ACE
Engineering Academy
Leading Institute for ESE/GATE/PSUs

Since 1995

Hyderabad | Kukatpally | Delhi | Bhopal | Pune | Bhubaneswar | Bengaluru
Lucknow | Patna | Chennai | Vijayawada | Vizag | Tirupathi | Kolkata

UPSC ENGINEERING SERVICES - 2017
ESE 2017 - PRELIMS

Civil Engineering

Questions with Detailed Solutions

VIDEO SOLUTIONS FOR ESE - 2017

Visit our website : www.aceenggacademy.com

SET - A

UPSC Engineering Services - 2017 (Prelims)

Civil Engineering [SET - A]

01.   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

01.   Ans: (a)

Sol:

    IS: 3583 – Burnt clay paving bricks

    IS: 5779 – Burnt clay soiling bricks

    IS: 3952 – Burnt clay hollow bricks

    IS: 2222 – Burnt clay perforated bricks, the only wrong option.

    Memory oriented question, difficult to remember critical code book numbers.

02.   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

02. Ans: (a)

Sol:

    1.   Infact, as Aggregate impact value increases the toughness decreases, strength also decreases. Therefore, Statement 1 is wrong

    2.   As Aggregate crushing value increases, crushing strength decreases & vice versa. Therefore, Statement 2 is true

3. Given that elongation index more than 15% is *generally* considered in the construction. Therefore to suit the given options, Statement 3 can be taken as correct. However, elongation index less than 15% is better in the construction.

4. Flakiness index $\ngtr$ 25%, obviously taken as wrong.

03. 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

03. Ans: (a)

Sol:

Statement 1 is correct: Refractory bricks can be used in blast furnaces where the temperatures are more than 1700° C

Statement 2 also correct: Silica content in refractory bricks should be less than 40%, otherwise it causes warping of bricks at high temperature in furnaces.

The only option which can be selected with the above two statements is (a).

However, as per the question the statements should be considered regarding refractory bricks in furnaces at higher temperature - where water absorption is not a problem.

04. 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

04. Ans: (a)

Sol:

1. Statement 1 is true: Calcination (heating) of lime stone results in quick lime

2. Statement 2 is true: Pure variety of chalk (CaO) is mixed with water (hydrated) gives hydraulic lime.

3. Statement 3 is true: Quick lime mixed with water gives hydraulic lime.

05. 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

05.   Ans: (c)

Sol:

1. Statement 1 is true: As water content increases it acts as a lubricant which reduces the friction between ingredients, thereby workability increases but strength decreases.

2. Statement 2 & 3 are false: Slump is a parameter of workability. Higher slump indicates higher workability.

3. Statement 4 is true: Workability is affected by w/c ratio as well as water content.

06. 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

06. Ans: (c)

Sol:

Due to addition of pozzolana

Statement 1 is true: workability increases

Statement 2 is wrong: infact, heat of hydration reduces but setting times are unaltered.

Statement 3 is true : pozzolana reduces sulphate attack

Statement 4 is true: it leaches calcium oxide

The only option with out statement 2 is option (c).

07. 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/m^3 (b) 570 kg/m^3 (c) 690 kg/m^3 (d) 1000 kg/m^3

07. Ans: (c)

Sol: Specific gravity, $S = \dfrac{\rho}{\rho_{std}} = \dfrac{\dfrac{M}{V}}{\rho_{std}}$

Volume, $V = \dfrac{M}{S\rho_{std}}$

$V_C + V_{FA} + V_{CA} + V_w = 1$

$\dfrac{400}{3.2 \times 100} + \dfrac{M_{FA}}{2.5 \times 1000} + \dfrac{1040}{2.6 \times 1000} + \dfrac{200}{1.0 \times 1000} = 1$ $M_{FA} = 687.5$ kg/m$^3 \simeq 690$

08. 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

08.   **Ans: (a)**

Sol:

Statement 1 is true: In cyclopean concrete, which is used in rubble masonry, the size of course aggregate should be more than 150 mm.

obviously Statement 2 is wrong.

Statement 4 is wrong: In this concrete cement content is less. Therefore, there will be lesser heat of hydration.

09. What is the stress at the section x- x for the bar ABCD with uniform cross-section 1000 mm^2 ?
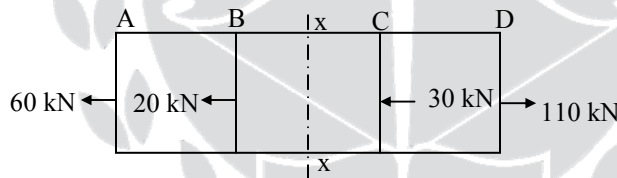
(a) 20 N/mm^2 (Tensile)

(b) 30 N/mm^2 (Compressive)

(c) 80 N/mm^2 (Tensile)
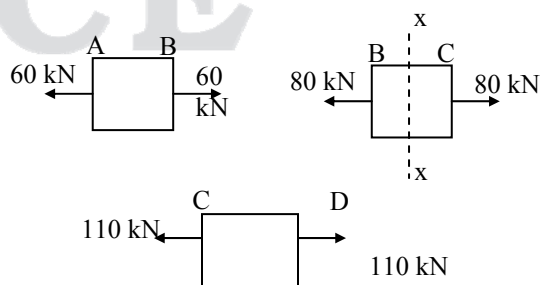
(d) 50 N/mm^2 (Compressive)

09.   **Ans: (c)**

Sol:

$$\sigma_{xx} = \frac{P_x}{A}$$
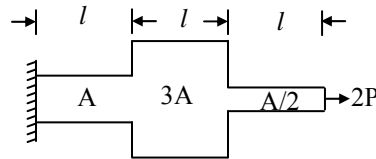
$$= \frac{80 \times 10^3}{1000}$$

$$= 80 \text{ N/mm}^2 \text{ (Tension)}$$

Free body diagram

10. 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) $6.66\,\dfrac{P\ell}{AE}$ (b) $5.55\,\dfrac{P\ell}{AE}$ (c) $4.44\,\dfrac{P\ell}{AE}$ (d) $3.33\,\dfrac{P\ell}{AE}$

10. Ans: (a)

Sol:

Total change in length of the bar is

$$\delta\ell = \frac{2P(\ell)}{AE} + \frac{(2P)(\ell)}{3AE} + \frac{(2P)(\ell)}{\left(\dfrac{A}{2}\right)E} = \frac{P\ell}{AE}\left[2 + \frac{2}{3} + 4\right] = \frac{P\ell}{AE}\left[\frac{6+2+12}{3}\right] \quad \delta\ell = \frac{20P\ell}{3AE} = 6.66\,\frac{P\ell}{AE}$$

11. A chain, working a crane, has sectional area of 625 mm^2 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 10 m. 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

11. Ans: (b)

Sol: A = 625 mm^2

W = 10,000 N

$v = 40 \text{ m/Min} = \dfrac{40}{60} \text{ m/s}$

Length of chain unwound = 10,000 mm

E = 210 × 10^3 MPa

Kinetic energy = strain energy stored

$$\frac{1}{2}mv^2 = \frac{\sigma^2}{2E}.V$$

$$\frac{1}{2}\left[\frac{W}{g}\right]v^2 = \frac{\sigma^2}{2E}.V$$

$$\frac{1}{2}\left[\frac{10,000}{9.81}\right]\left(\frac{40}{60}\right)^2 \times 10^3 = \frac{\sigma^2}{2\times210\times10^3}[625\times10,000]$$

$\sigma = 123.38 \text{ N/mm}^2 \simeq 120.4 \text{ N/mm}^2$

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

(a) $\dfrac{\ell^3}{48EI}$ (b) $\dfrac{\ell^3}{96EI}$ (c) $\dfrac{\ell^3}{192EI}$ (d) $\dfrac{\ell^3}{16EI}$

12. Ans: (b)
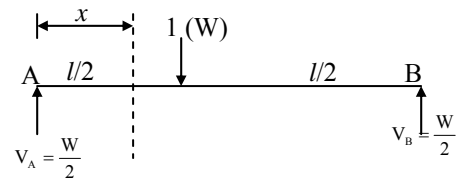
Sol: The bending moment at a section is given by

$$M_x = V_A \times x = \frac{W}{2}x;$$

Strain energy due to bending is given by $U_b = \displaystyle\int_0^\ell \frac{M_x^2 dx}{2EI}$

$$U_b = 2\times \int_0^{\ell/2}\left[\frac{W}{2}x\right]^2\frac{dx}{2EI} = \frac{W^2}{4EI}\left[\frac{x^3}{3}\right]_0^{\ell/2} = \frac{W^2\ell^3}{96EI} \quad U_b \atop (w=1) = \frac{\ell^3}{96EI}$$

13. In mild steel specimens subjected to tensile 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

13. Ans: (b)

14. 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 ρ N/mm^3 and its modulus of elasticity is E N/mm^2. The total extension of the rod due to its own weight would be

    (a) $\dfrac{\rho \ell^2}{2E}$
    (b) $\dfrac{\rho \ell}{2E}$
    (c) $\dfrac{\rho \ell}{4E}$
    (d) $\dfrac{\rho \ell^2}{4E}$

14. Ans: (a)

Sol:

Total extension of the rod due to its own weight is

$$\delta \ell = \frac{W \ell}{2AE}$$

$$\rho = \frac{W}{V}$$

$$W = \rho A l$$

$$\therefore \delta \ell = \frac{(\rho A \ell) . \ell}{2AE} = \frac{\rho \ell^2}{2E}$$

15. 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
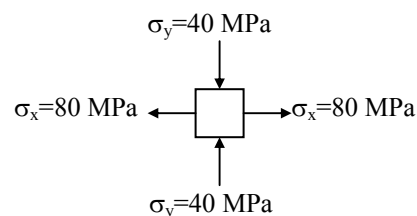
    (a) 60 MPa
    (b) 40 MPa
    (c) 20 MPa
    (d) 10 MPa

15. Ans: (a)

Sol:

The given principal stresses are

$$\sigma_1 = \sigma_x = 80 \text{ MPa}$$

$$\sigma_2 = \sigma_y = -40 \text{ MPa}$$

Radius of Mohr circle = $\dfrac{\sigma_1 - \sigma_2}{2}$

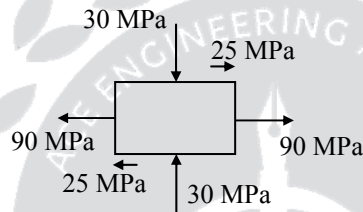$$= \dfrac{80 - (-40)}{2} = 60 \text{ MPa}$$

16. 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 30MPa

(c) 95 MPa and (−30) MPa   (d) 60 MPa and 35 MPa

16.   Ans: (a)

Sol:

Given Data:

$\sigma_x = 90$ MPa

$\sigma_y = -30$ MPa

$\tau_{xy} = 25$ MPa

Principal stresses

$$\left.\begin{array}{r}\sigma_{max} \\ \sigma_{min}\end{array}\right\} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^{\,2}}$$

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

$$= 30 \pm 65$$

$\sigma_{max} = 95$ MPa; $\sigma_{min} = -35$ MPa

17. 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

17. Ans: (c)

Sol:

Statement 1 is wrong: A shaft subjected to torsion, shear stress varies linearly (not in a parabolic manner)

Statement 2 is true: The torsional shear stress is zero at the centre of shaft.

