LIVE RPSC-AE (DLB) Full Length Test Series

Civil Engineering

Full Length Paper - 8

Answer Key & Detailed Solution

Test Id - 508 **Date:- 30/04/2023**

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

39. (d)

40. (a)

41. (a)

A portion of a beam between two sections is said to be in pure bending when there is Constant bending moment and zero shear force.

When beam is in pure bending then radius of curvature becomes constant or deflection of beam becomes circular.

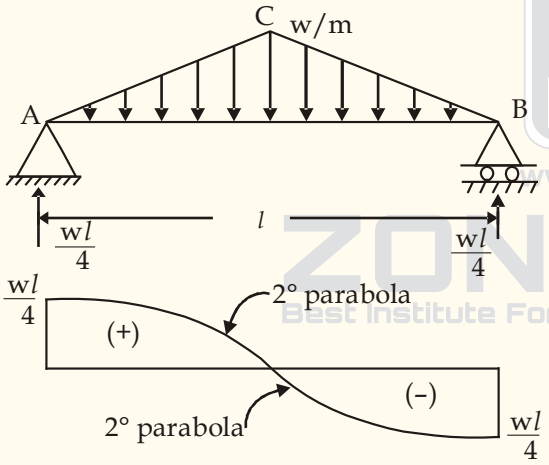
42. (c)

$$R_A + R_B = \frac{1}{2} + w \times l$$

By symmetry,

$$R_A = R_B$$

$$R_A = R_B = \frac{wl}{4}$$



Shear Force Diagram

∵ Shear force is zero at mid span that means maximum bending moment occurs at mid span

$$BM_C = \frac{wl}{4} \times \frac{l}{2} - \left(\frac{1}{2} \times w \times \frac{l}{2}\right) \times \left(\frac{1}{3} \times \frac{l}{2}\right)$$

$$= \frac{wl^2}{8} - \frac{wl^2}{24}$$

$$= \frac{wl^2}{12}$$

43. (b)

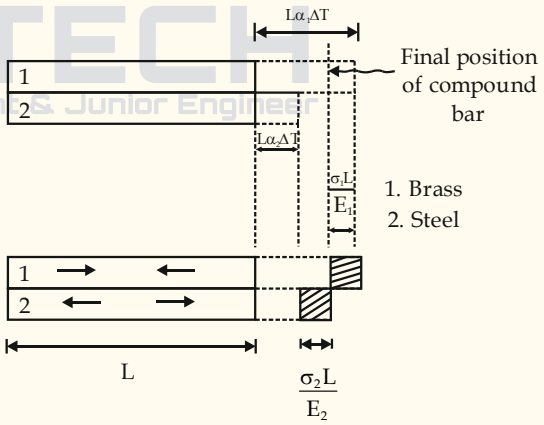
Shear flow:

In solid mechanics

1. When a transverse shear force is applied to a structure, such as beam, the result is variation in bending normal stresses along the length of the beam.
2. This variation necessitates internal horizontal shear stress within the beam that varies with position y' from the neutral axis in the beam.
3. The concept of complementary shear then dictates that shear stress also exists along the front face of the beam.
3. In thin-walled structures, the variation with thickness can be neglected, and the shear stress along the front face of the structure can be examined as shear flow, or the shear stress multiplied by the thickness of the element.

44. (d)

- Coefficient of thermal expansion of brass is more than steel, so brass will try to expand more but its expansion will be restrained by steel because both will move together by same amount (composite bar).
- Thus a couple will form against the expansion and produce compression in brass and tension in steel.



Coefficient of thermal expansion

$$\alpha_{\text{mild steel}} = 12 \times 10^{-6} / °C$$

$$\alpha_{\text{copper}} = 16 \times 10^{-6} / °C$$

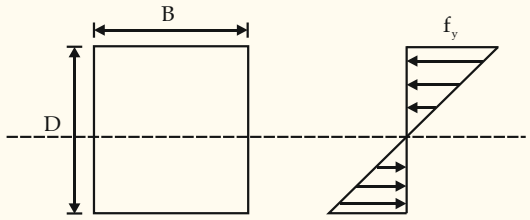
$$\alpha_{\text{Brass}} = 19 \times 10^{-6} / °C$$

$$\alpha_{\text{Aluminium}} = 23 \times 10^{-6} / °C$$

45. (a)

Yield Moment

- Within the elastic limit, the moment that cause extreme fibre yield and produce yield stress is called as yield moment.
- Within the elastic limit, bending moment has a relation with bending stress f_y as $M = f_y z$, where z is the distance from neutral axis.



46. (b)

Toughness

- The ability of the material to absorb energy till breaking/rupture/failure takes place is known as toughness.
- It represents the ability to resist fracture.
- Area under stress-strain curve upto fracture is called modulus of toughness.
- Modulus of toughness = Strain energy stored upto fracture per unit volume of material
- Toughness is desirable against impact loading
- As failure strain is more in ductile material. Mild steel is more tough than cast iron.

Note :

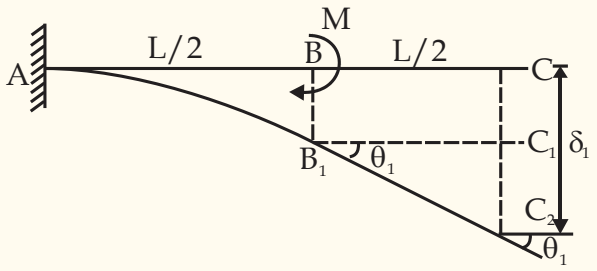
Hardness

- Ability to resist scratch or abrasion.
- Surface hardness is measured by carrying out nondestructive indentation test.
- The higher the yield stress, higher is the hardness.

Brittleness

- In brittle materials, strain at rupture is much smaller as compared to ductile material (rupture strain is elastic).
- There is no plastic zone for brittle material.
- In brittle materials, rupture occurs without any noticeable prior change in the rate of elongation.
- Brittleness is not an absolute property of material. A material which is brittle at room temperature is ductile at elevated temperature.

