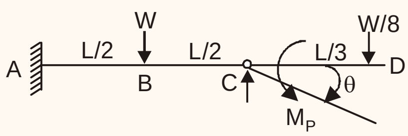


(a) $6.5\dfrac{M_P}{L}$ (b) $5.6\dfrac{M_P}{L}$

(c) $4.7\dfrac{M_P}{L}$ (d) $3.8\dfrac{M_P}{L}$

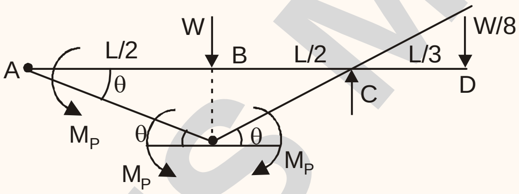
Ans. **(a)**

Sol. **Collapse mech-1**



$$\frac{W}{8}\times\frac{L}{3}\theta = M_P\theta \Rightarrow W = \frac{24\,M_P}{L}$$

Collapse mech-2

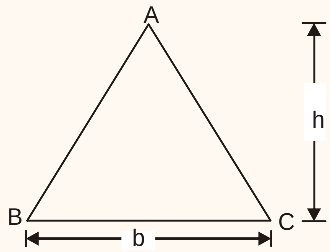


$$W\times\frac{L}{2}\theta-\frac{W}{8}\times\frac{L}{3}\theta = 3M_P\theta$$

$$\frac{11}{24}WL\theta = 3M_P\theta$$

$$\Rightarrow \quad W = 6.545\frac{M_P}{L}$$

18. Consider a triangular section with base b and height h as shown in the figure.



The shape factor will be nearly

(a) 2.3 (b) 3.2

(c) 4.1 (d) 5.0

Ans. **(a)**

Sol. Shope factor of triangular section is 2.34

19. Fatigue in RCC beams will ***not*** be a problem if the number of cycles is less than

(a) 20,000 (b) 25,000

(c) 30,000 (d) 35,000

Ans. **(a)**

20. The desired characteristic strength of a mix is 20 N/mm². The standard deviation is 4 N/mm² for 150 mm size of concrete cubes; and K = 1.645. The average strength of the cubes will be nearly

(a) 38.2 N/mm² (b) 32.4 N/mm²

(c) 26.6 N/mm² (d) 22.8 N/mm²

Ans. **(c)**

Sol. Mean strength or average strength of cube

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

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

$K = 1.645$

$\sigma = 4\ \text{N/mm}^2$

$\Rightarrow$ $f_m = 20 + 1.645\times 4$

$= 26.58\ \text{N/mm}^2$

$\cong 26.6\ \text{N/mm}^2$

21. A circular column is subjected to an un-factored load of 1600 kN. The effective length of the column is 3.5 m, the concrete is M 25, and the value of $\rho_g = \frac{A_{SC}}{A_g}$ = 2% for Fe 415 steel. The design diagram of the column will be nearly

(a) 446 mm (b) 432 mm

(c) 424 mm (d) 41 mm

Ans. **(a)**

Sol. From the options, it is clear that the column is a short colum.

As all the options are > $\frac{l_{eff}}{12} = \frac{3.5\times10^3}{12}$

= 291.67 mm

Hence we can consider the column as a short axially loaded column

$$P_u = 0.4 f_{ck} A_c + 0.67 f_y A_{sc}$$

$$A_{sc} = 2\% \text{ of } A_g = 0.02 A_g$$

$$\Rightarrow 1.5 \times 1600 \times 10^3 = 0.4\times25 (A_g - 0.02 A_g) + 0.67 \times 415 \times 0.02 A_g$$

$$\Rightarrow 2400 \times 10^3 = 9.8 A_g + 5.561 A_g$$

$$\Rightarrow A_g = \frac{2400\times10^3}{15.361} = 156239.82 \text{ mm}^2$$

$$\Rightarrow \frac{\pi}{4}D^2 = 156239.82$$

$$\Rightarrow D = 446 \text{ mm}$$

22. A strut is made of a circular bar, 5 m long and pin-jointed at both ends. When freely supported the bar gives a mid-span deflection of 10 mm under a load of 80 N at the centre.

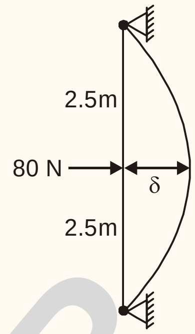
The critical load will be

(a) 8485 N (b) 8340 N

(c) 8225 N (d) 8110 N

Ans. **(c)**

Sol.



$$\delta = \frac{80(5)^3}{48 EI} = 10 \times 10^{-3}$$

$$EI = \frac{80(5)^3}{48\times10\times10^{-3}}$$

$$\text{Critical load} = \frac{\pi^2 EA}{\lambda^2}$$

$$= \frac{\pi^2 E}{\left(\frac{\ell_{eff}}{r_{min}}\right)^2} = \frac{\pi^2 EI_{min}}{\ell_{eff}^2}$$

$$= \frac{\pi^2}{\ell_{eff}^2}\times EI$$

$$= \frac{\pi^2}{(5)^2}\times\frac{80(5)^3}{48\times10\times10^{-3}} = 8224.67 \text{ N}$$

23. The recommended imposed load on staircase in residential buildings as per IS 875 is

(a) 5.0 kN/m^2 (b) 3.0 kN/m^2

(c) 1.5 kN/m^2 (d) 1.3 kN/m^2

Ans. **(b)**

Sol. The recommended imposed load on stair case in residential building as per IS 875

(IS 875 (part 2), clause 3.1) is 3 kN/m^2.

24. A 230 mm brick masonry wall is to be provided with a reinforced concrete footing on site having soil with safe bearing capacity of 125 kN/m^2, unit weight of 17.5 kN/m^3 and angle of shearing resistance of 30°. The depth of

footing will be nearly

(a) 0.8 m (b) 0.7 m

(c) 0.6 m (d) 0.5 m

Ans. **(a)**

Sol. Depth of footing = $\frac{q}{\gamma}\left[\frac{1-\sin\phi}{1+\sin\phi}\right]^2$

$$= \frac{125}{17.5}\times\left[\frac{1-\sin 30}{1+\sin 30}\right]^2$$

$$= \frac{125}{17.5}\times\left(\frac{1}{3}\right)^2 = \frac{125}{157.5}$$

$= 0.793$ m

$\cong 0.8$ m

25. A rectangular beam 200 mm wide has an effective depth of 350 mm. It is subjected to a bending moment of 24,000 Nm. The permissible stresses are c = 5 N/mm^2, t = 140 N/mm^2; and m is 18. The required area of tensile reinforced will be

(a) 688 mm^2 (b) 778 mm^2

(c) 864 mm^2 (d) 954 mm^2

Ans. **(b)**

Sol. b = 200mm

d = 350mm

M = 24000Nm

C = 5N/mm^2

(Permissible stress in concrete in bending compression)

t = 140N/mm^2

(Permissible stress in steel)

m = 18 (Modular ratio)

It is a WSM based quations,

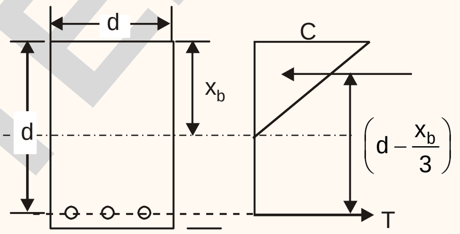
Balance depth of N.A = $\left[\frac{1}{1+\frac{3\sigma_{St}}{280}}\right]d$

$$= \left[\frac{1}{1+\frac{3t}{280}}\right]d$$

$$= \left[\frac{1}{1+\frac{3\times140}{280}}\right]\times 350$$

= 140mm

Balance moment = $0.5bx_bc\left(d-\frac{x_b}{3}\right)$



$$= 0.5\times200\times140\times5\times\left(350-\frac{140}{3}\right)\text{N.mm}$$

= 21233.33Nm

$\Rightarrow$ MOR$_{balance}$ < B.M

$\Rightarrow$ Section needs to be designed as a over reinforced

$\Rightarrow$ Depth of Neutral axis

$$0.5bxc\left(d-\frac{x}{3}\right) = 24000\text{Nm}$$

$$\Rightarrow 0.5\times200\times x\times5\times\left(350-\frac{x}{3}\right)$$

$= 24000\times10^3$N.mm

$\Rightarrow$ 175000x – 166.67x^2 – 24000 × 10^3 = 0

$\Rightarrow$ x = 887.78mm (it is out of section and shall be discarded)

x = 162.10mm

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ESE-2019 Conventional Test Schedule, Civil Engineering

Date	Topic
17th Mar 2019	**N.T.** : M-1, M-3, M-4, SM-1, SM-3, SM-8
	R.T. :
24th Mar 2019	**N.T.** : SA-1, SA-2, SA-5, HY-1, HY-4, HY-5, M-5
	R.T. : SM-1, M-1
31st Mar 2019	**N.T.** : DSS-4, DSS-5, FM-1, FM-4, FM-6
	R.T. : M-3, SA-1, SA-2
07th Apr 2019	**N.T.** : SA-6, SA-4, SA-3, EE-6, EE-5, EE-4
	R.T. : FM-4, FM-6, M-1, M-4, M-3, HY-1
14th Apr 2019	**N.T.** : FM-7, RCC-1, RCC-2, RCC-3, HY-2
	R.T. : SA-1, SA-2, SM-3, FM-6, EE-6
21st Apr 2019	**N.T.** : SM-4, DSS-1, DSS-2, DSS-3, RCC-4, RCC-5, RCC-6
	R.T. : SM-1, SA-3, EE-5
28th Apr 2019	**N.T.** : SU-1, SU-2, SU-3, SM-2, SM-5, SM-6, SM-7, HY-3, SU-5
	R.T. : FM-7, RCC-1, RCC-2, RCC-3, HY-1, EE-6
05th May 2019	**N.T.** : TF-1, TF-2, TF-3, TF-4, FM-5, M-2
	R.T. : RCC-5, DSS-1, DSS-2, SM-4, M-1, M-3, M-4, FM-4, SA-1
12th May 2019	**N.T.** : IR-1, IR-2, IR-3, IR-4, EE-7
	R.T. : SM-5, SM-6, FM-1, EE-5, DSS-3, DSS-4, HY-3, HY-4, HY-5, SU-1, SU-2
19th May 2019	**N.T.** : CPM-1, CPM-2, EE-1, EE-2, EE-3, SU-4 (Railway & Airport)
	R.T. : SM-4, FM-5, TF-1, TF-2, FM-7, SA-3, SU-3, SU-5, RCC-5
26th May 2019	**N.T.** : FM-2, FM-3, FM-8, Building Material, Ports & Harbors/Tunneling
	R.T. IR-1, IR-2, HY-2, DSS-4, DSS-2, SA-1, SA-2, SA-3, RCC-6, EE-2, FM-6
02nd Jun 2019	Full Length-1 (Test Paper-1 + Test Paper-2)
09th Jun 2019	Full Length-2 (Test Paper-1 + Test Paper-2)
16th Jun 2019	Full Length-3 (Test Paper-1 + Test Paper-2)

Test Type	Timing	Day
Conventional Test	10:00 A.M. to 1:00 P.M.	Sunday
Conventional Full Length Test Paper-1	10:00 A.M. to 1:00 P.M.	Sunday
Conventional Full Length Test Paper-2	02:00 P.M. to 5:00 P.M.	Sunday

Note : The timing of the test may change on certain dates. Prior information will be given in this regard.

*__N.T. :__ New Topic. *__R.T. :__ Revision Topic

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Subject Code Details

Subject	SA-1	SA-2	SA-3	SA-4	SA-5	SA-6
Structural Analysis (SA)	Slope Deflection Method	Moment Distribution Method	Truss, Cables, Arches	Force Method, • Consistent Deformation Method • Method of Least work • Castigliano's Method	Determinacy/ indeterminacy/ stability	Stiffness Matrix Method, Influence Line Diagram/Moving Load , Free and Forced Vibrations , Concepts and use of computer aided design

Subject	M-1	M-2	M-3	M-4	M-5
SOM (M)	Concept of Stress and Strain	Shear Force & Bending Moment, Deflection of Beams	Transformation of Stress & Strains, Theory of Failure, Combined Bending & Torsion/ Combined bending & Transverse shear stress/ combined bending & Axial stress, Torsion	Bending Stress, Shear Stress	Columns, Springs, Thick & Thin Shells, Moment of inertia

Subject	RCC-1	RCC-2	RCC-3	RCC-4	RCC-5		RCC-6
RCC & PSC (RCC)	Working stress Method of RCC Design	Limit State Method	Earthquake resistant structures, Beams (LS, WS), Lintels	Slab-One way, (LS, WS) Staircase	Column, (LS, WS) Water Tanks	Fooling (LS, WS), Retaining Wall	Cement & Concrete, Masonry Structures, PSC-Pre stressed Concrete

Subject	DSS-1	DSS-2	DSS-3	DSS-4	DSS-5	DSS-6
Design of Steel Structure (DSS)	Compression member	Plastic Analysis	Beams	Connections (Direct, Eccentric)	Tension Member	Plate girders, Industrial building

Subject	CPM-1	CPM-2
Pert & CPM (CPM)	Network analysis, Pert, CPM, Crashing, Resource allogaction, Levelling,Smoothing, Rate Analysis	Construction equipments, Engineering Economy,Tendering Process and Contract , Management Estimation and costing, Quality control, Productivity, Opration cost, Land Aquisition

Subject	BM-1	BM-2
Building Material (BM)	Cement, Concrete, Stone, Lime, Glass, Steel	Brick Mortar Timber, Plastics, FRP, Ceramics, Aluminium

Subject	EE-1	EE-2	EE-3	EE-4	EE-5	EE-6	EE-7
Environmental (EE)	Characteristics of water, Treatment of water	Distribution of water	Characteristics of Sewage	Disposal of Sewage	Sewer design	Treatment of Sewage	Air Pollution, Noise Pollution, Solid Waste Management, Miscellaneous topics

