LIVE RPSC-AE (DLB) Full Length Test Series

Civil Engineering

Full Length Paper - 1

Answer Key & Detailed Solution

Test Id - 501 **Date:- 12/03/2023**

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

31. (d)

32. (a)

33. (c)

34. (b)

35. (b)

36. (a)

37. (d)

38. (c)

39. (d)

40. (b)

41. (c)

- Loss in strength of soil due to remoulding at same water content is termed as **sensitivity**.
- Over a period of time soil regain a part of its lost strength is termed as **thixotropy**.
- When **seepage** takes place in upward direction, seepage pressure acts in upward direction and effective stress is reduced, consequently shear strength is reduced.
- In **liquefaction**, due to dynamic/cyclic loading in loose saturated sand, effective stress decreases and decrease in shear strength is recorded.

42. (d)

$N_f = 7$ $N_d = 24$ $H = 6$ m

Critical Hydraulic Gradient,

$$i_c = \frac{G-1}{1+e} = \frac{2.7-1}{1+0.7} = 1$$

Exit Gradient (i_{exit})

$$= \frac{\Delta h}{l} = \frac{\left(\frac{H}{N_d}\right)}{l} = \frac{\left(\frac{6m}{24}\right)}{1m} = \frac{1}{4}$$

$$\text{F.O.S.} = \frac{i_c}{i_{exit}} = \frac{1}{\left(\frac{1}{4}\right)} = 4$$

43. (c)

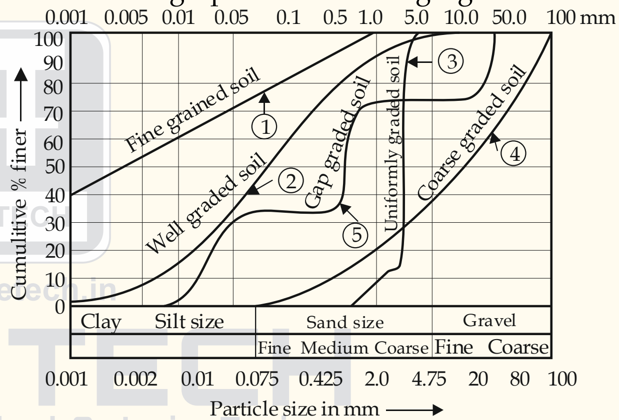
Pore pressure parameter B lies in between 0 to 1 and **pore pressure parameter A** may be as low as -0.5 and may be as high as 3.

44. (b)

Type of Soil	Transportation/Deposition
Lacustrine Soil	Deposited at the bottom of lake
Alluvial Soil	Transportation by running water
Aeolian Soil	Transportation by wind
Marine Soil	Deposited in sea water
Colluvial Soil	Transportation by gravity force
Glacial Soil	Transportation by ice

45. (c)

Steep slope in partial size distribution curve indicates a uniform graded/uniform size soil as shown is graph 3 of following figure.



46. (d)

The effect of compaction in dry of optimum and wet of optimum is shown in the following table:

Soil Property	Dry of Optimum	Wet of Optimum
Soil mineral structure	Flocculated clay structure, more random	Dispersed clay structure, more oriented
Pore water pressure	Lower pore water pressure at low strains	Higher pore water pressure at low strains
Shrinkage	Less	More
Swell	More	Less
Permeability	More	Less
Strength	Higher	Lower

47. (b)

Specific gravity of the soil can be measured by

(a) 50 ml density bottle

(b) 500 ml flask

(c) Pycnometer

- Density bottle method is the most accurate amongst all and is suitable for all types of soil.
- Flask and Pycnometer is suitable to be used for coarse grained soil and if it is used for fine grained soil then kerosene is used instead of water as it is better wetting reagent than water.
- In Density bottle only kerosene is used

48. (a)

The expression for calculating coefficient of permeability (k) by constant head lab method is as follows

$$k = \frac{V}{t\,i\,A}$$

Where,

V = Volume of water flow through the soil mass/ medium under constant head in any time 't'

A = Cross-sectional area of soil medium

i = Constant head (h) under which flow takes place divided by length of flow (l) i.e.

$i = \frac{h}{l}$ (hydraulic gradient)

Hence, $$k = \frac{V.l}{t.h.A}$$

$$k = \frac{500\times10^{-6}\times10^{9}\,mm^{3}\times60\,mm}{600\,sec\times500\,mm\times5000\,mm^{2}}$$

$$k = 0.02\,mm/sec$$

49. (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 $= 0.3 B\gamma N_\gamma$

and q_u for square footing $= 0.4\ B\gamma N_\gamma$

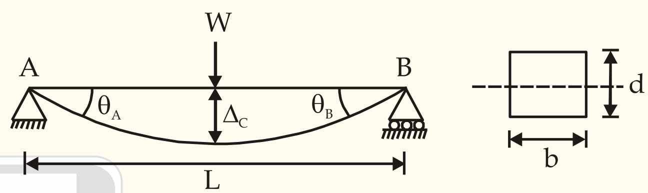
Hence, $$\frac{q_{u)\,circular}}{q_{u)\,square}} = \frac{3}{4}$$

50. (a)

- **Brinell hardness test uses hardened steel ball as an indentor.**
- It is 10 mm diameter ball.
- **Diamond indentor is used in Rockwell test.**
- Brinell hardness test is used for checking the hardness of a material. Here, a hardened steel or tungsten carbide ball indentor is forced into the surface of metal to be tested.

