LIVE RPSC-AE (DLB) Full Length Test Series

Civil Engineering

Full Length Paper - 9

Answer Key & Detailed Solution

Test Id - 509 **Date:- 07/05/2023**

1. (a)
2. (c)
3. (a)
4. (d)
5. (c)
6. (b)
7. (a)
8. (c)
9. (c)
10. (a)
11. (b)
12. (d)
13. (b)
14. (c)
15. (a)
16. (c)
17. **(c)**
18. (d)
19. **(b)**
20. **(c)**
21. **(d)**
22. **(c)**
23. **(c)**
24. **(b)**
25. **(c)**
26. **(a)**
27. **(b)**
28. **(d)**
29. **(a)**
30. **(b)**
31. **(d)**
32. **(c)**
33. **(a)**
34. **(c)**

35. (b)

36. (a)

37. (b)

38. (b)

39. (b)

40. (b)

41. (b)

Given:

$$G = K$$

$$\Rightarrow \quad \frac{E}{2(1+\mu)} = \frac{E}{3(1-2\mu)}$$

$$\Rightarrow \quad 2 + 2\mu = 3 - 6\mu$$

$$\Rightarrow \quad 8\mu = 1$$

$$\therefore \quad \mu = \frac{1}{8}$$

42. (b)

Amorphous Material - Materials in which atoms are arranged almost randomly, or those that do not have crystalline structure are called as amorphous materials.

Ex- Glass

Brittle Materials - A material is said to be brittle if, when subjected to stresses, it breaks with little elastic deformation without significant plastic failure i.e failure is sudden. Breaking is often accompanied by snapping sound.

Ex- Cast Iron, High Carbon steel

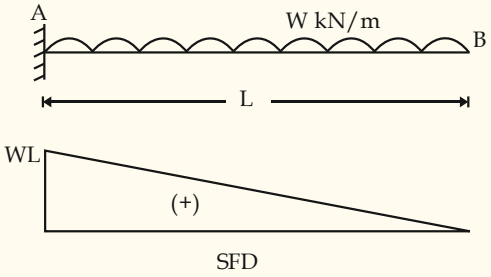
Elastic Material - A material is said to elastic if, it regains its original shape and size after removal of stresses from the material. Based on their behaviour they can be classified as linear and non-linear elastic material. A linear elastic material is one which obeys hooks law within the elastic limit while Non-linear elastic material does not obey hooks law.

Ex- Mild steel, Low carbon steel

Ceramic Material - A ceramic material is an inorganic, non-metallic often crystalline oxide, nitride or carbide material. Some elements such as carbon or silicon may be considered as ceramics. Ceramic materials are brittle, hard, strong in compression and weak in shearing and tension.

Ex- Earthenware, Porcelain, Brick

43. (c)



44. (d)

Ratio of $\frac{\text{Maximum shear stress}}{\text{Avg. shear stress}}$ for different cross-section is given below -

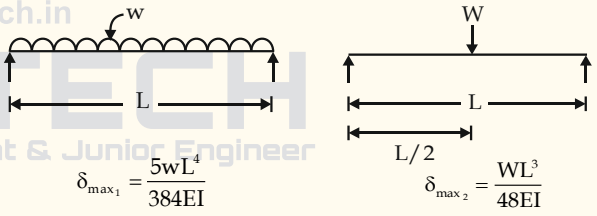
(1) For Rectangular section $= \frac{3}{2}$

(2) For Circular section $= \frac{4}{3}$

(3) For Triangular section $= \frac{3}{2}$

(4) For Diamond section $= \frac{9}{8}$

45. (d)



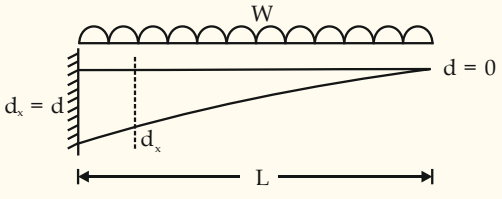
As per given in question,

$$\delta_{max_1} = \delta_{max_2}$$

$$\frac{5wL^4}{384EI} = \frac{WL^3}{48EI}$$

$$\Rightarrow \quad \frac{W}{w} = \frac{5}{8}L$$

46. (b)



Bending moment at fixed end, $M = \frac{WL^2}{2}$

Moment of inertia at fixed end, $I = \frac{bd^3}{12}$

Distance from centre to extreme fibre, $y = \frac{d}{2}$

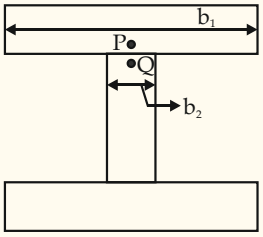
$$\frac{WL^2}{2\left(\frac{bd^3}{12}\right)} = \frac{\sigma}{d/2} \qquad \left[\because \frac{M}{I} = \frac{\sigma}{y}\right]$$

$$\frac{3WL^2}{bd^2} = \sigma$$

$$d^2 = \frac{3WL^2}{b\sigma}$$

$$d = \sqrt{\frac{3WL^2}{b\sigma}} \Rightarrow d = \sqrt{\frac{3W}{b\sigma}} \times L$$

47. (b)



Shear stress $\tau = \frac{VA\bar{y}}{Ib}$

$$\tau_p = 12 = \frac{VA\bar{y}}{Ib_1} = \frac{VA\bar{y}}{I \times 100}$$

Similarly, $\tau_Q = \frac{VA\bar{y}}{Ib_2} = \frac{VA\bar{y}}{(I)(20)}$

$$\frac{12}{\tau_Q} = \frac{20}{100} \Rightarrow \tau_Q = 60 \text{ MPa}$$

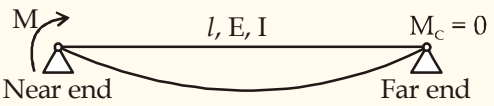
48. (a)

Carry-Over Factor (COF): It is the ratio of moment produced at the far end to the applied moment at that support end

$$\text{COF} = \frac{\text{Carry} - \text{over Moment at far end}}{\text{Applied Moment at Near end}}$$

Where, carry-over moment is the moment develop at one end due to the applied moment at another end.