Subject	FM-1	FM-2	FM-3	FM-4	FM-5	FM-6	FM-7	FM-8
Fluid Mechanics (FM)	Fluid properties, Hydrostatic Pressure, Liquid in relative equilibrium, Buoyancy & Flotation	Fluid Kinematics	Fluid Dynamics, Weirs & Notches	Laminar flow, Turbulent flow, Boundary layer theory, Drag & lift	Flow through Pipes	Open channel flow	Hydraulic Machines, Power House	Modal Analysis & Dimensional Analysis

Subject	SM-1	SM-2	SM-3	SM-4	SM-5	SM-6	SM-7	SM-8
Soil Mechanics (SM)	Classification of Soil, Soil water relationships, index properties of Soil, Compaction of Soil	Effective stress, Seepage, Permeability	Consolidation	Shear Stress/ Vertical Stress	Earth Pressure, Stability of Slopes	Bearing capacity-Shallow Foundation	Deep foundation - Piles	Exploration of Soil, Expansive Soil, Geosynthetics, Ground Modification Techniques

Subject	TF-1	TF-2	TF-3	TF-4
Transportation (TF)	Geometric Design	Pavement Design	Materials, Construction, Maintenance, Hill roads etc.	Traffic Engineering

Subject	SU-1	SU-2	SU-3	SU-4	SU-5
Surveying (SU)	Scale/ Accuracy, Measurements of horizontal distances, Theory of Errors	Angular Measurements, Theodolite	Levelling, Contouring, Curve setting, Measurment of Area & Volume	Triangulation & Traversing Plane tabling, Geology	Photogrammetry, Field Astronomy, GPS, Remote Sensing

Subject	IR-1	IR-2	IR-3	IR-4
Irrigation (IR)	Soil water relationships, irrigation requirements of crops (Duty, Delta)	Design of Canals (Lacey & Kennedy)	Gravity dams	Cross drainage works, Weirs & Barrages, Seepage theory, Canal Falls/ Canal Regulators, Energy dissipators, River training works

Subject	HY-1	HY-2	HY-3	HY-4	HY-5
Hydrology (HY)	Hydrographs	Flood Routing	Ground Water	Evapo-transpiration, Run off	Abstraction from Precipitation, Hydrological Cycle, Precipitation, Stream flow measurement

Railways / Airports / Ports & Harbours / Tunneling

For Any Query Regarding The Program

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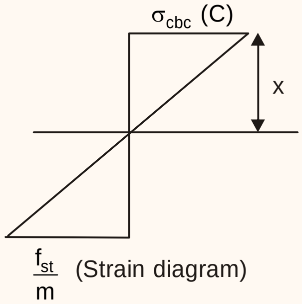


(For over reinforced section) (strain diagram)

$$\frac{c}{x} = \frac{f_{st}}{m(d-x)}$$

$$\Rightarrow \quad \frac{5}{162.20} = \frac{f_{st}}{18(350-162.20)}$$

$$\Rightarrow \quad f_{st} = 104.20 \text{ N/mm2}$$

MOR from tension side

$$\Rightarrow \quad 24000 \times 10^3 = f_{st} A_{st}\left(d-\frac{x}{3}\right)$$

$$= 104.20 A_{st}\left(350-\frac{162.20}{3}\right)$$

$$\Rightarrow \quad A_{st} = 778.30\text{mm}^2 \simeq 778\text{mm}^2$$

26. Which of the following statements are correct with reference to ensuring minimum shrinkage of prestressed concrete?

1. The water-cement ratio and proportion of cement paste should be kept minimum to reduce shrinkage.
2. Aggregates of larger size, well graded for minimum void, need a smaller amount of cement paste, and attendant shrinkage will be smaller.
3. Harder and denser aggregates of low water absorptions and high modulus of elasticity will exhibit small shrinkage.

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

Ans. **(d)**

Sol. Concrete with aggregates that are hard, dense and have low water absorption and high modulus of elasticity will have low creep and shrinkage.

These aggregate will generally not allow the change in volume due to higher rigidity.

Also, as cement paste and water-cement ratio is responsible for creep and shrinkage, keeping minimum water-cement ratio, larger aggregate size will lead to less shrinkage.

27. During earthquakes, the corner and edge columns may be subjected to

(a) Uniaxial bending
(b) Biaxial bending
(c) Combined biaxial bending and torsion
(d) Combined biaxial bending and tension

Ans. **(d)**

Sol. During earthquake structre can behave as a cantilever, inducing the tensile force in the columns lying on the side of application of lateral load while inducing compressive force on the columns on the opposite side.

Also, biaxial bending will be there in the corner and edge columns.

28. The minimum number of bars required in a rectangular column for an earthquake resistant design, is

(a) 4 (b) 6
(c) 8 (d) 10

Ans. **(c)**

29. The permissible of allowable compressive stress f_{ac} of brick masonry does ***not*** depend on

(a) Type of strength of bricks
(b) Efflorescence of bricks
(c) Strength of mortar
(d) Slenderness ratio

Ans. **(b)**

Sol. "Efflorescence" is a defect which is caused due to presence of excessive soluble salts in brick earth. These salts after getting dissolved in water, appear in form of fine whitish crystals on the exposed brick surface. This defect will result in ugly appearance. But it doesn't affect the strength of brick masonry.

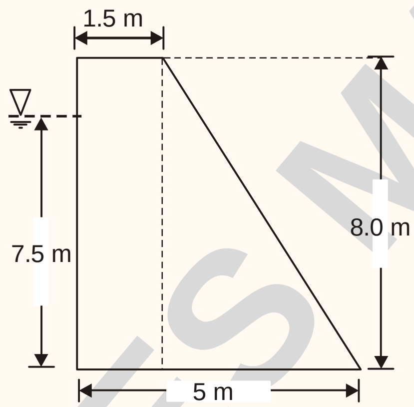
30. A masonry dam 8 m high 1.5 m wide at the top and 5 m wide at the base retains water to a depth of 7.5 m, the water face of the dam being vertical. If the weight of water is 9.81 kN/m^3, weight of masonry is 22 kN/m^3, the maximum intensity of stress developed at the base will be nearly.

(a) 196 kN/m^2 (b) 182 kN/m^2

(c) 160 kN/m^2 (d) 148 kN/m^2

Ans. **(b)**

Sol.



Weight of rectangular portion = 1.5 × 8×22

= 264 kN

Weight of triangular portion

= 0.5 × (5 – 1.5) × 8 × 22

= 308 kN

Overturning moment about toe

$$= 0.5 \times 9.81 \times 7.5^2 \times \frac{7.5}{3}$$

= 689.765 kN-m

Resisting moment about toe

$$= 264 \times \left(\frac{5-1.5}{2}\right) + 308 \times 2 \times \frac{(5-1.5)}{3}$$

= 1840.67 kNm

Eccentricity about centroid

$$= \frac{5}{2} - \bar{x}$$

$$\bar{x} = \frac{(M_R - M_0)}{\text{Vertical load}} = \frac{1840.67 - 689.765}{(308 + 264)}$$

= 2.01 m

$$e = \frac{5}{2} - 2.01 = 0.49 \text{ m}$$

$$\text{Stress at toe} = \frac{W}{b}\left(1 + \frac{6e}{b}\right)$$

$$= \frac{572}{5}\left(1 + \frac{6 \times 0.49}{5}\right)$$

= 181.80 kN/m^2 $\cong$ 182 kN/m^2

31. Consider the following data

Root zone depth = 2 m

Existing water content = 5%

Dry density of soil = 15 kN/m^3

Water applied to their soil = 500 m^3

Water loss due to evaporation and deep percolation = 10%

Area of plot = 1000 m^2

The field capacity of the soil will be nearly.

(a) 16.8 % (b) 17.7 %

(c) 18.8 % (d) 19.7 %

Ans. **(d)**

Sol. Root zone depth, D = 2 m

γ_d = 15 kN/m^3

γ_w = 9.81

Water applied to the soil = 500 m^3

$\because$ Water loss due to evaporation and deep percolation = 10%

$\therefore$ Amount of water lost = 50 m^3

$\therefore$ Total water stored = 450 m^3

$\because$ Area of plot = 1000 m^2

$\therefore$ Depth of water stored, $d' = \frac{450}{1000} = 0.45$ m

$\because$ Existing water content may be assumed as M_0 = 5%

$$\therefore \quad d' = \frac{\gamma_d}{\gamma_w} \times D \times (F_C - M_0)$$

$$0.45 = \frac{15}{9.81} \times 2\,(F_C - 0.05)$$

$$F_C = 0.1971$$

$$F_C = 19.71\%$$

32. Consider the following data for irrigation water:

	Concentration	Milli - equivalent per litre
1	Na^+	24
2	Ca^{++}	3.6
3	Mg^{++}	2

The solidum-Absorption ratio (SAR) is nearly

(a) 13.1 (b) 14.3

(c) 15.5 (d) 16.7

Ans. **(b)**

Sol. $$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}}$$

$$= \frac{24}{\sqrt{\frac{3.6+2}{2}}}$$

SAR = 14.34

33. Consider the following statements with respect to weir under discussion:

1. Its design corresponds to soft sandy foundation.
2. The difference in weir crest and downstream river bed may not exceed 3m.
3. When water passes over it, the longitudinal location of the formation of hydraulic jump is variable.

This weir is of the type.

(a) Vertical drop weir

(b) Masonry or concrete sloping weir

(c) Dry stone slope weir

(d) Parabolic weir

Ans. **(b)**

Sol. Masonary on concrete sloping weir.

Weir of this type are of recent origin. They are suitable for soft sandy foundation, and are generally used where the difference in weir crest and downstream river bed is limited to 3m, when water passes over such a weir, hydraulic jump is formed on the sloping glacis.

34. Consider the following data while designing an expansion transition for a canal by Mitra's method:

Length of flume = 16 m

Width of throat = 9 m

Width of canal = 15 m

If B_x is the width at any distance x from the flumed section, the values of B_X at x = 8 m and at x = 16 m are nearly

(a) 10.8 m and 15 m

(b) 11.3 m and 15 m

(c) 10.8 m and 13 m

(d) 11.3 m and 13 m

Ans. **(b)**

Sol. According to Mitra, channel at any section, at a distance x from the flumed section is given by,

$$B_x = \frac{B_n \times B_f \times L_f}{L_f B_n - (B_n - B_f)x}$$

where, B_n = 15 m, width of canal

B_f = 9 m, width of throat

L_f = 16 m, length of flume

B_x = width at any distance x from flumed section

at x = 8 m

$$B_x = \frac{15\times9\times16}{16\times15-(15-9)} = 11.25 \cong 11.3\text{ m}$$

at x = 16 m

$$B_x = \frac{15\times9\times16}{16\times15-(15-9)\times16} = 15\text{ m}$$

35. Consider the following data for a drain:

L = 50 m a = 10 m, b = 10.3 m, and

k = 1 × 10^{-5} m/s

If the drains carry 1% of average annual rainfall in 24 hrs, the average annual rainfall for which this system has been designed will be

(a) 78 cm (b) 84 cm

(c) 90 cm (d) 96 cm

Ans. **(b)**

Sol.

$$S = \frac{4k}{q}(b^2-a^2)$$

$$50 = \frac{4\times10^{-5}\times(10.3^2-10^2)}{q}$$

$$q = 4.872\times10^{-6}\text{ m}^3/\text{s}$$

$$q = \frac{\frac{1}{100}\times\alpha\times(S\times1)}{8.64\times10^4}$$

$$\alpha = 0.841\text{ m} \cong 84\text{ cm}$$

36. The purpose of constructing a ‘Groyne’ is to

(a) Expand a river channel to improve its depth

(b) Encourage meandering

(c) Train the flow along a certain course

(d) Reduce the silting in the river bed

Ans. **(c)**

Sol. Groynes are the embankment type structures, constructed transverse to the river flow, extending from the bank into the river. They are constructed to protect the bank from which they are extended, by deflecting the current away from the bank i.e, to train the flow along a certain course.

37. Which one of the following compounds of nitrogen, when in excessive amounts in water, contributes to the illness known as infant methemoglobinemia?

(a) Ammoniacal nitrogen

(b) Albuminoid nitrogen

(c) Nitrite

(d) Nitrate

Ans. **(d)**

Sol. Presence of nitrates in too much amount causes a disease called methemoglobinemia (also known as blue baby disease). Children suffering from this disease may vomit, their skin colour may become dark and may die in extreme cases.