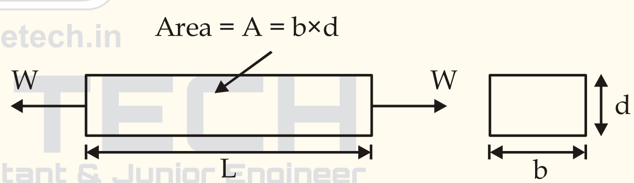
51. (c)

(a) When bar is simply supported subjected to load W at centre. Deflection will be



$$\Delta_C = \frac{WL^3}{48EI}$$

(b) Expansion in the bar due to the same load 'w'.



$$e = \frac{WL}{AE} = \frac{W\times L}{b\times d\times E}$$

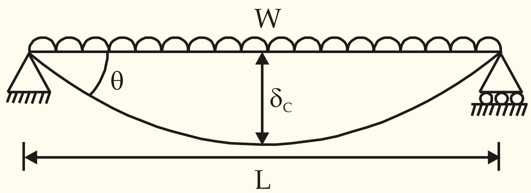
(c) Ratio of maximum deflection to the elongation

$$\frac{\Delta_C}{e} = \frac{\frac{WL^3}{48EI}}{\frac{WL}{b\times d\times E}} = \frac{L^2}{48\times I}\times b\times d$$

$$\frac{\Delta_C}{e} = \frac{L^2}{48\times\frac{bd^3}{12}}\times b\times d = \frac{L^2}{4d^2} = \left(\frac{L}{2d}\right)^2 \quad \left(\because I = \frac{bd^3}{12}\right)$$

$$\frac{\Delta_C}{e} = \left(\frac{L}{2d}\right)^2$$

52. (d)



Deflection is given by, $\delta_C = \frac{5}{384}\frac{wL^4}{EI}$

Slope is given by, $\theta = \frac{wL^3}{24EI}$

$$\delta_C = 10\,\text{mm} = \frac{5}{384}\frac{wL^4}{EI} \quad \text{... (i)}$$

$$\theta = 0.002 = \frac{wL^3}{24EI}$$

$$\frac{wL^3}{EI} = 0.002 \times 24 = 0.048 \quad \text{... (ii)}$$

Using equation (ii) in equation (i)

$$\frac{5}{384} \times 0.048 \times L = 10$$

$$L = 16000\,\text{mm} = 16\,\text{m}$$

53. (c)

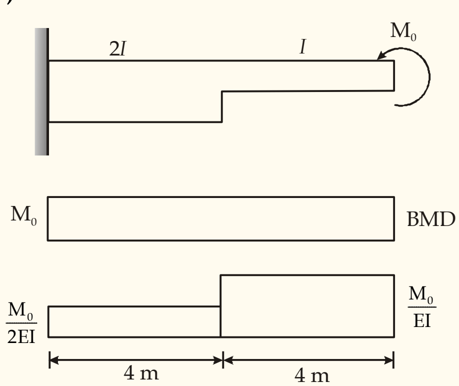
$$\because \frac{\text{Flexural rigidity}}{\text{Torsional rigidity}} = \frac{EI}{GJ} = \frac{E.\frac{\pi}{64}D^4}{G\frac{\pi}{32}D^4} = \frac{E}{2G}$$

$$\because \quad G = \frac{E}{2(1+v)}$$

$$\therefore \frac{\text{Flexural rigidity}}{\text{Torsional rigidity}} = \frac{E}{2 \times \frac{E}{2(1+v)}}$$

$$= 1 + v$$

54. (c)



$\because$ Deflection at free end

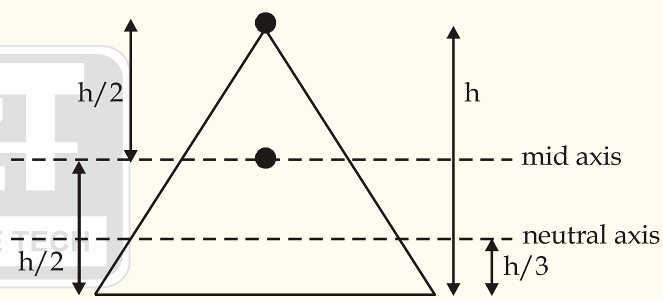
$$= \frac{M_0}{2EI} \times 4 \times (4+2) + \frac{M_0}{EI} \times 4 \times 2 = \frac{20M_0}{EI}$$

55. (a)

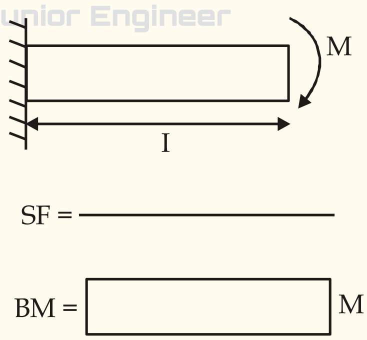
- At the point of maximum bending stress, shear stress is always zero but at the point of maximum shear stress, bending stress is not necessarily zero.

  For example -

  - In triangle we get maximum bending stress at ends where shear stress is zero but we get maximum shear stress at mid-axis (at distance h/2 from either end) and at this point bending stress is not zero while bending stress is zero at neutral axis (at distance h/3 from bottom end) which is different from mid axis in case of triangle.



56. (d)



57. (d)

Method of analysis of determinate structure

- Double integration method
- Macaulay's method
- Moment area method
- Conjugate beam method

Method of analysis of indeterminate structure	
Force method	**Displacement method**
– Consistent deformation method	– Slope deflection method
– Energy method	– Moment distribution method
– Unit load method	– Kani's method
– Flexibility matrix method	– Stiffness matrix method

58. (b)

$$D_s = D_{se} + D_{si}$$

D_{se} = External static indeterminacy = Re – 3

= 6 – 3 = 3

D_{si} = Internal static indeterminacy = 3 × a – r

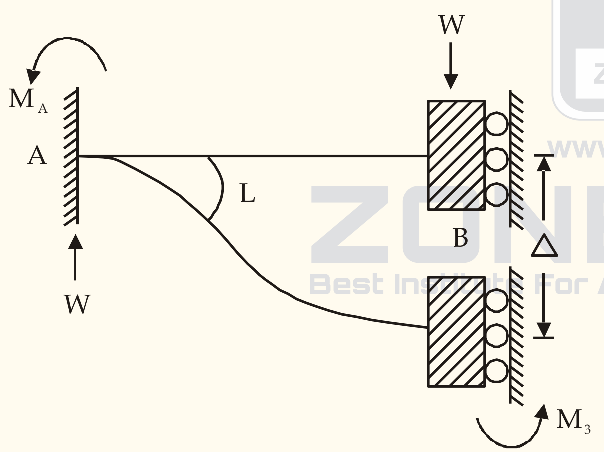
= 3 × 2 – {(2 – 1) + (2 – 1)}

= 4

D_s = 3 + 4 = 7

59. (c)

