IES MASTER

Institute for Engineers (IES/GATE/PSUs)

ESE 2017

Prelims Exam

Detailed Solution

CIVIL ENGINEERING (SET–C)

Office Address: F-126, Katwaria Sarai, New Delhi - 110 016
Telephone: 011-41013406, **Mobile:** 8130909220, 9711853908
Web: www.iesmaster.org **E-mail:** info@iesmaster.org

IES MASTER
Institute for Engineers (IES/GATE/PSUs)

Explanation of Civil Engg. Prelims Paper (ESE - 2017)

SET - C

1. Consider the following statements:

1. When the number of members (n) and joints (j) are such that the equation n = (2j – 3) is satisfied, the framed structure is said to be a perfect structure.
2. In a redundant frame, the number of members is less than that required for a perfect frame.
3. If, in a framed structure, the number of members provided is more than that required for a perfect frame, it is called as deficient frame.

Which of the above statements is/are correct?

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

(c) 2 only (d) 3 only

Ans. **(b)**

Sol. Perfect structure or frame are the one which can be analysed using the three conditions of static equilibrium. For these

$$m = 2j - 3$$

Redundant frame is a frame having more number of members than required such that there is always a member in which force can not be computed using equations of static equillbrium

$$\boxed{n > (2j - 3)}$$

Deficient frame is frame having less number of members than required for perfect frame

$$\boxed{n < (2j - 3)}$$

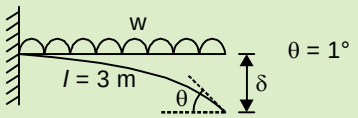
2. A cantilever beam, 3m long, carries a uniformly distributed load over the entire length. If the slope at the free end is 1°, the deflection at the free end is

(a) 49.27 mm (b) 39.27 mm

(c) 30.27 mm (d) 20.27 mm

Ans. **(b)**

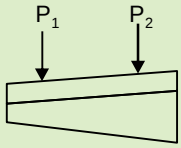
Sol.



$$\theta = \frac{wl^3}{6EI}$$

$$\delta = \frac{wl^4}{8EI}$$

$$\frac{\delta}{\theta} = \frac{6l}{8}$$



$$\delta = \frac{6 \times 3000}{8} \times \frac{\pi}{180}$$

$$= 39.25 \text{ mm}$$

3. The maximum bending moment at a given section, in which a train of wheel loads moves occurs when the average load on the left segment is

1. Equal to the average load on the right segment.
2. More than the average load on the right segement.
3. Less than the average load on the right segment.

Select the correct answer using the codes given below:

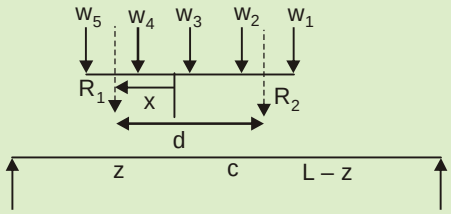
OFFICE
F-126, Katwaria Sarai, N.D-16. Ph : 011-41013406, 9711853908 , 8010009955
Email : ies_master@yahoo.co.in,http://www.iesmaster.org

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

(c) 2 only (d) 3 only

Ans. **(b)**

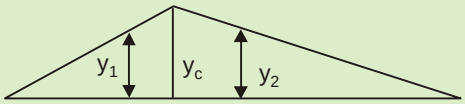
Sol.



Let R_1 be the resultant of loads on the left of the section and R_2 be resultant of the loads on the right of the section.

Distance between R_1 and R_2 be ϕ and R_1 be at a distance x from C.

Let ordinate ILD for moment at C be y_1 under R_1 and y_2 under R_2 and maximum ordinate at C be y_c



$$M_C = R_1y_1 + R_2y$$

$$= R_1\left(\frac{L-x}{z}\right)y_c + R_2 \times \frac{(L-2)-(d-x)}{(L-2)} \times y_c$$

for MC to be maximum

$$\frac{dM_c}{dx} = -\frac{R_1y_c}{z} + R_2 \times \left(\frac{y_c}{L-z}\right) = 0$$

$$\frac{R_1}{z} = \frac{R_2}{L-z}$$

Note : Seldom we get exactly equal average load on both sides of the section. For example when load w_1 is to the left of the section, the avg. load on left side may be heavier when it just rolls over the section, the avg load on right hand becomes heavier.

Hence the above condition for maximum bending moment can be interpreted as thebending moment is maximum when that load is on the section.

4. A single degree of freedom system of mass 22 kg and stiffness 17 kN/m vibrates freely. If damping in the system is 2%, the cyclic frequency and the damped circular frequency, respectively, are nearly

(a) 0.4 Hz and 0.88 rad/sec

(b) 0.88 Hz and 27.8 rad/sec

(c) 4.4 Hz and 27.8 rad/sec

(d) 0.88 Hz and 0.88 rad/sec

Ans. **(c)**

Sol. The natural frequency without considering damping

$$w_n = \sqrt{\frac{x}{m}}$$

$$K = 17 \text{ kN/m} = 17 \times 10^3 \text{ N/m}$$

$$m = 22 \text{ kg}$$

$$\Rightarrow w_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{17\times10^3}{22}} = 27.8 \text{ rad/sec}$$

Damping, $z = 2\% = 0.02$

$$w_d = w_n(1 - z^2)$$

$$= 27.8\,(1 - 0.02^2)$$

$$\simeq 27.8 \text{ rad/sec}$$

So, damped cyclic frequency=27.8 rad/sec

Cyclic frequency $f = \frac{w_d}{2\pi}$

$$= \frac{27.8}{2\pi} = 4.4 \text{ Hz.}$$

Alternative

The relation $f = \frac{w}{2\pi}$ can be directly used to eliminate options.

Only option 'c' satisfies the above relation.

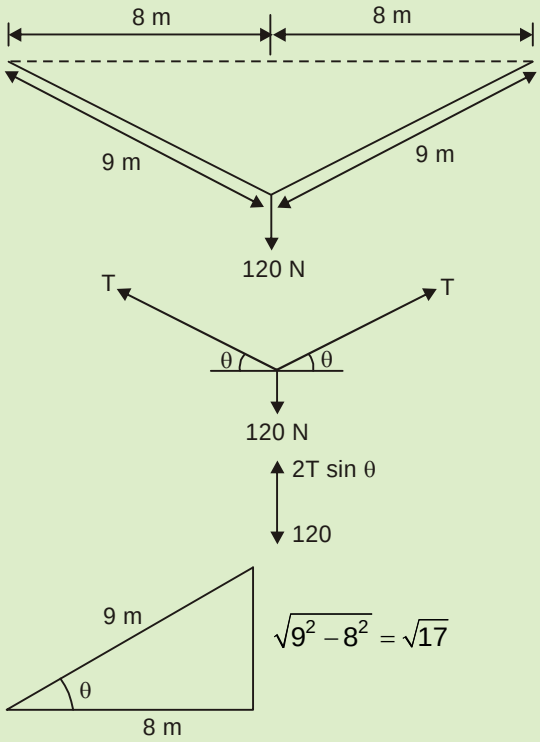
5. A cable of insignificant weight, 18 m long, is supported at its two ends, 16m apart, at the same level. The cable supports at its mid-reach a load of 120 N. The tension in the cable is nearly

(a) 136 N (b) 131 N

(c) 126 N (d) 121 N

Ans. **(b)**

Sol.



$\sqrt{9^2 - 8^2} = \sqrt{17}$

$$\sin\theta = \frac{\sqrt{17}}{9}$$

$$2T \sin\theta = 120$$

$$\Rightarrow \quad 2T \times \frac{\sqrt{17}}{9} = 120$$

$$\Rightarrow \quad T = \frac{120 \times 9}{2\sqrt{17}}$$

$$= 130.97 = 131 \text{ N}$$

6. The design strength of a tension member is governed by

1. Rupture at a critical section
2. Yielding of gross area
3. Block shear of end region

Select the correct answer using the codes given below:

(a) 1 only (b) 2 only

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

Ans. **(d)**

Sol. Design strength of a tension member is governed by there criterias

1. Rupture at a critical section
2. Yielding of gross area
3. Block shear of end region

1. Rupture strength of P plate is given by

$$T_{dn} = \left(\frac{A_n f_u}{\gamma_{m_1}}\right) \times 0.9$$

$$A_n = B.t = nd't + \frac{\Sigma p_1^2}{4g_i} \times t$$

2. Yield strength of plate = $\dfrac{f_y \times A_g}{\gamma_{m_0}}$

3. Block shear strength of plate

$$= \text{min. of} \begin{cases} \dfrac{A_{vg}\, f_y}{\sqrt{3}\,\gamma_{m0}} + \dfrac{A_{tn} \times 0.9 f_u}{\gamma_{m1}} \\ \dfrac{A_{v_n} 0.9 f_u}{\sqrt{3}\gamma_{m_1}} + \dfrac{At_g \times f_y}{\gamma_{m_0}} \end{cases}$$

and design strength of tension member is minimum of 1, 2, 3 given by above

7. Two parallel rails are running on railway sleepers. The centre-to-centre distance between the rail is 'b' with the sleepers projecting by an amount 'a' at each end beyond the rails. When the train passes over

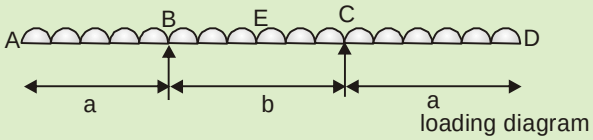
the rails, the reaction exerted by the ground can be taken as uniformly distributed over the sleeper. The ratio $\frac{b}{a}$ for the condition that the maximum bending moment is as small as possible is

(a) 2.83 (b) 2.90

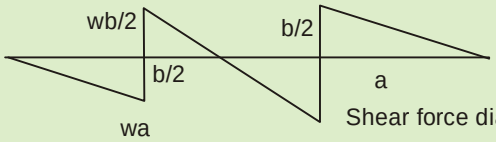
(c) 2.50 (d) 3.00

Ans. (a)

Sol.



loading diagram



Shear force diagram

maximum (+) bending moment will occur at the mid span of central span E and maximum -ve BM will occur at the supports B and C.

[Maximum +ve BM –BM at free end] = 0

$\int vdx$ = Area under SFD between A to E

$$= \frac{1}{2}\times\frac{wb}{2}\times\frac{b}{2}-\frac{1}{2}\times wa\times a$$

Maximum +ve BM = $\frac{wb^2}{8}-\frac{wa^2}{2}$

[Maximum -ve BM – BM at free end]

= area ofSFD between A and B

$$= \frac{1}{2}\times wa\times a$$

Maximum -ve BM = $\frac{wa^2}{2}$

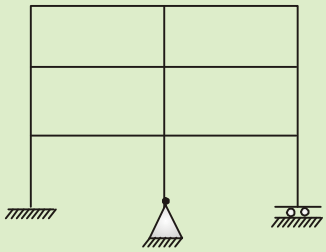
maximum +ve BM = Max. – ve BM

$$\frac{wb^2}{8}-\frac{wa^2}{2}=\frac{wa^2}{2}$$

$$a^2 = \frac{b^2}{8}$$

$$\frac{b}{a}=2\sqrt{2}=2.82$$

8. The kinematic indeterminacy of the structure shown in the figure is equal to

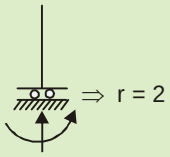


(a) 14 (b) 15

(c) 16 (d) 17

Ans. (a)

Sol. Kinematic indterminancy = 3j – r – m



j = no. of joints = 12

r = Reaction = 3 + 2 + 2 = 7

m = No. of members = 15

D_k = 3j – k - m

= 3 × 12 – 7 – 15

= 14

9. A beam-column is alternately bent either (1) in single curvature, or (2) in double curvature. The secondary moments induced are to be compared. These are indicated SM_2 and SM_2 as per the conditions (1) and (2) respectively

IES MASTER .org

Institute for Engineers (IES/GATE/PSUs)

ANNOUNCES NEW BATCHES FOR

IES/GATE/PSUs

BRANCHES

- CIVIL ENGG
- MECHANICAL ENGG
- ELECTRICAL ENGG
- ELECTRONICS & COMM. ENGG

Weekend Batches Start
28th Jan'17

Regular Batches Start
15th Feb'17

ADMISSION OPEN FOR
SESSION 2017-18

F-126, Katwaria Sarai, New Delhi - 16

8010009955, 9711853908

(a) $SM_1 > SM_2$

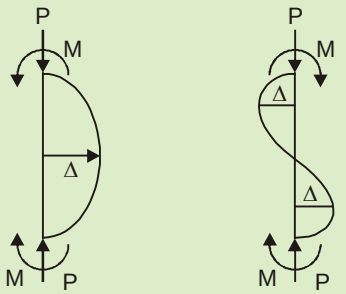
(b) $SM_1 < SM_2$

(c) $SM_1 = SM_2$

(d) Cannot be ascertained

Ans. (a)

Sol.



Single currature Double currature

- A beam column is a member which carry bending moment with axial compressive force.
- Due to bending deflection (Δ), the axial force P induces additional moment = $P \times \Delta$
- This $P \times \Delta$ moment is called secondary moment.
- In single curvature, maximum moment in member will be greater than the applied moment, but in double curvature, maximum moment neet not be greater than the applied moment.
- In single curvature, $P \times \Delta$ moment will be more than that in double curvature because of lower Δ in double curvature.

10. Gantry girders can be designed

1. As laterally supported beams.
2. As laterally unsupported beams.
3. By using channel sections.

Select the correct answer using the codes given below:

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

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

Ans. (b)

Sol. Gantry girders are designed using latterly unsupported beams generally while they can be designed as latterally supported beams. Also Gantry girders carry heavy loads and hence they should be designed as I section with plate or channels on compression flange. Since the main member is only I-section, we generally do not use channel as main member.

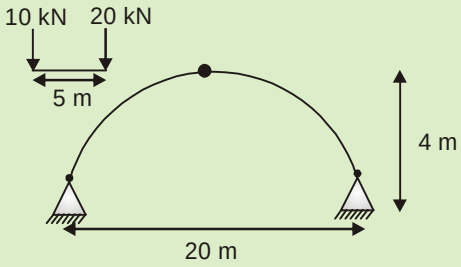
11. A three-hinged parabolic arch ABC has a span of 20 m and a central rise of 4·0 m. The arch has hinges at the ends and at the crown. A train of two point loads of 20 kN and 10 kN, 5 m apart, crosses this arch from left to right, with the 20 kN load leading. The maximum thrust induced at the supports is

(a) 25·0 kN (b) 28·13 kN

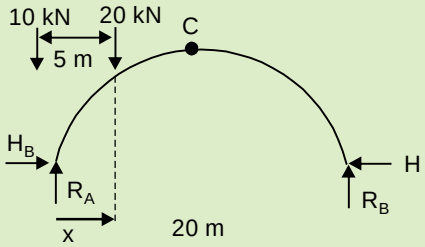
(c) 31·25 kN (d) 32·81 kN

Ans. (c)

Sol.