38. Consider the following data regarding a theoretical profile of a dam:

Permissible value of compressible stress $\sigma = 350$ tonnes/m^2

Specific gravity of concrete s = 2.4

Uplift coefficient c = 0.6m

The value of $\gamma = 1$

The height and base width will be nearly

(a) 125m and 63m

(b) 175m and 63m

(c) 125m and 93m

(d) 175m and 93m

Ans. **(c)**

Sol.

$$\sigma = 350 \text{ tonnes/m}^2$$
$$G_C = 2.4$$
$$\gamma = 1 \text{ tonnes/m}^3$$
$$\sigma = \gamma_w H(G_c - C + 1)$$
$$350 = 1 \times H(2.4 - 0.6 + 1)$$
$$H = 125 \text{ m}$$
$$B = \frac{H}{\sqrt{G_C - C}}$$
$$B = \frac{125}{\sqrt{2.4 - 0.6}} = 93 \text{ m}$$

39. Chlorine usage in the treatment of 25,000 m^3/day of water has been 9 kg/day. The residual chlorine after 10 minutes contact is 0.2 mg/ℓ. The chlorine demand of water would be nearly

(a) $0.28 mg/\ell$

(b) $0.22 mg/\ell$

(c) $0.16 mg/\ell$

(d) $0.12 mg/\ell$

Ans. **(c)**

Sol. Given,

Flow = 25000 m^3/day

Chlorine use = 9kg/day

Residual chlorine = $0.2 mg/\ell$

$$\text{Chlorine dose} = \frac{9 kg/day}{25000 m^3/day}$$
$$= \frac{9 \times 10^6}{25000 \times 10^3} \frac{mg}{\ell}$$
$$= 0.36 mg/\ell$$
$$\therefore \text{Chlorine demand} = 0.36 - 0.2 mg/\ell$$
$$= 0.16 mg/\ell$$

40. The demand of water is 150 litres/head/day in a city of one lakh population. The factor of safety is taken as 1.5, detention time as 4 h and overflow rate as 20,000 litres/day/m^2. The area of 3m deep plain sedimentation tank as per surface loading consideration will be

(a) 1025m^2

(b) 1075m^2

(c) 1125m^2

(d) 1175m^2

Ans. **(c)**

Sol. Given,

Water demand = 150litres/head/day

Population = 1 lakh

Factor of safety = 1.5

Detention time = 4hrs

Overflow rate = 20,000litres/day/m^2

Depth of tank = 3m

Water flow = $150 \times 10^5 \times 1.5$

= 22.5MLD

$$\text{Area of tank} = \frac{Q}{\text{Overflow rate}}$$
$$= \frac{22.5 \times 10^6}{20{,}000}$$
$$= 1125 m^2$$

41. The rain intensity over 54 hectares of land is 50 mm/h, 30% of area consists of roof surface with runoff rate as 0.9, 30% is open field with runoff rate of 0.2 and remaining 40% is road network with runoff rate of 0.4. The storm water flow will be nearly

(a) 2.6m^3/s (b) 3.7m^3/s

(c) 4.8m^3/s (d) 5.9m^3/s

Ans. **(b)**

Sol.

$$\text{Ceq} = \frac{C_1A_1 + C_2A_2 + C_3A_3}{A_1 + A_2 + A_3}$$

$= 0.9 \times 0.3 + 0.2 \times 0.3 + 0.4 \times 0.4$

$= 0.49$

$Q = C \, i \, A$

$$= 0.49 \times \frac{50 \times 10^{-3}}{3600} \times 54 \times 10^4$$

$= 3.675 \text{ m}^3/\text{sec}$

$\simeq 3.7 \text{ m}^3/\text{sec.}$

42. Critical dissolved oxygen (D.O.) deficit occurs in which one of the following zones of pollution of oxygen sag curve in case of self-purification of natural streams ?

(a) Zone of recovery

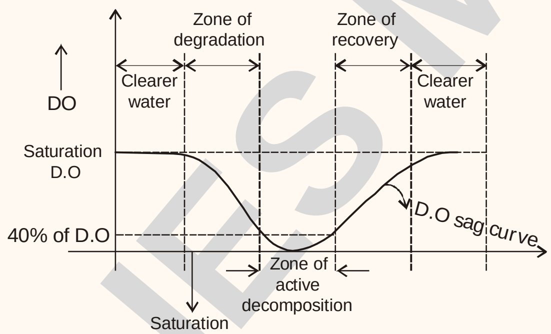
(b) Zone of active decomposition

(c) Zone of degradation

(d) Zone of clear water

Ans. **(b)**

Sol.



43. The MLSS concentration in an aeration tank as 2000 mg/l and the sludge volume after 30 minutes of settling in a 1000 ml graduated cylinder is 176ml. The value of sludge density index (SDI) will be nearly

(a) $3.34 \text{g}/\text{m}\ell$ (b) $2.22 \text{g}/\text{m}\ell$

(c) $1.14 \text{g}/\text{m}\ell$ (d) $0.26 \text{g}/\text{m}\ell$

Ans. **(c)**

Sol. As, sludge density index

$$= \frac{100}{\text{Sludge Volume index}(\text{m}\ell/\text{gm})}$$

$$= \frac{100}{\left(\frac{176}{2}\right)} \qquad [\because 2000\text{mg} = 2\text{g}]$$

$= 1.14 \text{g}/\text{m}\ell$

44. Which one of the following gases is the principal by-product of anaerobic decomposition of the organic content in waste water ?

(a) Carbon monoxide

(b) Ammonia

(c) Hydrogen sulphide

(d) Methane

Ans. **(d)**

Sol. Methane is the principal by-product of anaerobic decomposition of the organic content in waste water (around 60%).

45. Consider the following statements with reference to the mixing of industrial waste water with domestic waste water :

1. The industrial waste water can be mixed with domestic water when it has higher BOD.

2. The industrial waste water can be mixed with domestic water when the pH value of industrial waste water is highly alkaline.

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. **(d)**

Sol. Limit for disposal of industrial waste in sewer line for BOD is 500mg/l and for pH is 5.5 – 9.0 according to BIS standard.

And industrial waste compatible with domestic sewage can be mixed with domestic sewer hence neither of statements is true.

46. The waste water from a factory having a pH of 10, contains KOH only. For waste water discharge is $80m^3$/day. The total quantity of KOH per day will be nearly

(a) 4.5 kg/day (b) 5.4 kg/day

(c) 6.3 kg/day (d) 7.2 kg/day

Ans. (*)

Sol.

$$pH = 10$$

$$pOH = 14 - 10 = 4$$

$$[OH^-] = 10^{-pOH}$$

$$[OH^-] = 10^{-4} \text{ mole/litre}$$

Molecular weight of KOH = 39 + 16 + 1

= 56gm

Total quantity of KOH per day = discharge × concentration of KOH

$$= 80 \times 10^3 \times 10^{-4}$$

$$= 8 \text{ mol/day}$$

$$= 8 \times 56 \text{ gm/day}$$

$$= 0.448 \text{ kg/day}$$

47. Fanning type of plume behaviour takes place when

(a) Super-adiabatic lapse rate prevails with light to moderate wind speed

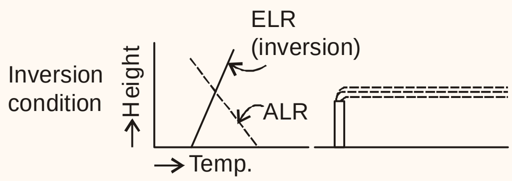
(b) Extreme inversion conditions exist in the presence of light wind

(c) There exists a strong super-adiabatic lapse rate above a surface of inversion

(d) Plume is caught between two inversion layers

Ans. (b)

Sol. Fanning plume behaviour takes place when extreme inversion conditions exist in the presence of light wind.



48. A thermal power plant burns coal at the rate of 8t/h. The coal has sulphur content of 4.5%. The rate of emission of SO_2 will be

(a) 180 g/s (b) 200 g/s

(c) 220 g/s (d) 240 g/s

Ans. (b)

Sol. Rate of coal Burning = 8t/hr = 8000kg/hr

Sulphur content in coal = 4.5%

Sulphur (S) present in coal after burning will be converted into SO_2 (sulphur di-oxide)

Rate of burning of sulphur present in coal

$$= 8000\text{kg/hr} \times \frac{415}{1000}$$

$$= 360\text{kg/hr}$$

As the sulphur converted into sulphur di-oxide, moles of sulphur present in coal will be equal to SO_2 released

$$S + O_2 \rightarrow SO_2$$

Moles of sulphur converting into

$$SO_2 = \frac{360\text{kg / hr}}{\text{Molecular weight}}$$

$$= \frac{360 \times 10^3}{32} / \text{hr}$$

$$= 11250 \text{ moles/hr}$$

Rate of emission of SO_2 = Rate of burning of sulphur × molecular weight of SO_2

$$= 11250 \times 64\text{gm per hour}$$

$$= \frac{11250 \times 64}{3600} \text{gm / sec}$$

$$= 200\text{gm/sec}$$

49. The property of clays by virtue of which they regain, if left alone for a time, a part of the strength lost due to remoulding at unaltered moisture content, is known as

(a) Thixotropy (b) Sensitivity

(c) Consistency (d) Activity

Ans. (a)

Sol. The property of soil due to which loss of strength on remoulding can be regained if left undisturbed for sometime is known as "Thixotropy".

Increase in strength with passage of time is due to tendency of clay soil to regain their chemical equilibrium with the reorientation of water molecule in adsorbed layer.

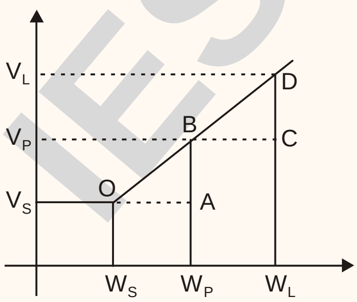
50. The plastic limit and liquid limit of a soil are 30% and 42% respectively. The percentage volume change from liquid limit to dry state is 35% of the dry volume. Similarly the percentage volume change from plastic limit to dry state is 22% of the dry volume. The shrinkage ratio will be nearly

(a) 4.2 (b) 3.1

(c) 2.2 (d) 1.1

Ans. (d)

Sol.



$$\frac{V_L - V_d}{W_L - W_S} = \frac{V_P - V_d}{W_P - W_S}$$

$$\Rightarrow \frac{\frac{V_L - V_d}{V_d} \times 100}{W_L - W_S} = \frac{\frac{V_P - V_d}{V_S} \times 100}{W_P - W_S}$$

$$\Rightarrow \frac{35}{0.42 - W_S} = \frac{22}{0.3 - W_S}$$

$$\Rightarrow W_S = 0.0969 = 9.69\%$$

$$\therefore \text{ Shrinkage ratio (SR)} = \frac{\frac{V_L - V_d}{V_d} \times 100}{W_L - W_S}$$

$$= \frac{35}{(42 - 9.69)} = 1.083 \approx 1.1$$

51. The ratio of a given volume change in a soil expressed as percentage of the dry volume, to the corresponding change in water content is called

(a) Specific gravity of soil solids

(b) Mass-specific gravity of soils

(c) Shrinkage ratio of soils

(d) Density ratio of soils

Ans. (c)

Sol.

$$\text{S.R.} = \frac{\left(\frac{V_1 - V_2}{V_d}\right) \times 100}{(w_1 - w_2)}$$

Here, $V_1 - V_2$ = change in volume of soil

V_d = dry volume of soil

$w_1 - w_2$ = change in water content

52. A masonry dam is founded on pervious sand a factor of safety of 4 is required against boiling. For the sand, n = 45% and G_B = 2.65. The maximum permissible upward hydraulic gradient will be nearly

(a) 0.18 (b) 0.23

(c) 0.28 (d) 0.33

Ans. (b)

Sol. G_S = 2.65

n = 45% = 0.45

$$\therefore\ e = \frac{n}{1-n} = \frac{0.45}{1-0.45} = \frac{0.45}{0.55} = 0.82$$

Critical hydraulic gradient (i_{Cr}) = $\dfrac{G_s - 1}{1+e}$

$$= \frac{1.65}{1.82} = 0.906$$

$$\text{FOS} = \frac{i_{Cr}}{i_{possible}}$$

$$\Rightarrow\ i_{possible} = \frac{0.906}{4} = 0.2265 \approx 0.23$$

53. The representative liquid limit and plastic limit values of a saturated consolidated clay deposit are 60% and 30%, respectively. The saturated unit weight of the soil is 19 kN/m³. The water table is at 8 m below ground level. At a depth of 10m from the ground surface, the undrained shear strength of the soil will be nearly

(a) 37.7 kN/m² (b) 33.5 kN/m²

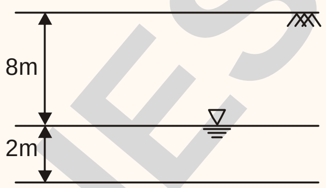
(c) 29.3 kN/m² (d) 25.1 kN/m²

Ans. (a)

Sol. Given : W_L = 60%

W_P = 30%

$$\gamma_{sat} = 19\ \text{kN/m}^3$$



For clayey soil, $\tau = Cu$

$$\frac{C_u}{\sigma_z'} = 0.11 + 0.037\ I_p(\%)$$

σ_z' = 8 × 19 + 2(19 – 9.81) = 170.38 kN/m²

I_p = 60 – 30 = 30%

$\therefore$ C_u = 170.38 × (0.11 + 0.0037 × 30)

= 37.65 ≈ 37.7 kN/m²

54. A 6m high retaining wall with a vertical back has a backfill of silty sand with a slope of 10° for the backfill. With values of K_R = 760 kg/m²/m and K_V = 100kg/m²/m, the total active earth pressure will approximately

(a) 128kN/m (b) 134kN/m

(c) 138kN/m (d) 142kN/m

Ans. (c)

Sol. k_H = 760 kg/m²/m

k_V = 100 kg/m²/m

By Peck, Hanson and Thornburn

$$P_H = \frac{1}{2}K_H \times H^2 = \frac{1}{2}\times 760 \times 6^2$$

= 13680 kg/m = 136.8 kN/m

$$P_V = \frac{1}{2}K_V \times H^2 = \frac{1}{2}\times 100 \times 6^2$$

= 1800 kg/m = 18 kN/m

$$\therefore P_A = \sqrt{P_H^2 + P_V^2} = \sqrt{136.8^2 + 18^2}$$

= 138 kNm

55. The vertical stress at any point at a radial distance r and at depth z as determined by using Boussinesq's influence factor K_B and Westergaard's influence factor K_W would be almost same for $\left(\dfrac{r}{z}\right)$ ratios equal to or greater than

(a) 2.0 (b) 1.8

(c) 1.5 (d) 1.2

Ans. (c)

Sol. Boussinesq's influence factor = k_B

$$= \frac{3}{2\pi}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]$$

Westergaard's influence factor = k_W

$$= \frac{1}{\pi\left[1+2\left(\frac{r}{z}\right)^2\right]^{3/2}}$$

When $\frac{r}{z} \geq 1.5,\ k_W \approx k_B$

Hence, $Q_{\text{Boussinesq}} \approx Q_{\text{Westergaard}}$

56. A strip footing 2m in width, with its base at a depth of 1.5m below ground surface, rests on a saturated clay soil with $\gamma_{sat} = 20\text{kN/m}^3$; c_u = 40kN/m^2; $\phi_u = 0$; c' = 10kN/m^2; and $\phi' = 20°$. The natural water table is at 1m depth below ground level. As per IS : 6403 – 1981, the ultimate bearing capacity of this footing will be

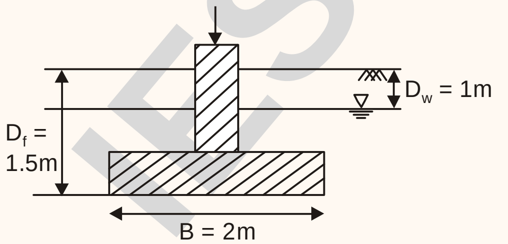
(taking the relevant N_c as 5.14)

(a) 327kN/m^2 (b) 285kN/m^2

(c) 253kN/m^2 (d) 231kN/m^2

Ans. **(d)**

Sol.