Let deflection at the end B due to load W be Δ.



$$\therefore \quad M_A = \frac{6EI\Delta}{L^2}(\text{anticlockwise})$$

$$M_B = \frac{6EI\Delta}{L^2}(\text{anticlockwise})$$

Taking moments about B, we get

$$-WL + M_A + M_B = 0$$

$$\Rightarrow \quad M_A + M_B = WL \; [\because M_A = M_B]$$

$$\Rightarrow \quad 2M_B = WL$$

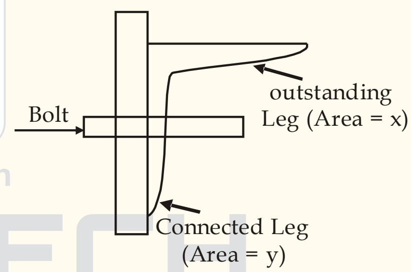
$$\Rightarrow \quad M_B = \frac{WL}{2}$$

60. (a)

As per IS 800 : 2007

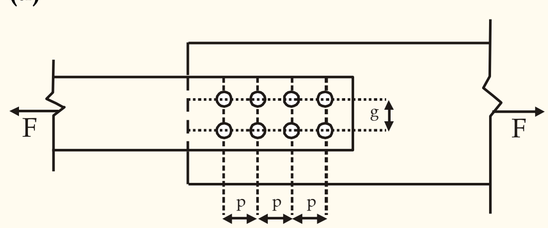
S.No.	Member	Maximum Slenderness Ratio
1	A tension member in which a reversal of direct stress due to loads other than wind or seismic forces occurs.	180
2	A member normally acting as a tie in a roof truss or a bracing system but subjected to possible reversal of stresses resulting from the action of the wind or earthquake forces.	350
3	Members always under tension (other than pre-tensioned members).	400

61. (c)



$A_n = y + kx$

62. (a)



- **Pitch (p) :** Distance between the centers of two adjacent fasteners lying on the same rivet or bolt line measured parallel to the direction of the force.

  Maximum pitch :

  Tension member - Min. of (16t or 200 mm)

  Compression member - Min. of (12t or 200 mm)

  t = Thickness of thinner connected member.
- **Gauge distance (g) :** Perpendicular distance between two adjacent gauge lines.

63. (c)

According to IS: 800 Purlin should be designed as a continuous beam.

Purlins are subjected to vertical loads due to dead and live loads and to loads normal to roof covering due to wind pressure. Therefore, purlins are subjected to biaxial bending.

Note :

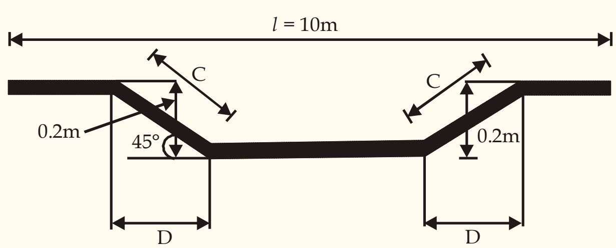
As per IS 800 - 2007 (clause 8.9), the maximum bending moment of purlins is $WL^2/10$.

64. (d)

As per IS 456 : 2000, Cl 11.3.1:

	Type of Formwork	Minimum Period Before Striking Formwork
(a)	Vertical formwork to columns, walls, beams	16-24h
(b)	Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)	3 days
(c)	Soffit formwork to beams (Props to be refixed immediately after removal of formwork)	7 days
(d)	Props to slabs	
	1. Spanning up to 4.5 m	7 days
	2. Spanning over 4.5 m	14 days
(e)	Props to beams and arches:	
	1. Spanning up to 6 m	14 days
	2. Spanning over 6 m	21 days

65. (a)



Length or reinforcement bar $= l + 2C - 2D$

$$= 10 + \frac{2 \times 0.2}{\sin 45°} - \frac{2 \times 0.2}{\tan 45°}$$

$$= 10 + \frac{2 \times 0.2}{\left(\frac{1}{\sqrt{2}}\right)} - \frac{2 \times 0.2}{1}$$

$$= 10.1657 \text{ m}$$

$$= 10.17 \text{ m}$$

66. (a)

Sr. No.	Tested as per	Permissible
1. Organic	IS 3025 (Part 18)	200 mg/L
2. Inorganic	IS 3025 (Part 18)	3000 mg/L
3. Sulphates (as SO_3)	IS 3025 (Part 24)	400 mg/L
4. Chlorides	IS 3025 (Part 32)	2000 mg/L (for plain concrete) 500 mg/L (for reinforced concrete)
5. Suspended matter	IS 3025 (Part 17)	2000 mg/L

67. (b)

Lap length of reinforcement in compression shall not be less than 24 ϕ.

Lap length of reinforcement in flexural tension shall be greater of L_d or 30ϕ.

Lap length of reinforcement in direct tension shall be greater of $2L_d$ or 30ϕ.

where L_d is the development length.

68. (a)

According to IS : 8112-2013

Time after which strength measured	Compressive strength (in MPa)
72 ± 1h, minimum	23
108 ± 2h, minimum	33
672 ± 4h, minimum	43
672 ± 4h, maximum	58

69. (d)

Reinforcement that will be required in central width band is :

$$\frac{\text{Reinforcement in central band width}}{\text{Total reinforcement in short direction}} = \frac{2}{\beta+1}$$

where,

β is the ratio of the longer side to the shorter side of the footing.