Statement 3 is false: The torsional shear stress is zero on extreme surface plane. The shear stress develops on the cross sectional plane.

18. A uniform T-shaped arm of weight W, pinned about a horizontal point C, is supported by a vertical spring of stiffness K. The extension of the spring is
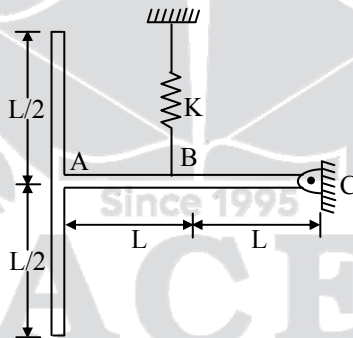
    (a) $\dfrac{3W}{4K}$ (b) $\dfrac{4W}{3K}$ (c) $\dfrac{3K}{4W}$ (d) $\dfrac{4K}{3W}$

18. Ans: (b)

Sol:

Assume weight of vertical member is W_1 also weight of horizontal member is $2W_1$.

Given that weight of total composite bar is W

Taking moments of weights about C

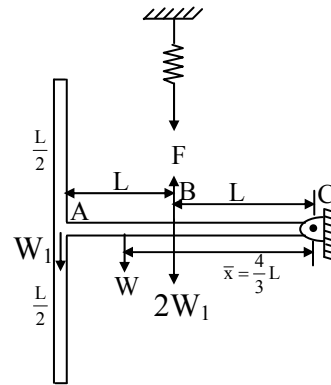$$\overline{x} = \frac{W_1(2L) + 2W_1(L)}{W_1 + 2W_1} = \frac{4}{3}L$$

Total weight of composite bar acts at $\bar{x} = \dfrac{4}{3}L$ from C

$\sum M_C = 0$ (on FBD of composite bar)

$F(L) = W\left(\dfrac{4}{3}L\right)$

$F = \dfrac{4}{3}W$

$\delta = \dfrac{F}{K} = \dfrac{4}{3}\dfrac{W}{K}$

19. The span of a cantilever beam is 2 m. The cross-section of the beam is a hollow square with external sides 100 mm; and its $I = 4 \times 10^5$ 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

19. Ans: (d)

Sol: From bending equation

$f = \dfrac{M}{I}(y_{max})$

$100 = \dfrac{M}{(4 \times 10^5)}(50)$

$M = (4 \times 10^5)\dfrac{100}{50}$
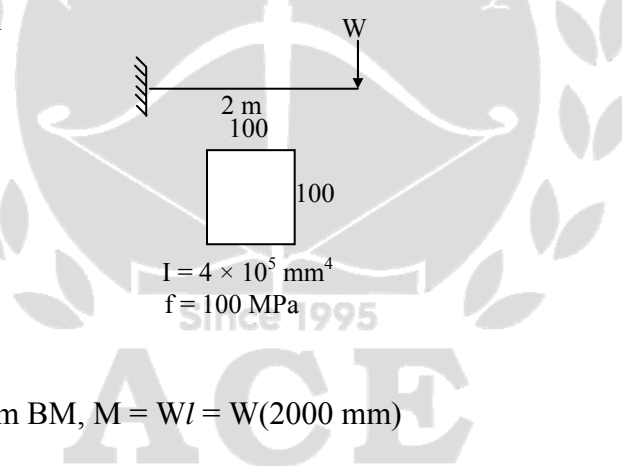
$M = 8 \times 10^5$ N-mm

For cantilever maximum BM, $M = Wl = W(2000\ mm)$
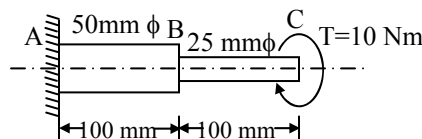
$M = W \times 2000$

$8 \times 10^5 = W \times 2000$

$W = 400$ N

20. 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

20.   Ans: (a)

Sol:

The strain energy due to torsion

$$U = \frac{T^2 L}{2GJ}$$

$$= \frac{(10 \times 10^3)^2 (100)}{2 \times 80 \times 10^3} \left[\frac{32}{\pi \times 25^4} + \frac{32}{\pi \times 50^4} \right] = 1.73 \text{ N-mm}$$

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

(a) $\dfrac{W\ell^3}{81EI}$ (b) $\dfrac{W\ell^3}{8EI}$ (c) $\dfrac{W\ell^3}{27EI}$ (d) $\dfrac{2W\ell^3}{27EI}$

21.   Ans: (b)

Sol:

The deflection at C due to rotation of support C is

$$y_1 = (\theta)\frac{\ell}{2} = \frac{M\ell}{3EI} = \frac{W\ell^2}{6EI}\left(\frac{\ell}{2}\right) = \frac{W\ell^3}{12EI}$$
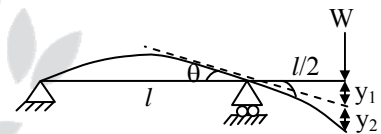
The deflection at C due to cantilever effect at overhang BC is

$$y_2 = \frac{W\left(\frac{\ell}{2}\right)^3}{3EI}$$
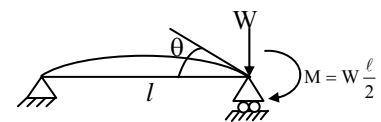
$$y = y_1 + y_2$$

$$= \frac{W\ell^3}{12EI} + \frac{W\left(\frac{\ell}{2}\right)^3}{3EI}$$

$$= \frac{W\ell^3}{EI}\left[\frac{1}{12} + \frac{1}{24}\right]$$

$$\frac{W\ell^3}{EI}\left[\frac{2+1}{24}\right] = \frac{3W\ell^3}{24EI} = \frac{W\ell^3}{8EI}$$

22. The principal stresses at a point in 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 $\mu = 0.3$. 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}

22.   Ans: No Answer

Sol:

The Principal stresses are

$\sigma_1 = 200$ MPa

$\sigma_2 = 150$ MPa

$\sigma_3 = 200$ MPa

$E = 210 \times 10^3$ MPa

$\mu = 0.3$

$$\varepsilon_1 = \frac{\sigma_1}{E} - \frac{\mu\sigma_2}{E} - \frac{\mu\sigma_3}{E} = (200 - 0.3 \times 150 - 0.3 \times 200)\frac{1}{E} = \frac{95}{E}$$

$$\varepsilon_2 = \frac{\sigma_2}{E} - \frac{\mu\sigma_1}{E} - \frac{\mu\sigma_3}{E} = (150 - 0.3 \times 200 - 0.3 \times 200)\frac{1}{E} = \frac{30}{E}$$

$$\varepsilon_3 = \frac{\sigma_3}{E} - \frac{\mu\sigma_1}{E} - \frac{\mu\sigma_2}{E} = (200 - 0.3 \times 150 - 0.3 \times 200)\frac{1}{E} = \frac{95}{E}$$

$$\varepsilon_v = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 = \frac{95}{E} + \frac{30}{E} + \frac{95}{E}$$

$$= \frac{95 + 30 + 95}{210 \times 10^3}$$

$$= 1.048 \times 10^{-3}$$

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

    (a) $\dfrac{1}{10\pi}$ mm   (b) $\dfrac{2}{5\pi}$ mm   (c) $\dfrac{4}{5\pi}$ mm   (d) $\dfrac{1}{5\pi}$ mm

23.   Ans: (b)

Sol:

For a tapering circular bar, change in length due to axial force

$$\delta\ell = \frac{4P\ell}{\pi E.D.d} = \frac{(4)(20 \times 10^3)(800)}{\pi \times 2 \times 10^5 \times 40 \times 20} = \frac{2}{5\pi} \text{ mm}$$

24. 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.
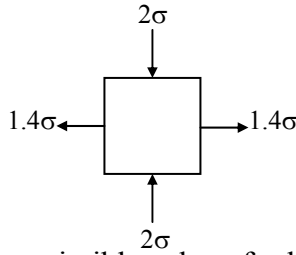
The permissible valve of σ by maximum strain theory is

(a) 75 MPa   (b) 100 MPa   (c) 150 MPa   (d) 200 MPa

24.   Ans: (b)

Sol: Given:

$\sigma_1 = 1.4\sigma$; $\sigma_2 = (-)2$; σ; $\mu = 0.3$; $f_y = 200$ MPa

Maximum strain theory

$$\frac{\sigma_1}{E} - \mu\frac{\sigma_2}{E} = \frac{f_c}{E}$$

$$\frac{1.4\sigma}{E} + 0.3\frac{2\sigma}{E} = \frac{200}{E};\quad (1.4 + 0.3 \times 2)\,\sigma = 200$$

$\sigma = 100$ MPa

25. 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

25. Ans: (d)

Sol:

Statement 1 is false: The load transfer in an arch is not only by cohesion between mortar particles, other parameters are to be considered.

Statement 2 and 3 are true: In the arch there will be only axial compression. Therefore the failure is by crushing of voussior material.

The option without statement (1) and with statements (2) and (3) is (d)

26. A homogeneous 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
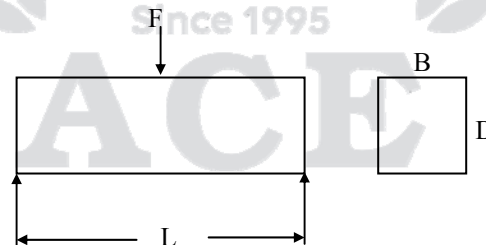
(a) $\dfrac{3FL}{2BD^2}$ (b) $\dfrac{3FL}{4BD^2}$ (c) $\dfrac{2FL}{3BD^2}$ (d) $\dfrac{4FL}{3BD^2}$

26. Ans: (a)

Sol:

From the figure, maximum BM, $M = \dfrac{FL}{4}$

Section modular, $Z = \dfrac{bD^2}{6}$

$$f = \frac{M}{Z} = \frac{\left(\dfrac{FL}{4}\right)}{\left(\dfrac{BD^2}{6}\right)}$$

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

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

    (a) $\dfrac{1}{2}$ (b) $\dfrac{3}{4}$ (c) $\dfrac{1}{1}$ (d) $\dfrac{4}{3}$

27. Ans: (b)

Sol:

$$\frac{S}{t} = \frac{\dfrac{3EI}{\ell}}{\dfrac{4EI}{\ell}} = \frac{3}{4}$$

$S = \dfrac{3EI}{\ell} \rightarrow$ Stiffness of a beam at the near end when far end is hinged.

$t = \dfrac{4EI}{\ell} \rightarrow$ Stiffness of the same beam at the near end when far end is fixed.