In our case carry-over moment is zero



So, $\text{COF} = \frac{0}{M}$

$\therefore$ COF = 0

49. (b)

Degree of static indeterminacy i.e. D_S of pin jointed plane frame -

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

Here, given $(3m + r) > 3j$

or $(3m + r) - 3j > 0$

or $D_s > 0$

$D_s > 0$ i.e. structure is statically indeterminate generally indeterminate structures are stable

So, the frame will stable & statically indeterminate

50. (d)

Method-1 (By Formula)

The degree of **static indeterminacy** for a rigid hybrid frame is given by,

$$D_S = 3m + r_e - r_r - 3(j + j')$$

Where, m = total number of members = 9

r_e = total number of external reactions

$= 2 + 1 + 1 = 4$

r_r = total number of released reactions at hybrid joint

$= \Sigma(m_j - 1) = (2-1) + (2-1) = 2$

j = total number of rigid joints = 6

j' = total number of hybrid joints = 2

$\therefore \quad D_S = (3 \times 9) + 4 - 2 - 3(6 + 2)$

$= 27 + 4 - 2 - 24 = 31 - 26 = 5$

Method - II (By Loop Method)

$$D_{si} = 3C - r_r$$

where C = no. of closed loops

$= 3 \times 2 - 2 = 4$

$D_{se} = r_e - 3 = 1$

$D_s = D_{si} + D_{se} = 4 + 1 = 5$

51. (d)

$K_H = 9 \times 10^{-7}$ cm/sec

$K_V = 4 \times 10^{-7}$ cm/sec

$$K_{eq} = \sqrt{K_H \times K_V} = \sqrt{9\times10^{-7}\times4\times10^{-7}}$$
$$= 6 \times 10^{-7}\ \text{cm/sec}$$

52. (d)
The quantity of Seepage of water through soils is given by

$$q = k \times h \times \frac{N_f}{N_d}$$

From the above equation we can say that

$$q \propto k \propto h$$

Where,
k = Coefficient of permeability of soil
h = Total head loss through the soil

53. (a)
Active Earth Pressure

$$K_a = \frac{1-\sin\phi}{1+\sin\phi}$$

If ϕ increases then active earth pressure coefficient decreases.
Passive Earth Pressure

$$K_P = \frac{1+\sin\phi}{1-\sin\phi}$$

If ϕ increases then passive earth pressure coefficient also increases.

54. (a)
As we know that -
q_u = 1.3 CN_C + $\gamma D_f N_q$ + 0.4 $B\gamma N_\gamma$ (For square footing)
q_u = 1.3 CN_C + $\gamma D_f N_q$ + 0.3 $B\gamma N_\gamma$ (For circular footing)
As both footings mention in question is on cohesionless soil and are founded on a surface so, c = 0 and D_f = 0 for both footings.
So, q_u for circular $= 0.3B\gamma N_\gamma$
and q_u for square footing $= 0.4\ B\gamma N_\gamma$

Hence, $\frac{q_{u\ circular}}{q_{u\ square}} = \frac{3}{4}$

55. **(a)**

Dry Density, $(\gamma_d) = \frac{G\gamma_w}{1+e}$

$$1.65 = \frac{2.65\times1}{1+e}$$

(γ_w = 1 gm/cc = 1000 kg/m^3)

$$e = \frac{2.65}{1.65} - 1 = 0.606$$

Degree of saturation, $(S) = \frac{wG}{e} = \frac{20.5\times2.65}{0.606}$
$= 89.6\%$
% of air content $= 100 - S$
$= 100 - 89.60$
$= 10.4\%$

56. **(a)**
Coefficient of gradation/curvature (C_c)

$$= \frac{D_{30}^2}{D_{60}\times D_{10}} = 1$$

Coefficient of uniformity $(C_u) = \frac{D_{60}}{D_{10}} = 4$

Where, D_{10} = Effective size of particle
= Particle size such that 10% of the soil is finer than this size
D_{30} = Particle size such that 30% of the soil is finer than this size
D_{60} = Particle size such that 60% of the soil is finer than this size

To find $\frac{D_{10}}{D_{30}} = ?$

$$\frac{D_{60}}{D_{10}} = 4 \Rightarrow D_{60} = 4D_{10} \quad \text{... (i)}$$

$$\frac{D_{30}^2}{D_{60}\times D_{10}} = 1 \quad \text{... (ii)}$$

Substitute (i) in (ii)

$$\frac{D_{30}^2}{4D_{10}\times D_{10}} = 1$$

$$\frac{D_{30}^2}{D_{10}^2} = 4 \Rightarrow \frac{D_{30}}{D_{10}} = 2$$

$$\frac{D_{10}}{D_{30}} = \frac{1}{2} = 0.5$$

57. **(d)**

Compression index $(C_c) = \frac{\Delta e}{\log(\sigma_2) - \log(\sigma_1)}$

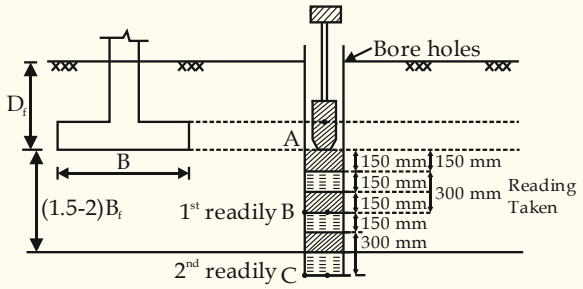
$$0.28 = \frac{\Delta e}{\log\left(\frac{\sigma_2}{\sigma_1}\right)}$$

$$\Rightarrow \quad 0.28 = \frac{\Delta e}{\log\left(\frac{21.6}{12}\right)} = \frac{\Delta e}{\log(1.8)}$$

$$\Rightarrow \quad \Delta e = (0.28 \times 0.255) = 0.0714$$

58. (d)