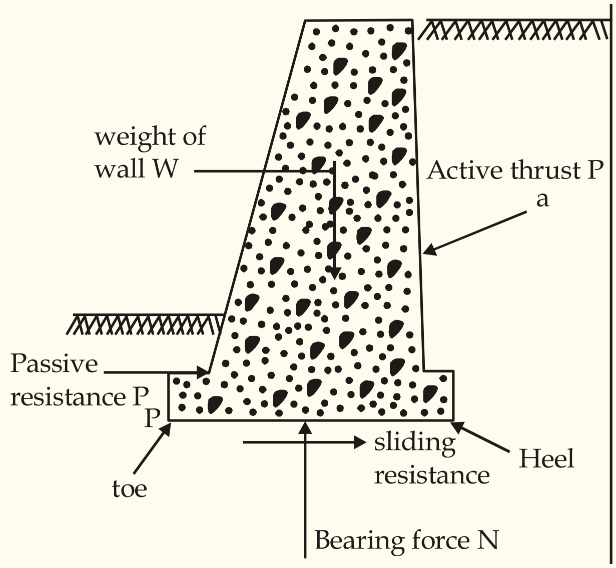
Longer side of footing = 3 m

The shorter side of footing = 2 m

Hence, $\beta = \frac{3}{2} = 1.5$

$$\frac{\text{Reinforcement in central band width}}{x} = \frac{2}{1.5+1} = 0.8$$

Reinforcement in central band width = 0.8x.



70. (d)

Retaining wall:

A retaining wall or retaining structure is used for maintaining the ground surfaces at different elevations on either side of it.

Whenever embankments are involved in construction, retaining walls usually necessary.

Types of retaining wall:

Depending upon the mechanisms used to carry the earth's pressure, some of the examples of retaining walls are:

Gravity retaining wall

Cantilever retaining wall

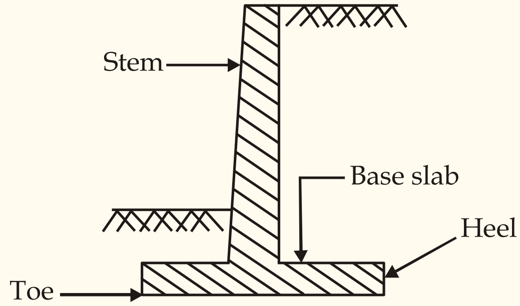
Counter-fort retaining wall / Buttressed retaining wall

Gravity retaining wall:

- Gravity retaining wall depends on its self weight only to resist lateral earth pressure.
- Commonly, gravity retaining wall is massive because it requires significant gravity load to counter-act soil pressure.
- Sliding, overturning, and bearing forces shall be taken into consideration while this type of retaining wall structure is designed.
- It can be constructed from different materials such as concrete, stone, and masonry units.
- It is not used for heights of more than 3.0 m.
- In it, the resistance to the earth's pressure is generated by the weight of the structure.

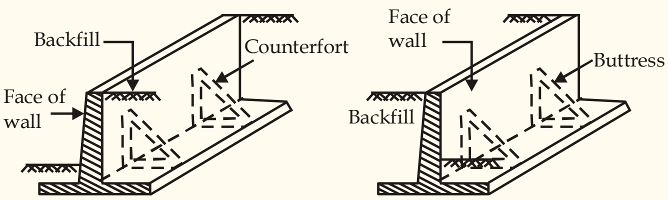
Cantilever retaining wall:

- Cantilever retaining wall composed of stem and base slab
- It is constructed from reinforced concrete, precast concrete, or prestress concrete.
- Cantilever retaining wall is the most common type used as retaining walls.
- Cantilever retaining wall is either constructed on site or prefabricated offsite i.e. precast.
- The portion of the base slab beneath backfill material is termed as heel, and the other part is called toe.
- Cantilever retaining wall is economical up to height of 6.0 m.
- It requires smaller quantity of concrete compare with gravity wall but its design and construction shall be executed carefully.
- Similar to gravity wall, sliding, overturning, and bearing pressure shall be taken into consideration during its design.



Counter-fort retaining wall / Buttressed retaining wall:

- It is a cantilever retaining wall but strengthened with counter forts monolithic with the back of the wall slab and base slab.
- Counter fort spacing is equal or slightly larger than half of the counter-fort height.
- These retaining walls are economical for height over about 6 m.



71. (d)

- For cube test, two types of specimens either cubes of 15 cm × 15 cm × 15 cm or 10 cm × 10 cm × 10 cm depending upon the size of aggregate are used.
- For most of the works cubical moulds of size, 15 cm × 15 cm × 15 cm are commonly used.
- This concrete is poured into the mould and tempered properly so as not to have any voids.
- After 24 hours these moulds are removed and test specimens are put in water for curing.
- The top surface of these specimen should be made even and smooth.
- This is done by putting cement paste and spreading smoothly on the whole area of the specimen.
- As per Clause 15.4 of IS 456-2000, the test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than ± 15% of the average. If more, the test results of the sample are invalid

72. (d)

Critical Sections for shear:

(i) While designing a concrete member for flexural shear, the critical section has to be located where the shear force reaches its maximum value, and/or where the area of cross-section is the minimum.

(ii) In Flexural members, maximum shear force generally occurs at the face of the support. (CL. 22.6.2 of IS 456:2000).

(iii) In the case of point loads, shear force is very high at locations between the support and the first concentrated load.

(iv) It is quite evident that support reaction gives rise to traverse compression in the end regions of the concrete member.

(v) This increases the shear strength of this region (i.e. support region) and the inclined cracks do not develop near the face of the support. In such a case, the critical section is located at a distance 'd' from the support faces (CL. 22.6.2.1 of IS 456:2000).

73. (d)

Divisional island is type of traffic island constructed within the roadway to establish physical channels through which vehicular traffic may be divided. Multilane highway are separated by constructing divisional islands to reduce accidents and also to reduce night glare from coming vehicles.

74. (d)

IRC 37 : 1985 deals with design of flexible pavement taking cumulative axle loads and CBR into account.

75. (c)

According to the third road development plan, the roads in the country are classified into three classes, for the purpose of transport planning, functional identification and assigning priorities on a road network :

- Primary System.
- Secondary System.
- Tertiary System.

76. (a)

Los Angeles Abrasion Test :

The principle of the Los Angeles Abrasion Test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as an abrasive charge. Los Angeles machine consists of circular drum of internal diameter 700 mm and length 520 mm mounted on a horizontal axis enabling it to be rotated. An abrasive charge consisting of cast iron spherical balls of 48 mm diameters and weight 340-445g is placed in the cylinder along with the aggregates.