Case-I



For vortical R×N R_B,

$$\Sigma M = 0 \text{ at A}$$

$$\Rightarrow R_B \times 20 = 20x + 10(x-5)$$

$$R_B = 1.5x - 2.5$$

Taking moment about C,

$$\Sigma M_C = 0$$

$$R_B \times 10 = H \times 4$$

$$H = \frac{10}{4}(1.5x - 2.5)$$

H is a linear function of x

So value of H will be maximum when x = 0

or at x = 10 (max. value of x)

at x = 10

$$\boxed{H = 31.25\ kN}$$

12. According to IS : 875 Part 3, the design wind speed acting on industrial roof is estimated based on the basic wind speed by multiplying it by factors K_1,K_2 andK_3, where K_1 is called

(a) Terrain height factor

(b) Structure size factor

(c) Topography factor

(d) Risk coefficient

Ans. (d)

Sol. According to IS-875 part 3 the design wind speed is calculated by multiplying basic wind speed to different factor K_1, K_2, K_3

K_1 – risk coefficient

K_2 – terrains, height and structure size factor

K_3 – Tapography factor

13. Consider the following two statements regarding Bearing stiffeners provided at the location of a concentrated load:

1. Bearing stiffeners have to resist bearing and buckling loads.
2. Bearing area and the area resisting buckling load are the same.

Which of the above statements is/are correct?

(a) 2 only (b) 1 only

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

Ans. (b)

Sol.

- Bearing stiffeners are provided at locations of support reactions and concentrated loads.
- Bearing stiffeners have to resist direct bearing of support reaction and also resist the buckling of web of girders.
- Bearing area and bucking area are not same.
- Bearing area is calculated at root of web by dispersion at a slope of 1:2.5.
- Buckling area is calculated at neutral axis by dispersion at 45º.

14. In a plate girder, the web plate is connected to the flange plates by fillet welding. The size of the fillet welds is designed to safely resist

(a) The bending stresses in the flange

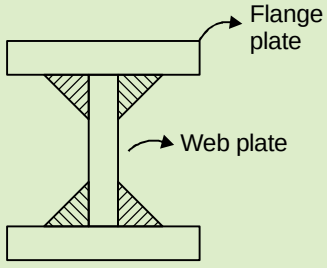
(b) The vertical shear force at the section

(c) The horizontal shear force between the flanges and the web plate

(d) The forces causing buckling in the web

Ans. (c)

Sol.



Fillet weld is good in resisting shear and hence it resists horizontal shear force between the flanges and the web plate.

15. For a rectangular cross-section, when the extreme fibre strain was ε_y, the yield moment capacity is M_y. What would be the value of the resisting moment when the extreme fibre strain is $2\varepsilon_y$?

(a) 1·000 M_y (b) 1·250 M_y

(c) 1·375 M_y (d) 1.550 M_y

Ans. (c)

Sol.

$$\frac{M}{M_y} = \frac{M_P}{M_y} - \frac{1}{2\left(\frac{K}{Ky}\right)^2}$$

$$\frac{K}{Ky} = \frac{2\varepsilon_y}{\varepsilon_y} = 2$$

$$\frac{M}{M_y} = \frac{3}{2} - \frac{1}{8} \Rightarrow \boxed{M = 1.375\, M_y}$$

16. A certain R.C. short column with 300 mm square cross-section is made of M 20 grade concrete and has 4 numbers, 20 mm diameter, longitudinal bars of Fe 415 grade steel. It is under the action of a concentric axial compressive load. Ignoring the reduction in the area of concrete due to the steel bars, the ultimate axial load carrying capacity of the column as by the relevant code is

(a) 1069 kN (b) 1198 kN

(c) 1548kN (d) 1659 kN

Ans. (a)

Sol. Ultimate axial load carrying capacity for short column

$\Rightarrow$ $0.4\, f_{ck}\, A_c + 0.67\, f_y\, A_{st}$

$= 0.4\, f_{ck}\, A_c + 0.67\, f_y\, A_{st}$

$= 0.4 \times 20 \times 300 + 0.67 \times 415$

$\times \frac{\pi}{4} \times 20^2 \times 4 \times 4$

$= 1069.41$ kN

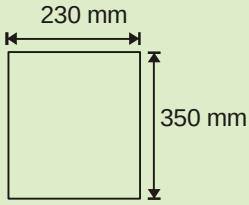
17. A rectangular 230 mm × 350 mm beam is (effective depth). The factored shear force acting at a section is 80 kN. If the permissible shear stress in concrete is 0·25 MPa, the design shear force is nearly

(a) 100 kN (b) 80 kN

(c) 60kN (d) 20 kN

Ans. (c)

Sol.



Shear force resisted by concrete section only (F_c)

$= 230 \times 350 \times 0.25 \times 10^{-3}$

$= 20.125$ kN

Design shear force (that will be resisted by shear stirrups)

F_d = factored shear force – F_c

$F_d = 80 - 20.125$

$F_d = 59.875$ kN

$\boxed{F_d \approx 60\text{ kN}}$

18. In a combined footing for two columns carrying unequal loads, the maximum hogging moment occurs at

(a) The inside face of the heavier column

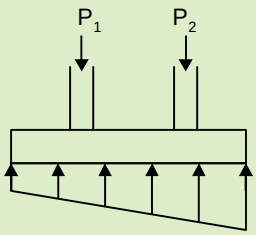
(b) A section equidistant from both the columns

(c) A section subjected to maximum shear force

(d) A section subjected to zero shear force

Ans. **(d)**

Sol.



For the above loading BM is maximum when shear force = 0.

19. Consider the following statements:

1. The minimum steel requirements of slabs are based on considerations of shrinkage and temperature effects alone, and not on strength.
2. Providing excessive reinforcement in beams can result in congestion, thereby adversely affecting the proper placement and compaction of concrete.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

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

Ans. **(c)**

Sol. (i) Minimum steel requirements of slab for transverse reinforcement are based on consideration of shrinkage and temperature effects alone and not on strength.

(ii) Providing excessive reinforcement in beams result in congestion because of too much reinforcement because of which aggretage in the mix get stuck in the reinforcement and mix do not get distributed uniformly and hence affect proper placement and compaction of concrete.

20. A T-beam becomes identical to a rectangular beam with width equal to its flange width when the neutral axis is

(a) Through the geometrical centre of the beam

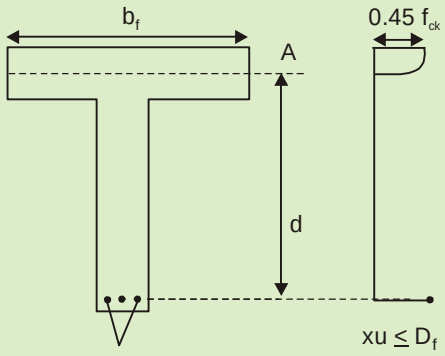
(b) At the junction of the rib and the flange

(c) Below the slab

(d) Within the flange

Ans. **(d)**

Sol.



When $xu \geq D_f$ = Neutral axis lies in flage.

Thus portion below neutral axis is not effective in tension.

hence analsysis and design will be as per a rectangular beam of width 'b_f' and depth 'd'

21. Consider the following statements in the light of IS : 456 - 2000 :

1. There is an upper limit on the nominal shear stress in beams (even with shear reinforcement) due to the possibility of crushing of concrete in diagonal compression.
2. A rectangular concrete slab whose length is equal to its width may not be a two-way slab for certain definable support conditions.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

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

Ans. (c)

Sol. (i) Generally concrete is strong in compression but under shear there is a chance of crushing of concrete due to diagonal compression hence an upper limit $\tau_{c\,max}$ is defined for nominal shear stress in diagonal compression.

(ii) A rectangular concrete slab whose length is equal to its width may not be a two way slab when there is absence of supports in two paralle edges. In this case it would be one way slabe.

22. A simply supported prestressed concrete beam is of 25m span. The initial stress is 1000 MPA. The slip in the jack during tensioning has been 2mm. If E_S = 200 GPa, the loss of prestress due to anchorage slip is

(a) 16% (b) 12%

(c) 10% (d) 1.6%

Ans. (d)

Sol. $\sigma_0 = 1000\ N/mm^2$

$\sigma_0 = 2\ mm$

$l = 25\ m$

Loss of prestress due to

Anchorage slip $= \frac{\Delta l}{l} \times \varepsilon_s$

$= \frac{2}{25 \times 10^3} \times 200 \times 10^3$

$= 16\ N/mm^2$

$\%\ loss = \frac{16}{1000} \times 100 = 1.6\%$

23. Which of the following measures are relevantly considered for earthquake loading and lateral stability of tall buildings?

1. Minimizing gravity loads
2. Adding masses at floor levels
3. Ensuring ductility at the locations of maximum moments
4. Providing shear walls
5. Providing basement

Select the correct answer using the code given below:

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

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

Ans. (c)

Sol. (i) Minimizing gravity loads will decrease the earthquake forces as mass is directly proportional to earthquake force.

Hence option (1) is correct

(ii) Adding of mass at floor levels will increase the earthquake force. Hence option (2) is incorrect.

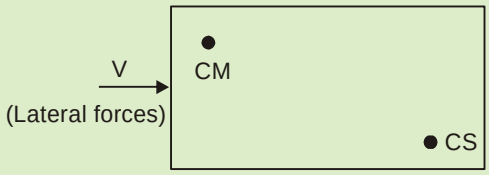
(iii) Ensuring ductility at the locations of maximum moments is considered in earthquake loading as this will increase the yielding capacity of joint. Hence option (3) is correct.

(iv) Providing shear walls will increase the lateral resistance of building and increase lateral stability. Hence option (4) is correct.

(v) Providing basement without infill walls will decrease the lateral resistance of the basement and hence option (5) may be incorrect.

So answer is 1, 3 and 4 only.

24. The figure shows the plan view of single-storey masonry shear wall building with rigid roof diaphragm. The traces of locations of the centre of mass (CM) and the centre of stiffness (CS) are as shown. Neglecting accidental eccentricity, the direction of the twisting moment on the diaphragm, for the lateral force direction shown, is



(a) Clockwise

(b) Anticlockwise

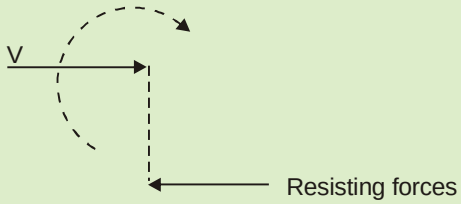
(c) Opposite to the direction of lateral force

(d) None of the above

Ans. (a)

Sol. Centre of stiffness – centre through which the restoring force of a system acts.

So,



So, clockwise twisting moment will be generated in the diphragm.

25. Which of the following statements is/are correct for a non-critical activity?

1. It demands very special attention and action.
2. One can do with normal attention to this activity with some leeway for action.

Select the correct answer using the codes given below:

(a) 1 only (b) 2 only

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

Ans. (b)

Sol. Non critical activities i.e., sub-critical activities can be done with normal attention and allows some amount of freedom to act.

26. Consider the following statements regarding tendering for a civil work:

1. Earnest money deposit (EMD) is a prerequisite to tender for a work.
2. It is not essential to call for the contractor's credentials when a tender is invited.

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. (a)

Sol. Earnest money deposit is the amount to be deposited by all the tenders when they submit their tender. The EMD amount varies from 1% to 3% of tender value.

It is mandatory to call for the contractor's credentials when tender is invited.

27. Consider the following statements regarding quality control:

1. It refers to absolute conformity to specifications.
2. It may not vouch against overspending.
3. It may unknowingly resort to overdesign in the hope of risk minimization.
4. It is intended to reduce maintenance costs.

Which of the above statements are correct?

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

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

Ans. (d)

Sol. Quality control refers to absolute conformity to specification and it is intended to reduce maintainance costs.

28. Which of the following statements are correct?

1. Depression of mercury in a capillary tube is dependent on density and surface tension.
2. Modelling of flow-induced drag on a ship is done invoking both of Froude number 30. and Reynolds number.
3. Flow of a fluid in a narrow pipe is relatable to both Reynolds number and Cauchy number.
4. Formation and collapse of a soap bubble is analyzed through employing surface tension and external pressure.
5. Flow over the downstream slope of an ogee spillway can be affected by surface tension.

Select the correct answer using the codes given below:

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

(c) 2, 3 and 4 only (d) 3, 4 and 5 only

Ans. **(a)**

Sol. (1) Depression of mercury in capillary tube

$$= \frac{4\sigma\cos\theta}{\text{rmsd}}$$

(2) In ship model we froude number and Reynolds number both

$$\frac{\rho VD}{\mu} = C \qquad \frac{V}{\sqrt{gy}} = C$$

(3) Flow of a fluid in a narrow pipe is relatable to both reynolds number and weber number.

(4) In soap bubble

$$\Delta p = \frac{8\sigma}{d}$$

(5) Flow over the downstream slope of an ogee spillway can not be affected by surface tension.

So option (a) 1, 2 and 4 only.

29. Which of the following factors are non-dimensional?

1. C is Chezy's equation
2. 11.6 as a measure of sub-layer
3. $\frac{H}{N^2D^2}$ employed in comparing performance of pumps.
4. $\frac{Q^2}{D^5}$ employed in computations in pipe networks
5. $\frac{U}{\sqrt{gL}}$ used in estimating wave-making drag

Select the correct answer using the codes given below:

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

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

Ans. **(a)**

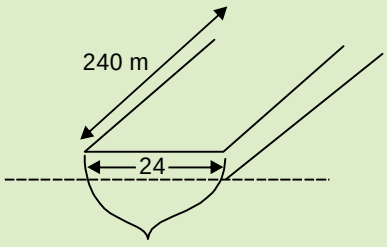
30. An ocean linear, 240 m long and 24 m wide, displaces 654 MN of sea-water ($\rho = 1025\ \text{kgf/m}^3$). The second moment of inertia of the water plane about its fore-aft axis is $\frac{2}{3}$ of that of the circumscribing rectangle. The position. The position of the centre of buoyancy is 2.30 m below the centre of gravity. How high is the metacentre above the centre of buoyancy (to the nearest cm)

(a) 49 cm (b) 53 cm

(c) 58 cm (d) 65 cm

Ans. **(b)**

Sol.



$$\overline{GM} = \overline{BM} - \overline{BG}$$

$$\overline{GM} = \frac{I}{v} - \overline{BG}$$

$$\boxed{\overline{GM} = \frac{I}{v} - 2.3}$$

$$\frac{I}{v} = \frac{2}{3} \times \frac{(240 \times 24^3)}{12} \times \frac{1025 \times 9.81}{654 \times 10^6} = 2.833 \text{ m}$$

$$\overline{GM} = 2.833 - 2.3$$

= 533 m = 53.3 cm

31. Consider the following statements regarding air pollution:

1. The pollutant caused by incomplete combustion of organic matter is carbon monoxide.
2. Depletion of ozone in outer atmosphere may trigger skin .
3. Acid rains are caused by SO_2 and NO_x.
4. The permissible standard for SO_2 in air for residential areas in India is $80 \mu g/m^3$.

Which of the above statements are correct?

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

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

Ans. **(a)**

Sol.

1. The pollutant caused by incomplete combination of organic matter is CO
2. Depletion of ozone is causing ultraviolet rays to come directly on earth which may cause skin cancer
3. Acid rain is caused by SO_2 and NO_x
4. Permissible standard for SO_2 in air for residential areas in India is 80 $\mu g/m^3$ measured by using ultraviolet flourescence.

If it is 50 $\mu g/m^3$ it is measured by using improved west and gacke method of measurement.

Explantion for (3) acid rain rsults when gaseous emissions of SO_2 and NO_x interact with water vapour and sunlight and are chemically converted to strong acidic compounds H_2SO_4 adn HNO_3.

32. Consider the following statements:

1. Illite is the mineral largely responsible for the swelling and shrinkage behaviour of clayey soils.
2. A differential free swell value of 55% indicates a soil with low degree of expansiveness.
3. Higher the plasticity index of a soil, greater its swelling potential.
4. A low shrinkage limit of a soil indicates possibility of swelling at low water content.