SPT Test :



- The values of 'N' is determined at Number of Selected bore holes and average value of corrected (N) is calculated for the depth from $[D_f + (1.5 - 2)B]$.
- While calculating the average value of (N), any value greater than 50% of average value is discarded.
- Suitable for **Granular soil.**
- Split spoon samples is used in the bore hole.
- Bore hole is advanced to a depth at which N-value is to be calculated.
- The split-spoon sampler is allowed to penetrate into the soil by applying impact load of 63.5 kg having a free fall of 75 cm.
- The sampler is allowed to penetrate for 150 mm depth, but reading is not noted i.e. (No. of blows required for 150 mm penetration is not Noted).
- Then the sampler is allowed to penetrate, further for 300 mm and No. of blows required to penetrate the sampler to this 300 mm is the SPT N-value

Corrections required for N-values :

1. Over burden correction

- It is necessary because the N-value will have effect on it due to confinement of soil at various depth.
- Two granular soils possessing the same relative density but having different confining pressures are tested, the one with a higher confining pressure will give higher N value.
- If N_0 = observed S.P.T. value then,

$$N_1 = N_0 \times \frac{350}{(\bar{\sigma} + 70)}$$

Where,

$\bar{\sigma}$ = Effective stress at level of test (kN/m^2)

N_1 = Corrected N-value of overburden.

- Overburden correction will not be applied if $\bar{\sigma} > 280\ kN/m^2$

2. Dilatancy Correction

- It is applied to the already corrected N-values for overburden pressure. Dilatancy correction is required only if [N_1 > 15] in saturated fine sand and silt (i.e., when water table is above test level). Corrected N value after Dilatancy Correction i.e. N_2 is

$$N_2 = 15 + \frac{1}{2}(N_1 - 15)$$

- This correction becomes more significant for fine dense sand.

59. (b)

$$\bar{\sigma}_n = \sigma - u$$
$$= 300 - 150$$
$$= 150\,kN/m^2$$
$$\tau = c + \bar{\sigma}_n \tan\phi'$$
$$= 10 + (150)\tan 30°$$
$$= 96.6\,kPa$$

60. (c)

As per IS 800 : 2007, Table 5, Clause : 5.4.1

Partial safety factor for material, γ_m		
S.No.	**Definition**	**Partial Safety Factor**
i.	Resistance, governed by yielding, γ_{mo}	1.1
ii.	Resistance of member to buckling, γ_{mo}	1.1
iii.	Resistance, governed by ultimate stress, γ_{ml}	1.25

61. (c)

Maximum pitch of rivets in tension i.e. p

$$= \text{Min. of} \begin{cases} 16\,t\ mm = 160\ mm \\ 200\ mm \end{cases}$$

Hence, p = 160 mm

62. (c)

To connect web & flange the fillet weld is horizontal so, size of weld will be according to horizontal shear force between the flanges &

web. Fillet welds mainly resists shear force along the weld.

63. (d)

In grillage footing, maximum shear occurs at the edge of the base plate and shear in the beam is zero at its ends and at the centre.

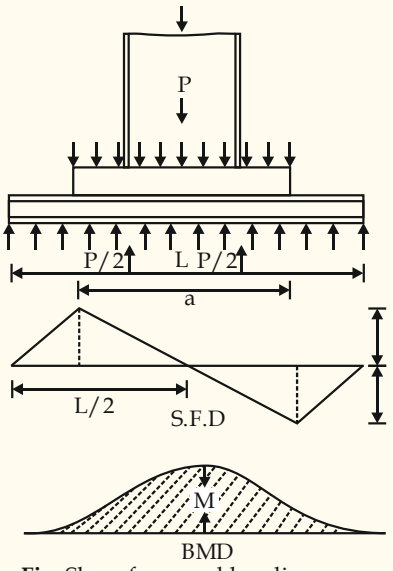


Fig. Shear force and bending moment diagrams for grillage beams

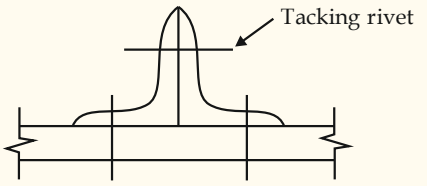
64. (a)

Splices: Splices in tension member are used to join two sections when a joint is to be provided i.e. these replace the members at the joint where it is cut.

The splice section as well as the connection are designed for the tensile load to be transmitted by the main tension member i.e. for the strength of main member.

65. (b)

Where tacking rivets is exposed to weather, pitch in line should not exceed 16 t or 200 mm.



66. (b)

Flexural tensile strength of concrete is given by modulus of rupture (f_{cr})

$$f_{cr} = 0.7\sqrt{f_{ck}}$$

$$= 0.7\sqrt{f_{ck}}$$

$$= 3.5\ N/mm^2$$

67. (c)

In both WSM and LSM, the assumption "The plane sections normal before bending remain normal after bending" is valid.

Note :-

This assumption implies that strain profile is linear.

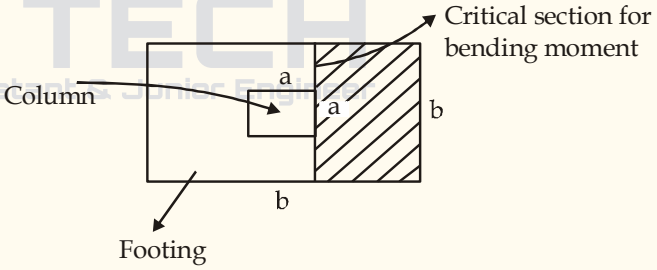
68. (b)

As per IS 456 : 2000 clause 26.5.1.5, The maximum spacing of shear reinforcement measured allong the axis of member shall not exceed **0.75 d** for vertical stirrups and **d** for inclined stirrups at 45°, where d is the effective depth of the section under consideration. In no case shall the spacing exceed 300 mm

69. (d)

In flat slabs, minimum thickness of slab shall be 125 mm (Clause 31.2.1, IS-456)

70. (a)



$$M = \frac{wl^2}{2} = \frac{pb[b/2 - a/2]^2}{2}$$

$$= \frac{pb[b-a]^2}{8}$$

71. (c)

Nominal shear stress = τ_v

Design shear strength = τ_c

Maximum design shear strength = $\tau_{c,max}$

(i) If $\tau_v > \tau_c$, then shear reinforcement is

provided for a shear force equal to $(\tau_v - \tau_c)$ bd.