As per IS6403:1981

$q_u = s_c d_c i_c$ CNc + $s_q d_q i_q$ qN_q

For footing we consider end of construction stability,

$\therefore$ C = C_u = 40 kN/m^2, $\phi = \phi_u = 0°$

$\frac{D_f}{B} < 1,\ d_c = d_q = 1$

For strip footing

$s_c = s_q = 1$

For $\phi = 0, N_c = 5.14, N_q = 1, N_\gamma = 0$

$\therefore$ q_u = CN_c + $(\gamma_t \times 1 + \gamma_{sub} \times 0.5) \times N_q$

q_u = 40 × 5.14 + (20 + (20 – 9.81)×0.5) × 1

= 230.695 kN/m^2 $\simeq$ 231 kN/m^2

(Assuming $\gamma_t \simeq \gamma_{sat}$ for clay)

57. The settlement due to secondary compression is predominant in

(a) Granular soils

(b) Inorganic clays

(c) Organic clays

(d) Very fine sand and silts

Ans. **(c)**

Sol. Seondary compression is caused by creep, viscous behaviour of the clay-water system, compression of organic matter etc.

In organic clays due to high content of organic matter, secondary consolidation is predominant.

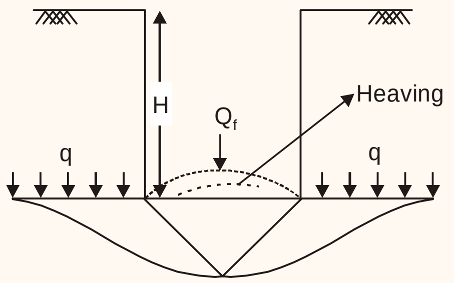
58. A raft foundation 10m wide and 12m long is to be constructed in a clayey soil having shear strength of 12kN/m^2. Unit weight of soil is 16kN/m^3. the ground surface carries a surcharge of 20kN/m^2; the factor of safety is 1.2 and the value of N_c = 5.7. The safe depth of foundation will be nearly

(a) 8.2m (b) 7.3m

(c) 6.4m (d) 5.5m

Ans. **(d)**

Sol.



Given : q = 20 kN/m^2, $\tau_u = C_u = 12\ kN/m^2$,

γ = 16 kN/m^3, B = 10 m, L = 12 m

Bearing capacity of soil for rectangular raft footing in cohesive soil is given by :

$$Q_f = \left(1+0.3\frac{B}{L}\right)CN_c + \gamma D_f + q$$

$$= \left(1+0.3\times\frac{10}{12}\right)12\times 5.7 + 16D_f + 20$$

= 105.5 + 16D

Base failure will occur when Q_f = 0

Hence, D = $\frac{-105.5}{16} = -6.59$

(minus sign indicates that it is excavation)

Safe depth = $\frac{D}{FOS} = \frac{6.59}{1.2}$ = 5.49 m

59. The skin frictional resistance of a pile driven in sand does not depend on

(a) Lateral earth pressure coefficient

(b) Angle of friction between pile and soil

(c) Pile material

(d) Total stress analysis

Ans. **(d)**

Sol. Skin frictional resistance for a driven pile in sand

$$Q_f = (K\cdot\bar{\sigma}_{av}\tan\delta)\times A_{surface}$$

Where, k = lateral earth pressure coefficient

δ = angle of friction between pile and soil

k, δ depend upon the pile material.

60. An excavation is made with a vertical face in a clay soil which has C_u = 50 kN/m^2, $\gamma_t = 18 kN/m^3$ and s_n = 0.261. The maximum depth of a stable excavation will be nearly

(a) 10.6m (b) 12.4m

(c) 14.2m (d) 16.0m

Ans. **(a)**

Sol. $S_n = \frac{C}{F_c\times\gamma_t\times H}$

As it is asked to calculate maximum depth of excavation, FOS = F_c = 1

$0.261 = \frac{50}{1\times 18\times H}$

$\Rightarrow$ H = 10.64 $\approx$ 10.6 m

61. Reconnaissance survey for determining feasibility and estimation of scheme falls under the classification based on the

(a) Nature of the field of survey

(b) Object of surveying

(c) Instruments used

(d) Method employed

Ans. **(b)**

Sol. During reconnaissance survey, surveyor should first of all thoroughly examine the ground to ascertain as how the work can be arranged in the best possible manner.

It falls under classification based on purpose or object of surveying (for which surveying is conducted).

On the basis of object of survey the classification can be as given below.

(1) Control survey

(2) Hand survey

(3) Topographic survey

(4) Engineering survey

(a) Reconnaissance survey

(b) Preliminary survey

(c) Location survey

(5) Route survey

(6) Construction survey

(7) Astronomic survey

(8) Mine survey

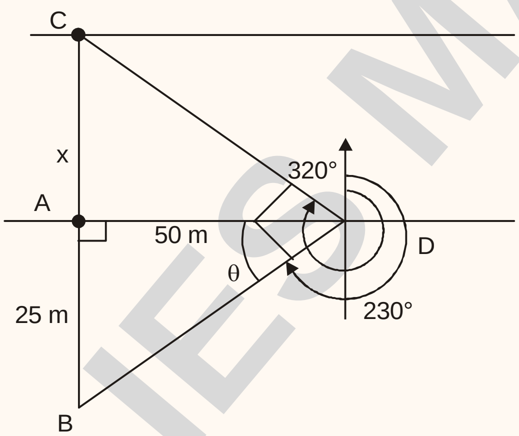
62. A survey line BAC crosses a river, A and C being on the near and distant banks respectively. Standing at D, a point 50m measured perpendicularly to AB from A, the bearings of C and B are 320° and 230° respectively, AB being 25m. The width of the river will be

(a) 80m (b) 90m

(c) 100m (d) 110m

Ans. **(c)**

Sol.



In ΔABD

$$\tan\theta = \frac{25}{50} = \frac{1}{2}$$

In ΔDAC

$$\tan(90-\theta) = \frac{x}{50}$$

$\because \cot\theta = 2$

$$2 = \frac{x}{50}$$

$x = 100$ m

$\because \tan(90-\theta) = \cot\theta$

63. In plane surveying where a graduated staff is observed either with horizontal line of sight or inclined line of sight, the effect of refraction is to

(a) Increase the staff reading

(b) Decrease the staff reading

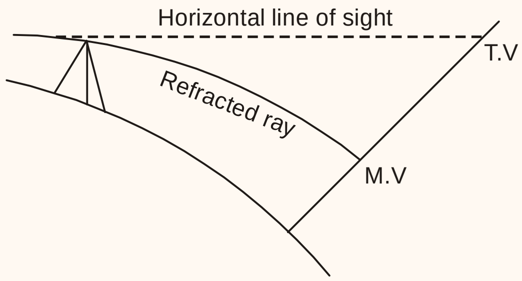
(c) Neither increase nor decrease the staff reading

(d) Duplicate the staff reading

Ans. **(b)**

Sol. Refraction is the phenomenon of light rays deviating from a straight line as they pass through different layers of air of different densities.

Due to refraction ray of light bend towards centre of earth. Hence refraction make reading lower than what it should be with a horizontal line of sight.



64. A sidereal day is the average time taken by

(a) The Earth to move around the sun once

(b) The Moon to move around the Earth once

(c) The first point of Aries to cross the same meridian successively

(d) The Earth to move around its own axis once

Ans. **(c)**

Sol. Side real day is the time interval between the movement of the first point of aries over the same meridian twice.

65. In triangulation in order to control the accumulation of errors of length and azimuth subsidiary bases are selected. At certain stations the astronomical observations for azimuth and longitude are also made. These stations are called

(a) Transportation stations

(b) Bowditch stations

(c) Universe stations

(d) Laplace stations

Ans. **(d)**

Sol. The defect of triangulation is that it tends to accumulate errors of length and azimuth, since the length and azimuth of each line is based on the length and azimuth of the preceding line.

To control the accumulation of errors, subsidiary bases are also selected. At certain stations, astronomical observations for azimuth and longitude are also made. These stations are called Laplace stations.

66. A vertical photograph is taken at an altitude of 1200m above mean sea level (a.m.s.l.) of a terrain lying at a elevation of 80m a.m.s.l. The local focal length of camera is 15cm. The scale of the photograph will be nearly

(a) 1 : 8376 (b) 1 : 7467

(c) 1 : 6558 (d) 1 : 5649

Ans. **(b)**

Sol. Scale, $S = \dfrac{f}{H-h} = \dfrac{15\times10^{-2}}{1200-80}$

$$= \frac{1}{7466.66} \cong \frac{1}{7467}$$

67. Aerial photographs are required to be taken to cover an area of 150 km^2. The longitudinal and side overlaps are to be 60% and 30% respectively. The scale of photograph is 1cm = 100 m; and the size of each photograph is 20cm × 20cm. The minimum required number of photographs will be

(a) 170 (b) 158

(c) 146 (d) 134

Ans. **(d)**

Sol. Number of photograph, $N = \dfrac{A}{a}$

$$N = \frac{A}{\left(\frac{(1-P_L)l}{S}\right)\times\left(\frac{(1-P_s)w}{S}\right)} \quad \left[\because S = \frac{1\,\text{cm}}{100\text{ m}} = \frac{1}{10{,}000}\right]$$

$$N = \frac{150\times10^6}{\frac{(1.06)\times0.2}{\frac{1}{10^4}}\times\frac{(1-0.3)\times0.2}{\frac{1}{10^4}}}$$

$$N = \frac{150\times10^6}{0.4\times0.2\times0.7\times0.2\times10^8}$$

$$N = \frac{15\times10^7}{4\times2\times7\times2\times10^4}$$

$N = 133.393 \cong 134$ Nos.

68. Which one of the following conditions is not correct with respect to the transition curve?

(a) It should be tangential to the straight approaches at the two ends

(b) It should meet the circular curve tangentially

(c) Its curvature will necessarily be non-zero at the point of take-off from the straight approaches

(d) The rate of increase of curvature along the transition reach should match with the increases of cant.

Ans. **(c)**

Sol. Radius of transition curve should be infinite when taking off from straight line or meeting the straight line.

$\because$ Curvature $= \frac{1}{R}$ and $R = \infty$

Curvature = 0

69. A circular curve has a long chord of 80m and a versed sine of 4m. The height and ordinate at a distance of 30m from the mid-ordinate will be nearly

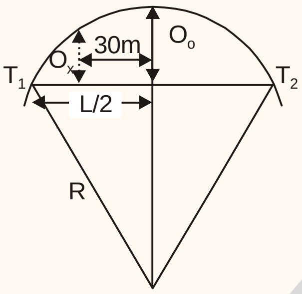
(a) 3.06m (b) 2.72m

(c) 2.24m (d) 1.76m

Ans. (d)

Sol. Long chord, L = 80 m

Versine = Mid-ordinate (M) = O_o = 4m



$$O_o = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2} = 4$$

$$(R-4) = R^2 - \left(\frac{L}{2}\right)^2$$

$(R - 4) = R^2 - (40)^2$

$R^2 - 8R + 16 = R^2 - 40^2$

$8R = 1616$

$R = 202$ m

$$O_x = O_o - \frac{x^2}{2R}$$

$$O_x = 4 - \frac{30^2}{2 \times 202} = 1.77 \text{ m}$$

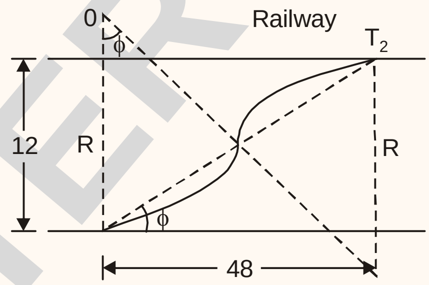
70. Two parallel railway lines are to be connected by a reverse curve, each section having the same radius. If the lines are 12m apart and the maximum distance between tangent points measured parallel to the straights is 48m, then the maximum allowable radius will be

(a) 51.1m (b) 52.3m

(c) 53.5m (d) 54.7m

Ans. (a)

Sol.



$$T_1T_2 = \sqrt{48^2 + 12^2}$$

$$= 49.47\text{m}$$

$$\sin\phi/2 = \frac{12}{49.47} = 0.2426$$

$$\phi = 28.07°$$

$$\text{Radius} = \frac{12}{2(1-\cos\phi)}$$

$$= \frac{12}{2(1-\cos 28.07)}$$

$$= 51.01\text{m}$$

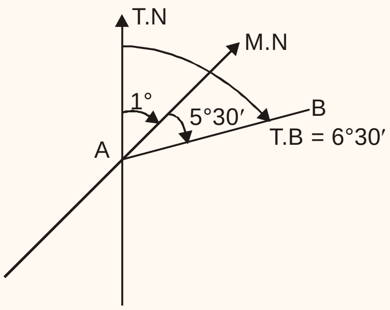
71. In an old map, a line AB was drawn to a magnetic bearing of 5°30', the magnetic declination at the time being 1° East. If the present magnetic declination is 8°30' East, the line should be set to a magnetic bearing of

(a) 358° (b) 2°

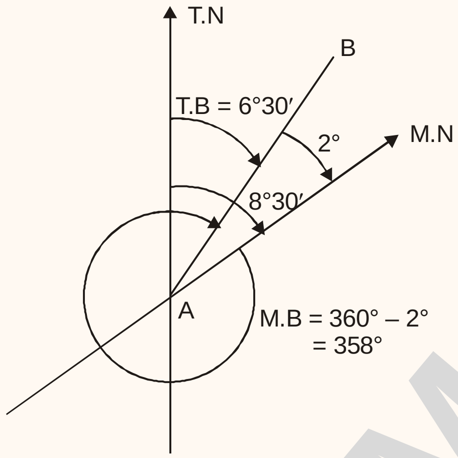
(c) 6°30′ (d) 257°

Ans. (a)

Sol.