The cylinder is then locked and rotated at the speed of 30-33 rpm for a total of 500-1000 revolutions depending upon the gradation of aggregates.

After specified revolutions, the material is sieved through 1.7 mm sieve and passed fraction is expressed as percentage total Weight of the sample.

This value is called the Los Angeles abrasion value. A maximum value of 40 percent is allowed for WBM base course in Indian conditions. For Bituminous concrete, a maximum value of 35 percent is specified.

77. (a)

Bridge Alignment:

Depending upon the angle which the bridge makes with the axis of the river, the alignment can be of two types:

a) Square Alignment:- In this, the bridge is at right angle to the axis of the river.

b) Skew Alignment:- In this the bridge is at some angle to the axis of the river which is not a right angle.

As far as possible, it is always desirable to provide square alignment.

The skew alignment suffers from the following disadvantages:-

- A great skill is required for the construction of Skew Bridges. Maintenance of such type of Bridges is also difficult.
- The water-pressure on piers in case of skew alignment is also excessive because of non-uniform flow of water underneath the bridge superstructure.
- The foundation of skew bridge is more susceptible to scour action.

78. (c)

Ideal shape of summit curve is circular due to constant sight distance throughout the curve.

In practice we use square parabolic curve because it is easy to compute and also give good riding comfort.

79. (b)

Initial concavity in CBR test is due to :

- Improper compaction
- Soft top layer
- Inclined plunger
- Uneven top surface

80. (b)

Radius of relative stiffness,

$$l = \left[\frac{Eh^3}{12k\left(1-\mu^2\right)}\right]^{1/4}$$

As μ increases then $1 - \mu^2$ decreases

$\therefore$ Relative stiffness also increases.

$\therefore$ Statement 1 is False.

As modulus of subgrade reaction (k) increases, (l) decreases

$\therefore$ Statement 2 is False.

81. (d)

Alkalinity of water sample is due to presence of $[HCO_3^-]$ and $[CO_3^{2-}]$

Total alkalinity = 1 mole of $[HCO_3^-]$ + 2 mole of $[CO_3^{2-}]$ in terms of $CaCO_3$

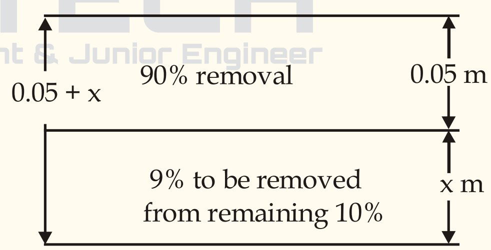
$$= \left(2\times10^{-3}\times50 + 2\times3.04 \times10^{-4}\times50\right)\times10^{3}\ \text{mg}/l$$

$$= 130.4\ \text{mg}/l \text{ as } CaCO_3$$

82. (b)

The sum total of organic nitrogen and ammonia nitrogen is called Kjeldahl nitrogen.

83. (a)



From the remaining 10% particles, 9% has to be removed, hence again 90% efficiency is to be achieved. So same depth i.e., 0.05 m has to be added to the filter of 0.05 m. Therefore, total depth to achieve 99% efficiency becomes 0.10 m.

84. (d)

The correct sequence of water treatment processes are:

Coagulation → Flocculation → Sedimentation → Filtration → Disinfection

85. **(a)**

	Dia of sewer	Design depth
1.	< 400 mm	1/2 depth of sewer pipe
2.	400 – 900 mm	2/3 depth of sewer pipe
3.	> 900 mm	3/4 depth of sewer pipe

86. **(d)**

Surface loading rate i.e. $\frac{\text{Flow rate}}{\text{Surface area}}$ is

$$= \frac{720}{12 \times 1.5} = 40\,\text{m}^3/\text{hr}/\text{m}^2$$

$$= 40{,}000 \text{ liter/hr/m}^2$$

Detention time i.e. $\frac{\text{Volume}}{\text{Flow rate}}$ is

$$= \frac{12 \times 1.5 \times 0.8}{(720/60)} = 1.2 \text{ minutes}$$

87. **(b)**

Efficiency of low rate trickling filter

$$= 100/\left(1 + 0.0044(\mu)^{1/2}\right)$$

$$= 100/\left(1 + 0.0044(900)^{1/2}\right)$$

$$= 100/1.132$$

$$= 88.3\%$$

88. **(c)**

The depth of Euphotic zone is measured by Secchi disk where it is put in the lake and the depth at which the disk becomes invisible is taken as the depth of Euphotic zone.

89. **(d)**

Temporary adjustment :

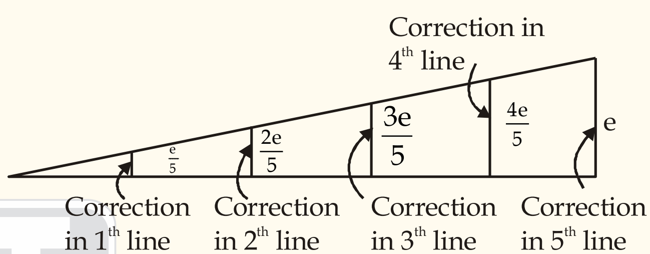
- Temporary adjustments are the adjustments which are required to be made at each setting of instrument before taking observations.
- Following five temporary adjustments are required
  1. Setting up
  2. Centering
  3. Levelling
  4. Focusing the eye-piece
  5. Focusing the objective

Permanent adjustment :

1. Horizontal axis should be perpendicular to vertical axis.

   Furthermore, vertical circle should also be perpendicular to horizontal axis.
2. The axis of plate bubble tube should be perpendicular to vertical axis.
3. The line of sight should be perpendicular to vertical axis.
4. When the telescope is horizontal and the altitude bubble is in center, the reading in vertical circle should be zero.