Which of the above statements are correct?

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

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

Ans. **(d)**

Sol.

1. Illite is the mineral which has plasticity index and activity of intermediate level while montmorillonite is the mineral which is largly responsible for swelling and shrinkage behaviour because it is present in most of the clayey soil and has maximum level of plasticity index and activity.
2. Differential free swell value of 55% indicates a soil with very high degree of expansiveness.

Degree of expansiveness	Differential free swell(%)
Low	Less than 20
Moderate	20 to 35
High	35 to 50
Very high	Greater than 50

3. Higher the plasticity index means more amount of water can be absorbed in the soil structure which will increase it's swelling potential
4. A low shrinkage limit signifies that soil will start swelling at low water content because soil is at saturated state at shrinkage limit. Hence after this whaatever the amount of water is added will increase the swelling

33. Consider the following effects as indicative of complete saturation of a soil sample:

1. Pore water pressure is positive.
2. Volume of water to volume of voids is equal to 1.
3. Relative density is equal to 1.

Which of the above statements are correct?

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

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

Ans. (a)

Sol.

1. When soil is in completely starurated state then pore water pressure is positive.
2. Voids in soil sample consists of air when there is no water. As water is filled it goes into voids and complete saturation occurs when water completely fills all the voids at this point

$$\frac{\text{Volume of water}}{\text{Volume of voids}} = 1$$

3. Relative density = $\frac{e_{max} - e_{nat}}{e_{max} - e_{min}}$

for relative density to be 1; $e_{nat} = e_{min.}$ and degree of complete saturation does not signify minimum void ratio.

Explanation for 1 positive pore water pressure gets generated when soil goes into denser state with consolidation.

34. Consider the following statements:

1. Secondary consolidation of soil follows Terzaghi's one-dimensional theory of consolidation.
2. Consolidation is a function of total stress.
3. Even after complete dissipation of excess pore pressure, the soil undergoes a little more consolidation.

Which of the above statements is/are correct?

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

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

Ans. (a)

Sol.

1. Terzaghi's one dimensional theory of consolidation assumes a unique relationship, independent of time, between void ratio and effective stress. (i.e., secondary consolidation is neglected).
2. Consolidation is a function of effective stress.
3. Even after complete dissipation of excess pore pressure, the soil undergoes a little more more consolidation which is called secondary consolidation.

35. An undrained triaxial compression test is carried out on a saturated clay sample under a cell pressure of 50 kN/m^2. The sample failed at a deviator stress of 100 kN/m^2. The cohesion of this clay sample would be

(a) 25 kN/m^2 (b) 50 kN/m^2

(c) 75 kN/m^2 (d) 100 kN/m^2

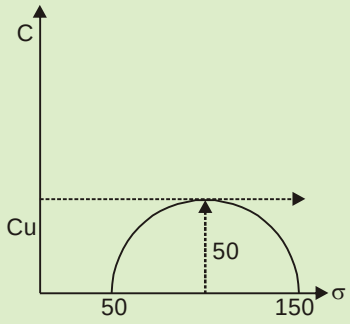
Ans. (b)

Sol. σ_3 = 50 kN/m^2 (cell pressure)

σ_d = 100 kN/m^2 (deviator stress)

$\sigma_1 = \sigma_3 + \sigma_d$ = 150 kN/m^2

Undrained triaxial test



$$Cu = \frac{150-50}{2} = 50\ kN/m^2$$

36. Consider the following statement regarding permeability of soils:

1. Permeability of coarse grained soil is inversely proportional to the specific surface at a given porosity.
2. Direct measurement of permeability of a soil specimen at any stage of loading in oedometer test can be made only fixed-ring type oedometer.

Which of the above statements are correct

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

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

Ans. (a)

Sol. (i) $K = C\, d_e^2 \frac{\gamma_w}{\mu} \frac{e^3}{1+e}$

d_e = representative grain size

$$d_e \propto \frac{1}{\text{Specific surface area}}$$

$$\text{Hence, } K \propto \frac{1}{(\text{Specific surface area})^2}$$

(ii) Two types of oedometer, floating ring type and fixed ring type, arc commonly used. However, it is only in the fixed ring test the drainage from the bottom porous stone can be measured or controlled. Hence, measurement of permeability of the soil can be made only in the fixed ring test.

(iii) Permeability decreases with decrease in temperature of water moving through the aquifier.

37. Which of the following statements are correct

1. Stress Isobar can be prepared using Boussinesq's stress distribution theory.
2. Equivalent point load method yields accurate results.
3. Newmarks's method relates the vertical stress with the help of influence chart.
4. Westergaard's method helps in determination of stress distribution for layered soils.

Select the correct answer using the codes given below:

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

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

Ans. (b)

Sol. (i) An isobar is a stress contour – it is a line joining all the points of equal vertical stress below the ground surface Boussinesq's theory can be used to prepare vertical stress isobar diagram.

(ii) Equivalent point load method is an approximate method for determining stress distribution for loaded areas.

(iii) Newmark developed influence chart to compute the vertical stress due to a loaded area of any shape, below any point either inside or outside of the loaded area.

(iv) Westergaard assumed water deposited sedimentary soils, which are quite common in occurance, are formed by deposition of alternate layers of silts and clap.

38. Consider the following statements:

1. Functions of reinforcements in reinforced soil and in reinforced concrete are comparable.
2. The design of a geotextile reinforced wall is similar in principle to that of a reinforced earth wall.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

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

Ans. (c)

Sol. The term 'reinforced soil' refers to a soil that has been strengthened by placement of reinforcing material within the soil mass in the form of strips, bais sheels or grids (meshes). When load is applied to the soil mass, these materials resist tensile stresses which develop within the soil mass in a manner similar to that of the reinforcement.

39. Consider the following statements:

1. Immediate settlement takes place as soon as the load is placed.
2. Secondary settlement is significant in the case of organic soil.
3. Secondary settlement is estimated based on the 'void' ratio versus time curve' for a particular load under consolidation test.

Which of the above statements are correct?

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

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

Ans. (b)

Sol. (1) Immediate settlement takes place due to expulsion of air from voids. So it occurs as soon as load is placed.

(2) Secondary settlement is significant in the case of peat organic soil and highly plastic soil.

(3) Secondary settlement

$$\Delta H = \frac{C_\alpha H_0}{1+e}\log\frac{t_2}{t_1}$$

So option (b) 1, 2 and 3

40. In a plate load test on a soil, at a particular magnitude of the settlement, it was observed that the bearing pressure beneath the footing is 100 kN/m^2 and the perimeter shear is 25 kN/m^2. Correspondingly, the load capacity of a 2m square footing at the same settlement will be

(a) 200 kN (b) 300 kN

(c) 400 kN (d) 600 kN

Ans. (d)

Sol. $Q = A\sigma_b + P\sigma_s$

σ_b = Bearing pressure

σ_s = Perimeter shear

A = Plate base area

P = Perimeter

Q = Load capacity

$Q = 2 \times 2 \times 100 + 2 \times 4 \times 25$

$$\boxed{Q = 600\ \text{kN}}$$

41. Consider the following statements:

1. According to Terzaghi, a foundation is shallow if its depth is equal to or less than its width.
2. Spread footing, strap footing and raft footing are types of shallow foundations.
3. Combined footing may be trapezoidal if the two columns carry unequal loads; and rectangular if both columns carry equal loads.
4. For water tanks, providing raft foundations will avoid unequal settlements.

Which of the above statements are correct?

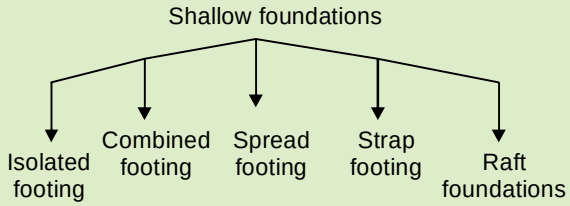
(a) 1, 2, 3 and 4 (b) 1, 2 and 3 only

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

Ans. (a)

Sol. (i) According to Terzaghi a foundation is shallow if its depth is equal to or a less than its width.

(ii)



(iii) Combined footings may be trapezoidal if two columns carry unequal loads in order to make uniform stress distribution and uniform settlement.

(iv) Water tanks foundation carry heavy loads with low and high safety level is required for its construction hence its foundation is designed as raft foundation.

42. Consider the following statements:

1. A braced cofferdam is used in shallow trench excavation as . well as in deep excavation exceeding 6 m in depth.
2. Cofferdams, braced or un-braced, are temporary structures either on land or in water bodies.
3. When sheet piling is used for retaining soil, or soil and water, without any bracing, it is called a bulkhead.

Which of the above statements are correct?

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

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

Ans. (b)

Sol. When sheet piling is used for retaining soil, or soil and water, without any bracing, it is called cantilever sheet pile.

43. Consider the following statements:

1. The maximum shear stress is one half of the normal stress in the case of uniaxial stress field.
2. In a biaxial stress field, acted upon by normal stresses unaccompanied by shear stresses, the maximum shear stress is anyone of the normal stresses.
3. The Mohr's stress circle will be tangential to the vertical axis in the case of uniaxial stress field.

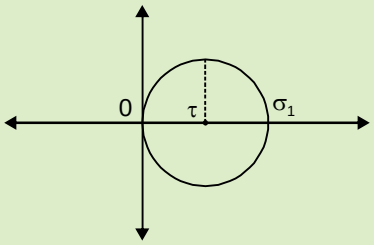
Which of the above statements are correct?

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

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

Ans. (d)

Sol. (i)

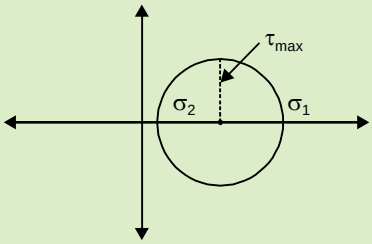


$$\tau_{max} = \frac{\sigma_1}{2}$$

Hence, in uniaxial stress field maximum shear stress is one half of the normal stress in case of uniaxial stress field.

(ii) For biaxial stress field

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



(iii) Mohr's stress circle comes out to be tangential to the vertical axis in the case of uniaxial stress field.

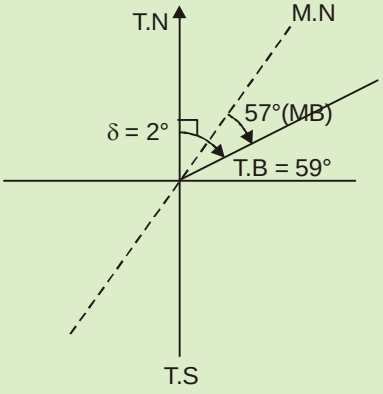
44. A line PQ in an old map had magnetic bearing of N 57° E when the local magnetic declination was 2° E. If the magnetic declination is now 4° W, what will be the magnetic bearing of the line PQ now?

(a) N 52°W (b) N 63° E

(c) N 54°E (d) N 52° E

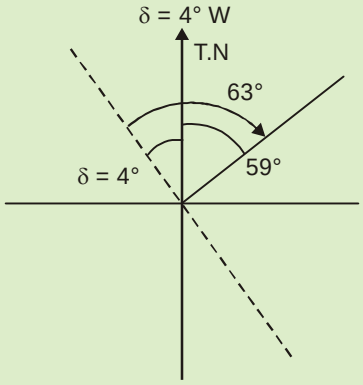
Ans. (b)

Sol. If an old map $\delta = 2°E$ then M.B = N57°E = 57° (WCB)



T.B = 57° + 2° = 59° (constant)

Now,



Now M.B = 59° + 4° = 63°

i.e., N 63° E

45. Consider the following characteristics of contours:

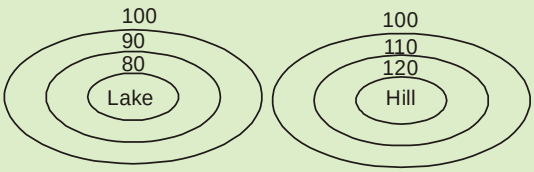
1. A uniform slope is indicated when contour lines are uniformly spaced.
2. Contour lines cannot end anywhere but can close on themselves.
3. A set of closed contours indicates a depression or a summit, according to the lower or higher values being respectively inward.

Which of the above statements are correct?

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

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

Ans. (b)



Sol. Contour lines form close loop that may be inside on outside the map.

46. The type of levelling operations carried out for laying a railway track are

1. Longitudinal levelling (LO.S.)
2. Fly levelling
3. Barometric levelling
4. Cross-sectioning

Select the correct answer using the codes given below :

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

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

Ans. **(d)**

Sol.

- Longitudinal levelling is done to setup gradient.
- Cross section levelling is done for estimation of filling or excavation.
- Fly levelling is done for approximate determination of R.L during preliminary route survey.

Barometric levelling is a type of indirect levelling in which elevation are determined indirectly from change in atmospheric pressure.

For railway track longitudinal, fly and cross sectional levelling are usually done.

47. Two reservoirs maintain a constant difference of water levels of 11.25 m and are connected by a 10 cm diameter pipeline of 294.3 m length. The total of all head losses, by friction, valve losses, bend losses, inlet and exit losses, and velocity head can be taken as 98.1 $v^2/2g$ (in m) where v is the flow velocity through the pipe (in m/sec). Assuming that the valve at the downstream end is suddenly opened so that there is no pressure wave, what will be the time taken for the velocity of flow in the pipe to attain 95% of the steady terminal velocity? Take $\frac{1}{9.81} = 0.102$.

(a) 2.25 $\log_e$ 19 (b) 2 $\log_e$ 19

(c) 2.25 $\log_e$ 39 (d) 2 $\log_e$ 39

Ans. **(d)**

Sol. We will first determine the steady state velocity 'v_0' by the application of Bernoulli's equation, at steady state, between a point at the inlet end of the pipe and a point at its outlet end as

$$H = \frac{v_0^2}{2g}(1+k)$$

$\frac{kv_0^2}{2g}$ $\rightarrow$ includes frictional head loss and the minor losses (entry loss, valve loss etc.)

$$11.25 = \frac{v_0^2}{2\times 9.81}\times(1+98.1)$$

$$v_0 = 1.49 \text{ m/sec}$$

Time taken for attaining 95% of steady state velocity be 't'

$$\therefore \quad t = \frac{Lv_0}{2gH}\ln\left(\frac{v_0+v}{v_0-v}\right) \quad (\text{where } v = 0.95v_0)$$

$$t = \frac{294.3\times 1.49}{2\times 9.81\times 11.25}\times\ln\left(\frac{1.95\times v_0}{0.05v_0}\right)$$

$$t = 1.99 \times \ln(39)$$

$$t = 2\times\log_e 39$$

48. Cleavage is a mode of folding :

1. It is a process wherein all internal movements are along shear planes which do not change their position during the entire process.
2. it is a process wherein all internal movements are along shear planes which change their position during the process.
3. The process involves dilation in the vertical direction.

4. The process involves compression in a lateral direction.

Which of the above statements are correct?

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

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

Ans. (d)

49. Consider the following statements concerning engineering geology :

1. Dams on sedimentary impervious strata dipping upstream will be unsafe
2. In general, igneous rocks are hard and are suitable for construction of large hydraulic structures.
3. Construction of a major dam must be preceded by thorough geotechnical investigations.
4. Construction of dams is never indicated in any active zone of seismicity.

Which of the above statements are correct?