Old map



New map

72. An unconformity is

(a) A surface of erosion or non-deposition as detected in a sequence of rocks

(b) A layer of boulders and pebbles in a sequence of rocks

(c) A layer of clay or shale in an igneous mass

(d) A type of joint especially associated with folded and faulted rocks

Ans. **(a)**

Sol. An unconformity is a buried erosional or non-depositional surface separating two rock masses or strata of different ages, indicating that sediment deposition was not continuous.

73. Consider two cars approaching from the opposite directions at 90km/h and 60km/h. If the reaction time is 2.5s, coefficient of friction is 0.7 and brake efficiency is 50% in both the cases, the minimum sight distance required to avoid a head-on collision will be nearly

(a) 154m (b) 188m

(c) 212m (d) 236m

Ans. **(d)**

Sol. Min sight distance required

$$= \left(v_1 t_r + \frac{v_1^2}{2g\mu}\right) + \left(v_2 t_r + \frac{v_2^2}{2g\mu}\right)$$

$$= \left(90 \times 0.278 \times 2.5 + \frac{(90 \times 0.278)^2}{2 \times 9.81 \times 0.35}\right)$$

$$+ \left(60 \times 0.278 \times 2.5 + \frac{(60 \times 0.278)^2}{2 \times 9.81 \times 0.35}\right)$$

$$= 235.92 \text{ m}$$

$$\simeq 236 \text{ m.}$$

Note : Co-eff^n of friction is taken as 0.35 (is 0.7 × 0.5)

74. What is the extra widening required (as nearest magnitude) for a pavement of 7m width on a horizontal curve of radius 200m, if the longest wheel of vehicle expected on the road is 6.5m and the design speed is 65km/h?

(a) 0.3m (b) 0.5m

(c) 0.7m (d) 0.9m

Ans. **(c)**

Sol.

$$W_e = \frac{nl^2}{2R} + \frac{v}{2.64\sqrt{R}}$$

$$= \frac{2 \times 6.5^2}{2 \times 200} + \frac{(65 \times 0.278)}{2.64 \times \sqrt{200}}$$

$= 0.6952$

$\simeq 0.7$ m.

75. A vehicle moving at 40km/h speed was stopped by applying brake and the length of the skid marks was 12.2m. If the average skid resistance of the pavement is 0.70, the brake efficiency of the test vehicle will be nearly

(a) 80% (b) 74%

(c) 68% (d) 62%

Ans. (b)

Sol.

$$\mu_{\text{braking test}} = \frac{v^2}{2gl}$$

$$= \frac{(40\times 0.278)^2}{2\times 9.81\times 12.2}$$

$$= 0.5166$$

$$\eta_{\text{braking}} = \frac{0.5166}{0.7}\times 100$$

$$= 73.79\%$$

$$\simeq 74\%.$$

76. The main drawback of automatic counters-cum-classifiers, used for traffic volume studies, is that it is not yet possible to classify and record

(a) Vehicle type (b) Axle spacing

(c) Axle load (d) Speed

Ans. (a)

77. Which one of the following is not a part of 'speed and delay' studies?

(a) Floating car method

(b) Vehicle number method

(c) Interview technique

(d) License number method

Ans. (d)

Sol. Various methods of speed and delay studies are :

1. Floating car method
2. License plate method or vehicle number method
3. Interview technique
4. Elevated observation
5. Photographic technique

78. Consider the following data with respect to the design of flexible pavement :

Design wheel load = 4200kg

Tyre pressure = 6.0 kg/m^2

Elastic modulus = 150 kg/cm^2

Permissible deflection = 0.25cm

(take $\pi^{1/2} = 1.77$, $\pi^{-1/2} = 0.564$, $\frac{1}{\pi} = 0.318$ and $\pi^2 = 9.87$)

The total thickness of flexible pavement for a single layer elastic theory will be nearly

(a) 42cm (b) 47cm

(c) 51cm (d) 56cm

Ans. (c)

Sol.

$$\text{Total thickness} = \left[\left(\frac{3P}{2\pi E\Delta}\right)^2 - a^2\right]^{1/2}$$

$$= \left[\left(\frac{3P}{2\pi E\Delta}\right)^2 - \left(\frac{P}{\pi p}\right)\right]^{1/2}$$

$$= \left[\left(\frac{3\times 4200}{2\times 3.14\times 150\times 0.25}\right)^2 - \left(\frac{4200}{3.14\times 6}\right)\right]^{1/2}$$

$\simeq$ 51 cm.

79. The minimum possible grade that can be provided in a tunnel and its approaches with providing adequately for proper drainage is

(a) 0.1% (b) 0.2%

(c) 0.3% (d) 0.4%

Ans. **(b)**

80. The section of the tunnel adopted perfectly in lieu of ease of construction and maintenance in hard rock tunnels, where the risk of roof failure or collapse caused by external pressure from water, or from loose or unstable soil conditions on tunnel lining is practically non-existent is

(a) Circular section

(b) Segmental roof section

(c) Horse-shoe section

(d) Egg-shaped section

Ans. **(a)**

Sol. According to IRC : SP-91, circular sections are structurally best and are commonly used for underwater tunnels, tunnels through soft ground and for tunnels excavated with TBM.

81. Which one of the following methods is adopted for tunneling in soft soils?

(a) Pitot tunnel method

(b) Drift method

(c) Needle beam method

(d) Heading and benching method

Ans. **(c)**

82. Which one of the following features does not pertain to Littoral drift?

(a) It depends on length of wave

(b) It is the process of erosion of deposition by waves

(c) Waves caused by prevailing wind, stir up and move sand particles

(d) Wind tends to carry drifting sand in a zigzag way

Ans. **(d)**

83. Consider the following data for designing a taxiway for operating Boeing 707 – 320 aeroplane :

Wheel base = 17.70m

Tread of main loading gear = 6.62m

Turning speed = 40km/h

Coefficient of friction between tyres and pavement surface = 0.13

The turning radius of the taxiway will be

(a) 98.5m (b) 94.5m

(c) 89.5m (d) 86.5m

Ans. **(a)**

84. Which one of the following instances of performance of aircraft is not considered for determining basic runway length ?

(a) Normal landing case

(b) Normal take-off case

(c) Engine failure case

(d) Emergency landing case

Ans. **(d)**

Sol. Basic runway length is determined by 3 cases:

(i) Normal landing case

(ii) Normal take off case

(iii) Engine failure case

Directions: Each of the next six (06) times consists of two statements, one labeled as ‘Statement (I)’ and the other as ‘Statement (II)’. You are to examine the two statements carefully and select the answers to these six items using the codes given below :

Codes:

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

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

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

(d) Statement (I) is false, but Statement (II) is true.

85. **Statement (I)**: Expansive cement is used in repair work for opened up joints.

Statement (II): Expansive cement expands while hardening.

Ans. **(a)**

Sol. Expansive cement is a cement, which when mixed with water, it will have a tendency to increase in volume significantly while setting.

This will be helpful to repair the damaged concrete surfaces.

86. **Statement (I)**: Plastic hinges are developed when stress at every point is equal to yield stress.

Statement (II): Plastic hinges are formed at sections subjected to the greatest curvature.

Ans. **(b)**

87. **Statement (I)**: If degree of fixity at supports is lessened, the maximum hogging moment at the ends will decrease.

Statement (II): If degree of fixity at supports is lessened, the maximum sagging moment at mid-span decreases.

Ans. **(c)**

88. **Statement (I)**: Torsion reinforcement is provided at (and near) corners in a two-way slab which is simply supported on both edges meeting at the corner.

Statement (II): The area of reinforcement in each of the layers shall be three-quarters of the area required for maximum mid-span moment in the slab.

Ans. **(b)**

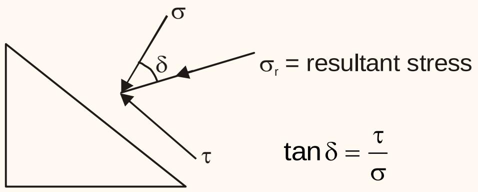
Sol. Both statements are individually correct. We provide torsion reinforcement in order to minimize the crack due to torsion.

89. **Statement (I)**: The inclination of the resultant stress with normal can exceed angle of repose (adopting old terminology).

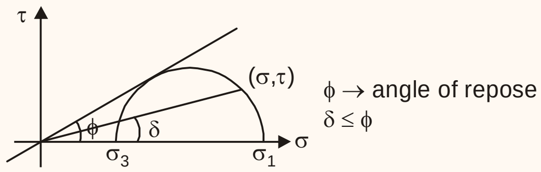
Statement (II): The ratio of the difference between greatest and least intensities of pressure to their sum cannot exceed the sine of the angle of repose (adopting old terminology).

Ans. **(d)**

Sol.



$$\tan\delta = \frac{\tau}{\sigma}$$



∴ The inclination of the resultant stress with normal (i.e., angle of obliquity) cannot exceed angle of repose, so statement (I) is incorrect

$\sigma_1 \rightarrow$ greatest pressure intensity

$\sigma_3 \rightarrow$ least pressure intensity

Now, $\quad \sin\phi = \dfrac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3}$

∴ statement II is correct

90. **Statement (I)**: Alum works in slightly alkaline range.

Statement (II): At higher temperatures, viscosity of water (resistance to settling) decreases and flocs settle better.

Ans. **(b)**

Sol. Alum is a coagulant which works efficiently in slightly alkaline range i.e. between 6.5 to 8.5.

At higher temperature viscosity of water decreases and floc formation is better

91. A front-end loader on a given job moves a load of 1.5 m^3 of loose soil in one cycle consisting of loading-lifting-travelling-unloading-return trip-and-ready for next loading. If each cycle time is 1.2 minutes, the actual output will be

(a) 75 m^3/hour (b) 70 m^3/hour

(c) 65 m^3/hour (d) 60 m^3/hour

Ans. **(a)**

Sol. Actual output = Volume in one cycle in cum × No. of cycle per hour

$$= 1.5 \times \frac{60}{1.2} = 75 \text{ m}^3$$

During this we will not consider idle time because in question it is accounted as ready for next loading.

92. Which of the following techniques belong to 'Project Time Plan'?

1. Critical path method
2. Precedence network analysis
3. Line of balance technique
4. Linear programme chart

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

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

Ans. **(a)**

Sol. Techniques for project time plan are critical path method, precedence network analysis and line of balance technique.

Linear programme chart is used for profit maximisation, cost minimisation and resources allocation.

93. A construction equipment has an initial cost of Rs. 2,00,000 and salvage value of Rs. 50,000 at the end of an economic life of 5 years. The rate of straight-line depreciation and total depreciation will be

(a) 0.1 and Rs. 1,50,000

(b) 0.2 and Rs. 1,50,000

(c) 0.1 and Rs. 1,00,000

(d) 0.2 and Rs. 1,00,000

Ans. **(b)**

Sol. Total depreciation = Initial cost – Salvage value

= 200,000 – 50,000

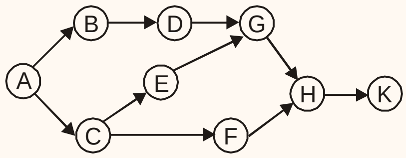
= 1,50,000

$\because$ Depreciation by straight line method

$$= \frac{C_i - C_s}{n}$$

$\therefore$ Rate of depreciation = $\frac{1}{n} = \frac{1}{5} = 0.2$

94. Consider the following assembly with different operations



Operation	Standard time minutes
A	60
B	65
C	29
D	37
E	28
F	63
G	36
H	126
K	64

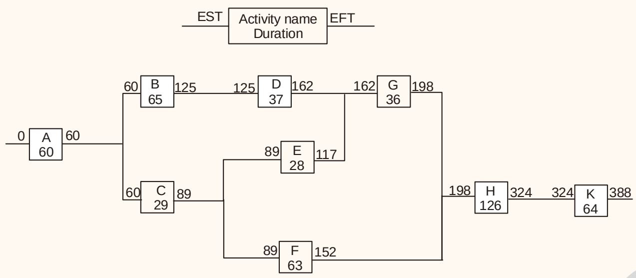
There are 250 working days in a year to produce 4000 units in a year. The minimum number of work stations required will be

(a) 13 (b) 12

(c) 11 (d) 10

Ans. **(a)**

Sol.



The time required to assemble 1 unit is 388 minutes.

Assuming 8 hours of working in a year.

No. of unit manufactured by 1 working station in 250 days will be $= \dfrac{250 \times 8 \times 60}{388} = 309.27$

No. of working station required to manufacture 4000 units in a year will be

$$= \frac{4000}{309.27} = 12.933 \simeq 13$$

95. Flattening and smoothing the road surface by scrapping is called

(a) Compaction (b) Consolidation

(c) Grading (d) Ditch digging

Ans. **(c)**

Sol. A motor grader in road construction is used for cutting, spreading and levelling of material i.e., flattening and smoothing.

96. The amount of time by which the start of the activity may be delayed without interfering with the start of any succeeding activity is called

(a) Activity float (b) Free float

(c) Total float (d) Interfering float

Ans. **(b)**

Sol. Activity float is range within which the start time may fluctuate without affecting the completion time of the project

Total float is the maximum time by which an activity can be delayed without affecting project completion time.

Free float is the time by which an activity can be delayed without affecting earliest start time of succeeding activity

Interfering float is difference between total float and free float.