47. (d)



$$\delta_C = \delta_1 = CC_1 + C_1C_2$$
$$\delta_C = BB_1 + C_1C_2$$

$$\delta_C = \frac{M\left(\frac{L}{2}\right)^2}{2EI} + \frac{M\left(\frac{L}{2}\right)}{EI}\left(\frac{L}{2}\right)$$

$$\delta_C = \frac{3}{8}\frac{ML^2}{EI}$$

48. (b)

Degree of **kinematic indeterminacy or total degree of freedom of joints.**

$$D_k = 3j - r_e - m'$$
$$= 3 \times 4 - 3 - 1$$
$$= 8$$

Note : Only beam is rigid, (not the columns)

$(\therefore m' = 1)$

49. (c)

Force method and Displacement method are the two methods used for analysis of structures.

If $D_s < D_k \rightarrow$ Then force method is best suitable.

If $D_k < D_s \rightarrow$ Then displacement method is best suitable.

Example of force method :

- Castigliano's theorem (method of least work)
- Strain energy thorem
- Flexibility matrix method
- Unit load method/virtual work method
- Column analogy method
- Clapeyron's three moment equation method.

Example of displacement method :

- Moment distribution method
- Slope deflection method
- Kani's method
- Stiffness matrix method

50. (a)

Mineral	Bonded by	Important points
Kaolinite	Hydrogen bonds	1) It is a two-layer unit that is formed by stacking a gibbsite sheet on a silica sheet.
		2) Kaolinite minerals are stable and do not expand under the saturation.
Illite	Potassium ions	1) Illite consists of the basic montmorillonite units but is bonded by potassium ions.
		2) This mineral is very stable and does not swell or shrinks largely.
Montmorillonite	Vander Walls forces	1) This bonding is very weak, and water can enter easily.
		2) Thus, this mineral can imbibe a large quantity of water causing swelling.

51. (a)

The actual velocity (v_a) at which the water is moving through an aquifer, i.e. on an average, the velocity at which a tracer would move through a permeable medium, is given by

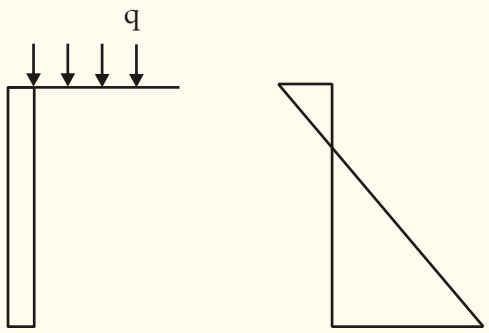
$$V_a = \frac{V}{n}$$

Where, V = Discharge velocity

n = Porosity

Hence, In ground water flow, the velocity with which a tracer would move is the same as the seepage velocity given by Darcy's law

52. (b)



Active pressure intensity with surcharge 'q' at top is

$$P_a = qK_a - 2C\sqrt{K_a}$$

For zero active pressure intensity at the top put above equation equal to zero

$$K_a q = 2C\sqrt{K_a}$$

$$q = \frac{2C\sqrt{K_a}}{K_a}$$

$$= \frac{2C}{\sqrt{K_a}}$$

$$= \frac{2C}{\sqrt{\cot^2\left(45 + \frac{\phi}{2}\right)}}$$

$$= 2C\tan\alpha$$

53. (b)

Depth of Exploration :

- The depth up to which the stress increment due to superimposed loads can produce a significant settlement and shear stresses is known as the significant depth.
- The depth of exploration should be at least equal to the significant depth.
- The significant depth is generally taken as the depth at which the vertical stress is 20% of the load intensity. As per the above criteria, the depth of exploration should be about **1.5 times the width of the square footing** and about 3 times the width of the strip footing.

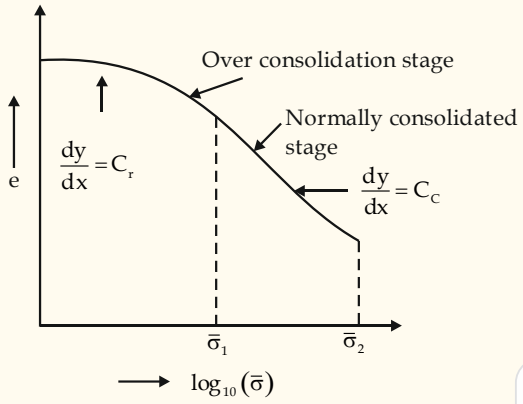
54. **(b)**

- A soil is termed as normally consolidated if the present effective over burden pressure is more than the maximum to which the soil was ever subjected in the past.

$$O.C.R = \frac{\text{Maximum effective stress applied in the past}}{\text{Existing effective stress}}$$

O.C.R > 1 for overconsolidated soil,
O.C.R = 1 for normally consolidated soil,
O.C.R < 1 for under consolidated soil

- Larger the value of coefficient of consolidation, the shorter it takes for full consolidation to occur.



$$T_V = C_V \cdot \frac{t}{d^2}$$

or, $$t = \frac{T_V . d^2}{C_V}$$

where, T_V = Time factor
C_V = Coefficient of consolidation
d = Length of drainage path
t = Time

55. (c)
Given:
Initial cell pressure, σ_{3i} = 0.1 N/sq.m
Final cell pressure, σ_{3f} = 0.26 N/sq.m
Initial pore water pressure, u_0 = 0.07 N/m²
Final pore water pressure, u_f = 0.15 N/m²
Change in cell pressure

$$(\Delta\sigma_3) = \sigma_{3f} - \sigma_{3i}$$

$$= 0.26 - 0.1 = 0.16 N/m^2$$

Change in pore water pressure,

$$(\Delta u_1) = u_f - u_0$$

$$= 0.15 - 0.07 = 0.08\ N/m^2$$

The skempton's pore pressure parameter,

$$B = \frac{\Delta u_1}{\Delta\sigma_3} = \frac{0.08}{0.16} = 0.5$$

56. (b)
The ultimate bearing capacity of a purely cohesive soil:

$$q_u = CN_C + \gamma D_f$$

The net ultimate bearing capacity of a purely cohesive soil:

$$q_{nu} = CN_C$$

From the above equations we can say that the ultimate bearing capacity of a purely cohesive soil (q_u) is depends on **depth of footing and is independent of width of footing** while the net ultimate bearing capacity (q_{nu}) of a purely cohesive soil is independent of both width and depth of footing