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

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

Ans. (c)

50. For an unconfined aquifer, the specific yield is 20%, specific retention is 15%, and permeability is 35 m^2/day. Consider the following statements :

1. The porosity of the aquifer is 35%.
2. The transmissibility is 35 m^2 /day.
3. The volume of water lost from storage per metre drop in the water table per 100 km^2 area of the aquifer is 20 million m^3.

Which of the above statements are correct ?

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

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

Ans. (a)

Sol. (i) Porosity (∩) = Specific yield + Specific retention = 20% + 15% = 35%

(ii) Transmissibility is the property of confined aquifer.

(iii) Volume of water lost = Specific yield × Volume of soil

$= 0.2 \times 1 \times 100 \times 10^6$

$= 20 \times 10^6\ m^3$

$= 20$ million m^3

51. The concentration of chloride ions in a water sample is estimated by titration with

(a) Sodium thiosulphate reagent using ferrion as an indicator

(b) Ferrous ammonium sulphate reagent using soluble starch as an indicator

(c) Silver nitrate reagent using potassium chromate as an indicator

(d) Silver nitrate reagent using potassium dichromate as an indicator

Ans. (c)

Sol. The concentration of chloride ion in a water sample is estimated by titration with standard silver nitrate solution using pottasium chromate as an indicator (Mohr's method)

52. In revised CBR design method recommended by the IRC for the design of flexible pavement, the total thickness depends upon

(a) Only the CBR value of the soil

(b) The CBR value of the soil and the magnitude of wheel load

(c) The CBR value of the soil cumulative standard axle loads

(d) The CBR value of the soil and number of commercial vehicles passing per day

Ans. (c)

Sol. In revised CBR design method recommended by the IRC. For the design of flexible pavement IRC has provided charts for different CBR in which relation between

pavement thickness and cumulative traffic axle is given.

53. The following purposes served by a transition curve in a highway alignment include :

1. Gradual introduction of the centrifugal force on moving vehicles from zero on the straight alignment to a constant final value on the circular curve.
2. Enabling the gradual introduction of superelevation on the roadway.

Select the correct answer using the codes given below :

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

Ans. (c)

Sol. Transition curve in a highway alignment is provided to include :

1. Gradual introduction of centrifugal force between the tangent point on straight curve zero to max on circular curve.
2. To enable the driver turn the steering gradually for has own comfort and security.
3. To provide gradual introduction of super elevation.
4. To provide gradual introduction of extrawidening.
5. To enhance the aesthetic appearance of the road.

54. The type of signalling system in which it is possible to vary the length of cycle, cycle division and the time schedule at each signal point is called

(a) Simultaneous system
(b) Alternate system
(c) Simple progressive system
(d) Flexible progressive system

Ans. (d)

Sol. **Flexible progressive system :** It is a type of co-ordination of signals for road network. In this system it is possible to automatically vary the length of cycle, cycle dimesion and the time schedule at each signalized intersection with the help of a computer. This is the most efficient system.

55. Consider the following statements regarding pavements :

1. Rigid pavements are more suitable than flexible pavements for stage construction.
2. Rigid pavements are more affected by temperature variations than flexible pavements.
3. In a flexible pavement, any deformation in the top layers is transferred to underlaid layers; but, in rigid pavements, there is slab or beam action due to which any deformation is only in the top layer of the concrete slab.

Which of the above statements are correct?

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

Ans. (d)

Sol.
1. Rigid pavements are more suitable than flexible pavements for stage construction.
2. Rigid pavements have more temperature venations.
3. Flexible pavements transfer the load by grain to grain contact which rigid pavements resist the deflection through flexural action.

56. Consider the following statements concerning railways ;

1. A level stretch equal to the maximum train length is to be provided between the gradient reaches where a rising gradient is followed by a falling gradient.
2. Vertical curves in railway tracks are not set out as parabolas.
3. Diamond crossings can be laid on curves also.

4. Curves should be avoided at the top level segment of bridges.

Which of the above statements are correct?

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

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

Ans. (a)

Sol. Vertical curves in railway tracks are set out as parabola.

Diamond crossing can be laid on straight line as well as curves.

A level stretch equal to the maximum train length is to be provided in order to avoid jerks at peak.

57. Which of the following options increase the sensitivity of a bubble tube?

1. Using a liquid of greater surface tension
2. Increasing the diameter of the tube
3. Increasing the length of the tube
4. Decreasing the diameter of the tube

Select the correct answer using the codes given below :

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

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

Ans. (b)

Sol. Sensitivity of level tube can be increased by changing the following parameter.

(i) By increasing the length of tube.

(ii) By increasing the diameter of tube.

(iii) By decreasing the viscosity of liquid.

(iv) By decreasing the roughness of inner wall of tube.

58. Consider the following statements in the context of capillary pressure in soils :

1. Pore water pressure is negative in capillary zone.
2. Water is in tension in capillary zone.
3. Capillary pressure is more in coarse grained soils.

Which of the above statements are correct?

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

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

Ans. (a)

Sol. Capillary pressure head $h_c = \frac{C}{eD_{10}}$

since D_{10} of coarse grain soil is more than fine grain soil so h_c is less for coarse grain soil. Hence, capillary pressure is less in coarse grained soil.

Due to capillary action (surface tension) water get sucked into the voids and comes under the tension which makes pore water pressure negative.

59. Consider the following statements :

For a rigid footing placed at the ground surface on sand, the contact pressure

1. is maximum at the edges.
2. is zero at the edges
3. distribution is parabolic
4. is uniform throughout the base of the footing.

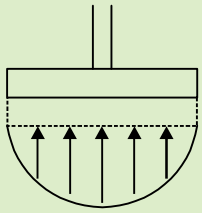
Which of the above statements are correct?

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

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

Ans. (c)

Sol.



In case of rigid footing on sand no resistance to deformation is offered at the outer edges

of the footing, making the contact pressure zero there. The pressure distribution is parabolic with maximum value at the centre.

60. Consider the following statements as suggestive of the bearing capacity of soil :

1. The maximum net loading intensity at which neither the soil fails in shear nor is there excessive settlement detrimental to the structure.
2. The maximum net pressure which the soil can carry without shear failure.
3. The net ultimate bearing capacity of the soil divided by a factor of safety.

Which of the above statements is/are correct?

(a) 1, 2 and 3 (b) 13 only

(c) 2 only (d) 3 only

Ans. (c)

Sol. Bearing capacity is defined with respect to shear failure while safe bearing pressure is defined with respect to settlement.

Directions: Each of the next Thirty (30) items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

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

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

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

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

61. Statement (I) : 'Compreg' timbers have higher specific gravity of up to 1.30 and are stronger than other timbers.

Statement (II) : Impregnation of resins and special curing methods are adopted to develop 'Compreg' timbers.

Ans. (a)

Sol. Processed timber whose cells are impregnated with a resin and compressed to reduce shrinkage and swelling and to increase density and strength. The curing of resin impregnated timbers (compreg timber) is carried out under high temperature and high pressure. The specific gravity of compreg timber is about 1.30 to 1.35. The strength and durability of compreg timber are more than normal timber.

62. Statement (I) : Deccan trap (basalt) is used in the foundations of blast furnaces.

Statement (II) : Deccan trap has high compressive strength more than 150 N/mm^2.

Ans. (a)

63. Statement (I) : Contemporarily, even in high-rise buildings, ordinary brick is being replaced by glass blocks for load-bearing walls.

Statement (II) : Bricks have high thermal conductivity and area not heat insulators.

Ans. (d)

Sol. Statement (I) : In high rise buildings non load bearing walls are used.

Statement (II) : True.

64. Statement (I) : In recent practice, sponge iron replaces pig iron in large foundries.

Statement (II) : Sponge iron can be produced in small plants using non-coking coal.

Ans. (b)

Sol. Statement (I) : True.

Statement (II) : True but not the correct explanation.

Sponge iron is superior to pig iron as it is richer in iron content.

65. Statement (I) : The fundamental storage equation through a river reach considers that the total inflow in balanced by total outflow plus the change in storage in the reach over the routing period as has been considered.

Statement (II) : To be adaptable for actual computations, the storage equation is recast in the form

$$\frac{1}{2}(I_1 + I_2)t + \left(S_1 - \frac{1}{2}D_1 t\right) = \left(S_2 + \frac{1}{2}D_2 t\right),$$

where suffixes 1 and 2 denote values at start and end respectively, of the routing interval t, the I's and D's denote, respectively, the inflow and outflow at the respective points of time and the S's denote the storage in the reach at the respective point of time.

Ans. **(a)**

66. Statement (I) : Hollow shafts are preferred in propeller shafts of airplanes.

Statement (II) : Use of hollow shafts affords considerable reduction in the weight of the shaft for equal performance.

Ans. **(a)**

Sol. For same weight strength of hollow circular shaft is greater than that of solid circular shaft the weight of hollow shaft will be less in hollow shaft most part of the material is away from the centre and shear stress increases as distance from centre increases. Hence, material strength is properly utilised.

67. Statement (I) : Foam glass is extensively used in air-conditioning units.

Statement (II) : Foam glass is termite proof and non-combustible.

Ans. **(b)**

Sol. Foam glass contains 350 million inert air cells per m^3. Hence, it floats in water and it can be cut easily like wood. It is prepared by throughly mixing finely ground glass and carbon and then melting in a furnace. The mixture expands at the time of melting and assume a form of black foam.

Such a glass is fire proof (non-combustible) rigid and **excellent heat insulator**. It is widely used in refrigeration and air-conditioning industry as a substitute for cork.

68. Statement (I) : Slope-deflection method is a displacement method of analysis.

Statement (II) : Forces are the basic unknowns in the slope-deflection method.

Ans. **(c)**

Sol. Slope-deflection method is a displacement method of analysis and unknown in this method are displacement (Δ, θ).

Displacement method is suitable when $D_K < D_S$.

69. Statement (I) : Hiring and firing is a poor substitute for proper selection and proper training of labourers.

Statement (II) : Bad training facilities for new employees cause them to be discharged during or at the end of the probationary period.

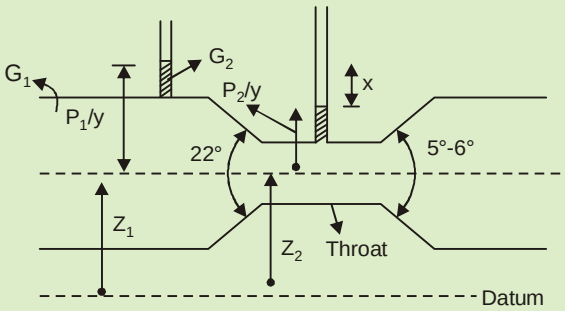
Ans. **(b)**

70. Statement (I) : When flow through a pipeline is measured through fixing a venturimeter, the computed flow will not be sensitive to the alignment of the centre line of the set-up – horizontal or sloping, up or down, along the flow direction.

Statement (II) : The difference in the readings not he manometer limbs is by itself always adjusted for the ratio of the densities of the two liquids – the manometer liquid and the liquid whose flow rate is being measured – in the development of the formula for computing the discharge.

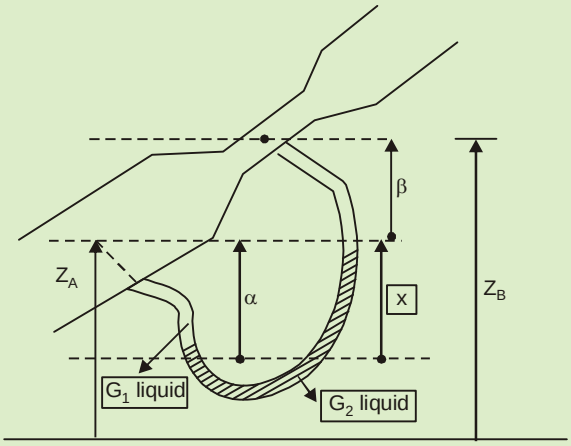
Ans. (a)

Sol.



$$Q = Cd\frac{a_1a_2}{\sqrt{a_1^2\ a_2^2}}\sqrt{2gh}$$

Where $h = \left(\frac{G_2}{G_1} - 1\right)x$



$$Q = \frac{Cda_1a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2g\left(\frac{G_2}{G_1} - 1\right)x}$$

71. Statement (I) : Collin's method for the determination of the unit hydrograph for a multi-period storm considers residuals as attributable to the unit graph of the period of the largest rain.

Statement (II) : Collin's method is ab initio premised on the Bernard method where a unit graph is necessarily to be proportional to the net rain.

Ans. (a)

72. Statement (I) : Tiny quantities of over 30 rare gases would warm the atmosphere over the Earth more rapidly than CO_2.

Statement (II) : A single molecule of some CFCs, methane and nitrous oxide absorbs as much heat as 15,000 molecules, 25 molecules and 230 molecules of CO_2, respectively.

Ans. (a)

Sol. Global worming potential for some green house gases relative to CO_2 global warming potential.

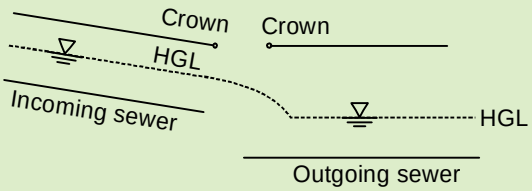
Gas	GWP(Global Warming Potential)
CO_2	1
CH_4	25
CFC	225 to 300
SF_6	2200 to 25000

73. Statement (I) : The invert of the lower (outgoing) larger size sewer is depressed suitably so as to match with the crowns of the upper (incoming) and the smaller size sewers.

Statement (II) : It ensures that the smaller sewer runs full by backwater effect from the larger sewer even if the larger sewer does not run full.

Ans. (c)

Sol.



The outgoing sewer HGL level should be below or at the same level (almost) of HGL level of incoming sewer to ensure such configuration the invert of the lower (outgoing) larger size sewer is depressed suitably so as to match with the crowns of the upper (incoming) and the smaller size sewer if such configuration is not maintained backing of sewer will take place.

74. Statement (I) : The rate of biomass production will be always lower than the rate of food utilization in a biological system having a mixed culture of micro-organisms.

Statement (II) : Catabolism converts part of the food into waste products.

Ans. **(a)**

Sol. Rate of biomass growth = $\frac{dx}{dt}$

Rate of food consumption = $-\frac{ds}{dt}$

$$-\frac{ds}{dt} > \frac{dx}{dt}$$

$$\frac{dx}{dt} = -y\frac{ds}{dt}$$

y is the fraction of food mass converted to biomass.

Some of food will get converted to biomass and some part of food converted in energy in catabolic reaction.

75. **Statement (I):** In the computations of velocity triangles, or the torque of well-encased roto-dynamic flow machines, whether of outward, or inward, flow type, the tangential component of velocity at the smaller radius flow section can be almost neglected.

Statement (II): This follows from the very concept of 'outward', or 'inward', flow — to a large extent — in visualizing the working features of the machine.

Ans. **(a)**

76. **Statement (I):** At shrinkage limit, the soil is fully saturated.

Statement (II): Montmorillonite clay minerals are non-expansive.

Ans. **(c)**

Sol. The max water content at which further reduction in water content does not cause any reduction in the volume is called shrinkage limit. It is the minimum water content at which soil is saturated.

Montmorillonite has large amount of water and other exchangable ions can easily enter between the layer causing the layers to be separated. So, it expansive in nature.

77. **Statement (I):** Cohesion and angle of internal friction are shear strength parameters of soils.

Statement (II): Cohesion is zero for pure sand and angle of internal friction is zero for pure clay.

Ans. **(b)**

Sol. Statement (I) : True

Statement (II) : True but not the correct explanation.