97. A crew consisting of two carpenters and one helper can fix 10 m^2 of a slab form work in 8 hours and the hourly labour rate of a carpenter is Rs. 85 and for a helper is Rs. 69.50. An average hourly rate per worker of the crew will be nearly

(a) Rs. 90 (b) Rs. 80

(c) Rs. 70 (d) Rs. 60

Ans. **(b)**

Sol. Average hourly rate per worker

$$= \frac{2 \times \text{Carpenter rate} + 1 \times \text{Helper rate}}{3}$$

$$= \frac{2 \times 85 + 1 \times 69.5}{3}$$

$$= 79.83 \simeq 80\,\text{Rs.}$$

98. A project with the production cost of Rs. 100 crores, has a 20,000 man-months as direct labour, of which 60% is non-productive time. The labour cost as estimated while tendering is 20% of project cost. If 15% of the wastage resulting from non-productive time is eliminated by using improved methods, the resulting saving in labour cost will be

(a) 14.5% (b) 18.5%

(c) 22.5% (d) 26.5%

Ans. **(c)**

Sol. Lobour costed = 20% of project cost

= 0.2 × 100

= 20 crores

Non productive labour time at 60% of labour cost

= 0.6 × 20 = 12 crores

Non productive time = 0.15 × 12

= 1.8 crores

Saving as percentage of productive work value

$$= \frac{1.8\,\text{crores}}{40\%\text{ of }20\,\text{crores}} \times 100$$

= 22.5

99. Consider the following data :

Work is carried out by a contractor employing labour with 25% overtime per day

Working for 5 days a week

Contractor peak manpower is 40 per day

Build-up period is 20%

Rundown period is 10%

Total effort in standard man days is 1200

The duration of work by Trapezoidal manpower distribution pattern will be

(a) 5.5 weeks (b) 6.5 weeks

(c) 7.5 weeks (d) 8.5 weeks

Ans. **(a)**

Sol. Effort in man-days = peak manpower

$$\times \left\{\frac{(\text{build up period})}{2} + \text{peak level period} + \frac{\text{rundown period}}{2}\right\}$$

$$1200 = 40\left(\frac{0.2d}{2} + 0.7\,d + \frac{0.1d}{2}\right)$$

= 40 × 0.85 d

$$\text{Duration} = d = \frac{1200}{40 \times 0.85} = 35.3\text{ days}$$

$$= \frac{35.3}{5 \times 1.25} = 5.648 \approx 5.5\text{ weeks}$$

100. A systematic measurement and evaluation of the way in which an organization manages its health and safety programme against a series of specific and attainable standards is called

(a) Safety inspection (b) Safety audit

(c) Safety plan (d) Safety committee

Ans. **(b)**

Sol. Safety audit-It is systematic measurement and evaluation of the way in which an organization manages its health and safety programme against a series of specific and attainable standards.

101. On a construction project, the contractor, on an average, employed 100 workers with 50 hours working per weeks. The project lasted for 35 weeks and, during this period, 14 disabling injuries occurred. The injury-frequency rate will be (based on one lakh of man hours worked)

(a) 5 (b) 6

(c) 7 (d) 8

Ans. **(d)**

Sol. Injury frequency rate

$$= \frac{\text{No. of injuries}}{\text{Total No. of hours worked}} \times 10^5$$

$$= \frac{14 \times 10^5}{100 \times 50 \times 35} = 8$$

102. The graphical representations wherein long duration jobs are broken down to key segmental elements, wherein events are shown in chronological order without attention to logical sequencing, and wherein interdependencies between the events is not highlighted, is referred to as

(a) CPM (b) Milestone chart

(c) GANTT chart (d) PERT

Ans. (b)

Sol. In milestone chart long duration jobs are broken down to key segmental elements which are called as events, these are present in chronological order. Interdependencies between events of various jobs is not shown.

103. A ship weighs 127 MN. On filling the ship's boats on one side with water weighing 600 kN with the mean distance of the boats from the centre line of the ship being 10 m, the angle of displacement of the plumb line is 2°16'. The metacentric height will be nearly

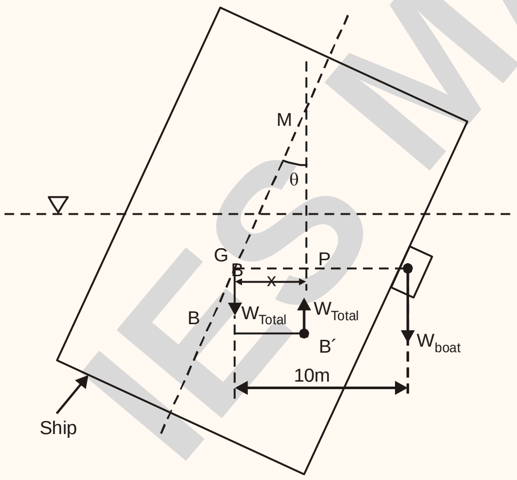
(Take sin2°16' = 0.04, cos2°16' = 0.9992 and tan2°16' = 0.04)

(a) 1.73 m (b) 1.42 m

(c) 1.18 m (d) 0.87 m

Ans. (c)

Sol.

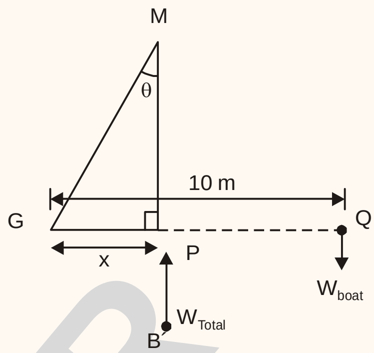


M = Metacentric

GM = Metacentric height

$\sin\theta$ = 0.04 (Given)

Total weight (W_{total}) = 127000 + 6000 = 127600kN



$$W_{boat} = 600kN$$

Take moment of all force about "M".

$$\sum M_M = 0 \text{ (equilibrium)}$$

$$W_{Total} \times x = W_{boat} \times GQ$$

$$127600x = 600 \times 10$$

$$x = 4.4022 \times 10^{-2} m$$

$$\Delta GMP \quad \sin\theta = \frac{x}{GM}$$

$$GM = \frac{x}{\sin\theta} = \frac{4.7022 \times 10^{-2}}{0.04}$$

$$GM = 1.176$$

$$\boxed{GM = 1.18m}$$

104. For frictionless adiabatic flow of compressive fluid, the Bernoulli's equation with usual notations is

(a) $\frac{k}{k-1}\frac{p_1}{w_1} + \frac{v_1^2}{2g} + z_1 = \frac{k}{k-1}\frac{p_2}{w_2} + \frac{v_2^2}{2g} + z_2 + h_L$

(b) $\frac{k}{k-1}\frac{p_1}{w_1} + \frac{v_1^2}{2g} + z_1 = \frac{k}{k-1}\frac{p_2}{w_2} + \frac{v_2^2}{2g} + z_2$

(c) $\frac{p_1}{w_1} + \frac{v_1^2}{2g} + z_1 + H_m = \frac{p_2}{w_2} + \frac{v_2^2}{2g} + z_2$

(d) $\frac{k}{k-1}\frac{p_1}{w_1} + \frac{v_1^2}{2g} + z_1 + H_m = \frac{p_2}{w_2} + \frac{v_2^2}{2g} + z_2 + h_L$

Ans. **(b)**

Sol. For compressive flows in fluid dynamic in adiabatic state Bernoulli's equation is

$$\frac{V^2}{2} + gz + \left(\frac{k}{k-1}\right)\frac{p}{\rho} = \text{constant}$$

Where k is ratio of specific heats of the fluid.

$$\therefore \quad \frac{k}{k-1}\frac{p_1}{w_1} + \frac{V_1^2}{2g} + z_1 = \frac{k}{k-1}\frac{p_2}{w_2} + \frac{V_2^2}{2g} + z_2$$

105. The phenomenon of generation of lift by rotating an object placed in a free stream is known as

(a) Coanda effect

(b) Magnus effect

(c) Scale effect

(d) Buoyancy effect

Ans. **(b)**

Sol. Magnus effect is a phenomenon associated with spinning object moving through a fluid producing lift force on the object

106. Which of the following assumptions is/are made in the analysis of hydraulic jump?

1. It is assumed that before and after jump formation the flow is essentially two-dimensional and that the pressure distribution is hydrostatic.
2. The length of the jump is small so that the losses due to friction on the channel floor are small and hence neglected.
3. The channel floor is horizontal or the slope is so gentle that the weight component of the water mass comprising the jump is very high.

(a) 1 only (b) 2 only

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

Ans. **(b)**

Sol. Before deriving the expression for the depth of hydraulic jump, the following assumptions are made.

1. The flow is uniform and pressure distribution is hydrostatic before and after the jump.
2. Losses due to friction on the surface of the bed of the channel are small and hence neglected.
3. The slope of the bed is small, so that the component of the weight of the fluid in the direction of flow is negligibly small.

107. Water is to be pumped out a deep well under a total head of 95 m. A number of identical pumps of design speed 1000 rpm and specific speed 900 rpm with a rated capacity of 150 l/s are available. The number of pumps required will be

(a) 1 (b) 3

(c) 5 (d) 7

Ans. **(b)**

Sol. Given,

Total head, $H = 95\text{m}$

$N = 1000\text{rpm}$

$N_s = 900\text{rpm}$

$Q = 150\ell/S$

We know, $N_s = \dfrac{N\sqrt{Q}}{H_m^{1/4}}$

$$900 = \frac{1000\sqrt{150}}{H_m^{3/4}}$$

$\Rightarrow \quad H_m = 32.5\text{m}$

For lefting water to a higher head, pumps are to be installed in series.

Required number of pumps $= \dfrac{H}{H_m}$

$$= \frac{95}{32.5}$$

$$= 2.92 \approx 3$$

108. Consider the following data from a test on Pelton wheel :

Head at the base of the nozzle = 32 m

Discharge of the nozzle = 0.18 m^3/s

Area of the jet = 7500 mm^2

Power available at the shaft = 44 kW

Mechanical efficiency = 94%

The power lost in the nozzle will be nearly

(a) 3.9 kW (b) 4.7 kW

(c) 3.5 kW (d) 2.3 kW

Ans. (b)

Sol. Given,

$$Q = 0.18 m^3/S$$
$$A = 7500 mm^2 = 7500 \times 10^{-6} m^2$$
$$\text{Shaft power} = 44 kW$$
$$x_m = 94\%$$
$$H = 32 m$$

$$\text{Power at the base of the nozzle} = \rho g Q H = 9.81 \times 0.18 \times 32 = 56.5 \text{ kW}$$

$$\text{Kinetic energy per second of Jet} = \frac{1}{2}\rho QV^2 = \frac{1}{2}\times 0.18 \times \left(\frac{0.18}{7500\times 10^{-6}}\right)^2 \times \frac{1000}{1000} kW = 51.84 kW$$

$$\text{Power lost in nozzle} = 56.5 - 51.84 = \boxed{4.66 kW}$$

109. A certain hydropower plant utilizes the flow as it occurs, without any provision for storage. It is premised that a defined minimum dry weather flow is available. Such a plant is classified as

(a) Diverted-flow plant

(b) Pooled storage plant

(c) Base-land plant

(d) Run-of-river plant

Ans. (d)

Sol. Run-off river plants are one which does not store any water and utilises the water as it flows.

110. Two turbo-generators, each of capacity 25,000 kW, have been installed at a hydel power station. The load of the hydel plant varies from 15,000 kW to 40,000 kW. The total installed plant capacity and the load factor are nearly

(a) 40,000 kW and 68.8%

(b) 50,000 kW and 68.8%

(c) 40,000 kW and 62.3%

(d) 50,000 kW and 62.8%

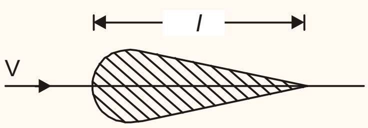
Ans. (b)

Sol. Since two generators each of capacity 25,000 kW have been installed, hence

$$\text{Total installed plant capacity} = 2 \times 25000 = 50{,}000 kW$$

$$\text{Now, load factor} = \frac{\text{Average load over a certain period}}{\text{Peak load during that period}} = \frac{\frac{15000+40000}{2}}{40000} = 0.6875 = 68.8\%$$

111. An airfoil is a streamlined body as shown in the figure below. Because of the streamlining of the body, the seperation occurs only at the extreme rear of the body, resulting in



(a) A very high pressure drag

(b) A small wave and consequently small pressure drag

(c) A moderate pressure drag

(d) No pressure drag

Ans. **(b)**

Sol. As Airfoil is a streamlined body, so separation of boundary layer occur only at the extreme rear of the body. So due to small wake size at back, pressure difference between front and back reduces. So, form drag (pressure drag) is comparatively very small in airfoil.

112. A plate 0.025 mm distant from a fixed plate moves at 60 cm/s and requires a force of 0.2 kgf/m^2 to maintain this speed. The dynamic viscosity of the fluid between the plates will be nearly

(a) 9.2×10^{-10} kgfs/cm^2

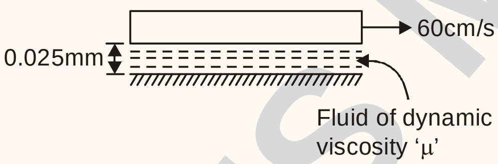
(b) 8.3×10^{-10} kgfs/cm^2

(c) 7.4×10^{-10} kgfs/cm^2

(d) 6.5×10^{-10} kgfs/cm^2

Ans. **(b)**

Sol.



$$\tau = 0.2 \text{ kg.f/m}^2$$

$$\tau = \mu \frac{du}{dy}$$

$$0.2 \frac{\text{kg.f}}{\text{m}^2} = \mu \times \frac{600\text{mm/sec}}{0.025\text{mm}}$$

$$\mu = 8.33 \times 10^{-6} \frac{\text{kg.fs}}{\text{m}^2}$$

$$= 8.33 \times 10^{-10} \text{kgfs/cm}^2$$

113. Which of the following are components parts for an oil pressure governor in modern turbines?

1. Servomotor, known as relay cylinder
2. Oil sump
3. Oil pump which is driven by belt connected to turbine main shaft
4. Draft tube

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

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

Ans. **(a)**

Sol. The main components of an oil pressure governor are :

(i) the servomotor or relay cylinder

(ii) The distribution valve or control valve

(iii) Actuator or pendulum

(iv) Oil pump

(v) Gear pump which runs by tapping power from the power shaft by belt drive.