90. **(c)**



91. **(b)**

Phenomenon	Staff reading	Nature of correction	Reduce level
Refraction	Decrease	Positive	Increase - object appears higher
Earth's curvature	Increase	Negative	Decrease - object appears lower

92. **(a)**

$$\text{Shrinkage factor} = \frac{9}{10} = 0.9$$

$$\text{Reduced plan area} = (\text{Shrinkage factor})^2 \times \text{Actual plane area}$$

$$\Rightarrow \quad 81 = (0.9)^2 \times \text{Actual plan area}$$

$$\Rightarrow \text{Actual plan area} = 100\text{cm}^2$$

$\therefore$ Actual area of survey in m²

$$= 100 \times (10)^2$$

$$= 10000$$

93. (c)

Height of instrument

$=\text{RL of bench mark + BS}$

$=155.305+1.500$

$=156.805\,\text{m}$

Now, the staff is held inverted and the foresight (FS) is 0.575 m

$\therefore$ RL of R = Height of instrument + FS

$=156.805+0.575$

$=157.380\,\text{m}$

94. (d)

Probable error in single measurement with unit weight i.e. E_s is

$$E_s=\pm 0.6745\sqrt{\frac{\Sigma(V^2)}{(n-1)}}$$

Probable error of the mean i.e. E_m is

$$E_m=\pm 0.6745\sqrt{\frac{\Sigma(V^2)}{n(n-1)}}$$

Where,

V = Difference between any single observation and the mean of the series.

n = Number of observation in the series.

So, $E_m=\frac{E_s}{\sqrt{n}}$

$\Rightarrow \frac{E_s}{E_m}=\sqrt{n}$

95. (c)

The contour interval = 20m

For 4% gradient, the length needed from one contour to another

$$=\frac{20}{0.04}=500\,\text{m}$$

$$\text{Radius of arc}=\frac{500\times 100}{20000}=2.5\,\text{cm}$$

96. (d)

Non-modular outlet : These are the outlets whose discharge depends on the difference in water levels in the distributing channel and the water course. The discharge of such outlets, therefore, varies with the variation of the water levels in the distributing channel and the water course.

Semi-modular outlet : These are the outlets whose discharge varies with the variation of the water level in the distribution channel but it is independent of the water level in the water course, so long as the minimum working head required for their working is available.

Modular outlet : These are the outlets whose discharge is independent of the water levels in the distributing channel and the water course, within reasonable working limits. In other words modular outlets maintain a constant discharge irrespective of variation of the water levels in the distributing channel and the water course.

97. (c)

Ephemeral river flows only when a storm occurs. This river soon after the end of storm becomes dry. This river has not any contribution to base flow throughout the year.

98. (c)

Storage capacity of soil

$$= d\left[\frac{\gamma_d}{\gamma_w}\right][FC-PWP]$$

$$=80\left[\frac{1.5}{1}\right][0.25-0.15]$$

= 12 cm

99. (b)

Consumptive Irrigation Requirement (CIR),

$CIR=C_u-R_e$

C_u is Consumptive use of crop

R_e is Effective rainfall

Net Irrigation Requirement (NIR),

NIR = CIR + Water lost as percolation in satisfying other needs such as leaching.

Field Irrigation Requirement (FIR),

$$FIR=\frac{NIR}{\text{Water application efficiency }(\eta_a)}$$

Thus,

FIR = NIR + percolation losses in field watercourses and field channels

Gross Irrigation Requirement (GIR),

$$GIR=\frac{FIR}{\text{Efficiency of water Conveyance }(\eta_c)}$$

GIR = FIR + Conveyance losses in distributaries upto the field.

Hence, GIR > FIR > NIR > CIR

100. (b)

Water logging : It is the condition of land in which the soil profile is saturated with water either temporarily or permanently. In waterlogged lands, the water table rises to an extent that the **soil pores in the crop root zone are saturated resulting in restriction of the normal circulation of air.**

This restriction causes a decline in the level of oxygen and increases the level of the carbon dioxide.

Below are the different values of depth of water table to specify water logging:

Nomenclature	Depth of water table
Water logged	< 2 m
Potential area for water logging	2-3 m
Safe	> 3 m

∴ **For a land, if the water table is within 2 meters below the ground surface, it is considered as waterlogged.**

101. (c)

For elementary profile of a gravity dam, if tension failure is prevented by passing resultant force within middle third of the body of dam then overturning failure also prevented.

- To prevent overturning failure

$$B \geq \frac{H}{\sqrt{2(S_c - c)}}$$

- To prevent tension failure

$$B \geq \frac{H}{\sqrt{(S_c - c)}}$$

Where, S_c = Specific gravity of dam material

c = Uplift pressure coefficient

From above expressions it can be clearly seen that if condition of tension failure is satisfied then overturning failure condition will automatically satisfied.

102. (a)

Lacey's theory is based on the concept of the regime condition of a channel which will be satisfied if,

- The channel is flowing uniformly in unlimited incoherent alluvium of the same character which is being transported by the channel.
- The silt grade and silt charge remain constant.
- The discharge remains constant.

103. (a)

As given in question the velocity field of an incompressible flow is given by

$$'V = (a_1x + a_2y + a_3z)i + (b_1x + b_2y + b_3z)j$$
$$+ (c_1x + c_2y + c_3z)k'$$

On comparing the above equation with

$'V = ui + vj + wk'$ we get,

$u = a_1x + a_2y + a_3z$

$v = b_1x + b_2y + b_3z$

$w = c_1x + c_2y + c_3z$

Now from continuity equation we know that,

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

$$\Rightarrow \quad a_1 + b_2 + c_3 = 0$$

$$\Rightarrow \quad 2 + b_2 - 4 = 0$$

$$\Rightarrow \quad b_2 = 4 - 2 = 2$$

104. (b)

F_1 and F_2 are the Froude numbers of flow before and after the hydraulic jump.