57. (a)
% soil retained on 4.75 mm sieve = 40%
% soil retained on 75 μ sieve = 70 – 40 = 30%
Gravel > Sand
So, it is gravel.
Also % fines is 30%

$$I_P = W_L - W_P = 35 - 27 = 8\%$$

$$(I_P)_{A\,line} = 0.73(W_L - 20) = 10.95\%$$

$$(I_P)_{soil} < (I_P)_{A\,line}$$

∴ Silt > Clay
Hence the given soil is **GM.**

58. (c)
Given,

$$q' = 500\ kN/m$$

$$x = 0$$ (Just below the line load)

As we know that,

$$\sigma_z = \frac{2q'}{\pi z}\left(\frac{1}{1+\frac{x^2}{z^2}}\right)^2$$

So, $$\sigma_z = \frac{2q'}{\pi z}$$

Hence, Ratio $$= \frac{(\sigma_z)at\,2m}{(\sigma_z)at\,4m} = \frac{\frac{2q'}{\pi\times 2}}{\frac{2q'}{\pi\times 4}} = \frac{4}{2} = 2$$

59. (b)
Aquitard is that geological formation which does not yield water freely to wells due to its less permeability, although seepage is possible through it. The yield from such formation is thus insignificant.

Note:

1. **Aquifer:** These are the geological formations which are both permeable and porous. Hence, sufficient discharge can be obtained through it.
   Ex. Fine sand and Course silt
2. **Aquiclude:** These are the geological formations which are highly porous but impermeable. Hence, water cannot be extracted through them
   Ex. Clay
3. **Aquitared:** These formations are porous but less permeable. Hence, water does not flow through them but instead it seeps
   Ex. Sandy clay.
4. **Aquifuge:** These formation are neither porous nor permeable
   Ex. Granite rock.

60. (c)

Exposure	Minimum cement content (kg/m^3)	
	PCC	RCC
Mild	220	300
Moderate	240	300
Severe	250	320
Very severe	260	340
Extreme	280	360

Hence, for PCC & severe exposure, minimum cement content = 250 kg/m^3

61. (c)
Table -16, IS 456 : 2000

Exposure	Minimum nominal cover (mm)
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

62. (b)
Target mean strength

$$= f_{ck} + 1.65\sigma$$

$$= 25 + 1.65 \times 4.0 = 31.6$$

Water content required

$$= 50 - \frac{(50-45)}{(35-25)} \times (31.6 - 25)$$

$$= 46.7\%$$

Say 46% (round off to the lower integer)

63. (c)
Clause 26.3.3b of IS 456 : 2000 limits the maximum diameter of reinforcing bars to **1/8th of the total slab thickness** with maximum spacing of these bars being limited to 3d or 300 mm (whichever is less)
Hence, diameter of steel reinforcement in slab

$$\nless \frac{\text{Thickness of slab}}{8}$$

$$\nless \frac{180}{8}$$

$$\nless 22.5 \text{ mm}$$

64. (b)
As per IS 456:2000 Clause 17.4.3
Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least **85 percent** of the cube strength of the grade of concrete specified for the corresponding age and no individual core has a strength less than **75 percent**.

65. (b)

$$\text{Design load} = \max^{m}\begin{cases} 1.5DL + 1.5LL \\ 1.5DL + 1.5SL \\ 1.2DL + 1.2LL + 1.2SL \end{cases}$$

$$\text{Design load} = \max^{m}\begin{cases} 1.5\times 50 + 1.5\times 50 \\ 1.5\times 50 + 1.5\times 20 \\ 1.2\times 50 + 1.2\times 50 + 1.2\times 20 \end{cases}$$

$$\text{Design load} = \max^{m}\begin{cases} 150 \text{ kNm} \\ 105 \text{ kNm} \\ 144 \text{ kNm} \end{cases}$$

Hence, Design load = 150 kNm

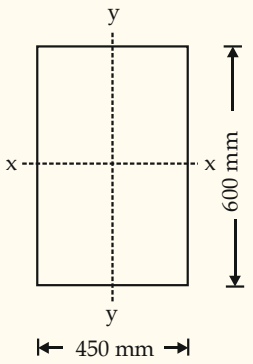
66. (d)

The volume of one bag (50 kg) of cement is 35 liters. So for batching 1 : 2 : 4 concrete mix by volume,

Fine aggregate = 2 × 35 liters = 70 liters

Coarse aggregate = 4 × 35 liters = 140 liters

67. (b)



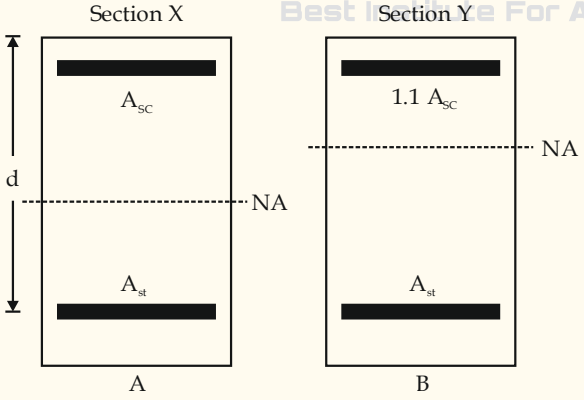
$$e_{min} = \text{maximum of} \begin{cases} \frac{L}{500} + \frac{D}{30} \\ 20 \text{ mm} \end{cases}$$

x-x will be major axis and y-y will be minor axis.

and $e_{minxx} = \frac{3000}{500} + \frac{600}{30} = 26 \text{ mm}$

$\therefore$ $e_{minyy} = \frac{3000}{500} + \frac{450}{30} = 21 \text{ mm}$

68. (a)



Due to presence of more compression steel in section Y, NA of section of Y is above than as of X. It means Y is more under-reinforced than X so ductility of Y is more.