(ii) If $\tau_v < \tau_c$, then minimum shear reinforcement is provided i.e.,

- $\tau_v < 0.5\tau_c \Rightarrow$ No shear reinforcement is required for beam.
- $0.5\tau_c \le \tau_v \le \tau_c \Rightarrow$ Provide minimum shear reinforcement.

(iii) If $\tau_v > \tau_{cmax}$, then concrete will fail in diagonal compression failure (brittle failure), in this case either the concrete of higher grade is adopted or dimension of section has to be increased.

$$0.87 f_y A_{sv}\left(\frac{d}{s_v}\right) = (\tau_v - \tau_c)bd$$

A_{sv} = Shear reinforcement area
d = Effective depth of beam
s_v = Spacing of shear reinforcement

Minimum shear reinforcement

$$0.87 f_y A_{sv}\left(\frac{d}{s_v}\right) = 0.4bd$$

72. (d)

By over-reinforced beam the moment of resistance can be increased not more than **25%.**

Singly Reinforced Beam : The beam that is longitudinally reinforced only in tension zone, it is known as singly reinforced beam.

Doubly Reinforced Beam : If the section dimensions are given & $M_u > M_{u,lim}$ provision of singly reinforced section will make the beam over-reinforced.

Hence, section dimensions need to be modified or higher grade of steel/concrete should be used.

If section dimension can not be modified (preferably depth), we need to provide steel on compression side also & the resulting section is called doubly reinforced beam.

Also the moment of resistance cannot be increased by increasing the amount of steel in tension zone. If can be increased by making the beam over reinforced but not more than **25%.** Thus, a doubly reinforced beam is provided to increase the moment of resistance of a beam having limited dimensions.

Besides this doubly reinforced section is also used in situation where reversal of moments is likely to occur.

Also, advantage of using compression reinforcement is reduction in long term deflection due to shrinkage & creep.

73. (a)

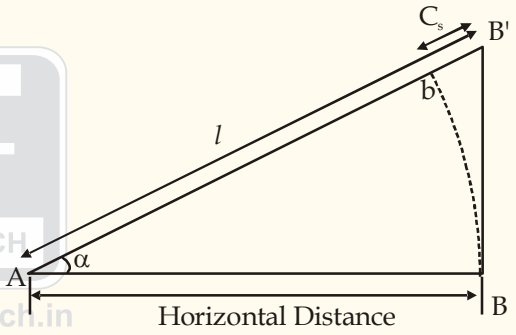
According to IS 456-2000

(i) The maximum compressive strain in concrete in axial compression is taken as 0.002.

(ii) The maximum compressive strain at the highly compressed extreme fibre in concrete subjected to axial compression and bending and when there is no tension on the section shall be 0.0035 minus 0.75 times the strain at the least compressed extreme fibre.

(iii) Maximum strain when compression and tension both occurred is taken as 0.0035.

74. (b)



So, horizontal distance = $l \cos\alpha$

Thus correction i.e. C_S is

C_S = Horizontal length – Length along slope

$C_S = l\cos\alpha - l$

$= l(\cos\alpha - 1)$

From Trigonometry,

As we know that -

$\cos 2q = 2\cos^2 q - 1 = 1 - 2\sin^2 q$

So, $\cos\alpha = 2\cos^2\frac{\alpha}{2} - 1 = 1 - 2\sin^2\frac{\alpha}{2}$

$$\therefore \quad C_S = l\left(1 - 2\sin^2\frac{\alpha}{2} - 1\right)$$

$$C_S = -2l\sin^2\frac{\alpha}{2}$$

Hence, Correction = $-2l\sin^2\frac{\alpha}{2}$

75. (d)

If fore-bearing of a line is S49°52'E and there is

no local attraction, then back bearing will be the same but quadrant will change i.e. N49°52'W

76. (b)

Horizontal distance between any two consecutive contours is called **Horizontal equivalent.**

Vertical distance between any two consecutive contours is called contour interval.

77. (d)

Given:

Length of one division of the main scale, S = 0.5 mm

Least count of vernier, L.C. = 0.05 mm

The least count (L.C.) of the vernier is equal to the value of the smallest division on the main scale (S) divided by total number (n) of division on the vernier.

$$L.C. = \frac{S}{n}$$

$$0.05 = \frac{0.5}{n}$$

$$n = 10$$

Total number of division on the vernier, n = 10

78. (b)

There are two types of errors in chaining –

Compensating error

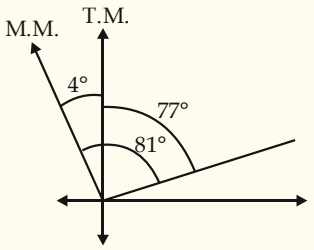
- These are caused by incorrect holding and marking of arrow, incorrect plumbing at slopes etc.
- These errors are proportional to square root of the length of a line
- They do not affect result much
- They can't be corrected.

Cumulative error

- These errors are liable to occur in same direction and tend to accumulate e.g. error due to sag, slope etc.
- These errors are proportional to length of line.
- They can be corrected.

79. Calculate the magnetic declination, if the magnetic bearing of a line is N 81°E and true bearing of the line isN77°E.