28. 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

28. Ans: (a)

Sol:

$D_s = (r - 2)$

1. Fixed beam
   $r = 4;\ D_s = 2$
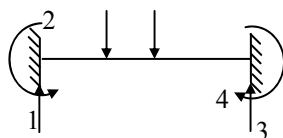
2. Continuous Beam
   r = 3; D_s = 1
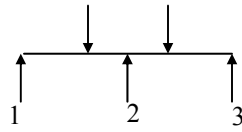
3. Two-hinged arch
   r = 4; D_s = 2
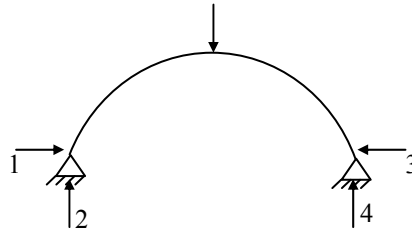
4. Over hanging beam
   r = 2; D_s = 0
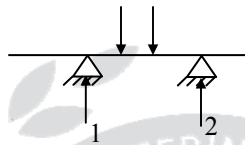
29. The rotational stiffness coefficient indicated as K_{11} for the frame with details as shown as
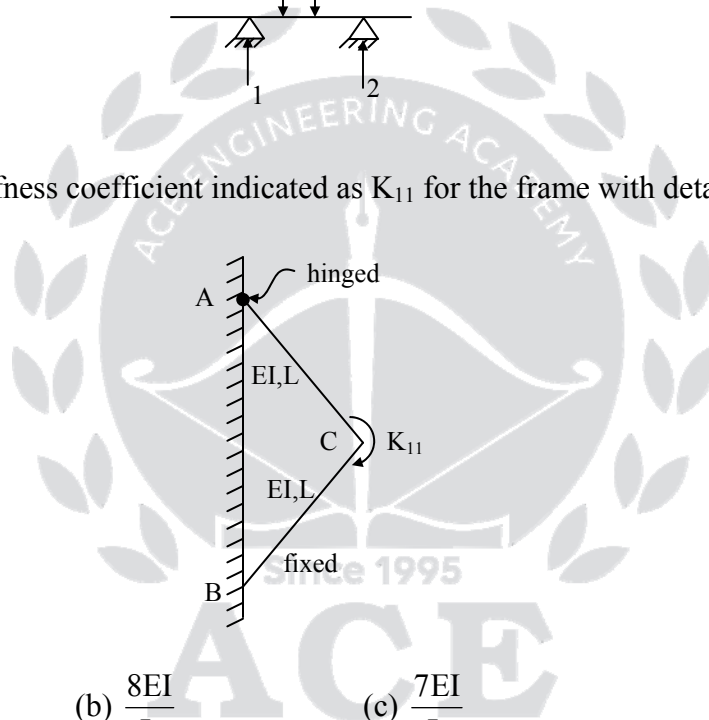
(a) $\dfrac{9EI}{L}$ (b) $\dfrac{8EI}{L}$ (c) $\dfrac{7EI}{L}$ (d) $\dfrac{6EI}{L}$

29.   Ans: (c)

Sol:

$$K_{11} = K_{CA} + K_{CB} = \frac{3EI}{\ell} + \frac{4EI}{\ell} = \frac{7EI}{\ell}$$

30. 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) $\dfrac{1}{h}$ (b) $\dfrac{1}{h^2}$ (c) $\dfrac{1}{h^3}$ (d) $\dfrac{1}{h^4}$

30.   Ans: (b)

Sol:

$$M = \frac{6EI\Delta}{h^2} \Rightarrow M\alpha\frac{1}{h^2}$$
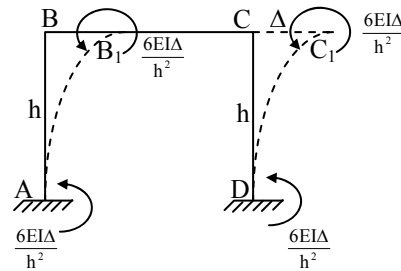
31.   Consider the following statements:

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 a deficient frame.

Which of the above statements is /are **correct?**

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

31.   Ans: (b)

Sol: n = (2j – 3) → Perfect frame

n > (2j – 3) → Redundant frame

n < (2j – 3) → Deficient frame

32.   A cantilever beam, 3 m 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

32.   Ans: (b)

Sol:

Given:

Length of beam = 3m
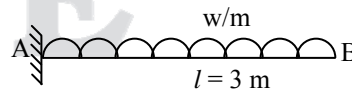
Slope at free end, $\theta_B = 1° = \dfrac{\pi}{180}$

Slope at free end, $\theta_B = \dfrac{w\ell^2}{6EI}$

Deflection at free end, $y_B = \dfrac{w\ell^3}{8EI} = \dfrac{w\ell^2}{6EI} \times \dfrac{6\ell}{8}$

$$= \frac{1° \times \pi}{180°} \times \frac{6 \times 3000}{8} = 39.27\,mm$$

33. 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 segment

   3. Less than the average load on the right segment.

   Select the *correct* answer using the codes given below.

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

33.   Ans: (b)

Sol:

   For tram of wheel loads moving on the given span, the maximum bending moment at a given section occurs when average load on the left segment = Average load on the right segment.

34. 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) 4.4 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

34.   Ans: (c)

Sol:

$$w_D = w\sqrt{1 - \varepsilon_g^2}$$

   ε_g = Damping ratio = 2%

   $$= \frac{2}{100}$$

   $$w_D \simeq w = \sqrt{\frac{K}{m}} = \sqrt{\frac{17 \times 10^3}{22}}$$

   $$= 27.8 \, \text{rad/sec}$$

   $$f = \frac{w}{2\pi} = 4.4 \, \text{Hz}$$

35. A cable of insignificant weight, 18 m long, is supported at its two ends, 16 m 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

35.   Ans: (b)

Sol: **Method 1 :**

$\Sigma V = 0$

$V_A + V_B = 120$ N

$\Sigma M_B = 0$

$V_A \times 16 - 120 \times 8 = 0$

$V_A = \dfrac{120 \times 8}{16}$

$V_A = 60$ N

$V_B = 60$ N

$9^2 = 8^2 + x^2$

$x = 4.123$ m

$\Sigma M_C = 0$

$-H \times 4.123 + V_A \times 8 = 0$

$H \times 4.123 = 60 \times 8$

$H = \dfrac{60 \times 8}{4.123} = 116.42$ N

$H = 116.42$ N

∴ The tension in the cable (T)

$$= R_A = \sqrt{V_A^2 + H^2}$$

$$= \sqrt{(60)^2 + (116.42)^2} = 131 \text{ N}$$

Method 2 :

Apply

$\Sigma V = 0$ at C

$9^2 = 8^2 + x^2$

$x^2 = 9^2 - 8^2$

$x = 4.123$ m

$2T \cos\theta = 120$

$\cos\theta = \dfrac{4.123}{9}$

$2 \times T \times \dfrac{4.123}{9} = 120$

$T = \dfrac{120 \times 9}{4.123 \times 2} = 131$ N
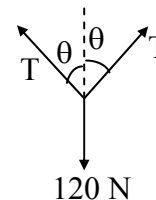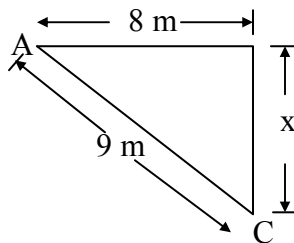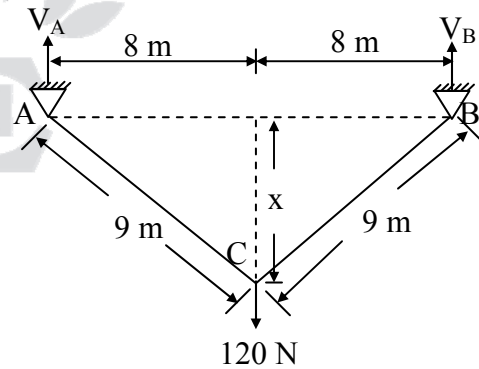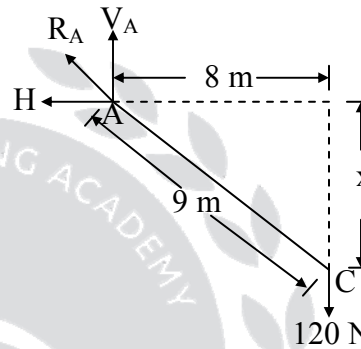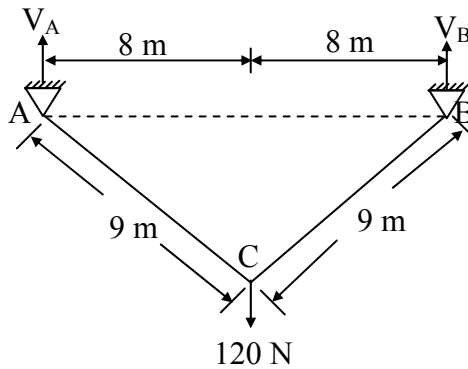
36. The design strength of a tension member is governed by

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

36. Ans: (d)

Sol:

A tension member under factored tensile load may chance to fail by three possible modes as per limit state of strength and limit state of serviceability, which are Gross section yielding or yielding of gross section Net section rupture or fracture at a critical section and Block shear of end region

Hence the design strength of a member under axial tension is governed by above three failures as per Limit state Design code of IS-800:2007.

37. Two parallel rails are running on railway sleepers. The centre-to-centre distance between the rails 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 $\dfrac{b}{a}$ 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

37. Ans: (a)

Sol:

For sagging moment is equal to hogging moment

The over hang distance, $a = 0.207l$

The distance between two supports is, $b = l - 2a$

$$\frac{b}{a} = \frac{\ell - 2 \times 0.207\ell}{0.207\ell} = 2.83$$
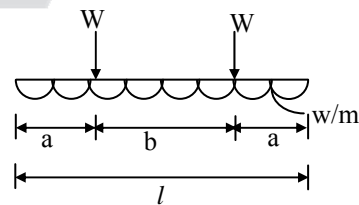
38. The kinetic indeterminacy of the structure shown in the figure is equal to
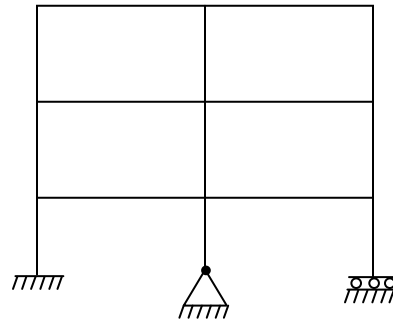
(a) 14   (b) 15   (c) 16   (d) 17

38. Ans: (a)

Sol:

$D_K = 3j - (r + m)$

$= 3 \times 12 - (7 + 15)$

$= 14$

$j = 12$
$r = 7$
$m = 15$
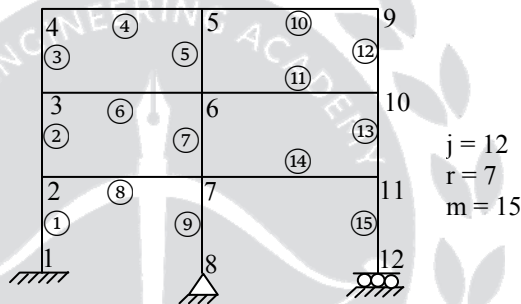
39. A beam-column is alternately bent either (1) in single curvature, or (2) in double curvature. The secondary moments induced are to be compared. These are indicated SM_1 and SM_2 as per the conditions (1) and (2) respectively

(a) $SM_1 > SM_2$ (b) $SM_1 < SM_2$ (c) $SM_1 = SM_2$ (d) Cannot be ascertained

39. Ans: (a)

Sol:

(1). Single curvature   (2). Double curvature

It is observed that, higher effective length is in case (1). It has less capacity. For a given condition, moment developed in a weaker member is high.