Since compression steel of Y is more so flexure resistance of X is less than as of Y.

69. (a)

As per the provisions of IS: 800-2007, the non-dimensional slenderness ratio of the steel cross-section i.e. λ is

$$\lambda = \sqrt{\frac{f_y}{f_{cr}}}$$

Where, f_y = Yield stress of steel = 250 N/mm^2

f_{cr} = Critical bending compressive stress in the extreme fiber = 1000 N/mm^2

Hence, $\lambda = \sqrt{\frac{f_y}{f_{cr}}} = \sqrt{\frac{250}{1000}} = 0.5$

70. (d)

As per codal provisions of IS 3370:

- **Minimum grade of concrete for the R.C.C. water tank is M30.**
- Maximum cement content is 400 kg/m^3 to take care of shrinkage effect.
- Minimum cement content is 320 kg/m^3
- Minimum grade of concrete for P.C.C. water tank is M20.
- Maximum w/c ratio is 0.45.
- Minimum nominal cover is 45 mm.
- Maximum allowed crack width is 0.2 mm in the LSM design.
- To reduce cracking due to temperature, shrinkage, and moisture loss at an early stage of concrete, curing should be done for at least 14 days.
- Permeability of concrete must be least so use lesser value of w/c ratio.
- No porous aggregate should be used.
- Part of structure retaining liquid and enclosing space above liquid should be taken under severe exposure condition.
- All the structures to be designed shall be designed for both empty and full condition.
- Cracking of concrete can be controlled to some extent by maintaining a slope filling rate of 1 m in 24 hours at the first time of filling.

71. (d)

- As fineness increases, specific surface area increases i.e. there is more surface area for reaction with water leads to increase the rate of strength development.
- As fineness increases void ratio or volume of voids also increases that leads to more shrinkage.

72. (b)

Percentage	Efflorescence
< 10%	Slight
10 - 50%	Moderate
> 50%	Heavy

73. (a)

Winders: Winders are steps that are narrower on one side than the other. **They are used to change the direction of the stairs without landings.** A series of winders form a circular or spiral stairway.

Note:

Nosing: The stair nosing can provide extra safety to your staircase. It overhangs the top of the tread and provides extra space for you to step on. It also helps protect the edge of your treads from getting damaged and wearing down over time.

Riser: The riser serves a double purpose. It supports the step and prevents deflection of the step under load and it also protects the user of the stairs from objects falling down from other flights upstairs. The string height depends on the angle of inclination of the flight and can be measured from the drawing floor.

74. (b)

Growth rings (or tree rings or annual rings):

- Each year in the growing season, the tree forms new cells arranged in concentric circles which are called growth rings or annual rings, or annual. These annual rings show the amount of wood produced during one growing season.
- These annual rings furnish valuable information regarding the age of the wood, the rapidity, and the uniformity of its growth.

Hardwood has less distinct and far apart annular rings and distinct medullary rays.

Softwood has distinct annular rings and indistinct medullary rays.

75. (d)

Plasticizer and super plasticizer increases workability with same water content or we can reduce the w/c ratio to get same workability with plasticizer and super plasticizer.

Reduction in w/c ratio increases strength of mix.

76. (b)

Sub classification of sedimentary rocks

1. Mechanical (Clastic Rock)
2. Chemical (Non-clastic rock)
3. Organic

77. (c)

There are no effect on venturimeter reading of inclination of venturimeter so the reading will be same at all angle.

78. (a)

GM > 0	M is above G	Stable equilibrium
GM = 0	M coincides with G	Neutral equilibrium
GM < 0	M is below G	Unstable equilibrium

79. (b)

For pipe flow

Type of flow	Reynolds number
Laminar flow	Re < 2000
Transition flow	2000 < Re < 4000
Turbulent flow	Re > 4000

80. (b)

A triangular notch or weir is preferred to a rectangular weir or notch due to the following reasons:

- The expression for discharge for a right-angled V-notch or weir is very simple.
- For measuring the low discharge, a triangular notch gives more accurate results than a rectangular notch.
- In case of the triangular notch, only one reading i.e. H is required for the computation of discharge.
- Ventilation of a triangular notch is not necessary.

81. (c)

For ideal plastic fluid, equation of shear stress is

$$\tau = \tau_0 + \mu\left(\frac{du}{dy}\right)$$

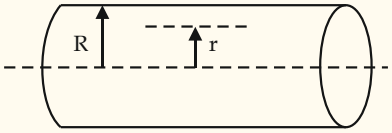
Where, τ_0 = Initial yield stress

$\frac{du}{dy}$ = Rate of shear strain or velocity gradient

μ = Coefficient of Dynamic viscosity

Hence, we can say that in case of ideal plastic fluid, shear stress is more than the yield value and is proportional to rate of shear strain

82. (c)



$$\tau = -\left(\frac{dp}{dx}\right)\frac{r}{2}$$

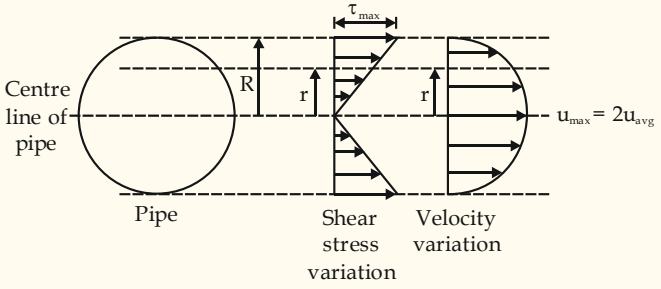
At central line

r = 0, hence $\tau = 0$

- Shear stress variation is linear with maximum value at the boundary of pipe.
- From newton's law of viscosity $\tau = \mu\frac{du}{dr}$
- Expression of velocity

$$u = \frac{1}{4\mu}\left(\frac{-dp}{dx}\right)\left(R^2 - r^2\right)$$

- From the above expression, it is clear that velocity distribution across the pipe is parabolic with maximum value at centre and zero at the boundary.