(a) +4 degree east ward
(b) –8 degree east ward
(c) –4 degree west ward
(d) +4 degree south ward



(c)

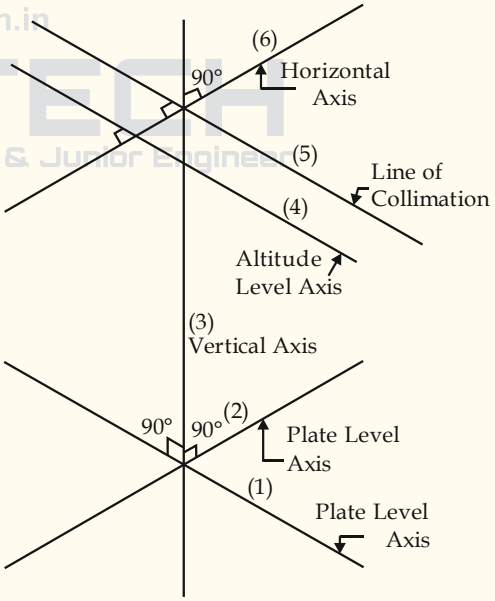
Given: Magnetic bearing = N81°E
True bearing = N77°E
True bearing = Magnetic bearing + Magnetic Declination
77° = 81° + Magnetic Declination
Magnetic Declination = –4° or 4°W

80. (c)

When theodolite is properly adjusted tangent to plate bubble tube must be perpendicular to vertical axis.

Note: Fundamental Lines of Theodolite

- The fundamental lines of a theodolite are the **vertical axis, the axis of plate levels, the line of collimation, the horizontal axis and the bubble line of altitude.**
- When the theodolite is in proper adjustment, following conditions should be satisfied.



1. Horizontal circle perpendicular to vertical axis.
2. Vertical circle perpendicular to horizontal axis.
3. Vertical axis must pass through the centre of

graduated horizontal circle.
4. Horizontal axis must pass through the centre of vertical circle.
5. **Tangent to plate bubble tube must be perpendicular to vertical axis.**
6. Line of sight must be perpendicular to transit axis (trunnion axis).
7. Transit axis must be perpendicular to vertical axis.
8. For horizontal position of telescope and for altitude bubble at centre, reading on vertical circle must be zero.
9. Line of sight, horizontal axis and vertical axis must meet at one point called the centres of instrument.

81. (c)

$$h = \frac{\text{Difference of staff reading at } P_1 \text{ and } Q_1 \text{ when instrument is at P} + \text{Difference of staff readings at } P_1 \text{ and } Q_1 \text{ when instrument is at Q}}{2}$$

$$\Rightarrow h = \frac{(2.800 - 1.700) + (2.700 - 1.800)}{2}$$

$$\Rightarrow h = 1$$

Staff reading shows that station Q is above station P

Hence, Reduced level of station Q
= Reduced level of P + h
$= 100.000 + 1 = 101.000\,m$

82. (b)

G is a measure of relative velocity of two particles of fluid and distance between them and Unit of G is sec^{-1}.

- For flocculation process, G = 20-75 s^{-1}
- For coagulation process, G > 300 s^{-1}

83. (d)

The ultimate BOD value of waste is the amount of biodegradable organic matter presents in the sewage sample. At any temperature the amount of organic matter present does not change, So the ultimate BOD will remain same for any temperature.

84. (b)

Soak pit:

- Soak pit is preferred only when water table is low, available land area is less.
- When a porous layer underlies an impervious layer at the top.
- **Dimension :**
  Minimum horizontal dimension = 1 m
  Minimum depth below invert level = 1 m

85. (c)

Year	Population	Increase in population
1951	100000	
		9000
1961	109000	
		7000
1971	116000	
		12000
1981	128000	

According to Arithmetical increase method

$$P_n = P_0 + nx$$

Given $n = \frac{2021 - 1981}{10} = 4$

$P_0 = 128000$

$\bar{x} = \frac{9000 + 7000 + 12000}{3} = 9333.33$

$P_{2021} = 128000 + 4 \times 9333.33 = 165333$

86. (c)

From Kuichling's formula,

$$Q = 3182\sqrt{P}$$

Where, Q = Amount of water in lit/min
P = Population in thousand

Hence, $Q = 3182\sqrt{\frac{400000}{1000}} = 63640$ lit / min

87. (b)

Alum react with alkalinity present in the water and leads to the formation of sticky Gelatinous precipitate (floc) of aluminium hydroxide ($Al(OH)_3$). $Al(OH)_3$ attracts other fine particles and suspended impurities over its surface and thus grow in size and gets easily settled in secondary sedimentation tank.

$$Al_2(SO_4)_3.18H_2O + 3Ca(HCO_3)_2 \rightarrow 2Al(OH)_3\downarrow + 3CaSO_4 + 6CO_2 + 18H_2O$$

Note: The above process also tends to add the permanent hardness ($CaSO_4$) and acidity (CO_2) in the water leads to corrosion.

- Effective in the pH range of 6.5 – 8.5
- Normal does is 10 – 30 mg/L of water.

88. (b)

A trap which is provided to disconnect house drain from the street sewer is called

intercepting trap.

Intercepting trap is provided at the junction of a house sewer and a municipal sewer so as to prevent the entry of foul gases of the municipal sewer into the house drainage system.

89. (c)

Following operational problems occur in standard rate trickling filters (because of their low hydraulic loading rate)

1. **Fly Nuisance:** Larvas of insects act as food for the flies. As filter medium is open to atmospheres, so insects grow over the surface of the filter.
2. **Odour problem:** Due to anaerobic decomposition of wastewater during intermittent flow.
3. **Ponding problem:** Due to chocking of the voids as sloughing do not take place due to low HLR.