$\therefore SM_1 > SM_2$

40. 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

40. Ans: (a)

Sol:

Gantry girders are used in an industrial buildings to support crane loads and these generally designed as a laterally unsupported beams under gravity loads, lateral loads, and longitudinal loads and impact loads. They can also be designed as a laterally supported beams when the compression flange is laterally supported by either a catwalk or by additional members but such arrangement will not be economical.

As a beam or a girder the most efficient section is I section but gantry girder under various loads, to enhance lateral stability or lateral bending strength to withstand lateral loads, normally a channel section is reinforced to the compression flange of I section.

41. 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, 5m apart, crosses this arch from left to right, with 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

41. Ans: (c)

Sol:

$H_{max} = 20 \times 1.25 + 10 \times 0.625$

$= 31.25$ kN
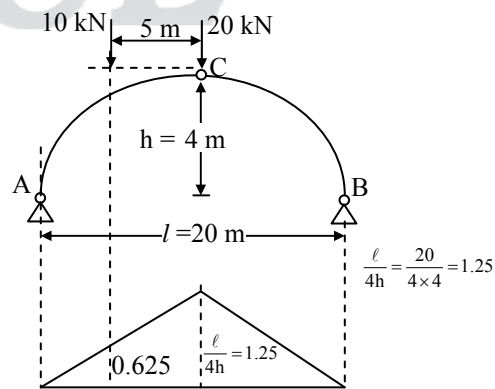
ILD for horizontal Thrust

42. 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 and K_3, where K_1 is called

    (a) Terrain height factor

    (b) Structure size factor

    (c) Topography factor

    (d) Risk coefficient

42.   **Ans: (d)**

Sol:

For the calculation of Design wind load on structure IS875-1987 part-III the relates the intensity of wind pressure to the basic maximum basic wind speed V_b in m/sec. This wind speed is modified to include risk level, terrain roughness, height and size of structure and local topography,

The design wind velocity V_z at any height for the structure is given below

    $V_z = k_1 . k_2 . k_3 . V_b$

k_1 = Risk coefficient or probability coefficient

k_2 = Terrain, height and structure size factor.

k_3 = Topography factor.

43. Consider the following two statements regarding Bearing stiffness 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

43.   **Ans: (b)**

Sol:

Load Bearing stiffener and end bearing stiffeners are provided at the points of concentrated load and at support to resist support reaction respectively in plate girders.

The critical section for bearing stress is root of web or root of fillet of rolled I section, for calculating bearing stress under concentrated load (or near support due to support reaction), Bearing area is considered at roof fillet by dispersion at a slope 1:2.5..

Under concentrated load (or buckling load) and near support due to support reaction (or buckling load), the web behaves as a thin compression member, the critical section for buckling stress under buckling load is centre of web by dispersion at 45^0. Hence the bearing area and buckling area are not same.

44. 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

44. Ans: (c)

Sol:

A continuous or intermittent fillet weld is provided between flange plate and web plate of a plate girder as they are meeting in two different planes and they are to be designed for shear stresses. The continuous or intermittent fillet weld size and its length is designed for horizontal shear stress or shear force between flange and web due to bending action
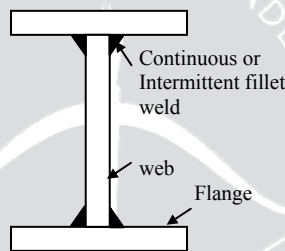
45. For a rectangular cross-section, when the extreme fibre strain was ε_y, the yield moment capacity is M_y. What would be the value of the resisting moment when the extreme fibre strain is $2\varepsilon_y$?

    (a) 1.000 M_y (b) 1.250 M_y (c) 1.375 M_y (d) 1.550 M_y

45. Ans: (c)

Sol:

$M = C_1Y_1 + C_2Y_2 + T_1Y_1 + T_2Y_2$

$M = \left\{\sigma_y \times b \times \dfrac{b}{4} \times \left(\dfrac{1}{2} \times \dfrac{h}{4} + \dfrac{h}{4}\right) + \dfrac{1}{2} \times \sigma_y \times b \times \dfrac{h}{4} \times \dfrac{2}{3}\dfrac{h}{4}\right\} \times 2$

$\quad = \dfrac{11}{48}bh^2\sigma_y$

$M_y = \sigma_y \times Z_e = \sigma_y \times \dfrac{bh^2}{6}$

$\dfrac{M}{M_y} = \dfrac{11}{8} = 1.375 \Rightarrow M = 1.375M_y$
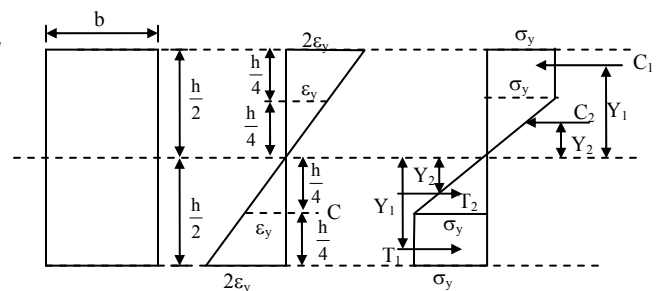
46. A certain R.C. short column with 300 mm square cross-section is made of M20 grade concrete and has 4 numbers, 20 mm diameter, longitudinal bars of Fe 415 grade steel. It is under the action of a concentric axial compressive load. Ignoring the reduction in the area of concrete due to the steel bars, the ultimate axial load carrying capacity of the column as by the relevant code is

(a) 1069 kN (b) 1198 kN (c) 1548 kN (d) 1659 kN

46. Ans: (a)

Sol:

Given:

Size of column = 300 mm × 300 mm

M20, Fe-415

$A_{sc} = 4$ -20 mmϕ, $A_c = A_g - A_{sc}$

Load carrying capacity $P_u = ?$

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

$P_u = 0.4 \times 20 \times 300 \times 300 + 0.67 \times 415 \times 4 \times \dfrac{\pi}{4} \times 20^2 P_u$

$= 1069 \times 10^3 \, N = 1069 \, kN$

47. A rectangular beam is of size 230 mm × 350 mm (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) 60 kN (d) 20 kN

47. Ans: (c)

Sol:

Size of beam = 230 mm × 350 mm

Factored shear force, $V_u = 80$ kN

Permissible shear stress in concrete, $(\tau_c) = 0.25$ MPa

Design shear force $V_{us} = ?$

Nominal shear stress $\tau_v = \dfrac{V_u}{bd}$

$= \dfrac{80 \times 10^3}{230 \times 350}$

$= 0.99 \, N/mm^2$

$\tau_v > \tau_c \therefore$ Not safe

Hene design for shear

$V_{us} = V_u - \tau_c \, bd$

$= 80 \times 10^3 - 0.25 \times 230 \times 350 = 59.875 \text{ k} \simeq 60 \text{ kN}$

$\tau_{permissible} = 0.25$ MPa

Design shear force $= 0.25 \times 230 \times 350$

$= 20.1$ kN
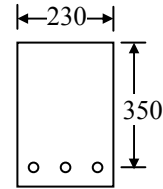
48. In a combined footing for two columns carrying unequal load, the maximum hogging moment occurs at

(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

48. Ans: (d)

Sol:

Combined Footing
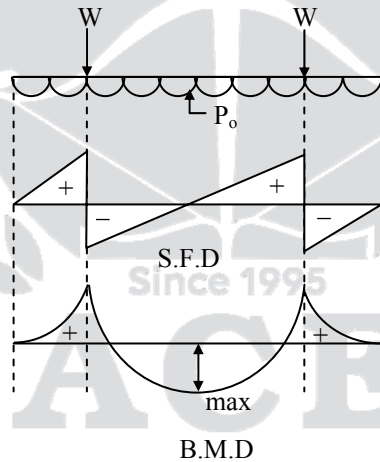
The max hogging moment occurs at a section subjected to zero shear force (i.e change in shear force)

Where

W = Column load

P_o = Net soil upward pressure

49. 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

49. Ans: (c)

Sol:

The functions of minimum steel in slabs are

- To keep the main reinforcement in positions
- To take care of secondary effects like shrinkage, creep, temperature change
- To receive the load from concrete and distributed to main steel safely

The limitation of max tension steel in beams as per IS:456-2000 is 4% of gross cross sectional area

It is because of avoiding the practical difficulty i.e. placing of reinforcement and compaction of concrete.

50. 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

50. Ans: (d)

Sol:

When the N.A lies within the flange, the section is treated like rectangular. The analysis and design is similar to rectangular section.
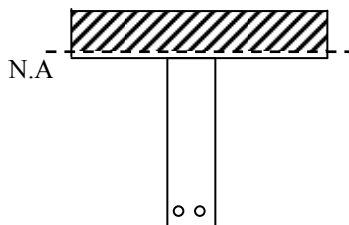
Above N.A like rectangle below the N.A concrete area is not consider because steel will alone take care of tensile stresses.

51. 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 hear 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 supports 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

51. Ans: (c)

Sol:

Statement 1: is true. As per IS:456-2000, when $\tau_v > \tau_{c\,max}$ ∴ Not safe

The section is redesigned because the nature of failure is brittle (diagonal compression failure).

Statement 2 :is also true. If a slab is said to be a two way slab, the following conditions must satisfy.

- The aspect ratio $\left(\dfrac{\ell_y}{\ell_x}\right) \not> 2$

- The slab must be rest over four supports as its edges.

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

    (a) 16%   (b) 12%   (c) 10%   (d) 1.6%

52. Ans: (d)

Sol:

Span (l) = 25 m

Initial stress (σ_o) = 1000 MPa

Anchorage slip (Δ) = 2mm

$$E_s = 200 \text{ GPa}$$

Loss of prestress in % = ?

Loss of stress (due to anchorage slip) $\Delta\sigma$

$$= \frac{\Delta}{L} \times E_s \ = \frac{2}{25 \times 10^3} \times 200 \times 10^3 = 16 \text{ N/mm}^2$$

$$\% \text{ Loss} = \frac{\Delta\sigma}{\sigma_o} \times 100 \ = \frac{16}{1000} \times 100 \ = 1.6\%$$

53. 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 codes 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

53. Ans: (c)

Sol: Minimizing the gravity loads will reduce the overall mass and thereby reducing the forces.

To have earthquake resistance higher ductility is required at maximum bending moment locations.

Providing shear walls and rigid basement floors will be higher inertia.

54. The figure shows the plan view of a 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
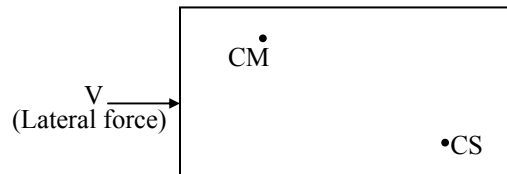
(a) Clockwise

(b) Anticlockwise

(c) Opposite to the direction of lateral force

(d) None of the above

54. Ans: (a)

Sol:

The shear wall rotates about centre of stiffness (CS), due to lateral loads.

Therefore, there will be clock wise rotation in the given condition.

55. 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

55. Ans: (b)

Sol: Non-critical activity can be carried out with normal attention. Whereas critical activity must be carried out with special attention.

56. 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

56. Ans: (a)

Sol: Statement II is incorrect, since it is essential to verify the credentials of contractor's before inviting the tenders.