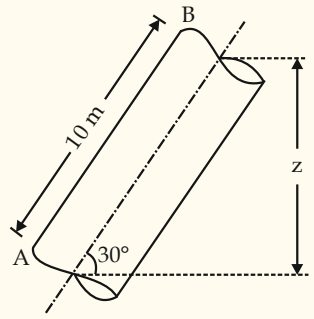
83. (c)

For most economical rectangular section:

1. Construction cost is minimum
2. Discharge carrying capacity is maximum
3. Perimeter should be minimum
4. Width i.e. B = 2y
5. Hydraulic radius i.e. R = y/2

84. (d)

Applying **Bernoulli's equation** between A and B, we get,



$$\because \quad \frac{p_A}{\gamma_w} + \frac{V^2}{2g} + 0 = \frac{p_B}{\gamma_w} + \frac{V^2}{2g} + z$$

$$p_A = p_B + \gamma_w z$$

Where,

$p_B = 12\,kN/m^2$

$\gamma_w = 9.879\ kN/m^3$

& $z = 10\sin 30° = 5cm$

Hence, $p_A = 12 + 9.879 \times 5$

$p_A = 12 + 49.4$

$p_A = 61.4\ kN/m^2$

85. (b)

Friction drag:

- Friction drag is also known as Skin Friction Drag.
- **The drag on a body resulting from viscous shearing stresses over its contact surface.**
- It is directly proportional to the area of the surface in contact with the fluid and increases with the square of the velocity.
- The drag of a very streamlined shape such as a thin, flat plate is frequently expressed in terms of a skin friction drag.
- This drag is a function of the Reynolds number.
- **An airfoil mainly experiences skin friction drag.** Friction drag is created in the boundary layer due to the viscosity of the air and the resulting friction against the surface of the aircraft.

Friction drag on the plate,

$$F = \frac{1}{2}\rho AV^2 C_D$$

For the laminar boundary layer,

$$C_D = \frac{1.328}{\sqrt{Re}}$$

Pressure Drag:

- The drag on a body resulting from the integrated effect of the static pressure acting normal to its surface resolved in the drag direction.
- Unlike the skin friction drag that results from viscous shearing forces tangential to a body's surface, form drag results from the distribution of pressure normal to the body's surface.
- In an extreme case of a flat plate normal to the flow, the drag is totally the result of an imbalance in the pressure distribution.

86. (b)

Explanation:

There are three types of similarities exists between model and prototype.

Geometric Similarity: When the ratio of all corresponding linear dimensions in the model and prototype are equal.

Kinematic Similarity: Kinematic similarity means the similarity of motion between model and prototype. If the ratio of velocity and acceleration at the corresponding points in the model and at the corresponding points in the prototype are same.

Dynamic Similarity: This similarity exists when the ratio of forces between model and prototype are equal.

87. (b)

Temperature Correction, $C_T = L\alpha(T_m - T_0)$

T_0 = Temperature at time of standarization

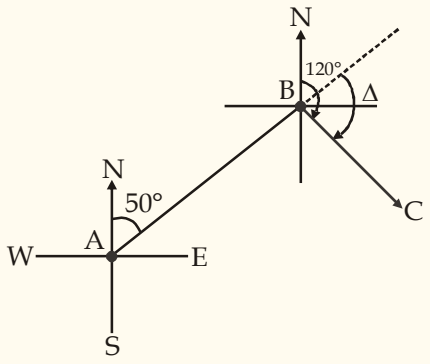
T_m = Temperature at time of measurement

So, $C_T = 30 \times 15 \times 10^{-6} \times (40 - 20)$

$= 9 \times 10^{-3}$ m

$\therefore$ Actual length $= 30 + 9 \times 10^{-3} = 30.009$ m

88. (a)



The deflection angle at B from AB to BC is

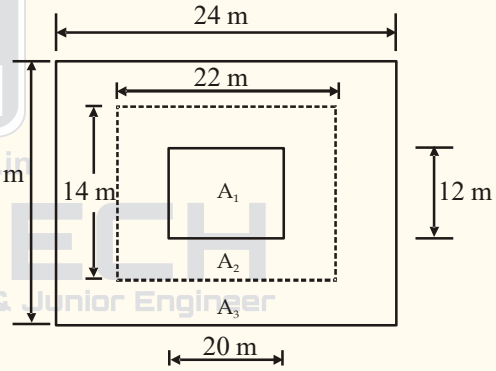
$\Delta = 120° - 50°$

$= 70°$

89. (a)

During levelling process we takes reading on staff only & least count of staff is 5 mm, so smallest reading can be taken during leveling is 5 mm .

90. (b)



Let assume common interval (d) = 1m

So number of planes/levels = $\frac{\text{Depth of excavation}}{d} + 1$

$= \frac{2\text{ m}}{1\text{ m}} + 1$

$= 3$

For the calculation of volume by prismoidal formula, consider three levels at common interval 1m. The areas of these levels at the bottom, mid and top are as follows-

$A_1 = 20 \times 12 = 240$ m^2

$A_2 = 22 \times 14 = 308$ m^2

$A_3 = 24 \times 16 = 384$ m^2

From prismoidal formula

$$V = \frac{d}{3}\left[\begin{pmatrix}\text{First}\\ \text{area}\end{pmatrix} + \begin{pmatrix}\text{Last}\\ \text{area}\end{pmatrix} + 4\begin{pmatrix}\text{Sum of}\\ \text{even areas}\end{pmatrix} + 2\begin{pmatrix}\text{Sum of}\\ \text{odd areas}\end{pmatrix}\right]$$

$$V = \frac{d}{3}\left[(A_1 + A_3) + 4(A_2)\right]$$

$$= \frac{1}{3}\left[(240 + 384) + 4 \times 308\right]$$

$$= 618.66 \text{ m}^3$$

91. (b)

Bowditch Rule

- Bowditch Rule, is also called as compass rule, is generally used for adjusting the traverse in which the angles and distances are measured with the same precision.
- Bowditch rule is based on the assumption that the errors introduced in the traverse are accidental (random) in nature.
- The probable error in a traverse line is assumed to be directly proportional to the square root of its length $\left(e \propto \sqrt{L}\right)$. According to this rule,

  Error in latitude of any line
  = Total error in latitude (e_y)
  $\times \frac{\text{Length of the line}}{\text{Perimeter of the traverse}}$
- Correction to the latitude of any line
  = Total correction in latitude ($-e_y$)
  $\times \frac{\text{Length of the line}}{\text{Perimeter of the traverse}}$
- Similarly correction to the departure of any line
  $= -e_x \times \frac{\text{Length of the line}}{\text{Perimeter of the traverse}}$
- When the traverse is adjusted by Bowditch's rule, both the lengths and bearings of the lines get changed. However, in comparison to the transit rule the lengths are changed less and the angles are changed more.