90. (a)

Compressibility (β) of ideal fluid = 0

We know that compressibility is reciprocal of bulk modulus (k)

So,

$$k = \frac{1}{\beta} = \frac{1}{0} = \infty$$

OR

An Ideal fluid is incompressible $\Rightarrow \Delta V = 0$

$$\because \quad k = \frac{\Delta P}{\left(\frac{\Delta V}{V}\right)} = \infty$$

91. (d)

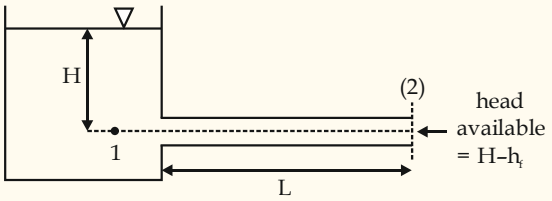
As we know that relationship between chezy's constant (C) and friction factor (f) is

$$C = \sqrt{\frac{8g}{f}}$$

So,
$$C \propto \frac{1}{\sqrt{f}}$$

92. (a)

Power transmission through pipe



Neglecting minor losses

Power available at point (2) $= \gamma Q(H - h_f)$

Power available at point (1) $= \gamma QH$

Efficiency of power transmission

$$\eta = \frac{\gamma Q(H - h_f)}{\gamma QH} = \frac{H - h_f}{H}$$

Condition for max power transmission

$$P = \gamma Q(H - h_f) = \gamma Q\left[H - \frac{flQ^2}{12.1D^5}\right]$$

For max power transmission,

$$\frac{dP}{dQ} = \gamma\left[H - \frac{3flQ^2}{12.1D^5}\right] = \gamma[H - 3h_f] = 0$$

$$H = 3h_f \Rightarrow h_f = \frac{H}{3}$$

Efficiency (η) (for max power transmission)

$$= \frac{H - h_f}{H} = \frac{2}{3} = 66.67\%$$

93. (a)

Given that:

Depth of flow (y) = 1 m

Velocity of flow (V) (D/s) = 2m/sec

As we know that,

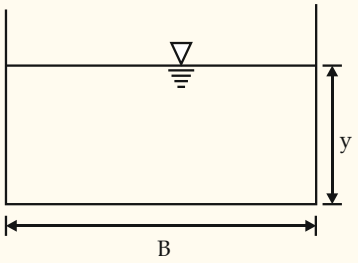
Velocity of wave in upstream side is

$$V_{wave} = C_0 - V$$

Where,

V = Velocity of flow = 2 m/sec

C_0 = Celerity i.e. represents a speed with which the disturbance created to flow travels in still water.



and $C_0 = \sqrt{g\frac{A}{T}} = \sqrt{g\frac{(By)}{P}} = \sqrt{gy}$

$\Rightarrow$ $C_0 = \sqrt{9.81\times 1} = 3.132 \text{ m/sec}$

$\therefore$ $V_{wave} = C_0 - V = 3.132 - 2$

$= 1.132 \text{ m/sec}$

Hence, velocity with which elementary wave can travel upstream is 1.132 m/sec.

Note: Velocity of wave in downstream side

$= C_0 + V = 3.132 + 2$

$= 5.132 \text{ m/sec}$

94. (c)

Given:

Diameter of sphere, D = 30 cm = 0.3 m

Velocity of sphere, V = 4 m/s

Dynamic viscosity, μ = 0.8 poise = 0.08 Pa-sec

Specific gravity of the liquid, G = 0.9

Reynolds number is defined as $\frac{VD}{\nu}$

where, ν = Kinematic Viscosity

$= \frac{\text{Dynamic Viscosity}}{\text{Density}}$

$\nu = \frac{\mu}{G\rho_w} = \frac{0.8\times 10^{-1}}{0.9\times 1000} = 8.88\times 10^{-5}$ Pa.sec

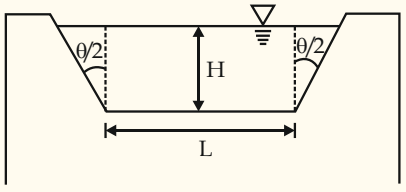
V = Velocity of flow = 4 m/sec

Hence, $R_e = \frac{VD}{\nu} = \frac{4\times 0.3}{0.08}\times 0.9\times 1000 = 13500$

Note : Reynold's Number (R_e) is defined as the ratio of inertia force of flowing fluid to the viscous force of the fluid.

95. (a)

For cippoletti weir,



(i) Side slope = 1 H : 4 V

(ii) $\tan\left(\frac{\theta}{2}\right) = \frac{1}{4}$ or $\theta = 28°$

(iii) Trapezoidal section

96. (c)

A hydraulically equivalent pipe means a pipe which can replace existing compound pipe while carrying same discharge under same losses. Thus, hydraulically equivalent pipes will have same discharge under same head loss.

Given :

Pipe 1: Length of the pipe 1, l_1 = 32000 m
Diameter of the pipe 1, d_1 = ?

Pipe 2: Length of the pipe 2, l_2 = 1000 m
Diameter of the pipe 2, d_2 = 0.2 m
Neglecting minor losses (and assuming 'f' to be same)

$h_{L1} = h_{L2}$

$\frac{8fl_1Q^2}{\pi^2 g d_1^5} = \frac{8fl_2Q^2}{\pi^2 g d_2^5}$

$\frac{l_1}{d_1^5} = \frac{l_2}{d_2^5}$

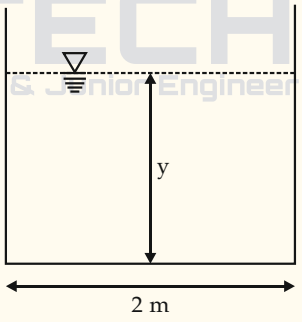
$d_1^5 = \frac{d_2^5}{l_2}\times l_1 = \frac{(0.2)^5\times 32000}{1000}$

$d_1 = \left(\frac{(0.2)^5\times 32000}{1000}\right)^{1/5}$

$= (0.2)^{5\times\frac{1}{5}}\left(2^5\right)^{\frac{1}{5}}$

$= 0.2\times 2 = 0.4\text{m}$

97. (a)



$S = \frac{1}{1000}, C = 50$

For maximum discharge, $R = \frac{y}{2}$ & $y = \frac{B}{2}$

Hence, $R = \frac{B}{4} = \frac{2}{4} = 0.5\text{m}$

98. (b)

As we know that,

Mechanical widening $= \frac{nl^2}{2R}$

For width = 10.5 m, n = 3

Hence, mechanical widening $= \frac{3l^2}{2R}$

99. (b)

Warning signs are in the shape of equilateral triangle with their apex pointing in upward direction. They have a white background, red border and black symbols. Warning signs are also known as cautionary signs

100. (c)

The Benkelman beam method is widely used for evaluation of the structural capacity of existing flexible pavements and also for estimation and design of flexible overlays for the strengthening of any weak pavement for highways.