57. 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

57.   Ans: (d)

Sol:

Quality control is meant for

i) Conforming the design specifications

ii) Reducing maintenance costs.

Statement 2: Quality control is not related to (Incorrect) over costs/overspendings.

Statement 3: Quality control is not focusing (Incorrect) on over design but it is focusing an exact designs.

58. 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 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

58.   Ans: (a)

Sol:

   Explanation:

   • Statement (1), (2) and (4) are correct

   • Statement (3) is wrong. Flow in narrow pipe is relatable to Reynolds number only, where as Cauchy number is square of mach number relatable to compressible flow.

   • Statement (5) is wrong. Surface tension property of river water not related to slope of ogee spillway.

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

1. C in Chezy's equation

2. 11.6 as a measure of the sub-layer

3. $\dfrac{H}{N^2 D^2}$ employed in comparing performance of pumps

4. $\dfrac{Q^2}{D^5}$ employed in computations in pipe networks

5. $\dfrac{U}{\sqrt{gL}}$ 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

59. Ans: (a)

Sol:

Explanation:

- Chezy's constant has dimensional formula $\sqrt{\dfrac{meter}{\sec ond^2}} = \dfrac{(L)^{1/2}}{T}$

- Laminar sub-layer thickness (δ′), $\delta' = \dfrac{11.6\gamma}{V^*}$

Where γ = kinematic viscosity (m²/sec)

     V^* = shear velocity (m/sec)

   11.6 = constant (dimensionless)

- $\dfrac{H}{N^2 D^2}$ is used comparing performance of turbines and pumps $\left[\dfrac{\sqrt{H}}{ND} = \text{Head coeff.} \right]$

- $Q\alpha D^2 \sqrt{H} \Rightarrow Q\alpha D^2 ND$

     $Q \alpha D^3 N$

     $\dfrac{Q}{D^3 N} = \text{Discharge coefficient}$

- $\dfrac{V}{\sqrt{gL}} = \text{Froude Number}$

Statement (2) and (5) are correct.

60. An ocean liner, 240 m long and 24 m wide, displaces 654 MN of sea-water (ρ = 1025 kgf/m³). The second moment of inertia of the water plane about its fore-aft axis is $\dfrac{2}{3}$ of that of the circumscribing rectangle. 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

60. Ans: No Answer

Sol:

Note: The distance between metacentre and centre of buoyancy is called Metacentric radius (BM).

$$BM = \frac{I}{V}$$

However, paper setter might have taught Metacentric height (GM).

$$GM = \frac{I}{V} - BG$$

$$= \frac{\dfrac{2}{3} \times \left(\dfrac{240 \times 24^3}{12} \right)}{\dfrac{654 \times 10^6}{10.25 \times 9.81}} - 2.3$$

$$= 0.53 \text{ m} = 53 \text{ cm}$$

61. 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

61. Ans: (c)

Sol:

Viscosity time (t) and mean density (ρ) are not explicit in the velocity vector. Hence flow is non-viscous, steady and incompressible.

$$V = \sqrt{(2xy)^2 + (yz)^2 + \left(-2yz - \frac{2^2}{2}\right)^2}$$

$$V = \sqrt{(2 \times 1 \times 4)^2 + (4 \times 3)^2 + \left(-2 \times 4 \times 3 - \frac{3^2}{2}\right)^2}$$

$$V = \sqrt{(18)^2 + (12)^2 + (28.5)^2}$$

$$V = 31.94 \text{ m/s}$$

Statement (1) and (4) are wrong

Statement (2) and (3) are correct.

62. 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

62. Ans: (a)

Sol:

Explanation: Flow net is used to analysis seepage, estimation of uplift of the dams etc and valid for irrotational flows.

Statement (1) and (2) are correct

Statement (3) is wrong.

63. 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

63. Ans: (d)

Sol:

Given:

Rectangular channel

Hydraulic jump

$q = 1.019 \text{ m}^3$/s/m

$y_1 = 101.9 \text{ mm} = 0.1019 \text{ m}$

$$F_{r1}{}^2 = \frac{q^2}{gy_1{}^3} = \frac{(1.019)^2}{10 \times (0.1019)^3}$$

$$= \frac{1.019}{(0.1019)^2} = \frac{101.9}{(1.019)^2}$$

$F_{r1} = 10$

$F_{r1} > 9$

Strong jump

64. A man, 65 kg, descends to the ground with the help of a parachute, 18 kg. The parachute is hemispherical in shape, 2 m 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

64. Ans: (a)

Sol:

$Mg = F_D$

$$(65+18) \times 10 = \frac{C_D \rho V^2 A}{2}$$

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

$V = 16.79$ m/sec

$V \simeq 16.6$ m/sec

65. 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%

65. Ans: (c)

Sol:

$$\frac{Q_2}{Q_1} = \left(\frac{y_2}{y_1}\right)^{5/3} = (1.2)^{5/3}$$

$$= 1.36$$

$\Delta Q = 36\%$

66. 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 contracta 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

66. Ans: (a)

Sol:

$$F = \frac{\gamma_w}{2}\left[\frac{(y-y_1)^3}{y+y_1}\right]$$

$$= \frac{1}{2} \times \frac{10000}{10}\left(\frac{(2-0.44)^3}{2+0.44}\right)$$

$$= 777.954 \simeq 770 \text{ kgf}$$

V= 1.25 m/s

2 m

$y_1 = 0.44$ m
$v_{vc} = 5.68$ m/s
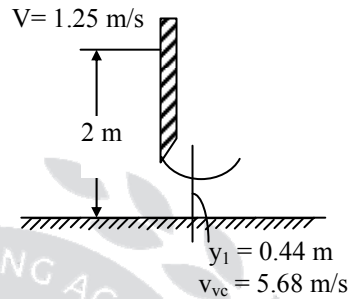
67. A centrifugal pump has an impeller of 30 cm diameter and runs at 1000 rpm giving best efficiency. It delivered 1.2 m³/minute against a head of 25 m. What is its non-dimensional specific speed (based on flow expressed in l.p.s.)? Take $\sqrt{9.81} = 3.132$; and $\sqrt{\sqrt{9.81}} = 1.77$.

(a) 55   (b) 63   (c) 72   (d) 80

67. Ans: (c)

Sol: $N_S = \dfrac{N\sqrt{Q}}{(gH)^{3/4}} = \dfrac{1000\sqrt{\dfrac{1200}{60}}}{(9.81 \times 25)^{3/4}} = 72.16 \simeq 72$

68. 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

68. Ans: (b)

Sol: Statement (1) & (2) are correct

Statement (3) is wrong

Increase in specific speed of the turbine, decreases efficiency.

69. 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

69. Ans: (a)

Sol:

$$P = (\Delta I) \times \omega$$

$$= 15915 \times \frac{2\pi \times 600}{60} = 1000 \times 10^3 \text{ W}$$

$$= 1000 \text{ kW}$$

70. 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 cavitaiton 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

70. Ans: (d)

Sol:

- Kaplan turbine is an axial flow turbine. (Statement (1) is wrong)

- Statement (2) is correct

- Cavitation is observed in runner exit only for reaction turbine (wrong statement (3).

- $N_s \alpha \dfrac{N_s \text{multijet}}{\sqrt{\text{No. of nozzles}}}$

$$N_s = \frac{28}{\sqrt{4}} = \frac{28}{2} = 14$$

Statement (4) is wrong.

Statement (2) and (4) are correct.

71. 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

71.   **Ans: (a)**

Sol:

- Surge tanks are substituted in penstock pipes.
- Pumped stage power plat are used for base and peak load plants which boom to power solid networks.
- Water hammer in penstock is dangerous
- Kaplan turbine are used for low head, low discharge power plants.

    2 and 4 statements are correct.

72. 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

72.   **Ans: (c)**

Sol:

SCN – CN Method of runoff estimation

$$\text{Runoff } Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad P = 100 \text{ mm}$$

$$= 3.937 \text{ inch}$$

$$S = \frac{1000}{CN} - 10$$

$$= \frac{1000}{75} - 10 = 3.333$$

$$Q = \frac{(3.937 - 0.2 \times 3.333)^2}{3.937 + 0.8 \times 3.333} = 1.619 \text{ inch}$$

$$= 1.619 \times 2.54 = 4.11 \text{ cm} \simeq 41 \text{ mm}$$

73. 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

73. Ans: (b)

Sol:

It may damage the storm's

Statement 1 and 3 are correct.

Statement 2 is incorrect.

74. 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 rainfall 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

74. Ans: (d)

Sol:

When ϕ Index= 0.5 cm/hr

$P_e = 0.8 + 1.2 + 0.9 + 1.8 + 1 + 1.0 + 0.8$

$= 6.5$ cm

$t_e = 6$ hr

ϕ Index $= 0.5$ cm/hr

ϕ Index $= \dfrac{P_e - R}{t_e}$

$0.5 = \dfrac{6.5 - R}{6} \Rightarrow R = 3.5$ cm

When ϕ Index $= 0.6$ cm/hr

ϕ Index $= \dfrac{P_e - R}{6}$

$0.6 = \dfrac{6.5 - R}{6} \Rightarrow R = 2.9$ cm

Correction $= 3.5 - 2.9 = +0.6$ cm

75. 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%

75. **Ans: (b)**

Sol: $T = 10$ yr $p = \dfrac{1}{T} = \dfrac{1}{10} = 0.1$

   $n = 4$ $q = 1 - p = 1 - 0.1 = 0.9$

   Occurring at least once in next 4 yrs

   $= \text{Risk} = 1 - [q]^n$

   $= 1 - (0.9)^4 = 1 - 0.6561$

   $= 0.35 = 35\%$

76. Tortuosity of a meandering river is the ratio of

   (a) Meander length to width of the meander

   (b) Meander length of 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

76. **Ans: (c)**

Sol: $\text{Tortuosity} = \dfrac{\text{curved length}}{\text{direct length(chord)}}$

   $\text{Meander Ratio} = M_R = \dfrac{M_B}{M_L}$

77. 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

77. Ans: (b)

Sol:

Statement-1 is wrong.

Specific storage and specific capacity is not same.

Statement-2 is correct.

$$\text{Specific capacity} = \frac{\text{Discharge}}{\text{Drawdown}}$$

Statement-3 is wrong.

Specific capacity $\propto$ discharge. The change in yield of the well will change the specific capacity.

Statement-4 is correct.

78. An extended layer of soil with homogenous 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

78. Ans: (d)

Sol:

$k = CD_{10}^2$

C = a constant = 750 (given)

D_{10} = 0.07 mm

k will be obtained in m/day

$k = 750 \times (0.07)^2 = 3.675$ m/day

79. 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 the 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

79. Ans: (a)

Sol:

1, 2 are correct

3rd choice: Available moisture not hygroscopic

4th choice: After certain limit yield decreases with further increasing discharge.

80. 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

80. Ans: (a)

Sol: Statements 1 & 2 are correct

Silt transportation is having same concept in both theories.

Lacey has an improvement on Kennedy's

But both theories have some defects.

81. 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 0.1 g 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

81. Ans: (a)

Sol: Statement 1 is correct. A grout curtain at the toe increases the seepage length and there by reduces the exit gradient.

Statement 4 is wrong since the Tehri dam is a rock and earth fill embankment dam.