92. (a)

The first reading is always BS. The second reading is foresight because the instrument has been shifted after this reading which is evident from the low value of third reading. Since the instrument has been shifted the third reading is backsight again. Successively the fourth reading is foresight.

93. (a)

As per IRC the width of carriageway

Single lane	3.75 m
Double lane	7 m
Double lane with kerb	7.5 m
Multiple lanes	3.5 m/lane
Intermediate lane	5.5 m

94. (c)

Traffic signal are provided at intersection to control the volume or to increase the capacity of road which reduces right angle collision but due to functioning of light there may be increment in rear end collisions.

95. (d)

Optimum cycle length as per webster method is

$$C_0 = \frac{1.5L + 5}{1 - y}$$

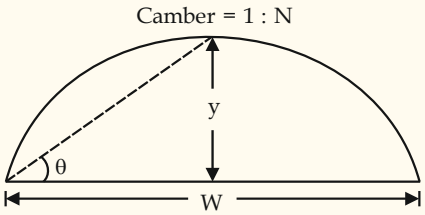
$$= \frac{1.5 \times 10 + 5}{1 - 0.5}$$

$$= 40$$

96. (d)

The C.B.R. values are usually calculated for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater than at 5 mm and in such a case the former shall be taken as C.B.R. for design purpose. If C.B.R. for 5 mm exceeds that for 2.5 mm, the test should be repeated. If identical results follow, the C.B.R. corresponding to 5 mm penetration should be taken for design.

97. (d)



Parabolic camber is provided in Bitumen concrete road and the equation is given by

$$y = \frac{2x^2}{NW}$$

$$y = \frac{2\times(3.5)^2}{50\times 7}$$

$$y = 0.07 \text{ m}$$

98. (c)

Width	
Motor vehicle other than transport vehicle	2.5 m
Transport vehicle	2.7 m
Length	
Motor vehicle other than transport having not more than two axles	9.5 m
Transport vehicles with rigid frame with two or more axles	11.25 m
Articulated vehicle with more than two axles	16 m
Truck & trailer or tractor & trailer combination	**18 m**
Height	
Double decker buses	4.75 m
Others for normal application	3.8 m
Others for carrying ISO containers	4.2 m

99. (a)

Tack coat: Bituminous tack coat is the application of bituminous material over an existing pavement surface which is relatively impervious like an existing bituminous surface or a cement concrete pavement.

Prime coat: Bituminous prime coat is the first application of a **low viscosity liquid bituminous material** over an existing porous or absorbent pavement surface like the WBM base course.

The main **objective** of priming is to **plug in the capillary void of the porous surface** and to bond the loose mineral particles on the existing surface, using a binder of low viscosity which can penetrate into the voids.

Seal coat:

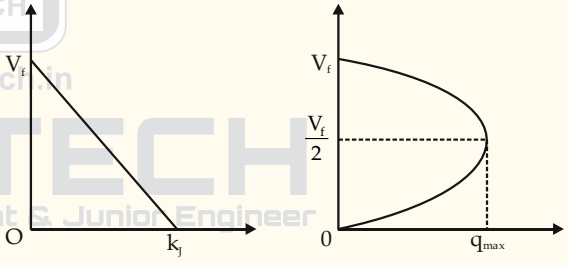
- Recommended as a top coat over certain bituminous pavement to seal the surfacing against the ingress of water.
- To develop skid resistance texture.
- To enliven an existing dry or weathered bituminous surface.

Emulsion is a two phase system consisting of two immiscible liquids.

- The bitumen/tar content in emulsion range from 40 to 60% and the remaining portion is water.
- Emulsions are used especially in maintenance and patch repair works. The main advantage of emulsion is that it can be used in wet weather even when it is raining. Emulsion can be used for soil stabilization in deserts.

100. (d)

Free flow speed (V_f) is that speed at which flow and density is negligible.



101. (b)

As we know that,

$$\Delta = 1.18\frac{Pa}{E}$$

Here, a = radius of plate

$$a = \frac{20}{2} = 10 \text{ cm} = 0.1 \text{m}$$

Hence, $$\frac{0.5}{100} = \frac{1.18\times 1.25\times 10^5 \times 0.1}{E}$$

$$\Rightarrow \quad E = \frac{1.18\times 1.25\times 10^5 \times 0.1\times 100}{0.5}$$

$$= 29.5\times 10^5 \text{ N/m}^2$$

102. (a)

Slow sand filters work through the formation of a gelatinous layer (or biofilm) called the **hypogeal layer or Schmutzdecke** in the top few millimetres of the fine sand layer. The Schmutzdecke is formed in the first 10–20 days of operation and consists of bacteria, fungi, protozoa, rotifera and a range of aquatic insect larvae. As an epigeal biofilm ages, more algae tend to develop and larger aquatic organisms may be present including some bryozoa, snails and Annelid worms. The surface biofilm is the layer that provides the effective purification in potable water treatment, the underlying sand providing the support medium for this biological treatment layer. As water passes through the hypogeal layer, particles of foreign matter are trapped in the mucilaginous matrix and soluble organic material is adsorbed. The contaminants are metabolised by the bacteria, fungi and protozoa. The water produced from an exemplary slow sand filter is of excellent quality with 90–99% bacterial cell count reduction.

103. (d)

Laying of sewer pipes start from outfall end and proceed upwards. The sewer pipe are usually laid from lowest point with their socket ends facing upstream so that spigot end can be easily inserted in socket of already laid pipe.