If y_1 and y_2 are the sequent depths then–

$$\frac{y_1}{y_2} = \frac{1}{2}\left[\sqrt{1 + 8F_2^2} - 1\right]$$

and $$\frac{y_2}{y_1} = \frac{1}{2}\left[\sqrt{1 + 8F_1^2} - 1\right]$$

Multiplying both the equations–

$$\frac{y_1}{y_2} \times \frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1 + 8F_2^2} - 1\right) \times \frac{1}{2}\left(\sqrt{1 + 8F_1^2} - 1\right)$$

$$\Rightarrow \quad \frac{4}{\left(\sqrt{1 + 8F_1^2} - 1\right)} = \left(\sqrt{1 + 8F_2^2} - 1\right)$$

$$\Rightarrow \quad \sqrt{1 + 8F_2^2} = \frac{4}{\left(\sqrt{1 + 8F_1^2} - 1\right)} + 1$$

$$\Rightarrow 1+8F_2^2 = \frac{\left(3+\sqrt{1+8F_1^2}\right)^2}{\left(\sqrt{1+8F_1^2}-1\right)^2}$$

$$\Rightarrow 8F_2^2 = \frac{8+8\sqrt{1+8F_1^2}}{\left(\sqrt{1+8F_1^2}-1\right)^2}$$

$$\Rightarrow F_2^2 = \frac{1+\sqrt{1+8F_1^2}}{\left(\sqrt{1+8F_1^2}-1\right)^2}\times\frac{\left(-1+\sqrt{1+8F_1^2}\right)}{\left(\sqrt{1+8F_1^2}-1\right)}$$

$$\Rightarrow F_2^2 = \frac{\left(\sqrt{1+8F_1^2}\right)^2-1^2}{\left(\sqrt{1+8F_1^2}-1\right)^3}$$

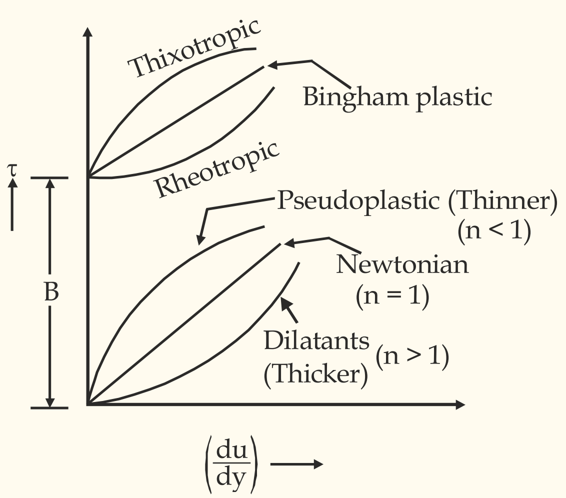
$$\Rightarrow F_2^2 = \frac{1+8F_1^2-1}{\left(\sqrt{1+8F_1^2}-1\right)^3}$$

$$\Rightarrow F_2^2 = \frac{8F_1^2}{\left(\sqrt{1+8F_1^2}-1\right)^3}$$

105. (c)

In fluid flow, if the absolute pressure of the flow becomes less than vapour pressure of the liquid at a given temperature then bubbles are formed and if these bubbles are carried in a region of high pressure then they get collapsed and may erode the surface. This phenomena is known as cavitation.

106. (a)



As we know that the general relationship between the shear stress τ and the rate of shear strain du/dy is expressed as

$$\tau = B + k\left(\frac{du}{dy}\right)^n$$

where,

n = Flow behaviour index

k = Consistency index

Note :-

For pseudoplastic, B = 0 and n < 1

Hence the relationship between the shear stress τ and the rate of shear strain du/dy for pseudoplastic is expressed as

$$\tau = k\left(\frac{du}{dy}\right)^n$$

107. (b)

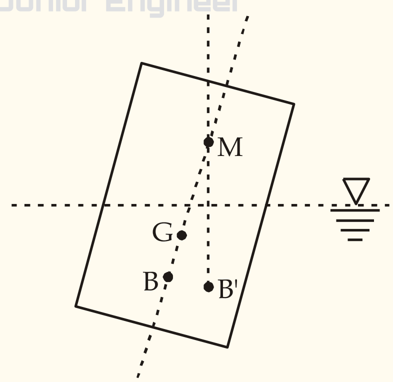
$$P_{water} = P_{liquid}$$

$$\rho_w \times g \times (100) = 0.8 \times \rho_w \times g \times h$$

$$h = \frac{100}{0.8} = 125\,m$$

108. (c)

The distance between metacentre (M) and the centre of gravity (G) of the floating body is known as metacentric height (GM). The point about which the body is in stable equilibrium start to oscillate when given a small angular displacement is called metacenter.



$$GM = BM - BG$$

$$\because \quad BM = \frac{I}{V_{fd}}$$

where

I = MOI of water line area about tilting axis

V_{fd} = volume of displaced fluid

109. (b)

$$L_r = \frac{1}{25},\ T_m = 10\,\text{min}$$

From froude's law, $V_r = \sqrt{L_r}$

$$T_r = \frac{L_r}{V_r} = \frac{L_r}{\sqrt{L_r}} = \sqrt{L_r}$$

$$\frac{T_m}{T_p} = \sqrt{\frac{L_m}{L_p}} = \left(\frac{1}{25}\right)^{1/2}$$

$$\frac{10}{T_p} = \left(\frac{1}{25}\right)^{1/2}$$

$$T_p = 50\,\text{min}$$

110. (d)

$$D_A = 1.2\ D_B$$

$$h_f = \frac{fLV^2}{2gD} = \frac{fLQ^2}{(12.1)D^5}$$

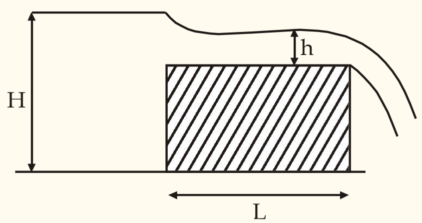
For identical friction factor & length,

$$h_f \propto \frac{1}{D^5}$$

$$\frac{(h_f)_A}{(h_f)_B} = \left(\frac{D_B}{D_A}\right)^5 = \left(\frac{1}{1.2}\right)^5$$

$$= 0.402$$

111. (c)



$$V = \sqrt{2g(H-h)}$$

$$A = L \times h$$

$$\text{Discharge } (Q) = C_d \times (L \times h) \times \left(\sqrt{2g(H-h)}\right)$$

$$Q = C_d L \times \sqrt{2g}\left(\sqrt{Hh^2 - h^3}\right)$$

For maximum discharge, $\frac{dQ}{dh} = 0$

$$\frac{d\left(Hh^2 - h^3\right)}{dh} = 0$$

$$h = \frac{2}{3}H$$

112. (b)

The floatation and sinking of an object are dependent upon the relative density of each other. If the density of the object is more than the density of the liquid, the object will sink. On the other side, if the density of an object is less than the liquid, then it will float over it. If the density of the object and liquid is equal to each other, they are in equilibrium and float and sink both at the same time i.e the whole of the object will be immersed with its top surface at liquid level.