101. (a)

Various methods for carrying out speed and delay studies are

- License plate method
- Interview technique
- Photographic technique
- Floating car method

102. (a)

Given: Ruling gradient $= \frac{100}{20} = 5\%$

Grade compensation (GC)

$$= \min\left\{\left(\frac{30+R}{R}\right)\%, \left(\frac{75}{R}\right)\%\right\}$$

$$= \min\left\{\left(\frac{30+200}{200}\right)\%, \left(\frac{75}{200}\right)\%\right\}$$

$$= \min\{1.15\%, 0.375\%\}$$

$$= 0.375\% \simeq 0.38$$

$(\text{Compensated gradient})_{\text{final}}$ = [(Initial gradient)–(GC)] = 5% – 0.38% = 4.62% $\not<$ 4%

- It is given after grade compensation the grade to be provided should not be less than 4%.

So compensated gradient = 4.62%

Note: Grade compensation:

- When a vehicle is negotiating a horizontal curve, if there is a gradient also, then there will be increased resistance to traction due to both curve and the gradient.
- When sharp horizontal curve is to be introduced on a road the gradient should be decreased to compensate for the loss of tractive effort due to the curve.
- This reduction in gradient at the horizontal curve is called 'grade compensation', which is intended to off-set the extra tractive effort involved at the curve.
- Grade compensation is not required for grades flatter than 4% because the loss of tractive force is negligible.

103. (c)

Theoretical capacity $= 1000 \times \frac{V}{S}$

$V \rightarrow$ Velocity in (kmph)

$S \rightarrow$ Spacing of vehicles (m)

$C = 1000 \times \frac{40}{12.8} = 3125$ vehicles / hr / lane

104. (c)

Comparison between Tar & Bitumen

Properties	Bitumen	Tar
1. Colour	Colour is black to dark brown	Colour same as bitumen
2. Production	Bitumen is a petroleum product	Tar is produced by the destructive distillation of coal or wood
3. Solubility	Bitumen is soluble in carbon disulphide (CS_2) & in carbon tetrachloride (CCl_4)	Tar is soluble only in Toluene (C_7H_8)
4. Ductility	Bitumen is less ductile	Tar is more ductile compare to bitumen
5. Temperature susceptibility	Bitumen are less temperature susceptible	Tar is more temperature susceptible resulting in greater variation in viscosity with temperature
6. Carbon content	Bitumen has less free carbon content	Tar having more free carbon content as seen from solubility test

105. (d)

In stone masonry, the pressure acting on the stones in stone masonry construction should be perpendicular to the direction of bedding planes to ensure maximum strength of stonework.

106. (c)

Composition of Cement				
S. No.	**Constituents**	**Formula**	**Range**	**Average**
1	Lime	(CaO)	62 - 67%	64%
2	Silica	(SiO_2)	17 - 25%	20%
3	Alumina	(Al_2O_3)	3 - 8%	6%
4	Calcium Sulphate	($CaSO_4$)	3 - 4%	3%
5	Iron oxide	(Fe_2O_3)	3 - 4%	3%
6	Magnesia	(MgO)	1 - 3%	1%
7	Sulphur	(S)	1 - 2%	1%
8	Alkalies	(K_2O, Na_2O)	0.2 - 1%	0.5%

107. (b)

Fat Lime:

- Also known as high calcium lime, pure lime, rich lime or white lime.
- Slakes vigorously and its volume increases about 2-2.5 times volume of quick lime.
- Impurities < 5%

Uses:

- White washing and plastering of walls.
- As lime mortar in thin joints.
- Manufacture of cement.
- In metallurgical industry.

108. (b)

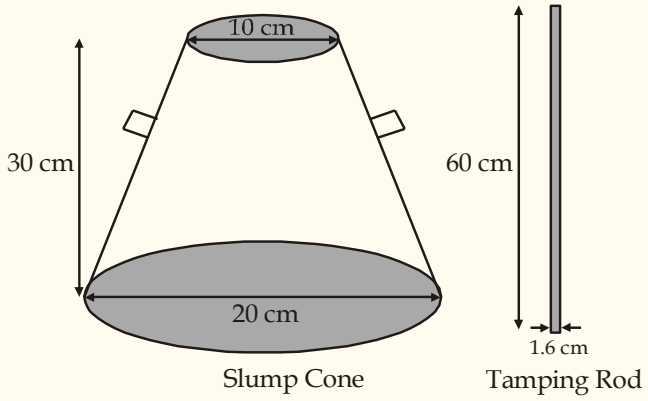
Slump tests is one of the most extensively and most commonly used method for determining the consistency of concrete which relates work-ability.

Slump cone

Bottom diameter : 20 cm or 200 mm

Top diameter : 10 cm or 100 mm

Height : 30 cm or 300 mm



109. (a)

Plenum System :

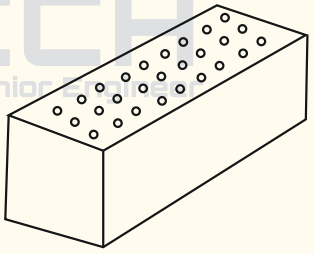
A system of mechanical ventilation in which fresh air is forced into the spaces to be ventilated from a chamber (plenum chamber) at a pressure slightly higher than atmospheric pressure, so as to expel foul air.

110. (b)

Hollow bricks are also called perforated bricks.

Burnt Clay Perforated Bricks (IS : 2222)

- These bricks have cylindrical holes throughout their thickness. **These bricks are light in weight have heat insulating properties,** require less quantity of clay, drying and burning of these bricks is easy



Perforated brick

- Direction of perforations can be vertical or horizontal
- Area of perforations shall be between 30 to 45% of the area of face
- Area of each perforation shall not exceed 500 mm^2
- Shall have minimum average compressive strength of 7 N/mm^2 on net area.
- For 24-hour cold water test water absorption > 20% by dry weight.
- The modular and non modular size available is 19 × 9 × 9 cm and 23 × 11 × 7 cm respectively.