Assertion (A) is wrong

The socket end faces upstream becauase there are high chances of sliding of them if faced downstream due to improper connection with spigot

Reason (R) is correct

104. (a)

Method	Decomposition	Contact Mechanism
Trickling filter	Aerobic	Attached
Rotating biological /contractor	Aerobic	Attached
Activated sludge process	Aerobic	Suspended
Oxidation pond	Aerobic	Suspended
Septic tank	Anaerobic	Suspended
Sludge digestion tank	Anaerobic	Suspended

105. (c)

When chemical formula and concentrations of different organic compounds is known, then theoretically calculating the oxygen required to completely oxidize the organic matter using balanced chemical equation is called as **theoretical oxygen demand.**

Given, concentration of glucose = 500 mg/L

Equation for oxidation of glucose $\rightarrow$

$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$

Molecular weight of glucose

$\Rightarrow 12 \times 6 + 1 \times 12 + 16 \times 6 \Rightarrow 180$ gm

Molecular weight of oxygen

$\Rightarrow O_2 \Rightarrow 16 \times 2 \Rightarrow 32$ gm

1 mole of glucose requires 6 moles of oxygen to oxidise hence 180 gm of glucose requires 6 × 32 = 192 gm of oxygen to oxidise

Hence, 500 mg/L glucose requires

$$= \frac{192}{180} \times 500 \text{ mg/L of oxygen}$$

= 533.33 mg/L of oxygen

Note: Chemical oxygen demand (COD) of the raw water or waste water is used to measure the content of organic matter in waste water (both biodegradable and non biodegradable). COD is determined by dichromate test.

106. (b)

Surface overflow rate (V_0)

= 43.2 m^3/m^2-d = 43.2 m/d

$$= \frac{43.2 \times 10^3}{24 \times 60 \times 60} \text{ mm/s}$$

$$= 0.5 \text{ mm/s}$$

Particles which have settling velocities more than surface overflow rate will be 100% removed. Other particles are removed in the ratio of $\left(\frac{V_S}{V_0}\right)$

$\therefore$ Total percentage of particles removed

$$= 30 + 60 \times \frac{0.2}{0.5} + 10 \times \frac{0.1}{0.5}$$

$$= 30 + 24 + 2 = 56\%$$

107. (c)

Explanation:

Design of sewer:

- The peak flow can be considered as 1.5 times the annual average daily flow.

- For a design of the treatment facility, the peak factor is considered as 1.5 times the annual average daily flow.
- The minimum flow passing through sewers is also important to develop self-cleansing velocity to avoid silting in sewers. This flow will generate in the sewers during late night hours. The effect of this flow is more pronounced on lateral sewers than the main sewers.

Sewers must be checked for minimum velocity as follows:

- **Minimum daily flow = 2/3 Annual average daily flow**
- Minimum hourly flow = 1/2 Minimum daily flow
- Minimum hourly flow = 1/3 Annual average daily flow

108. (c)

Oxidation Ponds:

- It is one of the biological systems which are used for the treatment of wastewater.
- It is considered the secondary treatment method by which natural purification and stabilization of wastewater like domestic sewage, trade waste, and industrial effluents are accelerated.
- **Depth = 1.0 to 1.8 m**
- Detention period = 2 to 6 weeks
- Length to width ratio = 2

Lagoons:

- Lagoon systems include one or more pond-like bodies of water or basins designed to recieve, hold, and treat wastewater for a predetermined period of time.
- Lagoons are constructed and lined with material, such as clay or an artificial liner that will prevent leaks to the groundwater below.
- While in the lagoon, wastewater receives treatment through a combination of physical, biological, and chemical processes.
- Much of the treatment occurs naturally, but some systems are designed to also use aeration devices that increase the amount of oxygen in the wastewater.
- **Depth = 2.5 to 4.5 m**
- Detention period = 1 to 2 weeks

Hence, Aerated Lagoons are deeper than the oxidation pond.

109. (d)

Water supply discharge

$$= 200 \times 80000\ l/\text{day}$$

$$= \frac{16 \times 10^6 \times 10^{-3}}{24 \times 60 \times 60}\ \text{m}^3/\text{s}$$

$$= 0.185\ \text{m}^3/\text{s}$$

Sewage discharge $= 0.75 \times 0.185$

$$= 0.1387\ \text{m}^3/\text{s}$$

Design sewage discharge = Peak factor × sewage discharge

$$= 2 \times 0.1387$$

$$= 0.28\ \text{m}^3/\text{s}$$

110. (c)

Failure of an embankment dam can result from instability either the upstream or downstream slopes. The failure surface may lie within the embankment or may pass through the embankment and foundation soil.

The critical stages in an upstream slope are:

1. At the end of construction
2. During Sudden or rapid drawdown

The critical stages in a downstream slope are:

1. At the end of construction
2. During steady seepage when reservoir is full.

To ensure stability, the various conditions must be investigated:

1. The slopes must be safe against surface slipping. To ensure this the slopes must be no steeper than the angle of repose.
2. The dam must be safe against sliding on the foundation.
3. The mass of the embankment must be safe against circular arc failure or composite line failure. This is likely to occur within the earth core or weak foundation.

Hence, the most critical codition for which the stability of downstream slope must be examined occurs when reservoir is full and seepage is taking place at full rate.

111. (d)

Location of canal headwork :-

It depends upon the stages of flow of a river :

Rocky stage : In this stage, a river is in hills. The bed slope and velocities are high. It is generally not suitable for the location of a diversion headworks.

Boulder stage : In this stage, the beds and the banks of the river are composed of boulders and gravels. In this stage, seepage losses are high.

Trough stage : In this stage, the cross-section of the river is made up of alluvial sand and silt. The bed slope and velocity are small. In this stage, seepage losses are less that's why **the most suitable location of canal headworks is in this stage.**

Delta stage : As the river cross section is very wide, therefore this stage is not suitable for the location of canal headworks.