78. **Statement (I):** Fine-grained soils are difficult to drain.

Statement (II): Capillary forces act on pore water.

Ans. **(a)**

Sol. Statement (I) : True

Statement (II) : True and the correct explanation smaller the size of particles, smaller will be the pore size, resulting in greater suction or capillary force on pore water.

79. **Statement (I):** Saturated fine, as well as medium, sands of uniform particle size are most susceptible to liquefaction.

Statement (II): Fine particles reduce the permeability which is a prime factor for liquefaction.

Ans. **(a)**

Sol. If rate of loading is larger and soil is saturated +ve pore water pressure will develop. This will reduce effective stress and hence strength. If effective stress reduce to zero the soil will loose all its shear strength. This phenomenon is known as liquefaction. Presence of fine particle reduces the permeability. Thus, it will increase the chance of liquefaction as dissipation of excess pore water pressure become more difficult.

80. **Statement (I):** Reciprocal levelling is adopted to decide the difference of level between two points, a considerable distance apart, with great precision.

Statement (II): Reciprocal levelling eliminates errors due to curvature, refraction and collimation.

Ans. **(a)**

81. **Statement (I):** Curvature correction must be applied when the sights are long.

Statement (II): Line of collimation is not a level line but is tangential to the level line.

Ans. **(a)**

Sol. Level line is a curved line and line of collimation is a horizontal line which is tangential to the level line. Therefore in case of long sights horizontal line is not a level line and hence levels obtained by means of levelling instrument are have to be corrected for the curvature of earth

$$C_c = -0.0785\ d^2$$

82. **Statement (I):** All old systems of surveying can be completely replaced by remote sensing system basing on INSAT data.

Statement (II): Reference data in-situ is essential in interpreting satellite imageries.

Ans. **(d)**

83. **Statement (I):** Mud bricks can be completely replaced by Flyash lime-Gypsum (Fal-G) bricks in building.

Statement (II): Useful fertile soil is used in manufacturing mud bricks, causing high CO_2 release in the atmosphere.

Ans. **(a)**

84. **Statement (I):** Softening of clear groundwater should be carried out immediately after collection by pumping out, or from springs.

Statement (II): Iron and manganese precipitates can foul the exchange medium surface if oxidation occurs in, or prior to, the ion-exchange phase.

Ans. **(d)**

Sol. Most common problem associated with ground water may be hardness. Generally associated with an abundance of calcium and/or magnesium dissolved in water. At the same time iron and manganese are naturally occuring and most ground water contains iron and manganese.

Softening of clear groundwater should not be carried out immediately after collection by pumping out or from springs because zeolite process results in zero hardness. The process is costlier for water containing Fe^{2+} and Mn^{2+} because Fe and Mn zeolites are formed which can not be regenerated into sodium zeolite.

85. **Statement (I):** Consolidation is the process of expulsion of pore water by applying steady load for a long time.

Statement (II): Volume change occurs immediately after the action of the load in case of consolidation tests.

Ans. **(c)**

Sol. In consolidation test volume changes very showly and this is the reason consolidation test is performed in days.

86. **Statement (I):** The stresses and strains in a soil mass depend on the stress-deformation characteristics, anisotropy and non-homogeneity of the soil and also on the boundary conditions.

Statement (II): Boussinesq's theory of stress distribution in soils deals with layered soils only.

Ans. **(c)**

Sol. Westergaard assumes soil mass as an isotropic but Boussinesq assumed that soil mass is isotropic Westergaard's theory of stress distribution in soil deals with layered soil while Boussinesq equation can be applied to actual field problems.

87. **Statement (I):** When a loop rating curve is prepared at a gauging station when a flood wave passes, the maximum discharge occurs earlier than the maximum stage.

Statement (II): When a flood wave passes through a reach, during rising stages, some water may get into depressions on the floodplains of the river and, may be, only part of this spill returns to the channel runoff when flood levels recede.

Ans. **(b)**

88. **Statement (I):** The Muskingum method of routing a flood through a river reach is not a simple recast of the storage equation

$$I = D + \frac{d}{dt}(S).$$

Statement (II): The Muskingum method first develops trial storage loops considering contributions from both inflow and outflow and also the algebraic difference between them.

Ans. **(a)**

89. **Statement (I):** Incrustation of sand occurs in rapid sand filter when water softened by lime-soda is fed in for filtration.

Statement (II): The sand gets coated with precipitates of $Ca(OH)_2$ and $Mg(OH)_2$ generated during softening of water by lime-soda process which leads to incrustation of sand.

Ans. **(c)**

Sol. Statement I : True

Statement II : False

Sand incrustation may occur either due to deposition of sticky gelations materials from the influent water or due to an after crystallization of calcium carbonate is case where heavy line treatment of water is practiced.

90. **Statement (I):** Dilution of the wastewater sample with organic-free, oxygen-saturated water is necessary to measure 5-day 20°C BOD values greater than 7 mg/l.

Statement (II): Saturation concentration of oxygen in water at 20°C is approximately 9 mg/l.

Ans. **(b)**

91. A fluid flow field is given by

$$U = 2xyi + yzj - \left(2yz + \frac{z^2}{2}\right)k.$$

1. The flow is viscous.
2. The flow is steady.
3. The flow is incompressible.
4. The magnitude of the total velocity vector at a point (1, 4, 3) is nearest to 27 units.

Which of the above statements are correct?

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

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

Ans. **(c)**

Sol. $\frac{\partial u}{\partial x} = 2y$

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

$\frac{\partial \omega}{\partial z} = -2y - z$

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

$\Rightarrow$ Flow is steady and incompressible

Also, at (1, 4, 3)

$u = 2 \times 1 \times 4 = 8$

$v = 4 \times 3 = 12$

$\omega = -\left(2 \times 4 \times 3 + \frac{9}{2}\right)$

$= -24 - 4.5$

$= -28.5$

$V = \sqrt{u^2 + v^2 + \omega^2} = \sqrt{64 + 144 + (28.5)^2}$

$= 31.94$ m/s

92. Consider the following statements regarding flow net:

1. It helps determine the quantity of seepage.
2. It helps determine the upward lift below a hydraulic structure.
3. It is applicable to rotational flow only.

Which of the above statements are correct?

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

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

Ans. **(a)**

Sol. (i) Flow net is graphical representation of path taken by water particle and head variation along the path which are used for seepage calculation.

(ii) In hydraulic structures which are generally used for retaining or restricting water, water seeps into the soil below structure and creates upward pore water pressure which can be calculated using flow net because it also gives head variation along the path and gives idea about exit gradient.

(iii) Since equations of flow net are derived from Laplace equation i.e.,

$$\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2} = 0$$

and the flow which satisfies Laplace equation is irrotational flow. Hence, seepage through flownet is irrotational flow.

93. Hydraulic jump forms in a horizontal rectangular channel carrying a unit discharge of 1.019 m^3/sec/m at a depth of 101.9 mm. This jump is classified as

(a) Weak jump (b) Oscillating jump

(c) Steady jump (d) Strong jump

Ans. **(d)**

Sol. $F_r^2 = \frac{q^2}{gy^3} = \frac{1.019^2}{9.81 \times 0.10193}$

$F_r = 10$

$F_r > 9.0 \Rightarrow$ Strong jump.

94. A man, 65 kg, descends to the ground with the help of a parachute, 18 kg. The parachute is hemispherical in shape, 2m diameter. Density of air can be taken as 0.00125 g/cm^3 and its kinematic viscosity as 0.15 stoke. What is the terminal velocity of the parachute?

(Take $C_D = 1.5$ and $g = 1000$ cm/sec^2)

(a) 16.6 m/sec (b) 15.8 m/sec

(c) 15.0 m/sec (d) 14.1 m/sec

Ans. **(a)**

Sol. For terminal velocity total weight of man and parachute will be balanced by drag force

$$\text{Drag force} = \frac{1}{2}\times c_0\rho A V_1^2$$

Total weight = 65 + 18 = 83 Kg

$$83 \times g = \frac{1}{2}c_0\rho A V_t^2$$

$$83 \times 10 = \frac{1}{2}\times 1.5\times 1.25\times\frac{\pi}{4}\times 2^2\times V_t^2$$

$$V_t^2 = 16.787 \text{ m/s}$$

So, terminal velocity = 16.78 m/s.

95. In a wide rectangular channel, the normal depth is increased by 20%. This would mean an increase in the discharge of the channel nearly by

(a) 20% (b) 26%

(c) 36% (d) 56%

Ans. **(c)**

Sol. For wide rectangular channel

$$R = \frac{A}{P} = \frac{By}{B+2y} \qquad B >>> y$$

$$R \approx y$$

$$Q = \frac{1}{n}AR^{2/3}\sqrt{5}$$

$$Q \propto y^{5/3}$$

$$Q_1 \propto y_1^{5/3}$$

$$Q_2 \propto y_2^{5/3}$$

$$\frac{Q_2 - Q_1}{Q_1} = \frac{(y_2)^{5/3} - (y_1)^{5/3}}{(y_1)^{5/3}}$$

$$= \frac{(1.2)^{5/3} - 1^{5/3}}{1^{5/3}} = 35.51\%$$

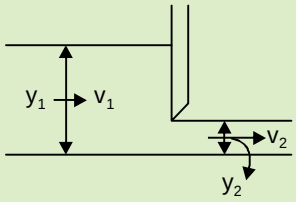
96. At a sluice gate across a rectangular channel, the upstream flow conditions are: depth of 2.0 m; velocity of flow of 1.25 m/sec. The flow conditions at the vena contract just downstream of the gate can be taken as: depth of 0.44 m; velocity of flow of 5.68 m/sec. What is the total thrust on the gate on its upstream face (to the nearest 10 units)?

(a) 770 kgf (b) 800 kgf

(c) 825 kgf (d) 870 kgf

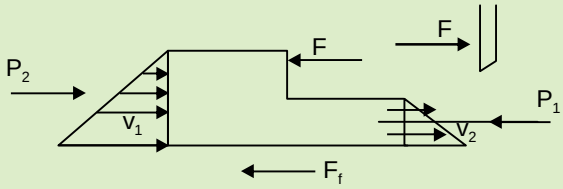
Ans. **(a)**

Sol.



$y_1 = 2$ m $y_2 = 0.44$ m

$v_1 = 1.25$ m/s $v_2 = 5.68$ m/s



$$P_1 - P_2 - F - F_f = \rho Q(v_2 - v_1)$$

$$F = P_1 - P_2 - \rho Q(v_2 - v_1)$$

(Neglecting F_f)

$$= \frac{\gamma y_1}{2}\times By_1 - \frac{\gamma y_2}{2}\times By_2 - \rho By_1 v_1(v_2 - v_1)$$

$$= B\left[\frac{9810}{2}(4-(0.44)^2)\right]$$

$$-B[1000\times 2\times 1.25(5.68-1.25)]$$

$$= 7595.392B \text{ N/m}$$

$$= 774.25 \text{ Kgf/m}$$

97. A centrifugal pump has a impeller of 30 cm diameter and runs at 1000 rpm giving best efficiency. It delivered 1.2 m^3/minute against a head of 25m. What is the non-dimensional specific speed (based on flow expressed in l.p.s.)? Take $\sqrt{9.81}$ = 3.132; and $\sqrt{\sqrt{9.81}}$ = 1.77.

(a) 55 (b) 63

(c) 72 (d) 80

Ans. **(c)**

Sol. $N_s = \dfrac{N\sqrt{Q}}{(gH)^{3/4}} = \dfrac{1000 \times \sqrt{1.2 m^3/min}}{\left(9.81 m/s^2 \times 25\ m\right)^{3/4}}$

$$N_s = \frac{1000 \times \sqrt{\frac{1.2 \times 10^3}{60}}}{(9.81 \times 25)^{3/4}}$$

N_s = 72

98. Consider the following statements regarding a turbine:

1. Specific speed plays an important role in the selection of the type of turbine.
2. An increase in specific speed of the turbine is accompanied by higher maximum efficiency.
3. The runner of too high specific speed with high available head increases the cost of the turbine on account of the high mechanical strength required.

Which of the above statements are correct?

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

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

Ans. **(c)**

Sol. An increase in specific speed of turbine is accompanied by lower maximum efficiency.

99. In a hydraulic machine, the moment of momentum of water is reduced by 15915 N.m, when the machine is rotating at 600 rpm. The power developed is

(a) 1000 kW (b) 1500 kW

(c) 2000 kW (d) 2500 kW

Ans. **(a)**

Sol. $P = Tw$

$= 15915\ Nm \times w$

$= \dfrac{2\pi \times 600}{60}$

$= 15915 \times 20\pi\ Nm = 999968.94\ w$

$\boxed{P = 999.968\ kN}$

100. Consider the following statements in connection with hydraulic turbines:

1. The Kaplan turbine is a radial flow turbine in which the guide vane angles as well as the runner vane angles are adjustable.
2. Francis and Kaplan turbines are provided with draft tubes which carry water from exit of runner to tailwater to increase the gross-head across the turbine.
3. The parts of turbines susceptible to cavitation are the guide vanes and runner vanes — drastically reducing the turbine efficiency.
4. The specific speed of a 4-jet Pelton turbine will be 28 if the specific speed of a single-jet Pelton turbine is 14.

Which of the above statements are correct?

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

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

Ans. **(d)**

Sol. 1. Kaplan turbine is axial flow turbine which operates under low head and high discharge.

3. Changes of cavitation occurs where velocity is maximum and pressure falls below the vapour pressure of the liquid. This condition is most likely to occur near or in draft tube.

4. $N_{S\ multiple\ jet} = \sqrt{n}\, N_{S\ single\ jet}$

$= \sqrt{4} \times 14 = 28$

101. Consider the following statements:

1. Surge tanks are not substitutes for forebays.
2. Pumped storage power plants are a boon to power generation.
3. Water hammer in penstocks is not dangerous.
4. Kaplan turbines are used in low head power plants.

Which of the above statements are correct?

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

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

Ans. (a)

Sol. (i) Surge tanks can be substitutes for forebays.

(ii) Pumped storage power plants are helpful to power generation.

(iii) Water hammer in penstock is dangerous.

(iv) Kaplan turbines are axial flow turbines that are used for high discharge and low head.

102. In the standard SCS-CN method of modelling runoff due to daily rainfall, if CN = 75, the runoff magnitude for a one-day rainfall of 100 mm is nearly

(a) 17 mm (b) 31 mm

(c) 41 mm (d) 57 mm

Ans. (c)

Sol. For standard SCS–CN method

$$Q = \frac{(P - 0.25)}{P + 0.85} \text{ for } P > 0.25 \qquad \ldots(i)$$

Q = Daily runoff (mm)

P = Daily rainfall (100 mm on given)

where $S = 254\left(\frac{100}{CN} - 1\right)$

for CN = 75

$\Rightarrow$ S = 84.66 mm

Hence for P = 100 mm and S = 84.66 mm

We have Q $\simeq$ 41 mm

103. Consider the following statements concerning precipitation:

1. The Isohyetal map method of determining the average precipitation is considered to be better than the Thiessen method.
2. There is no possibility of damaging the storms because of cloud seeding activity.
3. Water that percolates through the soil emerges as the dry weather flow in streams.

Which of the above statements are correct?

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

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

Ans. (b)

Sol. 1. Isohyetal map method as most accurate method of determining average precipitation because in it topographic influences are taken into account and new isohyets have to be made for each rainfall event.