113. (c)

Metamorphic rock : Metamorphic rock form from heat and pressure changing the original or parent rock into a completely new rock. The parent rock can be either sedimentary, igneous, or even another metamorphic rock. The word "metamorphic" comes from Greek and means "To Change Form".

Some metamorphic rocks and their original rocks:

Original rock		Metamorphic Rocks
• Granite	→	Gneiss
• Sand stone	→	Quartzite
• Lime stone	→	Marble
• Shale	→	Slate
• Dolerite/Basalt	→	Schist

Marble is a metamorphic rock composed of recrystallized carbonate minerals, most commonly calcite or dolomite.

114. (b)

$$CaO + H_2O \rightarrow Ca(OH)_2 + \text{Heat}$$

(Quick lime) (Hydrated lime)

Hydrated lime is in the form of white powder.

Hydraulic lime is also known as water lime as it sets under water. It is obtained from lime stones containing clay to the extent of about 5-30% and some amount of ferrous oxide

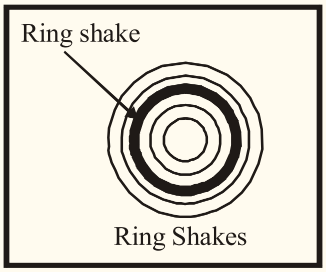
115. (c)

Shakes : Shakes represents cracks in the wood between the annual rings.

Following are the different varieties of shakes:

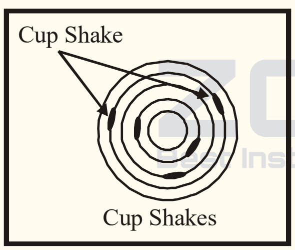
- Ring Shakes
- Cup Shakes
- Heart Shakes
- Star Shakes
- Radial Shakes

(a) Ring Shakes : When shakes cover the entire ring, they are known as the ring shakes.



(b) Cup Shakes : It is curved crack which partly separates annual rings.

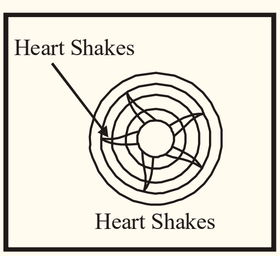
They are caused by rupture of tissue in circular direction.



(c) Heart Shakes : It occurs due to shrinkage of heartwood (interior of a tree) when tree is over matured.

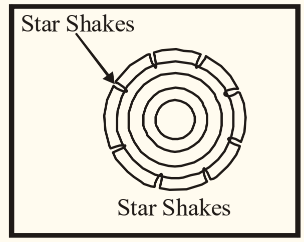
Cracks start from pith and run towards sapwood.

These are wider at centre and diminish towards outwards.

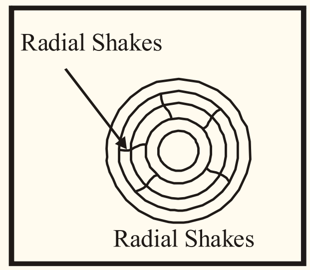


(d) Star Shakes : It is radial splits or cracks wide at circumference (bark) and diminishing towards the centre of the tree.

They are usually formed due to extreme heat or severe frost during growth of tree.



(e) Radial Shakes : These are similar to star shakes, but they are fine, irregular and numerous.



116. (d)

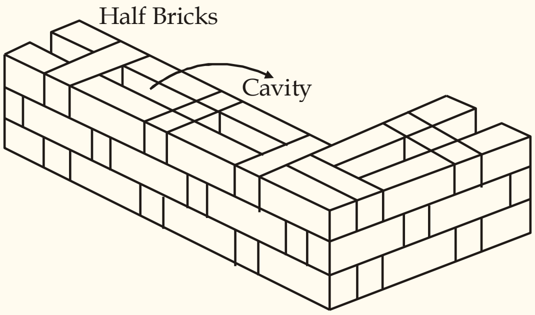
The **slump test** is most widely used because of the simplicity of apparatus required and the test procedure. This is suitable for concrete of **medium to high workability** (i.e. having slump values of 25 mm to 125 mm). The **compacting factor test** has been held to be more accurate than slump test, especially for **medium and low workability** i.e., compacting factor of 0.9 - 0.8 or slump 25-50 mm, for concrete of very low workability of the order of 0.7 or below, the test is not suitable. **Vee-bee consistometer test** is suitable for stiff concrete mixes having **low and very low workability**.

117. (b)

When the height above floor level exceeds about 1.5 m a temporary structure, usually of timber, is erected close to the work to provide a safe working platform for the workers and to provide limited space for the storage of plant and building materials. This temporary framework is known as scaffolding or simply of scaffold.

118. (b)

Rat-trap bond : Rat-trap bond is a modular type of masonry bond in which the bricks are placed in a vertical position, which creates a cavity in the wall while maintaining the same wall thickness as that of the conventional brick masonry wall. It is also known as a Chinese brick bond.



119. (a)

An indent called frog, 1-2cm deep, is provided for 9cm high bricks. The size of frog should be 10*4*1 cm. The purpose of providing frog is to form a key holding the mortar and therefore, the bricks are laid with frogs on top. It is not provided in 4 cm high bricks and extruded bricks.

120. (c)

According to the Indian Standard Code IS: 3362-1977, in the case of natural ventilation, flow per unit area of the opening is greatest when the inlet and outlet openings are of nearly **equal Areas**. Also, inlet openings should be located on the windward side and outlet openings should be located on the leeward side.