Hence, option (a) is correct.

82. 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

82. Ans: (b)

Sol: Statement 3 is wrong.

River training works make the river course to be stable and prevent bank erosion.

83. 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

83. Ans: (a)

84. Consider the following statements with regards to the shear force diagram for the beam ABCD:
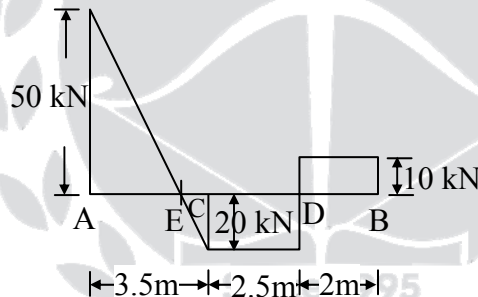
1. The beam ABCD is an overhanging beam having supports at A and D only.

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

84. Ans: (b)

Sol: The statement-2 is wrong

The beam carries a point load of 20 kN at C is a wrong statement. There must be a sudden jump of 20 kN at C if there is a point load.

The option without statement-2 is Option (b)

85. 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

85. Ans: (c)

Sol:

A good disinfectant should only destroy organisms and should be absolutely safe to humans. Therefore dose should be less than the toxic threshold of humans.

Statement 1 and 3 are correct and statement 2 is incorrect.

86. 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

86. Ans: (d)

Sol:

Cl_2 dose = Cl_2 demand + Residual Cl_2

$\quad\quad\quad = 1.0 + 0.2$

$\quad\quad\quad = 1.2$ mg/l

B.P. dose required $= \dfrac{Cl_2 \text{ dose}}{\%Cl_2 \text{ in B.P}}$

$= \dfrac{1.2}{20/100} = \dfrac{1.2 \times 100}{20} = 6$ mg/l

Total B.P. required $= 10000 \times \dfrac{1}{10^6} \times 6$

$\quad\quad\quad\quad\quad$ (ML) $\quad\quad$ (mg/l)

$\quad\quad\quad = 0.06$ kg

$\quad\quad\quad = 60$ gm

$\quad\quad\quad \simeq 68$ gm

87. The approximate value of BHP of a pump to supply 1 m³/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

87. Ans: (c)

Sol:

Power of pump receiver

$P_{pump} = \gamma \, Q \, H$

Where $\gamma = 9.81$ kN/m³

$Q = 1$ m³/s

$H = $ RL of $400 - $ RL 320

$= 80$ m

$P_{pump} = 9.81 \times 1 \times 80$

$= 784.8$ kW

Brake hose power $= \dfrac{784.8}{0.736}$

$= 1066.30$ HP

$\simeq 1070$ HP

88. 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. Collodial 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

88. Ans: (b)

Sol:

Settleable solids are not removed by filtration. Volatile solids are not removed by sedimentation. Dissolved solids are removed by reverse osmosis and colloids can be removed by coagulation.

Statements 1 and 2 are incorrect and statements 3 and 4 are correct.

89. 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

89. Ans: (c)

Sol:

Contact stabilization is a modification suggested to conventional "ASP.

Contact stabilization is the process where return sludge is aerated for 3 to 6 hr before taking back to aeration tank. This reduces aeration period thus reduce the volume of aeration tank and there is possibility of BOD reduction in two stages at stabilization unit and at aeration tank.

Therefore 1, 2, 3 are correct. Statement 4 may be wrong statement. Mentioned 30 to 90 min only aerated.

90. 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 $500^{o}C$ and $1000^{o}C$.

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

90. Ans: (d)

Sol:

Pyrolosis is burning in the absence of air is O_2 free condition of elevated temperature to bring physical and chemical changes of plastic and rubber waste. It is an endothermic process.

Therefore statement 1, 2 and 3 are correct.

91. 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 cancer.

    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

91. Ans: (a)

Sol:

Air pollutants caused by incomplete combustion of wood (or) tobacco which in turn release CO.

Depletion of ozone cause ozone hole which trigger skin cancer.

Acid rains are caused by photochemical reactions between SO_x, NO_x with moisture and sunlight.

As per NAAQS (National ambient air quality standards) in residential areas $SO_2 \leq 80\ \mu g/m^3$

All statements are correct.

92. 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

92. Ans: (d)

Sol:

Statement-1 is wrong.

Montmorillonite clay mineral is largely responsible for swelling and shrinkage of clayey soil. Illite mineral causes medium swelling and shrinkage.

Statemen-2 is wrong.

If the differential free swell is more than 50%, it is considered as "very high degree of expansiveness".

Statement-3 is correct.

The swelling potential increases with increase in plasticity index. Higher the plasticity index, higher the quantum of water that can be imbibed within the soil structure and hence greater swelling potential.

I_P (%)	Swelling potential
0-15	Low
10-35	Medium
20-35	High
>35	Very high

Statement-4 is correct.

Shrinkage limit is the minimum water content at which soil becomes 100% saturated. Therefore a low shrinkage limit indicates that a soil would begin to swell at low water content.

93. 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

93. Ans: (a)

Sol:

Pore water pressure may be +ve or –ve.

If the volume of water (V_w) is equal to volume of voids, soil is said to be fully saturated. Hence statement-2 is correct.

Statement-3 is wrong.

Relative density $(I_D) = \dfrac{e_{max} - e}{e_{max} - e_{min}} \times 100$

Relative density of 1 indicates the soil is in very dense state and it need not be in completely saturated state. A dry soil can also have relative density of 1, if thoroughly compacted.

94. 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

94. **Ans: (a)**

Sol:

Terzaghi's one-dimensional consolidation theory deals with primary consolidation only. After the primary consolidation, secondary consolidation follows. But in the Terzaghi's theory, the secondary consolidation is disregarded. Therefore, the statement-1 may not be correct.

Statement-2 is wrong.

The consolidation is a function of effective stress.

Statement-3 is correct.

After complete dissipation of excess pore pressure, the soil undergoes a littlemore compression due to plastic readjustment of particles and it is called secondary consolidation.

95. 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

95. **Ans: (b)**

Sol:

For undrained test, $\phi_u = 0$

$$\sigma_1 = \sigma_3 \tan^2\left(45 + \frac{\phi_u}{2}\right) + 2\,C_u \tan\left(45 + \frac{\phi_u}{2}\right)$$

$$\sigma_1 = \sigma_3 + 2\,C_u$$

$$C_u = \frac{\sigma_1 - \sigma_3}{2}$$

$$= \frac{\sigma_d}{2} = \frac{100}{2} = 50\,kPa$$

96. Consider the following statements 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 in fixed-ring type oedometer.

3. The permeability of an aquifer increases with decrease in temperature of water moving through it.

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

96. Ans: (a)

Sol: 1.   As per Kozny – Carmen equation, $k \propto \dfrac{1}{s^2}$

Where s = specific surface area.

Statement-1 can be considered to be correct.

2   There are two types of consolidometer tests.

(a) Floating ring cell type

(b) Fixed ring cell type

The floating cell type has the advantage of having smaller effects of friction between the specimen ring and soil specimen.

The fixed ring has the advantage of direct measurement of permeability of the soil specimen at any stage of loading.

Therefore statement -2 is *correct*

3.   The permeability of soil increases with increases in temperature; as the temperature increase causes decrease of the viscosity $\left(k \propto \dfrac{1}{\mu} \right)$

Hence statement -3 is wrong

97. 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. Newmark'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 give 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

97. Ans: (b)

Sol: The equivalent point load method: In this method the total loaded area of any shape is divided into a number of small areas and the distributed load on each small area is assumed as an equivalent point load. The vertical stress at any point is equal to the sum of vertical stresses due to all these point loads. Hence it is an approximate method.

Hence statement -2 is wrong

All other statements are correct.

98. Consider the following statements:

1. Functions of reinforcement 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

98. Ans: (c)

Sol:

Statement-1 is correct

Soil is weak in tension like that of concrete. Hence reinforcement is used in concrete and soil to take care the tensile forces. Therefore the basic principles of incorporating reinforcement members into soil are same as those utilised in RCC.

Statement-2 is correct

The reinforced earth wall consists of the wall facing elements and compacted soil mass within which reinforcing elements are embedded. The reinforcing elements include horizontal metal strips**,** wire grids, bamboos, geotextiles etc.

Therefore the principles of design of reinforced earthwall and geotextile reinforced wall with regards to internal stability and external stability will be same.

99. 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

99. Ans: (b)

Sol:

1. Immediate settlement (or elastic settlement) is the settlement that occurs immediately after application of load

2. Secondary settlement is significant only in the case of organic soils. In other type of soil it is negligible.

3. Secondary settlement is independent of the load. It is time dependent only.

Hence all the statements given in the question are correct.

100. 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 2 m square footing at the same settlement will be

(a) 200 kN   (b) 300 kN   (c) 400 kN   (d) 600 kN

100. Ans: (d)

Sol:

Bearing pressure, m = 100 kN/m^2

Peripheral shear, n = 25 kN/m

(in the question , n is given wrongly as kN/m^2)

Given area, a = 2×2 = 4 m^2

Perimeter, p = 4×2 = 8 m

Q = a m + p n

   = 4 × 100 + 8 × 25 = 600 kN

101. 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 type 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 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

101. Ans: (a)

Sol:

If D ≤ B, the foundation is called "Shallow".

A raft foundation, due to its rigidity, tends to undergo uniform settlement and thus avoids unequal settlements.

All the statements given in the question are correct.

102. 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 structure 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

102. Ans: (d)

Sol:

Statement-1 is wrong

For shallow trench excavation, a braced coffer dam may not be necessary. Braced coffer dam is required only for deep excavations. For shallow trench excavation, a cantilever sheet piling coffer dam otherwise, un-braced coffer dam can be used.

Statement-2 is correct

A coffer dam is a temporary structure built to enclose an area of excavation either on land with shallow water tubes or in water bodies.

Statement-3 is correct

The bulk head is a sheet pile generally anchored with anchor cables or anchor rods behind the sheet in the backfill. It is not provided with bracing on the front size. Sometimes, the bulk head is also classified as

(i)   Cantilever bulk head

(ii)   Anchored bulk head

Bracing is nothing but the lateral supporting system between the two sheetings provided on both sides of the excavation. The bracing consists of wale beams (running parallel to excavation) and struts (running across the trench) provided on the front side of the sheet pile

103. 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 any one 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

103. Ans: (d)

Sol:

The given data is related to unconfined compression test, for which Mohr's circle is plotted as shown below.
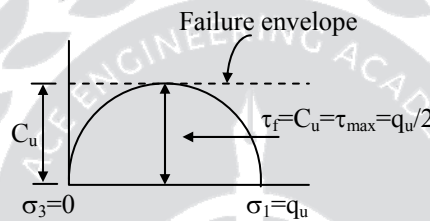
The statement-2 is wrong.

In biaxial stress field, the $\tau_{max} = \dfrac{\sigma_1 - \sigma_3}{2}$

104. 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

104. Ans: (b)

Sol:

True Bearing = Magnetic Bearing ± Magnetic declination

Use +ve for Eastern

-ve for Western

∴ T.B = 57° + 2° = 59°

M.B = T.B ∓ magnetic declination

use –ve for Eastern

+ve for western

= 59° +4° = 63° (N63°E)

105. Consider the following characteristics of contours:

   1. A uniforms 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

105. Ans: (b)

Sol:

Characteristics of contours:

1. The contour lines are closed curves. However they may close either on the map itself or outside the map, depending upon the topography.