2. Cloud seeding is dropping the crystals in clouds in order to cause rain. This however may cause damage to storm.

3. Water that percolates through the soil, flow as base flow and joins dry weather flow in streams ultimately.

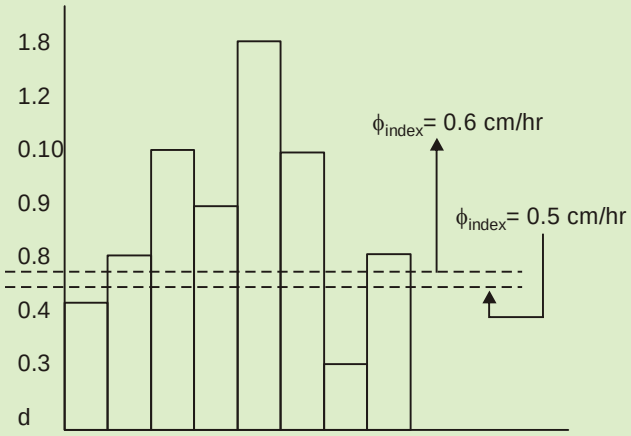
104. An 8-hour storm with incremental rainfall during each successive hour is tabulated herewith. What will be the correction to total runoff when, whereas the actual φ index was 0.5 cm/hour, a wrong magnitude of 0.6 cm/hour was adopted in computing the total runoff?

Time from start (hour)	Incremental rainf all in each hour (cm)
1	0.4
2	0.8
3	1.2
4	0.9
5	1.8
6	1.0
7	0.3
8	0.8

(a) + 1.0 cm (b) + 0.9 cm
(c) + 0.8 cm (d) + 0.6 cm

Ans. **(d)**

Sol.



Runoff when ϕ index = 0.6 cm/hr

Runoff = 6.5 – 3.6 = 2.9 cm

Runoff when ϕindex = 0.5 cm/hr is

6.5 – 0.5 × 6 = 3.5 cm

Correction to be applied

= 3.5 – 2.9 = 0.6 cm

105. The probability of a 10-year flood to occur at least once in the next 4 years is

(a) 45% (b) 35%
(c) 30% (d) 20%

Ans. **(b)**

Sol. The probability of 10-yhear flood to occur at least once in next 4 years

$$= 1-\left(1-\frac{1}{10}\right)^4$$

$$= 1 - (0.9)^4$$

= 34.66% = 35%

106. Tortuosity of a meandering river is the ratio of

(a) Meander length to width of the meander

(b) Meander length to width of the river

(c) Curved length along the river to the direct axial length of the river

(d) Direct axial length of the river to the curved length along the river

Ans. **(c)**

Sol. Tortuosity of a meandring river is the ratio of curved length along the river to the direct axial length of the river.

107. Consider the following statements in respect of ground water aquifers:

1. Specific storage is specific capacity per unit depth of the aquifer.
2. Specific capacity is storage coefficient per unit aquifer depth.
3. Specific capacity is a constant for a given well.
4. For one-dimensional flow in a confined aquifer between two water bodies, the piezometric head line in the aquifer is a straight line.

Which of the above statements are correct?

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

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

Ans. **(b)**

Sol. For one dimensional flow in confined aquifer

$$h = h_0 + \frac{x}{L}(h_1 - h_0)$$

In case of confined flow between two reservoir hydraulic grade line varies linearly from h_0 to h_1.

Storage coefficient per unit depth of confined aquifer is called specific storage.

Specific capacity is the discharge from well per unit drawdown.

108. An extended layer of soil with homogeneous rounded grains has 10% of the material finer than 0.07 mm. The constant to be adopted to determine its permeability has been recommended as 750. What is its permeability?

(a) 2.583 m/day (b) 2.857 m/day

(c) 3.244 m/day (d) 3.675 m/day

Ans. **(d)**

Sol. $K = CD_{10}^2$

$= 750 \times 0.07 \times 0.07$

$= 3.675$ m/day

109. Consider the following statements in connection with soil-water-crop relationship:

1. Water utilization by plants is mainly from capillary water.
2. The amount of irrigation water required to meet the evapotranspiration needs of the crop during its full growth duration is its consumptive irrigation requirement.
3. The depth of water required to bring the soil-moisture level of a given soil up to its field capacity is called hygroscopic water.
4. With continuous increase in quantity of water applied, the yield of most crops increases up to a certain limit and then is expected to be constant.

Which of the above statements are correct?

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

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

Ans. **(a)**

Sol. 1. The capillary water is held in the soil against the force of gravity.

The plant roots gradually absorb the capillary water which thus constitutes the principal source of water for plant growth.

2. Consumptive irrigation requirement is defined as the amount of irrigation water that is required to meet the evapotranspiration needs of crop during its full growth.
3. Below the permanent wilting point, the soil contains only hygroscopic water.
4. The crop yield is expressed as quintal/ha or tonnes/ha which increases with water, reaches a certain maximum value and then falls down.

110. Consider the following statements regarding design of channel by Lacey and Kennedy:

1. The theoretical concept of silt transportation is the same in both the theories.
2. Lacey improved upon Kennedy's formula.
3. There are no defects in either the theories of Lacey or of Kennedy.

Which of the above statements are correct?

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

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

Ans. **(a)**

Sol. 1 Lacey and Keneddy both approved that, with the flowing streams silt also gets transported from one place to other place.

2. Lacey on extensive investigation on stable channels in allumins came out with the statement that even a channel showing no silting no scouring may actually may not be in regine.

He differentiated between 3 regime conditions

(i) True regime

(ii) Initial regime

(iii) Final regime

While Keneddy had said that a channel showing rather silting nor scouring will be in state of regime.

3. Even after improvement of Lacey on Kennedy theory there are various drawbacks of Lacey's theory are present.

e.g. Lacey did not precisely define the characteristic of regime channel.

111. Consider the following statements in respect of dams:

1. In a gravity dam, a grout curtain is provided near the toe to reduce the exit gradient.
2. A drainage gallery with its drainage pipe system provided in a gravity dam reduces the uplift pressure at all levels below the upstream water level.
3. An earthquake acceleration of 0.1g acting vertically downward causes a decrease of 10% in the unit weight of concrete and of water in a gravity dam.
4. The Tehri dam is a gravity dam.

Which of the above statements are correct?

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

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

Ans. **(a)**

Sol. Tehri dam is a rock and earthfill embakment dam.

$I_{eff} = (g \pm \alpha)$ $\alpha \rightarrow$ –ve when acting upward

$\alpha \rightarrow$ –ve when acting downward

Uplift pressure reduces below the water level.

112. Objectives for river training are

1. High flood discharge may pass safely through the reach.
2. Sediment load (including bed and suspended load) may be transported efficiently.
3. By making the river course unstable whereby to increase bank erosion.

Select the correct answer using the codes given below:

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

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

Ans. **(b)**

Sol. 1. High water training is done in order to provide sufficient cross-section for safe passage of high flood.

2. Mean water training is done for efficient disposal of suspended load and bed load.
3. River training aims at protecting the banks from erosion and improve alignment by stabilizing the river channel.

113. Consider the following statements regarding coagulant aids:

1. They are employed when temperature is low as they then accelerate the process of coagulation.
2. They are employed when flocs are small and water is coloured.
3. With their use, water purification capacity of the plant is increased.

4. Most widely used materials are oxidants, absorbents, weighing agents, activated carbon and polyelectrolytes.

Which of the above statements are correct?

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

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

Ans. **(a)**

Sol. Coagulation by metallic salts is adversely affected by low temperature. The effect is more pronounced in using Alum, hence the recommendation is to switch to iron salts at low temperature. Alternatively we can add coagulation aid like bentonite.

The increase in the rate of coagulation at higher temperature can be due to

(i) Increase in the velocity of molecules and hence in kinetic energy.

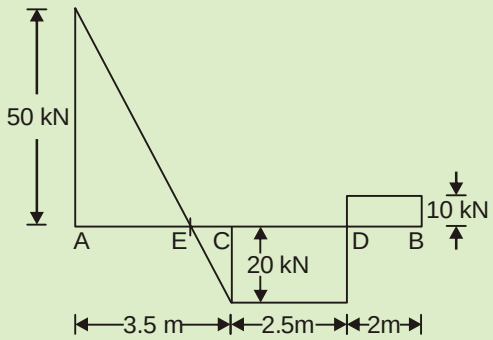
(ii) Increase in the rate of chemical reaction.

(iii) Decrease in the time of floc formation.

(iv) Decrease in viscosity of water.

(v) Alteration in the structure of the flocs resulting in larger agglomeration.

114. Consider the following statements with regards to the shear force diagram for the beam ABCD:



1. The beam ABCD is an overhanging beam having supports at A and D only.

2. The beam carries a point load of 20 kN at C.

3. The beam carries a concentrated load of 10 kN at the end B.

4. The beam is an overhanging beam having supports at C and D only.

5. The beam carries a uniformly distributed load of 70 kN over the left hand portion AC only.

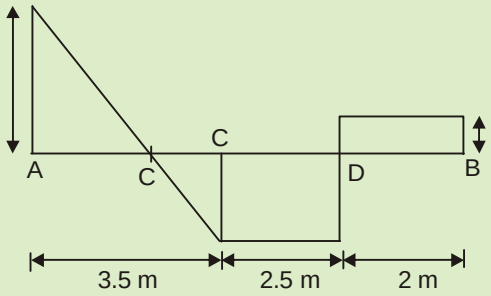
Which of the above statements are correct?

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

(c) 2, 3 and 4 only (d) 2, 4 and 5 only

Ans. **(b)**

Sol.



$$w = \frac{dV}{dx}$$

At A: $w = 50\,kN\,(\uparrow)$

B/W A and C; $w = \frac{(-20)-(50)}{3.5}$

$= 20$ kN/m

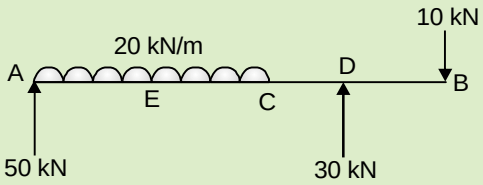
uniformly distributed load of 20 kN/m

between C and D; $w = \frac{20-20}{2.5} = 0$

between D at D; w = – (–20) +(10) = +30 kN

between C and B; $\frac{10-10}{2} = 0$

At B; $w = -10\,kN$



$$\sum M_A) = 10\times(2+3.5+2.5) - 30\times 6 + 20\times 3.5\times\frac{3.5}{2}$$

$$= 22.5 \neq 0$$

Hence there is a couple of 22.5 kN-m somewhere in the beam.

115. A good disinfectant

1. Should be persistent enough to prevent regrowth of organisms in the distribution system.
2. Must be toxic to micro-organisms at concentrations well above the toxic thresholds of humans and higher animals.
3. Should have a fast rate of kill of micro-organisms.

Select the correct answer using the codes given below:

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

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

Ans. **(c)**

Sol.

1. A good disinfectant should be persistent enough in distribution system in order to ensure prevention of regrowth of microorganisms.
2. A good disinfectant must be toxic at concentrations well below the toxic thresholds of humans and higher animals so that users could be safe well safe.
3. A good disinfectant should have a fast rate of kill of micro-organisms so that water could be safety used as soon as possible.

116. How much bleaching powder (having 20% available chlorine) is needed to disinfect 10,000 litres of water whose chlorine demand is 1.0 mg/l? It should be ensured that, after about 1 hour contact time, 0.2 mg/l chlorine is available.

(a) 30 g (b) 40 g

(c) 48 g (d) 68 g

Ans. **(d)**

Sol. Chlorine demand = Applied chlorine – Chlorine residue

Applied Cl_2 = 1.2 mg/l

for 10000 litre Cl_2 added = 12 g

Let us assume amount of bleaching powder = x gm

$$x\times\frac{20}{100} = 12$$

$$x = \frac{1200}{20}$$

x = 60 gm

No option is matching.

117. The approximate value of BHP of a pump to supply 1 m^3/s water to a town at RL 400 m from a source, whose water level is at RL 320 m, would be

(a) 940 (b) 1000

(c) 1070 (d) 1120

Ans. **(c)**

Sol. $P = \gamma_w QH$

= 9810 × 1 × (400 – 320)

= 9810 × 80

= 784800 watt

1 HP = 746 watt

$$784800 \text{ watt} = \frac{784800}{746}$$

= 1052 BHP

= 1052 BHP

≈ 1070 BHP

(Assuming 100% η)

118. Consider the following statements regarding removal of impurities from water:

1. Settleable solids are removed by filtration.
2. Volatile solids are removed through sedimentation.
3. Dissolved solids are removed through reverse osmosis.
4. Colloidal solids are removed by coagulation.

Which of the above statements are correct?

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

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

Ans. **(b)**

Sol.

1. Settleable solids are generally removed by sedimentation and grit chamber.
2. The residues or waste obtained by sedimentation are directly disposed off which can not be done in case of volatile solids because of volatile solids are disposed off openly then it may decompose and cause pollution.
3. Reverse osmosis removes many types of dissolved and suspended solids.
4. Coagulant aids are added which destabilize the colloidal solids and ultimately makes them settle.

119. Consider the following statements regarding contact stabilization process:

1. Primary settling tank is not required in some cases.
2. BOD removal occurs in two stages.
3. Aeration volume requirements are approximately 50% of those of a conventional — or tapered — aeration plant.
4. Returned sludge is aerated for 30 min to 90 min in sludge aeration tank.

Which of the above statements are correct?

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

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

Ans. **(d)**

120. Consider the following statements regarding pyrolysis:

1. It is an irreversible chemical change brought about by the action of heat in oxygen-free atmosphere.
2. Range of temperature is 500°C to 1000°C.
3. Internal heating causes organic matter to decompose physically and chemically rather than burn.
4. It is a highly exothermic process.

Which of the above statements are correct?

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

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

Ans. **(d)**

Sol. Pyrolysis is chemical change brought about by the action of heat in oxygen free atmosphere which is irreversible and endothermic occuring in the temperature range of 500°C to 1000°C.

Since it occurs in absence of oxygen, an internal heating makes organic matter to decompose rather than get burnt.

121. Consider the following statements:

1. IS 3583 refers to Burnt Clay Paving Bricks.
2. IS 5779 refers to Burnt Clay Soling Bricks.
3. IS 3952 refers to Burnt Clay Hollow Bricks.
4. IS 2222 refers to Burnt Clay Lay Bricks.

Which of the above statements are correct?

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

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

Ans. (a)

Sol. Burnt clay paving bricks — 153583

Burnt clay soiling bricks — 155779

Burnt clay hollow bricks — 153952

Burnt clay peforated bricks — 152222

122. Consider the following statements:

1. A high aggregate impact value indicates strong aggregates.
2. A low aggregate crushing value indicates high crushing strength of aggregates.
3. Aggregates having elongation index values greater than 15% are generally considered suitable for pavement construction.
4. Flakiness index of aggregates should not be less than 25% for use in road construction.

Which of the above statements are correct?

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

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

Ans. (a)

Sol.

1. A high aggregate impact value indicates weak aggregate.
2. A low aggregate crushing value indicates high crushing strength of aggregates.
3. Elongation index value greater than 15% are generally considered suitable for pavement construction. Elongation index should not be graded than 45%.
4. The flakiness index value of aggregate should be below 35% that recommended for road construction.

123. Consider the following statements regarding refractory bricks in furnaces:

1. The furnace is fired at temperatures more than 1700°C.
2. Silica content in the soil should be less than 40%.
3. Water absorption of bricks should not exceed 10%
4. Chrome bricks are known as basic bricks.

Which of the above statements are correct?

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

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

Ans. (c)

Sol.