(vi) A pipe system communicating with the control valve servometer and the pump

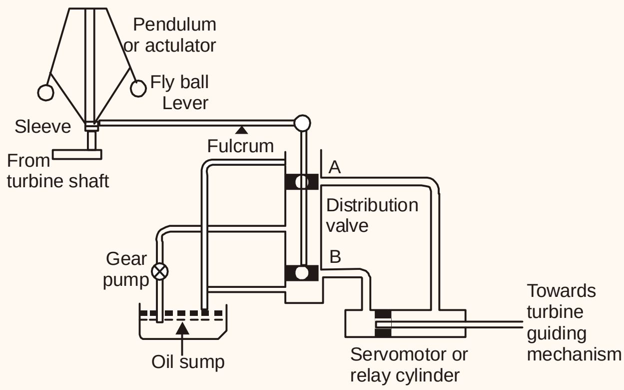


Fig. Oil pressure governor

114. A double-acting reciprocating pump having piston area 0.1 m^2 has a stroke 0.30 m long. The pump is discharging 2.4 m^3 of water per minute at 45 rpm through a height of 10 m. The slip of the pump and power required to drive the pump will be nearly

(a) 0.005 m^3/s and 4.8 kW

(b) 0.003 m^3/s and 4.8 kW

(c) 0.005 m^3/s and 4.4 kW

(d) 0.003 m^3/s and 4.4 kW

Ans. **(c)**

Sol. Given,

Piston Area, A = $0.1m^2$

Stroke length, L = 0.3m

Actual discharge, Q_{act} = $2.4m^3/min$

= $0.04m^3/s$

Speed, N = 45rpm

H = 10m

$$Q_{th} = \frac{2ALN}{60}$$

$$= \frac{2 \times 0.1 \times 0.3 \times 45}{60}$$

$= 0.045m^3/s$

$\therefore$ Slip = $Q_{th} - Q_{act}$

= 0.045 – 0.04

= $0.005m^3/s$

Theoretical power required = $\rho g Q_{th}.H$

= 9.81 × 0.045 × 10

= 4.4kW

115. In intensity-duration analysis of Sherman, the intensity of rainfall i is represented as

(a) $\frac{b^n}{(t+a)}$

(b) $\frac{a^n}{(t+b)^n}$

(c) $\frac{(a+t)^n}{b}$

(d) $\frac{a}{(t+b)^n}$

Ans. **(d)**

Sol. Sherman equation is given as :

$$i = \frac{a}{(t+b)^n}$$

116. Which one of the following points should be kept in mind while selecting the site for a rain gauge station?

(a) The site where a rain gauge is set up should be close to a meteorological observatory.

(b) The rain gauge should be on the top of a hill.

(c) A fence, if erected to protect the rain gauge from cattle etc. should be located within twice of the height of the fence.

(d) The distance between the rain gauge and the nearest object should be atleast twice the height of the object.

Ans. **(d)**

117. Which of the following statements relates to a retarding reservoir?

1. There are no gates at the outlets and hence the possibility of human error in reservoir operation is eliminated.
2. The high cost of gate installation and also its operation is saved.
3. An automatic regulation may cause coincidence of floor crest farther downstream where two or more channels taking off from retarding reservoirs join together.

(a) 1, 2 and 3

(b) 1 and 2 only

(c) 1 and 3 only

(d) 2 and 3 only

Ans. **(a)**

118. The coefficient of transmissibility T for a confined aquifer can be determined by a pumping-out test together with other relevant observations. The applicable formula is (where Q = Discharge, and ΔS = Difference in drawdowns in two wells)

(a) $\frac{Q}{2.72\Delta S}$

(b) $\frac{Q}{1.72\sqrt{\Delta S}}$

(c) $\frac{Q}{2.72}\Delta S$ (d) $\frac{Q}{2.72}\sqrt{\Delta S}$

Ans. (a)

119. The volume of water below the minimum pool level in a reservoir is known as

(a) Useful storage

(b) Surcharge storage

(c) Dead storage

(d) Bank storage

Ans. (c)

120. Depending upon the source from which the water is drawn, flow irrigation can be sub-divided into

1. River canal irrigation
2. Reservoir or tank irrigation
3. Combined storage and lift irrigation
4. Combined storage and diversion irrigation

Which of the above designations are relevant?

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

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

Ans. (b)

Sol. Flow irrigation system can be further classified on the basis of source of water from which the flow irrigation canal take off.

(a) Direct irrigation system or river canal irrigation $\rightarrow$ weir or barrage

(b) Storage irrigation system eg reservoir or tank irrigation.

(c) Combined storage and diversion irrigation $\rightarrow$ Dam or river and a diversion weir or barrage or the river at a suitable place on the down stream of dam to divert water into the canal.

121. Which of the following statements are wholly correct regarding broken-brick aggregate useable in concrete?

1. Broken-brick aggregate is obtained by crushing waste bricker, and it has a density varying between 1000 kg/m^3 – 1200 kg/m^2.
2. Such aggregate is usable in concrete for foundation in light buildings, floorings and walkways.
3. Such aggregate may also be used in light weight reinforced concrete floors.

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

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

Ans. (b)

Sol.

- Broken–brick aggregate is obtained by crushing waste brick and has a density varying between 1600 – 2000 kg/m^3
- It is used in concrete in light-weight reinforced concrete floors.
- It is used in concrete for foundation in light building flooring and walkways.

122. In handling air-entraining admixtures the beneficial amount of entrained air depends upon certain factors like

1. Type and quantity of air-entraining agent
2. Water-cement ratio of the mix
3. Strength of aggregates
4. Extent of compaction of concrete

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

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

Ans. (b)

Sol. The beneficial amount of entrained air depends on

(i) Type and quantity of air entraining agent

(ii) Water cement ratio of mix

(iii) Mixing time

(iv) extent of compaction of concrete

(v) Type of cement

123. Which one of the following statements is not correct with respect to fly ash?

(a) As part replacement of cement in the range of 15%-30%, fly ash reduces the strength in the initial period, but once the Pozzolanic process sets in, higher strength can be obtained.

(b) Fly ash as a part replacement of sand has a beneficial effect on strength even at early age.

(c) Fly ash as a part replacement of sand is economical.

(d) A simultaneous replacement of cement and fine aggregates enables the strength at a specified age to be equalled depending upon the water content.

Ans. (c)

Sol. Flyash is costlier than sand. Hence using this in the place of sand will not be economical.

Flyash will only contribute to strength only when the pozzolanic reaction sets in.

124. Which one of the following statements is not correct with respect to the properties of cement?

(a) Highly reactive Pozzolanas enhance the early age strength of the composite cement

(b) Pozzolanic activity refines pore structure which decreases electrolytic resistance of concrete.

(c) The expansion due to alkali-silica reaction can be controlled by replacement of as high as 60% of OPC with high-calcium Pozzolana.

(d) Such high amounts of replacement cements result in higher accelerated carbonation depths compared to pure use of OPC only.

Ans. (a)

Sol. Pozzolanas don't have any cementitious properties as such. But when they react with free lime in cement in presence of water, improve durability of concrete at later stage, but doesn't contribute to early age strength of composite cement.

125. Hydration of which compound is responsible for increase in strength of cement in later age?

(a) Tri-calcium Aluminate (C_3A)

(b) Tetra-calcium Aluminoferrite (C_4AF)

(c) Tri-calcium Silicate (C_3S)

(d) Di-calcium Silicate (C_2S)

Ans. (d)

Sol. C_2S hydrates and hardens slowly and takes a long time to add to the strength. Generally, after one year contribution to the strength and hardness of cement is predominately due to C_2S.

126. The creep strain of cement attains its terminal values by

(a) 1 year (b) 2 years

(c) 5 years (d) 6 months

Ans. (c)

Sol. Creep is a time dependent phenomenon and creep strain decreases with time. Although it doesn't stop for a long period, but creep strain at 5-years are taken as terminal values.

127. Which of the following methods will help in reducing segregation in concrete?

1. Not using vibrator to spread the concrete
2. Reducing the continued vibration
3. Improving the cohesion of a lean dry mix through addition of a further small quantity of water.

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

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

Ans. (d)

Sol. Segregation can be reduced by preventing over-vibration, using good design mixes, avoiding dropping concrete from heights, avoiding excess water etc.

But vibration is an excellent method for compaction so it shouldn't be avoided.

128. On an average, in a 125 mm slump, the concrete may lose about (in first one hour)

(a) 15 mm of slump (b) 25 mm of slump

(c) 40 mm of slump (d) 50 mm of slump

Ans. **(d)**

Sol. The loss of workability varies with the type of cement, the concrete mix proportions, the initial workability and the temperature of the concrete.

On an average a 125 mm slump concrete may lose about 50 mm slump in the 1st one hour.

129. Permeability in concrete is studied towards providing for, or guarding against, which of the following features?

1. The penetration by materials in solution may adversely affect the durability of concrete; moreover, aggressive liquids 'attack' the concrete.
2. In case of reinforced concrete, ingress of moisture and air will result in corrosion of steel leading to an increase in volume of steel, resulting in cracking and spelling of the concrete cover.
3. The moisture penetration depends on permeability and if the concrete can become saturated with water it is less vulnerable to frost action.

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

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

Ans. **(b)**

Sol. In permeable conctete, ingress of water leads concrete susceptible to chemical attack, frost action, rusting of steel reinforcements.

If pores are saturated with water, the concrete will be more vulnerable to frost action.

130. Poisson's ratio of concrete μ can be determined using the formula

(a) $\left(\frac{V}{2nL}\right) = \frac{(1-\mu)}{(1-2\mu)(1+\mu)}$

(b) $\left(\frac{V}{2nL}\right) = \frac{(1+\mu)}{(1-2\mu)(1+\mu)}$

(c) $\left(\frac{V^2}{2nL}\right) = \frac{(1-\mu)}{(1-2\mu)(1+\mu)}$

(d) $\left(\frac{V^2}{2nL}\right) = \frac{(1-\mu^2)}{(1-2\mu)(1+\mu)}$

where

V is pulse velocity, in mm/s,

n is resonant frequency of longitudinal vibration, in Hz,

L is distance between transducers, in mm.

Ans. **(*)**

Sol. $\left(\frac{2nl}{V}\right)^2 = \frac{(1+\mu)(1-2\mu)}{1-\mu}$

[IS 13311(part-I : 1992)]

$$\Rightarrow \left(\frac{v}{2nl}\right)^2 = \frac{1-\mu}{(1+\mu)(1-2\mu)}$$

131. Which one of the following methods/ techniques will be used for placing of concrete in dewatered 'Caissons or Coffer' dams?

(a) Tremie method

(b) Placing in bags

(c) Prepacked concrete

(d) In-the-dry practice

Ans. **(d)**

Sol. The placing of concrete in dewatered caissons or coffer dams follows the normal in-the-dry-practice

132. The minimum cement content (kg/m^3) for a pre-specified strength of concrete (using standard notations) premised on 'free water-cement ratio' will be as

(a) $1-\dfrac{C}{1000S_C}-\dfrac{W}{1000}$

(b) $\dfrac{\text{Water content}}{\text{Water Cement ratio}}$

(c) Water content × Water cement ratio

(d) $\dfrac{100F}{C+F}$

Ans. **(b)**

Sol. The minimum cement content for a pre-specified strength of concrete premised on "free-water-cement ratio" will be as

$$\boxed{\dfrac{\text{Water content}}{\text{Water cement ratio}}}$$

133. A bar specimen of 36 mm diameter is subjected to a pull of 90 kN during a tension test. The extension on a gauge length of 200 mm is measured to be 0.089 mm and the change in diameter to be 0.0046 mm. The Poisson's ratio will be

(a) 0.287
(b) 0.265
(c) 0.253
(d) 0.241

Ans. **(a)**

Sol. $\mu = -\dfrac{\text{lateral strain}}{\text{longitudinal strain}}$

$$= \frac{-\left(\dfrac{-0.0046}{36}\right)}{\left(\dfrac{0.089}{200}\right)} = 0.287$$

134. A steel rod 15 m long is at a temperature of 15°C. The values of α = 12 × 10^{-6}/°C and E = 200 GN/m^2 are adopted. When the temperature is raised to 65°C, what is the free expansion of the length; and if this expansion of the rod is fully prevented, what is the temperature stress produced?

(a) 5 mm and 120 MN/m^2
(b) 9 mm and 120 MN/m^2
(c) 5 mm and 150 MN/m^2
(d) 9 mm and 150 MN/m^2

Ans. **(b)**

Sol. Free expansion = $\ell\alpha\Delta T$

= 15000 mm × 12 × 10^{-6} × (65 – 15)

= 9 mm

Temperature stress = $E\alpha\Delta T$

= 200 × 10^9 N/m^2 × 12 × 10^{-6} × 50

= 1.2 × 10^8 N/m^2

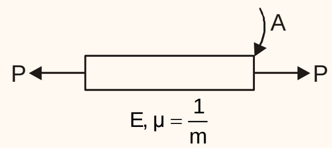
= 120 MN/m^2.

135. A bar of uniform rectangular section of area A is subjected to an axial tensile load P; its Young's modulus is E and its Poisson's ratio is $\dfrac{1}{m}$. Its volumetric strain, e_v is

(a) $\dfrac{P}{AE}\left(1+\dfrac{3}{m}\right)$
(b) $\dfrac{P}{AE}\left(1+\dfrac{2}{m}\right)$
(c) $\dfrac{P}{AE}\left(1-\dfrac{2}{m}\right)$
(d) $\dfrac{P}{AE}\left(1-\dfrac{1}{2m}\right)$

Ans. **(c)**

Sol.