2. The spacing between contour lines depends upon the slope of the ground. In steep slopes, the spacing is small, but for gentle slopes, the spacing is large.

3. If the contour lines are equally spaced, they indicate a uniform slope.

4. Irregular contours indicate rough, rugged terrain, whereas smooth contours denote gradual slopes and changes.

5. In case of a depression, the contours increase in elevation from inside to outside, whereas incase of a hill the contours increase in elevation from outside to inside.

6. Contour lines cross a ridge line/watershed line at right angles and forms V-shaped curves.

7. Contour lines cross a valley line at right angles and forms V-shaped curves.

8. Two contour lines of different elevations cannot cross each other except in case of over-hanging cliff

9. Two contour lines will meet and form a single line incase of vertical cliff.

Exp1anation: (b)

As the points 1, 2 & 3 given in the question paper are same as 3,1,5 points given above.

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

   1. Longitudinal levelling (L.S)

   2. Fly levelling

   3. Barometric levelling

   4. Cross-sectioning

   Select the *correct* answer using the codes given below:

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

106. Ans: (d)

Sol: Methods of levelling:

(1) Barometric   (2) Trigonometric   (3) Spirit levelling

Types of levelling:

1. Differential levelling /fly levelling

2. Precise levelling

3. Profile levelling

4. Longitudinal sectioning (L.S.) & Cross sectioning

5. Reciprocal levelling

Explanation: For laying a road or railway track, it is needed to conduct, fly levelling for calculating R.L's of various points marked on the centre line.

To know the in detail calculations for earth work excavation (cutting & filling) on both longitudinal and cross sectional directions, it is needed to conduct,

Longitudinal sectioning and cross sectioning. But Barometric levelling is not needed.

So, option: d (1,2 and 4) only

107. 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 $\dfrac{1}{9.81} = 0.102$.

(a) $2.25\ \log_e 19$ (b) $2\ \log_e 19$ (c) $2.25\ \log_e 39$ (d) $2\ \log_e 39$

107. Ans: (d)

Sol: Unsteady state Bernoulli's equation is

$$\frac{P_1}{\rho g} + \frac{V_1^{\,2}}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^{\,2}}{2g} + Z_2 + h_f + \frac{1}{g}\int \frac{\partial V}{\partial t}\,ds$$

$$H = 98.1\frac{V^2}{2g} + \frac{1}{g}\int_1^2 \frac{\partial V}{\partial t}\,ds$$
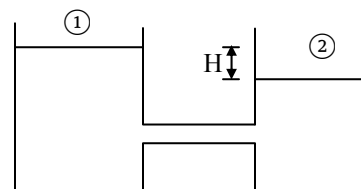
The integration is evaluated over reservoirs and pipe. However as velocity inside the reservoir is very small, the velocity gradient is also small and can be neglected. Therefore integration is evaluated over pipe only.

$$\therefore \int_{1}^{2} \frac{\partial V}{\partial t} \, ds = \frac{dV}{dt} \cdot L \quad (L = \text{pipe length})$$

$$H = \frac{98.1}{2g} V^2 + \frac{L}{g} \frac{dv}{dt}$$

$$H = 5V^2 + \frac{L}{g} \frac{dV}{dt}$$

$$(H - 5V^2) = \frac{L}{g} \frac{dV}{dt}$$

$$\frac{g}{L} dt = \frac{dV}{H - 5V^2} = \frac{dV}{5\left(\dfrac{H}{5} - V^2\right)}$$

$$\frac{5g}{L} dt = \frac{dV}{\dfrac{11.25}{5} - V^2}$$

$$\frac{5 \times 9.81}{294.3} dt = \frac{dV}{2.25 - V^2}$$

$$\frac{t}{6} = \frac{dV}{1.5^2 - V^2}$$

$$\int \frac{dx}{a^2 - x^2} = \frac{1}{2a} \ell n \left(\frac{a + x}{a - x}\right)$$

$$\therefore \frac{t}{6} = \frac{1}{3} \ell n \left(\frac{1.5 + V}{1.5 - V}\right)$$

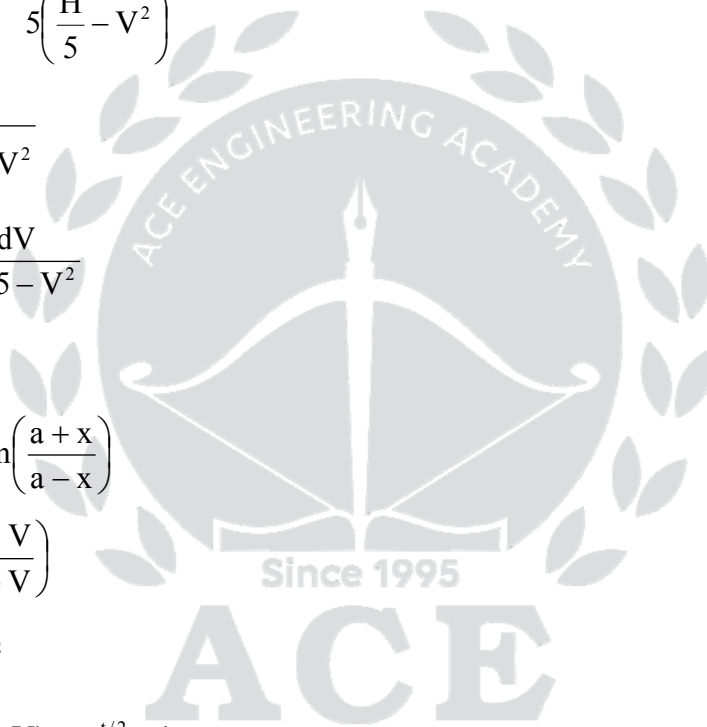$$\text{Or } \frac{1.5 + V}{1.5 - V} = e^{t/2}$$

$$\frac{(1.5 + V) + (1.5 - V)}{(1.5 + V) - (1.5 - V)} = \frac{e^{t/2} + 1}{e^{t/2} - 1}$$

$$\frac{3}{2V} = \frac{1 + e^{-t/2}}{1 - e^{-t/2}}$$

$$V = \frac{3}{2} \cdot \left(\frac{1 - e^{-t/2}}{1 + e^{-t/2}}\right)$$

$$V = V_{max} \text{ when } t \to \infty$$

$$\therefore V_{max} = \frac{3}{2} \, m/s$$

$$\frac{V}{V_{max}} = \frac{1 - e^{-t/2}}{1 + e^{-t/2}}$$

Let t = T at V = 0.95 V_{max}

$$\therefore 0.95 = \frac{1 - e^{-T/2}}{1 + e^{-T/2}}$$

$$\frac{0.95 + 1}{0.95 - 1} = \frac{(1 - e^{-T/2}) + (1 + e^{-T/2})}{1 - e^{-T/2}) - (1 + e^{-T/2})}$$

$$\frac{1.95}{-0.05} = \frac{2}{-2e^{-T/2}}$$

$$39 = e^{T/2}$$

$$T = 2\,ln\,39$$

108. 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***?

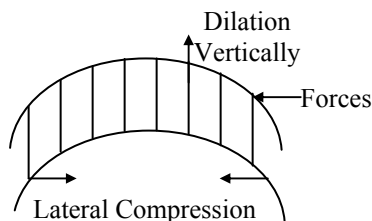(a) 1, 2 and 3 only   (b) 1, 3 and 4 only   (c) 1, 2 and 4 only   (d) 2, 3 and 4 only

108. Ans: (d)

Sol:

Sedimentary Bed   → Cleavage

(Before Folding)

Dilation Vertically

Forces

Lateral Compression
(After Folding)
Displacement of Cleavage planes

109. 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

109. Ans: (c)

Sol:

Geological information is most important in planning stage, design phase and construction phase of an engineering project.

Hydraulic structures like Dams can be built on competent rocks. Igneous rocks are formed from molten strata and are considered good constructions for building dams on them.

110. For an unconfined aquifer, the specific yield is 20%, specific retention is 15%, and permeability is 35m/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 he above statements are **correct?**

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

110. Ans: (a)

Sol:

$S_y = 20\%$, $S_r = 15\%$ K = 35 m/day

Porosity, $n = S_y + S_r$

$= 0.2 + 0.15 = 0.35 = 35\%$

Volume of water lost from storage $= S_y \times$ volume of a aquifer

$= 0.2 \times 100 \times 10^6 \times \ m^3$

$= 0.2 \times 100 \times 10^6 \times 1 \times \dfrac{1}{10^6} M.m^3 = 20 \ M.m^3$

T = KH = 35 × H (but H is not given)

111. 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

111. Ans: (c)

Sol:

The concentration of chloride are estimated by Mohr's method which is a titrometric procedure titrated with silver nitrate using potassium chromate as an indicator.

112. 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 magnitude of wheel load

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

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

112. Ans: (c)

Sol:

Thickness is based on CBR & CSA = $\dfrac{365A\{(1+r)^n - 1\}}{r} \times VDF \times LDF$

113. 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

113. Ans: (c)

Sol:

Transition curve is of varying radius and varying curvature can be introduced between straight line and curve or between branches of compound curve or reverse curve to provide a transition.

Purpose of providing transition curve:

1. It allows a gradual transition of curvature from the tangent to the circular curve or from circular curve to the tangent.

2. The radius of curvature increases or decreases gradually.

3. It is provided for the gradual change in superelevation in a convenient manner.

4. It eliminates the damper of derailment, overturning, slide slipping of vehicles and discomfort to the passengers.

Explanation: (c) The given two points 1 & 2 in the question paper as same as 1, 2 & 3 of the above.

114. 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

114. Ans: (d)

Sol:

In

i) **Simultaneous System:** All signals with same cycle length & divisions, operated simultaneously.

ii) **Alternate system:** All signals with same cycle length & divisions, operated alternatively.

iii) **Simple Progressive system:** Each signal with different cycle length & divisions, which are fixed.

iv) **Flexible Progressive system:** Each signal with varying cycle length & divisions.

115. 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

115. Ans: (b)

Sol:

Stage construction will not be preferred in rigid pavements due to high flexural stresses.

116. 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

116. Ans: (d)

Sol:
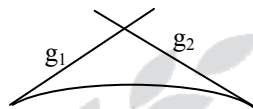
Circular curves are preferred over parabolic for vertical curves due to uniform change in the gradient.

117. 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

117. Ans: (b)

Sol:

Sensitivity of bubble tube in a level increases due to

1. The larger the radius of the tube (R)

2. The larger the length of a division (l)

3. The larger the diameter of the tube

4. The larger the length of the tube

5. The lesser the viscosity and the surface tension of the liquid in the tube.

Tube as 2,3 points are correct and same as points 2 & 5 as above.

118. 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

118. Ans: (a)

Sol:

Statement-1 & 2 are correct

In the capillary zone, the pore water pressure is negative (suction/tensile) as the water is held in the pores of soil due to surface tension, against the gravity.

Statement-3 is wrong.