1. Fire clays are capable of resisting very high temperature upto 1700°C without limiting or softening and resist spelling.
2. Silica content in slice bricks are upto 95%.
3. The water absorption of fireclay bricks varies from 4-10%.
4. Chroma bricks are known as neutral bricks.

124. Consider the following statements about lime:

1. Calcination of limestone results in quick lime.
2. Lime produced from pure variety of chalk is hydraulic lime.
3. Hydrated lime is obtained by treating quick lime with water.

Which of the above statements are correct?

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

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

Ans. (d)

Sol.

1. Calcination of limestones

$$CaCO_3 \xrightarrow{\text{heat}} \underset{\text{quicklime}}{CaO} + CO_2$$

2. Calcium react in the lime kiln with the clay minerals to produce silicates that enables some of lime to set through hydration. Any unreacted calcium is slaked to $Ca(OH)_2$ which sets through carbonation.

3. $\underset{\text{quick lime}}{CaO} + H_2O \rightarrow Ca(OH)_2$

Slaked lime or hydrated lime

125. Consider the following statements:

1. If more water is added to concrete for increasing its workability, it results into concrete of low strength.
2. No slump is an indication of a good workable concrete.
3. Higher the slump of concrete, lower will be its workability.
4. Workability of concrete is affected by water content as well as water-cement ratio.

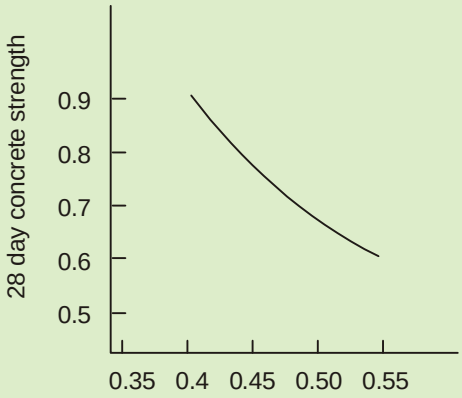
Which of the above statements are correct?

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

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

Ans. (c)

Sol. (1) Fludity of concrete increases with water content because addition of water enhance interparticle lubrication so it increases the workability and lowers the strength of concrete by increasing water content w/c ratio increases.



As w/c ratio increases strength decreases.

(2) Slump test is an indication of worability.

(3) Higher the slump of concrete higher will be its workability

(4) Workability of concrete is affected by water content as well as water cement ratio

Hence option (c) 1 and 4 only

126. Pozzolana used as an admixture in concrete has the following advantages:

1. It improves workability with lesser amount of water.
2. It increases the heat of hydration and so lets the concrete set quickly.
3. It increases the resistance of concrete to attack by salts and sulphates.
4. It leaches out calcium hydroxide.

Select the correct answer using the codes given below:

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

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

Ans. (c)

Sol.

1. Pozzolana due to its ball bearing action increases the workability without increasing the amount of water but the amount of pozzolana should be in appropriate amount otherwise it will make paste sticky.
2. Pozzolana reacts slowly so initially heat of hydration is low and concrete setting becomes slow.
3. Pozzolana + $Ca(OH)_2 \rightarrow$ C-S-H (low density) . On the later stage more C-S-H gel and fill the void so make the concrete durable and increases the resistance against sulphate attack.
4. Pozzolana reacts with excess $Ca(OH)_2$. So $Ca(OH)_2$ amount reduces.

127. Consider the following particulars in respect of a concrete mix design:

	Weight	Specific Gravity
Cement	400 kg / m^3	3.2
Fine aggregates	–	2.5
Coarse aggregates	1040 kg / m^3	2.6
Water	200 kg / m^3	1.0

What shall be the weight of the Fine aggregates?

(a) 520 kg/m³ (b) 570 kg/m³

(c) 690 kg/m³ (d) 1000 kg/m°

Ans. **(c)**

Sol. Let us assume the weight of fine aggregate by absolute volume principle

$$\frac{M_c}{f_c}+\frac{M_{fa}}{\rho_{fa}}+\frac{M_{ca}}{f_{ca}}+V_\omega=1$$

$$\frac{400}{3200}+\frac{x}{2500}+\frac{1040}{2000}+\frac{200}{1000}=1$$

$$\frac{x}{2500}+\frac{29}{40}=1$$

$x = 687.5$ kg/m³

Weight of fine aggreate 690 kg/m³

128. Consider the following statements regarding Cyclopean Concrete:

1. Size of aggregate is more than 150 mm.
2. Size of aggregate is less than 150 mm.
3. High slump.
4. High temperature rise due to heat of hydration.

Which of the above statements are correct?

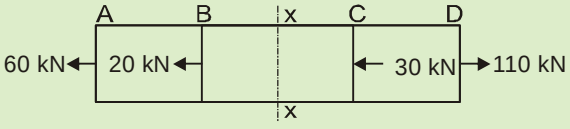
(a) 1 and 3 only (b) 1 and 4 only

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

Ans. **(b)**

Sol. In cyclopean concrete size of aggregate is more than 14 cm and slump is very low because cyclopean concrete is stiff in nature.

129. What is the stress at the section x – x for the bar ABCD with uniform cross-section 1000 mm²?



(a) 20 N/mm² (Tensile)

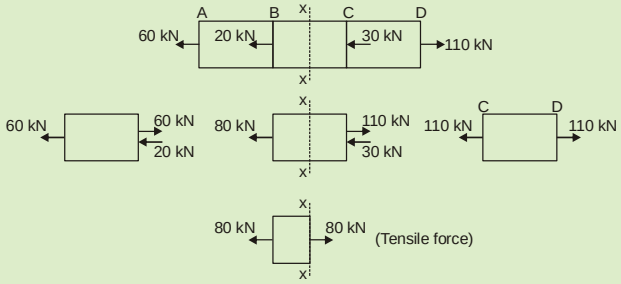
(b) 30 N/mm² (Compressive)

(c) 80 N/mm² (Tensile)

(d) 50 N/mm² (Compressive)

Ans. **(c)**

Sol.



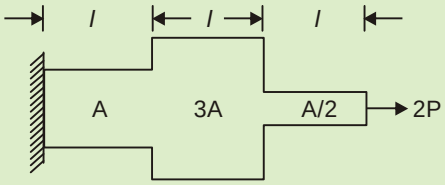
$$\sigma = \frac{P}{A}$$

$$= \frac{80\text{kN}}{1000\text{mm}^2} \text{ (uniform cross section)}$$

$$= \frac{80\times10^3\text{N}}{1000\text{mm}^2}$$

$= 80$ N/mm²(tensile)

130. The total elongation of the structural element (fixed at one end, free at the other end, and of varying cross-section) as shown in the figure, when subjected to load 2P at the free end is

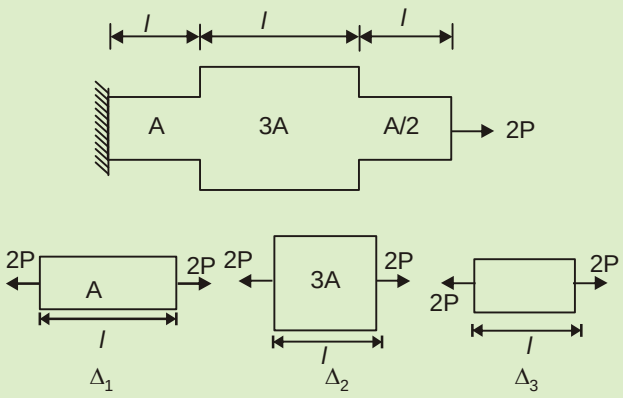


(a) $6.66\frac{Pl}{AE}$ (b) $5.55\frac{Pl}{AE}$

(c) $4.44\frac{Pl}{AE}$ (d) $3.33\frac{Pl}{AE}$

Ans. (a)

Sol.



$$\Delta_{Total} = \Delta_1 + \Delta_2 + \Delta_3$$

$$= \frac{2Pl}{AE} + \frac{2Pl}{3AE} + \frac{2Pl}{\frac{AE}{2}}$$

$$= \frac{2Pl}{AE} + \frac{2Pl}{3AE} + \frac{4Pl}{AE}$$

$$= \frac{6PL}{AE} + \frac{2Pl}{3\,AE}$$

$$= 6.66\frac{Pl}{AE}$$

131. A chain, working a crane, has sectional area of 625 mm2 and transmits a load of 10 kN. When the load is being lowered at a uniform rate of 40 m/min, the chain gets jammed suddenly at which time the length of the chain unwound is 10m. Assuming E = 200 GPa, the stress induced in the chain due to this sudden jamming is

(a) 100.6 N/mm^2 (b) 120.4 N/mm^2

(c) 140.2 N/mm^2 (d) 160.0 N/mm^2

Ans. (b)

Sol. $V_{max} = \frac{\sigma_{max}^2 \cdot V}{2E}$

(V = Volume of spring)

Since $V_{max} = \int \frac{\sigma_{max}^2}{2E} dV$

$$V_{max} = \frac{1}{2}mV_0^2$$

$$\Rightarrow \sigma_{max} = \sqrt{\frac{mV_0^2E}{V}}$$

$$= \sqrt{\frac{\frac{10\times10^3}{9.81}Kg\times\left(\frac{40}{60}\frac{m}{s}\right)^2\times200\times10^9\frac{N}{m^2}}{(625)\times(10\times10^3)\times10^{-9}m^3}}$$

$$= 120.4\ N/mm^2$$

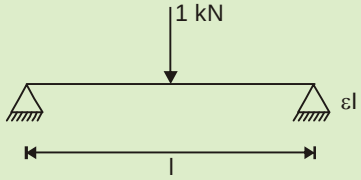
132. A simply supported beam of span l and flexural regidity EI carries a unit load at its mid-span. The strain energy at this condtions in the beam due to bending is

(a) $\frac{l^3}{48EI}$ (b) $\frac{l^3}{96EI}$

(c) $\frac{l^3}{192EI}$ (d) $\frac{l^3}{16EI}$

Ans. (b)

Sol.



Strain energy $= \frac{1}{2}\times P\times\delta$

$$= \frac{1}{2}\times1\times\frac{1\times l^3}{48EI}$$

$$= \frac{l^3}{96EI}$$

133. In mild steel specimens subjected to tenile test cycle, the elastic limit in tension is raised and the elastic limit in compression is lowered, This is called

(a) Annealing effect

(b) Bauschinger effect

(c) Strain rate effect

(d) Fatigue effect

Ans. **(b)**

Sol. Bauchinger effect :

It refers to property of materials where the materials stress/strain characteristics change as a result of the microscopic stress distribution of the material.

Hence an increase in tensile yield strength occurs at the expense of compressive yield strength.

134. A solid uniform metal bar of diameter D mm and length l mm hangs vertically from its upper end. The density of the material is $\rho N/mm^3$ and its modulus of elasticity is E N/mm^2. The toal extension of the rod due to its own weight would be

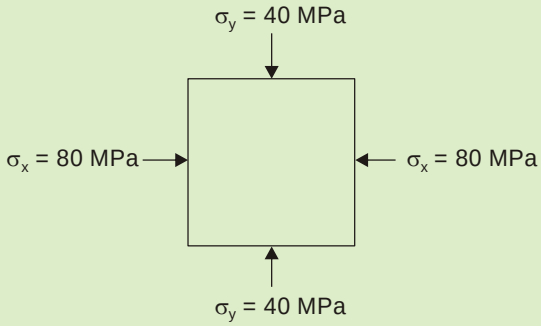
(a) $\frac{\rho l^2}{2E}$ (b) $\frac{\rho l}{2E}$

(c) $\frac{\rho l}{4E}$ (d) $\frac{\rho l^2}{4E}$

Ans. **(a)**

Sol. $\Delta = \frac{wl}{2AE} = \frac{\rho}{2} \times \frac{l \cdot A \cdot l}{AE} = \frac{\rho l^2}{2E}$

135. The state of stress at a certain point in a stressed body is as shown in the figure. Normal stress in x-direction is 80 MPa (Tensile) and in y-direction is 40 MPa (compressive). The radius of the Mohr's circle for this state of stress will be

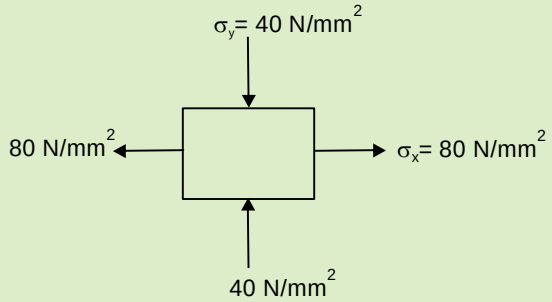


(a) 60 MPa (b) 40 MPa

(c) 20 MPa (d) 10 MPa

Ans. **(a)**

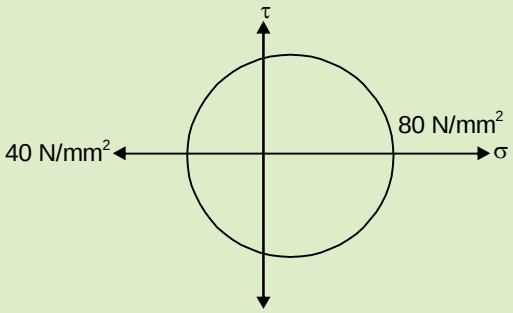
Sol.



Draw 1st coordinate = (80, 0)

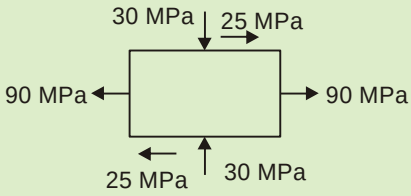
2nd coordinate = (–40, 0)

(–) because force is compressive



Radius of Mohr circle = $\frac{80+40}{2}$ = 60MPa

136. For the state of stress shown in the figure, the maximum and minimum principal stresses (taking tensile stress as +, and compressive stress as –) will be



(a) 95 MPa and (–35) MPa

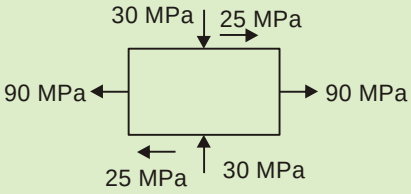
(b) 60 MPa and 30 MPa

(c) 95 MPa and (–30) MPa

(d) 60 MPa and 35 MPa

Ans. (a)

Sol.



$$\sigma_{max/min} = \frac{\sigma_1+\sigma_2}{2} \pm \sqrt{\left(\frac{\sigma_1-\sigma_2}{2}\right)^2+\tau^2}$$

$$= \frac{90-30}{2} \pm \sqrt{\left(\frac{90+30}{2}\right)^2+25^2}$$

$$= 30 \pm \sqrt{60^2+25^2}$$

$$= 95, -35 \text{ N/mm}^2$$

137. Consider the following statements :

1. The shear stress distribution across the section of a circular shaft subjected to twisting varies parabolically.
2. The shear stress at the centre of a circular shaft under twisting moment is zero
3. The shear stress at the extreme fibres of a circular shaft under twisting moment is maximum.

Which of the above statements is/are correct?

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

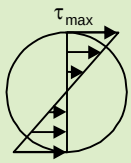
(c) 2 only (d) 3 only

Ans. (c,d)

Sol.

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{l}$$

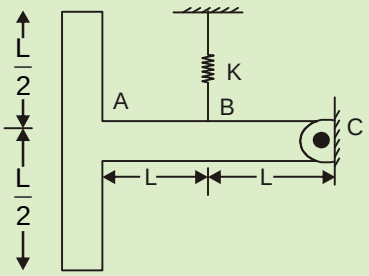
The shear stress distribution across the section of a circular shaft subjected to twisting varies lineary.