- Efflorescence should not be more than slight.
- Average Warpage < 3 percent.

111. (d)

Name	Property	Use
Chir	• It is moderately • It decays easily	Used in framing of doors, windows, pattern making etc.
Shisham	• Strong and tough • Durable and maintains its shape well • Easily seasoned • Difficult to work with	• In high class furniture • In sport goods • For decorative works and carvings
Sal	• Hard and coarse grained • Light in colour when freshly cut • Resinous and less durable • Not suitable for painting	• It has medicinal uses • Used in Ayurveda for thousand of years to treat variety of diseases including piles, skin disorders, dysentery etc.
Teak	• Moderately hard • Durable and fire resistant • Easily seasoned and worked • Not attached by white ants & dry rot • Shrinks less	• Limited to superior work only as it is comparatively very costly • For ship building furniture, railway carriages, mallets etc.

112. (b)

Concentration of soluble salts (μmho/cm)	Type of Irrigation water
0-250	C_1(Low saline water)
250-750	C_2(Moderate saline water)
750-2250	C_3(High saline water)
> 2250	C_4(Very high saline water)

113. (c)

Crop period : It is the time in days, that a crop takes from the instant of its sowing to that of its harvesting.

Base period : It is the time in days between the first watering of a crop at the time of its sowing to its last watering before harvesting.

114. (b)

Concrete or Masonry Gravity Dam :

- The bottom portion of concrete or a masonry gravity dam is usually stepped at the base to **increase the shear strength at the base and at other joints.**
- It also enhances the bonds between the dam and the rock foundation.
- By ensuring a better bond between the surfaces the shear strength of these joints should be increased as much as possible.

115. (d)

Given -

$$Q = 3\ m^3/sec,$$
$$CCA = 1500\ ha,$$
$$IOI(\%) = 50$$
$$B = 140\ days$$

$$\text{Area to be irrigated} = \frac{IOI(\%)}{100} \times CCA$$

$$= \frac{50}{100} \times 1500 = 750\ ha$$

$$\text{Duty, } D = \frac{\text{Area to be irrigated}}{\text{Discharge}} = \frac{750}{3}$$

$$= 250\ ha/cumec$$

$$\because \Delta(m) = \frac{8.64\ B}{D} = \frac{8.64 \times 140}{250} = 4.8384\ m$$

116. (a)

Mulching

- It is the process of applying or spreading material to the surface of soil.
- It helps in conservation of soil moisture, improving fertility and health of the soil, reducing weed growth, **increases infiltration and reduces evaporation.**

Paleo Irrigation

- It is defined as the watering done prior to the sowing of a crop.
- This is done to prepare the land for sowing and to add sufficient moisture to the soil which would be required for the initial growth of the crop.

Ploughing: It is the process of turn up the earth (an area of land) with a plough, especially before sowing.

Tillage: It is the agricultural preparation of soil by mechanical agitation of various types such as digging, striking and overturning.

117. (d)

Net Irrigation Requirement (NIR) = 15 cm

Water Application Efficiency (n_a) = 80% = 0.80

Water Conveyance Efficiency (n_c) = 60% = 0.60

To calculate: Gross Irrigation Requirement (GIR)

As we know that,

$$GIR = \frac{FIR}{n_c} = \frac{NIR}{n_a . n_c}$$

Where,

FIR = Field Irrigation Requirement $= \frac{NIR}{\eta_a}$

$$\therefore \quad GIR = \frac{15\,cm}{0.8 \times 0.6}$$

$$GIR = 31.25\ cm$$

118. (b)

(1) Saturation Capacity

- Saturation capacity is defined as the total water content of a soil when all the pores of the soil are filled with water.
- This is also known as the maximum water holding capacity of the soil.
- At saturation capacity, soil moisture tension is almost equal to zero as it is equal to the surface tension at free water surface.

(2) Field Capacity

- Field capacity is defined as the maximum amount of moisture which can be held by a soil against gravity. After the gravity water has drained off.
- Field capacity is the upper limit of the capillary water or the moisture content available to the plant roots.
- The soil moisture tension at field capacity ranges between 1/10 to 1/3 atmospheres.

(3) Permanent wilting point

- Permanent wilting point is the moisture content at which the films of water around the soil particles are held so tightly that the plant roots cannot extract enough moisture at sufficiently rapid rate to satisfy transpiration requirements thus resulting in the wilting of the plants.
- The soil moisture tension of a soil at the permanent wilting point ranges from 7 to 32 atmospheres depending on soil texture, kind and condition of the plants etc.

(4) Available moisture

- The difference in moisture content of the soil between the field capacity and the permanent wilting point is termed as the available moisture.
- Also called as maximum storage capacity of soil.

(5) Readily available moisture

- It is that portion of the available moisture which is most easily extracted by plant roots.
- Only about 75% of the available moisture is usually readily available

119. (a)

1. Wetted perimeter,

$$P = 4.75\sqrt{Q}$$

$$\Rightarrow \quad P \propto \sqrt{Q}$$

Hence, P increase with increase in design discharge.

2. Hydraulic radius, $R = \frac{5}{2}\frac{V^2}{f}$

$$R \propto \frac{1}{f}$$

Hence, R decreases with increase in silt factor.

Also consider,

$$v = \left(\frac{Qf^2}{140}\right)^{1/6}$$

or $$v^6 = \frac{Qf^2}{140}$$

or $Q \propto \frac{1}{f^2}$

120. (b)

Useful storage = Volume of water stored in reservoir between normal and minimum pool level

Surcharge storage = Volume of water stored between the maximum pool level and normal pool level

Valley storage = Before construction of the dam, a variable amount of water is stored in the stream channel called valley storage

Effective storage for flood mitigation = Useful storage + surcharge storage – valley storage