Volumetric strain $(e_V) = \dfrac{(\sigma_x+\sigma_y+\sigma_z)(1-2\mu)}{E}$

$\sigma_x = \dfrac{P}{A}$

$\sigma_y = 0$

$\sigma_z = 0$

$\Rightarrow e_V = \dfrac{P}{AE}\left(1-\dfrac{2}{m}\right)$

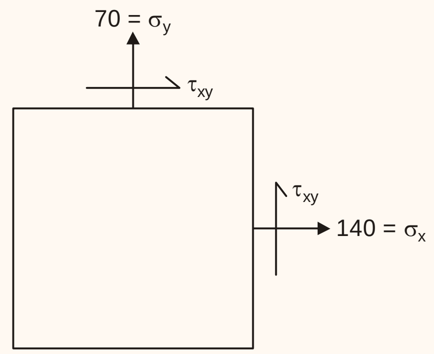
136. The normal stresses on two mutually perpendicular planes are 140 N/mm^2 (Tensile) and 70 N/mm^2 (Tensile). If the maximum shear stress is 45 N/mm^2, the shear stress on these planes will be nearly

(a) 20.9 N/mm^2 (b) 24.6 N/mm^2

(c) 28.3 N/mm^2 (d) 32.0 N/mm^2

Ans. **(c)**

Sol.



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

$$45 = \sqrt{\left(\frac{140-70}{2}\right)^2 + \tau_{xy}^2}$$

$$\sqrt{(45)^2 - (35)^2} = \tau_{xy} = 28.284 \text{ N/mm}^2$$

137. The normal stresses on the two mutually perpendicular planes at a point are 120 MPa (Tensile) and 60 MPa (Tensile). If the shear stress across these planes is 30 MPa, the principal stresses will be nearly

(a) 124 MPa (Tensile) and 24 MPa (Compressive)

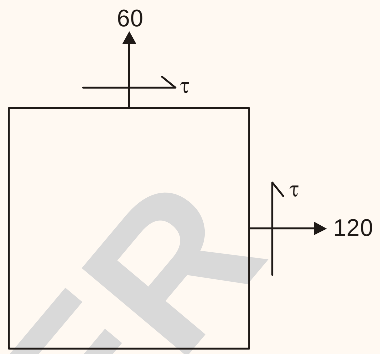
(b) 132 MPa (Tensile) and 24 MPa (Compressive)

(c) 124 MPa (Tensile) and 48 MPa (Tensile)

(d) 132 MPa (Tensile) and 48 MPa (Tensile)

Ans. **(d)**

Sol.



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

$$= 90 \pm \sqrt{(30)^2 + (30)^2}$$

$$= 90 \pm \sqrt{2} \times 30$$

$= 90 \pm 42.426$

$= 132.426,\ 47.574$

Both principal stress are tensile.

138. At a point in a material, the stresses acting on two planes at right angles to each other are :

σ_z = 120 MPa and σ_y = –200 MPa and σ_{zy} = –80 MPa.

The maximum shear stress on the element will be nearly

(a) 142 MPa (b) 155 MPa

(c) 167 MPa (d) 179 MPa

Ans. **(d)**

Sol. $$\tau_{max} = \sqrt{\left(\frac{\sigma_y - \sigma_z}{2}\right)^2 + (\tau_{yz})^2}$$

$$= \sqrt{\left(\frac{320}{2}\right)^2 + (80)^2}$$

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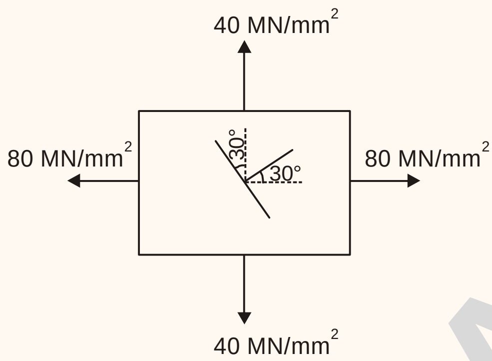
$$= \sqrt{(160)^2 + (80)^2}$$

$$= 80 \times \sqrt{5}$$

$$= 178.885 \text{ MPa}$$

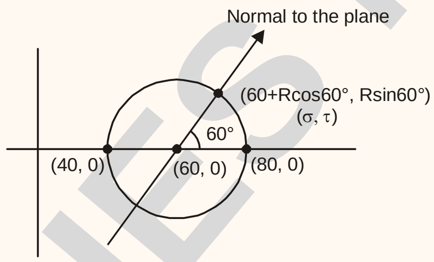
139. The principal stresses in the wall of a container are 40 MN/mm^2 and 80 MN/mm^2. The normal makes an angle of 30° with a direction of maximum principal stress. The resultant stresses (in magnitude) in the plane will be nearly



(a) 84 MN/m^2
(b) 72 MN/m^2
(c) 64 MN/m^2
(d) 58 MN/m^2

Ans. **(b)**

Sol.



$$R = \frac{80-40}{2} = 20\,\text{MN/mm}^2$$

$$\sigma = 60 + 20\cos 60°$$

$$= 70\text{MPa}$$

$$\tau = 20\frac{\sqrt{3}}{2} = 10\sqrt{3}$$

$\Rightarrow$ Resultant Stress = $\sigma_r = \sqrt{\sigma^2 + \tau^2}$

$$= \sqrt{(70)^2 + (10\sqrt{3})^2}$$

$$= 72.11 \text{ MPa}$$

140. The change in shearing force between two points on the beam is equal to the area of

(a) Loading diagram between the two points
(b) Shear force diagram between the two points
(c) Bending moment diagram between the two points
(d) M/EI diagram between the two points

Ans. **(a)**

141. Which one of the following statements specifies shear flow?

(a) Flow of shear force along the beam
(b) It is the product of the shear stress at any level and the corresponding width b (of the section)
(c) Unbalanced force on any side of given section divided by area of section
(d) The deformation at any level due to sudden variation in shear stress

Ans. **(b)**

142. Which one of the following statements is correct for the rotating shafts transmitting power?

(a) Lower the frequency of shaft lower will be the torque
(b) Higher the frequency of shaft lower will be the torque
(c) Frequency of the shaft does not influence the torque
(d) Higher the frequency of shaft higher will be the torque

Ans. **(b)**

Sol.

$$T\omega = \text{Power} = T \times 2\pi f$$

$$T = \frac{\text{Power}}{2\pi f}$$

As, $f\uparrow, T\downarrow$

143. The maximum shear stress induced in a solid circular shaft of diameter 15 cm, when the shaft transmits 150 kW power at 180 rpm, will be

(a) 16 N/mm^2 (b) 14 N/mm^2
(c) 12 N/mm^2 (d) 10 N/mm^2

Ans. **(c)**

Sol.

$$\text{Max shear stress} = \frac{Tr}{J} = \frac{Td/2}{\frac{\pi}{32}d^4} = \frac{16T}{\pi d^3}$$

$$T = \frac{P}{\omega}$$

$$\tau_{max} = \frac{16P}{\pi d^3 \omega}$$

$$= \frac{16\times150\times10^3}{\pi(0.15)^3\times\frac{180\times2\pi}{60}}$$

$$= 12\times10^6\ \text{N/m}^2$$

$$= 12\ \text{N/mm}^2$$

144. A closely coiled helical spring made of 10 mm diameter steel wire has 15 coils of 100 mm mean diameter. The spring is subjected to an axial load of 100 N. For a modulus of rigidity of 8.16 × 10^4 N/mm^2, the stiffness of the spring will be nearly

(a) 5.9 N/mm (b) 6.8 N/mm
(c) 7.7 N/mm (d) 8.8 N/mm

Ans. **(b)**

Sol. d = 10 mm

n = 1

D = 100 mm

P = 100 N

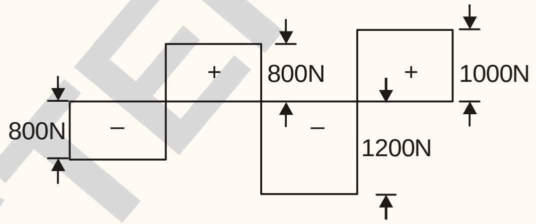
G = 8.16 × 10^4 N/mm^2

$$\text{Stress of spring} = \frac{P}{\delta} = \frac{Gd^4}{64R^3n}$$

$$= \frac{8.16\times10^4\ \text{N/mm}^2\times(10)^4\ \text{mm}^4}{64(50\text{mm})^3\times15}$$

= 6.8 N/mm

145. The shear force diagram of a beam is shown in the figure

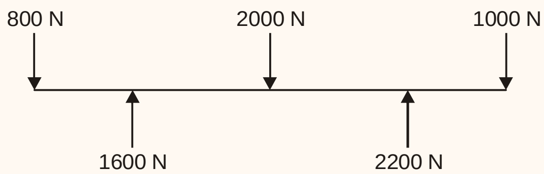


The total of the vertically downward loads on the beam is

(a) 2600 N (b) 2000 N
(c) 2400 N (d) 2800 N

Ans. **(d)**

Sol.



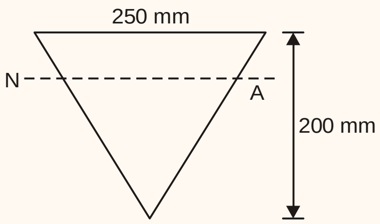
Total $\downarrow$ Force = 3800 N

146. A beam of triangular cross-section is subjected to a shear force of 50 kN. The base width of the section is 250 mm and the height is 200 mm. The beam is placed with its base horizontal. The shear stress at neutral axis will be nearly

(a) 2.2 N/mm^2 (b) 2.7 N/mm^2
(c) 3.2 N/mm^2 (d) 3.7 N/mm^2

Ans. **(b)**

Sol.



$$\tau_{N.A.} = \frac{4}{3}\tau_{av}$$

$$= \left(\frac{50\times 10^3\text{ N}}{\frac{1}{2}\times 250\times 20}\right)\times\frac{4}{3}$$

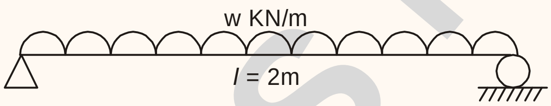
$$= 2.67 \text{ MPa}$$

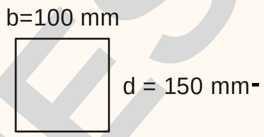
147. A timber beam, 100 mm wide and 150 mm deep, supports a UDL over a span of 2 m. If the safe stresses are not to exceed 28 MPa in bending and 2 MPa in shear, the maximum load that the beam can support is

(a) 16 kN/m
(b) 20 kN/m
(c) 24 kN/m
(d) 28 kN/m

Ans. **(b)**

Sol.





$$M_{max} = \frac{wl^2}{8}$$

$$V_{max} = \frac{wl}{2}$$

$$\tau_{max} = \frac{M_{max}}{\frac{bd^2}{6}} \le 28\text{N/mm}^2$$

$$\frac{w(2000)^2}{8\times 100\frac{(150)^2}{6}} \le 28$$

$$w \le 21 \text{ N/mm}$$

$$\tau_{max} = \frac{3}{2}\times\frac{V_{max}}{bd} \le 2\text{N/mm}^2$$

$$= \frac{3}{2}\times\frac{\left(\frac{w\times 2000}{2}\right)}{100\times 150} \le 2$$

$$w \le 20 \text{ N/mm}$$

w should be min of the w from the above two criteria.

$\Rightarrow$ w_{max} = 20 KN.m

148. A 1.5 m long column has a circular cross-section of 50 mm diameter. Consider Rankine's formula with values of f_d = 560 N/mm^2, $\alpha = \frac{1}{1600}$ for pinned ends and factor of safety of 3. If one end of the column is fixed and the other end is free, the safe load will be

(a) 9948 N
(b) 9906 N
(c) 9864 N
(d) 9822 N

Ans. **(b)**

Sol. $$P = \frac{f_C\, A/\text{F.O.S.}}{1+a\lambda^2}$$

$$= \frac{f_C\, A/\text{F.O.S.}}{1+\alpha\left(\frac{l}{r_{min}}\right)^2}$$

α for pinned end $= \frac{1}{1600}$

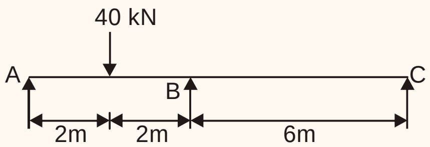
$\Rightarrow$ α for one end fixed other free = 4α

$$P = \frac{\left[560\times\frac{\pi}{4}(50)^2\right]/3}{1+\frac{4}{1600}\left(\frac{1.5\times 1000}{50/4}\right)^2}$$

$$r_{mm} = \sqrt{\frac{I_{min}}{A}} = \sqrt{\frac{\frac{\pi d^4}{64 \times \frac{\pi d^2}{4}}}{}} = \frac{d}{4}$$

= 9905.92 N

149. A continuous beam with uniform flexural rigidity is shown in the figure.



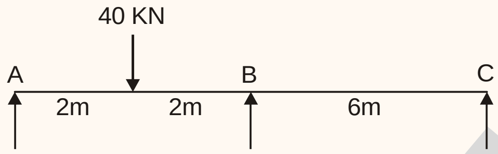
The moment at B is

(a) 18 kNm (b) 16 kNm

(c) 14 kNm (d) 12 kNm

Ans. **(d)**

Sol.



EI = Constant

Joint	Member	Member Stiffness	DF
B	BA	$\frac{3EI}{4} = \frac{9EI}{12}$	$\frac{9}{15} = 0.6$
	BC	$\frac{3EI}{6} = \frac{6EI}{12}$	$\frac{6}{15} = 0.4$

A	B		C
	0.6	0.4	
$\frac{-40\times4}{8}$	$\frac{40\times4}{8}$	0	0
$\frac{40\times4}{8}$	$\frac{40\times2}{8}$		
0	30 –18	0 –12	0
0	12	–12	0

M_{BA} = 12 KNm

150. The maximum shear stress across a circular section is

(a) $\left(\frac{4}{3}\right)$ Average shear stress

(b) $\left(\frac{3}{2}\right)$ Average shear stress

(c) $\left(\frac{5}{4}\right)$ Average shear stress

(d) $\left(\frac{9}{5}\right)$ Average shear stress

Ans. **(a)**