Shear stress at centre = 0

Shear stress at top fibre = τ_{max} .

138. A uniform T-shaped arm of weight W, pinned about a horizontal point C, is support by a vertical spring of stiffness K. The extension of the spring is

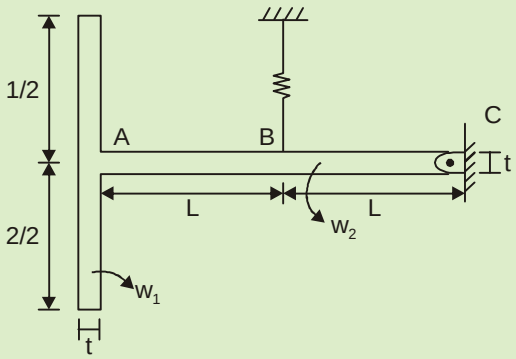


(a) $\frac{3W}{4K}$ (b) $\frac{4W}{3K}$

(c) $\frac{3K}{4W}$ (d) $\frac{4K}{3W}$

Ans. (b)

Sol.



$$W_1 + W_2 = W \qquad ...(i)$$

Weight is directly proportional to Area since material is same.

...(ii)

$$A_1 = Lt \quad A_2 = 2Lt$$

$$A_{total} = 3Lt$$

$$A_1 = \frac{A_{total}}{3}$$

$$A_2 = \frac{2}{3}A_{total}$$

Hence by (i) and (ii) ..

$$w_1 = \frac{w}{3} \qquad w_2 = \frac{2}{3}w$$

Taking Moments about C i.e. hinge;

$$\frac{w}{3}\times 2L + \frac{2}{3}w \times L = 4x \times L$$

$$\frac{4}{3}w = Kx$$

$$x = \frac{4w}{3K}$$

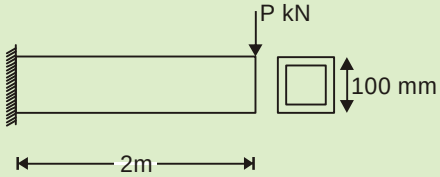
139. The span of a cantilever beam is 2m. The cross-section of the beam is a hollow squre with external sides 100 mm; and its 1 = 4 × 10^5 mm^4. The safe bending stress for the beam material is 100 N/mm^2. The safe concentrated load at the free end would be

(a) 100 N (b) 200 N

(c) 300 N (d) 400 N

Ans. (d)

Sol.



f_{safe} = 100 N/mm^2

I = 4 × 10^5 mm^4

M at fixed end = P × 2 = 2P kNm

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

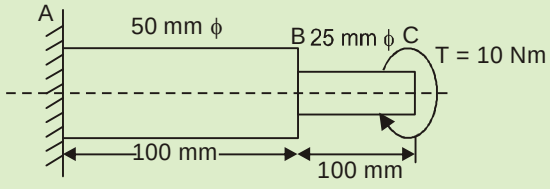
$$\Rightarrow \frac{\frac{100}{2}}{\frac{100}{2}} = \frac{2P\times 10^6}{4\times 10^5}$$

$$\Rightarrow \frac{2\times 4\times 10^5}{2\times 10^6} = P$$

$$\Rightarrow 4 \text{ kN} = P$$

$$\Rightarrow 400 \text{ N} = P$$

140. A stepped steel shaft is subjected to a clockwise torque of 10 Nm at its free end. Shear modulus of steel is 80 GPa. The strain energy stored in the shaft is



(a) 1.73 Nmm (b) 2.52 Nmm

(c) 3.46 Nmm (d) 4.12 Nmm

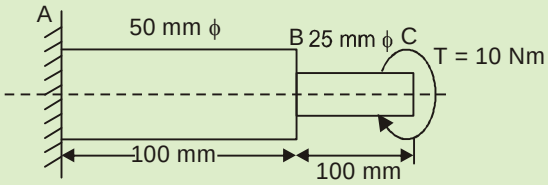
OUR TOP RESULTS IN ESE-2016

IES MASTER
Institute for Engineers (IES/GATE/PSUs)

Received so far..... [If found any discrepancy please bring it to our notice.]

Ans. (a)

Sol.



$G = 80\ GPa = 80 \times 10^3\ N/mm^2$

Strain energy stored $= \dfrac{T^2L}{2GI_P}$

$$= \frac{T^2L}{2GI_{P_1}} + \frac{T^2L}{2GI_{P_2}}$$

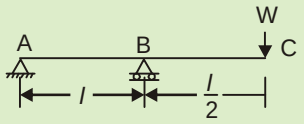
$$= \frac{T^2L}{2G}\left[\frac{1}{I_{P_1}} + \frac{1}{I_{P_2}}\right]$$

$$= \frac{(10\times10^3)^2\times1000}{2\times80\times10^3}\left[\frac{32}{\pi\times25^4} + \frac{32}{\pi\times50^4}\right]$$

$$= \frac{100\times10^6\times1000}{2\times80\times10^3}[2.77\times10^{-5}]$$

$= 1.73$ Nm

141. An overhanging beam of uniform EI is loaded as shown below. The deflection at the free end is

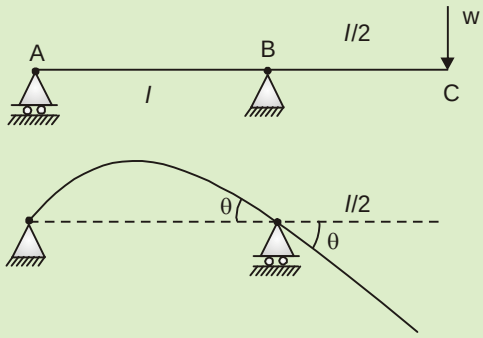


(a) $\dfrac{Wl^2}{81EI}$ (b) $\dfrac{Wl^3}{8EI}$

(c) $\dfrac{Wl^3}{27EI}$ (d) $\dfrac{2Wl^3}{27EI}$

Ans. (b)

Sol.



$\Delta = \Delta_{\text{due to }\theta} + \Delta_{BC}$ (Considering B fixed)

$$= \frac{\left(\frac{wl}{2}\right)}{3EI}\times\frac{l}{2} + \frac{w\times\left(\frac{l}{2}\right)^3}{3EI}$$

$$= \frac{wl^3}{12\,EI} + \frac{wl^3}{24\,EI} = \frac{wl^3}{8\,EI}$$

142. The principal stresses at a point a stressed material are

$\sigma_1 = 200\ N/mm^2$, $\sigma_2 = 150\ N/mm^2$, and

$\sigma_3 = 200\ N/mm^2$. E = 210 kN/mm^2 and

$\mu = 3.0$. The volumetric strain will be

(a) 8.954×10^{-4} (b) 8.954×10^{-2}

(c) 6.54×10^{-3} (d) 6.54×10^{-4}

Ans. (No answer is matching)

Sol.

$$\frac{\Delta}{V} = \frac{(\sigma_1+\sigma_2+\sigma_3)(1-2\mu)}{E}$$

$$= \frac{(200+150+200)\times(1-2\times3)}{210\times10^3}$$

$$\frac{\Delta V}{V} = 1.047\times10^{-3}$$

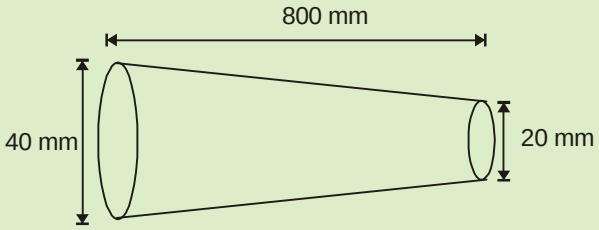
143. A mild steel bar, circular in cross-section, tapers from 40 mm diameter to 20 mm diameter over tis length of 800 mm. It is subjected to an axial pull of 20 kN. E = 2 × 10^5 N/mm^2. The increase in the length of the rod will be

(a) $\frac{1}{10\pi}$mm (b) $\frac{2}{5\pi}$mm

(c) $\frac{4}{5\pi}$mm (d) $\frac{1}{5\pi}$mm

Ans. **(b)**

Sol.

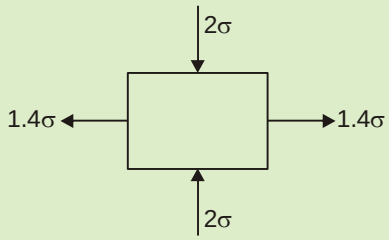


$E = 2 \times 10^5$ N/mm^2

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

$$= \frac{4\times 20\times 10^3 \times 800}{\pi \times 20 \times 40 \times 2 \times 10^5} = \frac{2}{5\pi}\text{mm}$$

144. The state of stress at a point in an elastic material, with yield stress of 200 MPa in simple tension and Poisson's ratio 0.3, is as shown in the figure



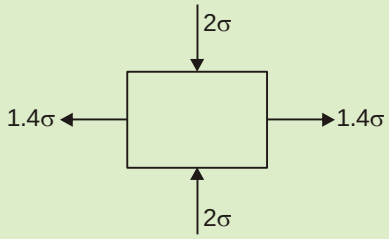
The permissible value of σ by maximum strain theory is

(a) 75 MPa (b) 100 MPa

(c) 150 MPa (d) 200 MPa

Ans. **(b)**

Sol.



According to maximum strain theory

$$\frac{\sigma_1}{\varepsilon} - \frac{\mu(\sigma_2+\sigma_3)}{\varepsilon} \le \frac{f_y}{\varepsilon \text{fos}}$$

(Considering tension)

$$\Rightarrow \frac{1.46 + 2\sigma\times\mu}{\varepsilon} \le \frac{f_y}{\varepsilon}(\text{fos} = 1)$$

$$\Rightarrow \frac{1.4\sigma + 2\times 3\sigma}{\varepsilon} \le \frac{200}{\varepsilon}$$

$$\Rightarrow \frac{2\sigma}{\varepsilon} \le \frac{200}{\varepsilon}$$

$$\Rightarrow \sigma \le 100\,\text{N/mm}^2$$

145. Consider the following statements in respect of arched construction made of voussoirs:

1. The superimposed load is transferred to the sidewalls only by the strength of cohesion of the mortar between the voussoirs
2. The arch may fail under crushing when the compressive stress or thrust in it exceeds the safe crushing strength of the voussoir material
3. Every element in the arch is subjected to compression only
4. Failure of the arch due to the sliding of any voussoir past the adjacent one due to transverse shear can be avoided by reducing the height of the voussoirs

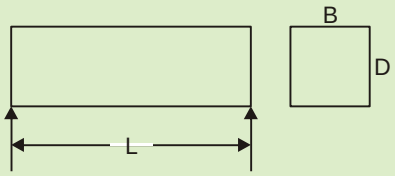
Which of the above statements are correct?

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

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

Ans. (d)

146. A homogenous prismatic simply supported beam is subjected to a point load F. The load can be placed anywhere along the span of the beam. The very maximum flexural stress developed in the beam is

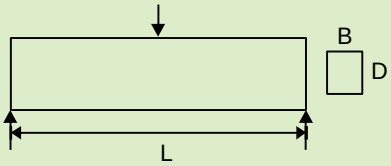


(a) $\frac{3FL}{2BD^2}$ (b) $\frac{3FL}{4BD^2}$

(c) $\frac{2FL}{3BD^2}$ (d) $\frac{4FL}{3BD^2}$

Ans. (a)

Sol.



Max. bending moment occurs at mid span of beam.

Hence $M_{max} = \frac{FL}{4}$

$$\frac{f}{y} = \frac{M_{max}}{I}$$

$$\Rightarrow \frac{f}{(D/2)} = \frac{FL/4}{\frac{BD^3}{12}}$$

$$\Rightarrow f = \frac{3FL}{2BD^2}$$

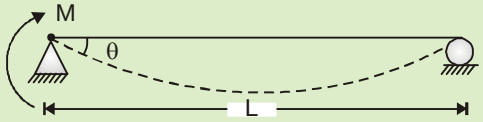
147. The ratio $\left(\frac{s}{t}\right)$ of, (s) stuffiness of a beam (of constant EI) at the near end when the far end in hinged, to (t) the stiffness of the same beam at the near end when the far end is fixed, is

(a) $\frac{1}{2}$ (b) $\frac{3}{4}$

(c) $\frac{1}{1}$ (d) $\frac{4}{3}$

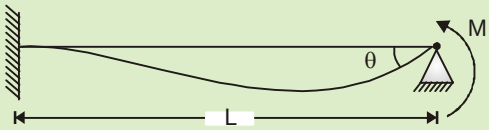
Ans. (b)

Sol.



$$\Rightarrow \theta = \frac{ML}{3EI}$$

$$\Rightarrow \frac{M}{\theta} = \frac{3EI}{L} = S$$



$$\Rightarrow \theta = \frac{ML}{4EI}$$

$$\Rightarrow \frac{M}{\theta} = \frac{4EI}{L} = t$$

$$\Rightarrow \boxed{\frac{S}{t} = \frac{3}{4}}$$

148. Which of the following are examples of indeterminate structures?

1. Fixed beam
2. Continuous beam
3. Two-hinged arch
4. Beam overhanging on both sides

Select the correct answer using the codes given below:

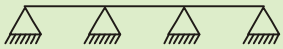
(a) 1, 2 and 3 only (b) 1, 2 and 4 only

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

Ans. **(a)**

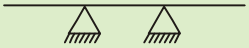
Sol. (i)

(ii)



(iii)

(iv)



Except

(i) $D_s = 3$

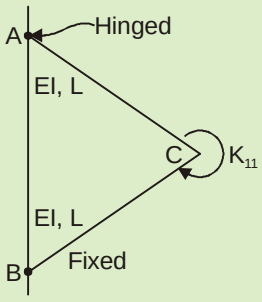
(ii) $D_s = 3$

(iii) $D_s = 1$

(iv) $D_s = 0$

Hence overhanging beam would be determinate structure.

149. The rotational stiffness coefficient indicate as K_{11} for the frame with details as shown is

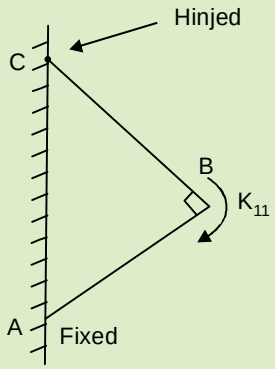


(a) $\frac{9EI}{L}$ (b) $\frac{8EI}{L}$

(c) $\frac{7EI}{L}$ (d) $\frac{6EI}{L}$

Ans. **(c)**

Sol.



$$K_{BA} = \frac{4EI}{l}$$

$$K_{BC} = \frac{3EI}{l}$$

$$K_{11} = K_{BA} + K_{BC}$$

$$K_{11} = \frac{4EI}{L} + \frac{3EI}{L} = \frac{7EI}{L}$$

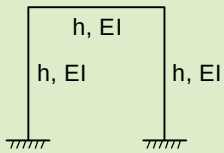
150. A single-bay portal frame of height h fixed at the base is subjected to a horizontal displacement Δ at the top. With constant EI, the base moment developed is proportional to

(a) $\frac{1}{h}$ (b) $\frac{1}{h^2}$

(c) $\frac{1}{h^3}$ (d) $\frac{1}{h^4}$

Ans. **(b)**

Sol.



For horizontal member length is not given. Let us assume it to be h. Hence support moment will be $\frac{2EI\Delta}{h^2}$

$$\Rightarrow M \propto \frac{1}{h^2}$$