The capillary pressure is more in fine grained soil as the capillary height is large due to small void size. In the case of coarse grained soil, the capillary pressure is very small or negligible.

$$h_c \propto \frac{1}{\text{diameter of void}}$$

119. Consider the following statements:

    For a rigid footing placed at the ground surface on sand, the contact pressure
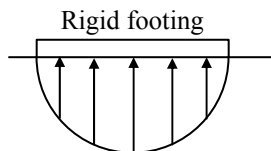
    1. is maximum at the edges

    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

119. Ans: (c)

Sol:

Pressure distribution under a rigid footing resting on sand.

120. 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) 1 only   (c) 2 only   (d) 3 only

120. Ans: (b)

Sol:

Statement-1 appears to be the most appropriate.

The bearing capacity of soil is usually implied to be the one which can be used for design (i.e. net allowable bearing capacity). The net allowable bearing capacity is the maximum net pressure at which there is neither shear failure nor excessive settlement.

The statements 2 & 3 are same in meaning and they are the definitions for 'net safe bearing capacity' which deals with shear failure criteria only.

*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) ad 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

121. **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.

121. Ans: (a)

Sol: 'Compreg' timber, pressed with resins, has high specific gravity and having higher strength.

The higher strength is achieved by impregnation of resins.

122. **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/mm².

122. Ans: (a)

Sol:

Deccan trap is having higher compressive strength, therefore it is a common building material for blast furnace foundations.

123. **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 are not heat insulators.

123. Ans: (c)

Sol: Statement 1 is correct: The new trend is to use glass blocks in place of conventional clay blocks.
Statement 2 is false: Infact, the clay bricks are thermal and heat insulators.

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

     Statement (II): Sponge iron can be produced in small plants using no-coking coal.

124. Ans: (a)

125. **Statement (I):** The fundamental storage equation through a river reach considers that the total inflow is 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

$$\frac{1}{2}(I_1 + I_2)t + \left(S_1 - \frac{1}{2}D_1t\right) = \left(S_2 + \frac{1}{2}D_2t\right),$$

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

125. Ans: (a)

Sol:

$$I - D = \frac{ds}{dt}$$

This can be written as

$$\bar{I} - \bar{D} = \frac{\Delta s}{\Delta t} \Rightarrow \frac{I_1 + I_2}{2} = \frac{S_2 - S_1}{\Delta t}$$

$$\left[\frac{I_1 + I_2}{2}\right]\Delta t + \left[\left(S_1 - \frac{D_1}{2}.\Delta t\right)\right] = S_2 + \frac{D_2}{2}\Delta t$$

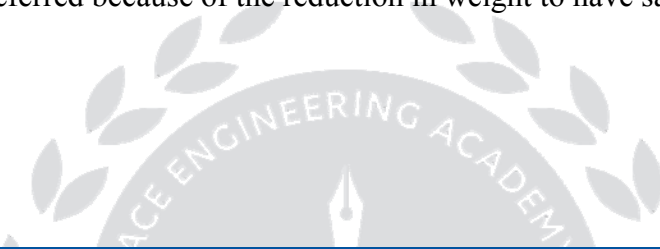∴ Statement I & II are true and II is correct explanation of I.

126. **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.

126. **Ans: (a)**

Sol:

Hollow shafts are preferred because of the reduction in weight to have same strength.

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

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

127. Ans: (a)

Sol:

Foam glass (glass with voids) is used in air conditioning system, as it is good thermal insulating property. It is also proved that foam glass is non-combustible and termite proof.

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

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

128. Ans: (c)

Sol:

Statement I: True

Statement II: False $\rightarrow$ The correct statement is displacements are the basic unknowns in the slope deflection method.

129. **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.

129. Ans: (a)

130. **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 on the 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.

130. Ans: (a)

131. **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.

131. Ans: (a)

Sol:

Statement I is correct

Collin's method is a successive approximation method.

For various duration, the multiple storms are recorded and by convolution method, the multiple storms are converted into a unit hydrograph.

Statement II is correct.

Unit graph is proportional to the net rain. If it is not proportional this method cannot be used.

So, both statements are true and Statement II is the correct explanation of statement I.

132. **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 CFC_s, methane and nitrous oxide absorbs as much heat as 15,000 molecules, 25 molecules and 230 molecules of CO_2, respectively.

132. Ans: (a)

Sol:

Tiny quantities are rare gases such as CFC, methane and NO cause global warming more than global warming caused by CO_2. Therefore both statements are correct. Statement 2 is correct explanation of statement 1.

133. **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.

133. Ans: (c)

Sol:

Small diameter sewers connected to large diameter sewers either by crown alignment (or) by invert alignment. But crown alignment is preferred to invert alignment which prevent back flow.

Therefore Statement 1 is correct, but statement 2 is wrong.

134. **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.

134. Ans: (a)

Sol:

The rate of biomass production will be always lower than rate of food utilization.

Metabolism : Catabolism + Anabolism

Catabolism : Convert food into waste product and energy

Anabolism: Energy derived in catabolism used is cellular synthesis and new cells form and trigger the growth.

Both statements are correct. Statement 2 is correct explanation of statement 1.

135. **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.

135. Ans: (a)

Sol:

Tangential component of velocity i.e whirl velocity component is neglected at smaller region of flow of runner wheel.

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

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

136. Ans: (c)

Sol:

Statement-I is correct. The shrinkage limit is the minimum water content at which soil is fully saturated.

Statement-II is wrong

Montmorillonite clay minerals are highly expansive.

137. **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.

137. Ans: (b)

Sol:

Statement-I is correct

The C and ϕ are usually called shear strength parameter of soils.

Statement-II is correct but not the explanation for statement-II

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

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

138. Ans: (a)

Sol:

Fine grained soils are difficult to drain, due to the low permeability of soil. Moreover, in fine grained soils the capillary forces are relatively high. Due to this capillary forces the water is held in the soil voids against gravity without getting drained.

139. **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.

139. Ans: (a)

Sol:

The phenomenon of cohesionless soils losing their shear strength due to sudden increase of pore pressures caused by reduction in volume of soil due to earthquake loads and other vibration effects and behaving like dense liquid is called liquefaction. This phenomenon generally takes place in the case of low permeable cohesionless soils like silts, fine sand and medium sand. The presence of fine particles reduces the permeability of soil which inturn reduces the dissipation of excess pore pressures and leads to liquefaction.

140. **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.

140. Ans: (a)

Sol:

(a) When it is required to find the true R.L difference between 2 points which are at longer distance apart and also not possible to keep the instrument in between them like in case of river or marine to balance the sights, reciprocal levelling is adopted.

(b) The following errors will be eliminated by reciprocal levelling.

1. Error in the line of collimation

2. Combined effect of curvature and refraction.

3. Variation in the average refraction

Explanation: Option (a)

Statement (I) is true, as per (a)

Statement (II) is true, as per (b)

Statement (II) is correct explanation of statement (I) as per (b) mentioned above

141. **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.

141. Ans: (a)

Sol:

(a)   Correction for curvature is applied if the distance between the 2-stations are very long as the line of or sight deviates from level line.
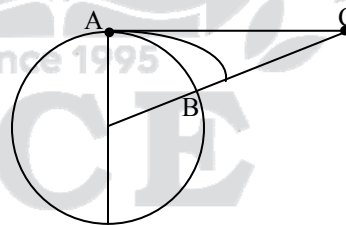
A → Location of Instrument

B → Levelling staff

AB → Levelling

AB = Distance

= D

AC → Line of sight.

(b)   Due to curvature of earth, the line of sight bisect as the levelling staff at 'C' but not at 'B' because line of sight is tangential to the level line at a point of observation.

Option : (a)

Statement (I) is true as per (a)

       II is true as per (b)

Statement (II) is correct explanation of statement (I) as per (b) above.

142. **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.

142. Ans: (d)

Sol:

(a) Remote sensing is the process of obtaining information about an object, terrain or phenomenon through the analysis of data acquired by a sensor device without having physical contact-with object, terrain, or phenomenon which are under observation.

Collection of data is usually carried out by highly sophisticated sensor. i.e. camera, multispectral scanners, radars etc.

(b) The data collected for and the field with sensors from satellite imageries can be examined by visual image interpretation technique for analysis to compile maps, tables and or computer files.

Explanation: (d)

Statement (I) is false as per (a) above because all old types of surveying cannot be replaced by remote sensing system.

Statement (II) is true as per (b) above.

143. **Statement (I):** Mud bricks can be completely replaced by Fly ash 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.

143. Ans: (a)

144. **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.

144. Ans: (d)

Sol: Softening of ground water is carried out only after removing iron and manganese by aeration. Aeration can produce insoluble precipitates of iron and manganese which can be settled out. If not removed it form iron and manganese zeolite instead of sodium zeolite which foul the exchange medium.

Statement I is wrong and Statement II is correct.

145. **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.

145. Ans: (c)

Sol: Statement-I is true

Consolidation is slow compression of soil due to expulsion of pore water under steady long term loading.

Statement-II is false.

Volume change occurs slowly after applying loads due to low permeability of the clay used in the consolidation tests.

146. **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.

146. Ans: (c)

Sol: Statement-I is true

Statement-II is false

Boussinesq's theory of stress distribution in soils is applicable to homogenous and isotropic soils only. The layered soil doesn't represent the homogeneity and isotropic condition. Hence for layered soils, Boussinesq's theory is not applicable. For layered soils, Westergaard's theory is appropriate.

147. **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 level recede.
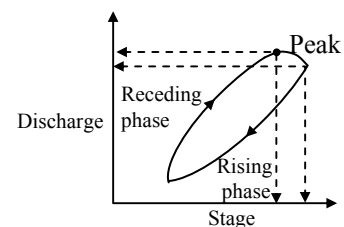
147. Ans: (c)

Sol: Statement I is correct.

The peak discharge occurring before maximum stage occurring.

Statement II is correct.

When flood wave recedes, all of the water stored recedes.

148. **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.

148. Ans: (a)

Sol:

$$I - Q = \frac{ds}{dt}$$

$$\Rightarrow I = Q + \frac{ds}{dt}$$

Both statements are correct

$$Q_n = C_o\, I_n + C_1\, I_{n-1} + C_2\, Q_{n-1}$$

149. **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.

149. Ans: (c)

Sol:

Incrustation of sand occur when filtration is carried out immediately after water softening with lime-soda process.

Incrustation occur due to calcium carbonate and magnesium hydroxide precipitates. Its not due to calcium hydroxide.

Therefore statement I is correct and statement II is incorrect.

150. **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.

150. Ans: (b)

Sol:

Statement I is correct.

The 5-day BOD at 20°C can be calculated with the help of dissolved oxygen.

$$y_5{}^{20°C} = [(DO)_I - (DO)_F] \times DF$$

Some amount of dissolved oxygen should be present in waste water.

Statement II is correct.

$$DO \propto \frac{1}{Temp}$$

For 0°C, the DO level is 15 mg/*lit*.
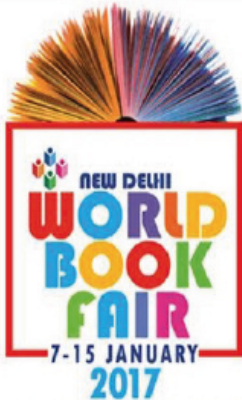
For 20°C, the DO level is 9 mg/*lit*.