112. (b)

Methods to minimize evaporation

- Reduction of surface area and increase in depth
- Providing mechanical covers over waterbody such as roof of plastic materials
- Sprinkling of chemicals such as **cetyl alcohol ($C_{16}H_{33}OH$) and stearyl alcohol ($C_{18}H_{37}OH$)**

113. (d)

Canal Lining :

The laying of the impervious layer which protects the bed and sides of the canal is called canal lining. The lining of the canal is necessary for the following reasons:

- To minimise the seepage losses through the bed and sides of the canal.
- To prevent scouring and erosion of bed and sides of the canal due to the high velocity of flood water at the time of heavy rainfall.
- Increase the discharge in the canal section by increasing the velocity.
- To prevent the growth of weeds along the bed and sides of the canal.
- To increase the command area.

114. (b)

(a) Inundation canal

1. An inundation canal is the one which gets its supplies only when the water level in the river, from which it takes off rises during floods.
2. These canals are not provided with any headworks for diversion of river water to the canal but obtain their supplies through open cuts in the bank of the river, which are called "heads".
3. The inundation canal are therefore non-perennial canals and the flow in these canal depend on the periodical rise of water level in the river.

(b) Feeder canal

1. A feeder canal is the one which is constructed only to feed another canal.
2. No direct irrigation is carried out from a feeder canal.
3. One of the important examples of feeder canal is Indira Gandhi feeder canal.

(c) Ridge canal or watershed canal

1. A ridge or watershed canal is the one which is aligned along the ridge or the natural watershed line.
2. When the canal runs on a watershed it can irrigate areas on both sides and hence a large area can be brought under construction i.e. the canal has a higher command area.
3. Further no drainage can intersect a ridge line or watershed, as all the drainage flow away from the ridge line, a ridge canal does not cross drainage line and hence for this canal cross drainage works are not required to be provided.

(d) Contour canal

1. A contour canal is the one which is aligned nearly parallel to the contours of the country.
2. It can irrigate area only on one side. As the ground level on the other side is higher it is not necessary to construct a bank on the side. Such a canal with only one bank is known as single bank canal.
3. When both the banks are provided it is known as double bank canal.

115. (b)

Δ = Total water depth required–Effective rainfall

$\Delta = 48 - 8 = 40$ cm

$$\text{Duty (D)} = \frac{864B}{\Delta(\text{cm})} = \frac{864 \times 10}{40} = 216 \text{ ha / cumec}$$

116. (d)

Furrow is a long, narrow irrigation trench made in the ground used for an optimal supply of water.

Furrows can be level and are very similar to long narrow basins. **However, a minimum grade of 0.05% is recommended so that effective drainage can occur following irrigation or excessive rainfall.**

Note:

The maximum recommended furrow slope is 0.5% to avoid soil errosion. Furrows can be set when the mainland slope does not exceed 3%. Beyond this, there is a major risk of soil erosion following a breach in the furrow system. On steep land, terraces can also be constructed and furrows cultivated along the terraces.

117. (d)

As per IS 800 : 2007 clause 10.5.2.3,

Thickness of thicker part (mm)	Minimum size (mm)
< 10 mm	3 mm
10 to 20 mm	5 mm
20 to 32 mm	6 mm
32 to 50 mm	8 mm for first run, 10 mm for minimum size of weld

118. (b)

Thickness of Lacing member should not be less than $1/40^{th}$ of the length between inner end rivets for single lacing and not less than $1/60^{th}$ of the length between inner end rivets for double lacing.

119. (c)

For compression member consisting of angle sections:

Sections	Type	Allowable compressive stress
1. Single or double angle	Continuous	σ_{ac}
2. Single angle connected with one rivet	Discontinuous	$0.8\ \sigma_{ac}$
3. Single angle connected with more than one rivet or with weld	Discontinuous	σ_{ac}
4. Double angles placed back to back on opposite sides of gusset plate	Discontinuous	σ_{ac}
5. Double angles placed back to back on same side of gusset plate	Discontinuous	$0.8\ \sigma_{ac}$

Thus,

For single angle discontinuous strut,

$A = 30\ cm^2$

Allowable stress, $\sigma_{ac} = 625\ kg/cm^2$

Hence,

Safe load carrying capacity = $A \times 0.8\ \sigma_{ac}$

$= (30 \times 0.8 \times 625) kg$

$= 15000\ kg$

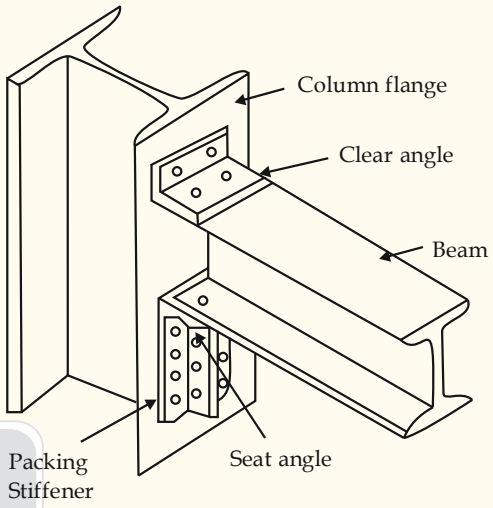
$= 15\ tonnes$

120. (c)

Seated Connection: The connection between one beam to another beam or column with the angle at top & bottom is called seated connection

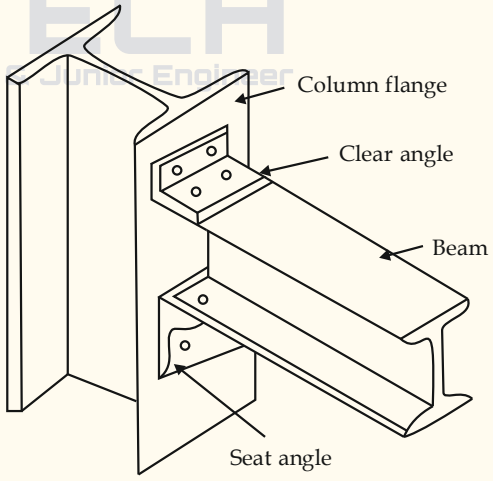
Seated connection is of two types

1. **Stiffened seated connection:**
   If packing stiffener is provided with angle at top & bottom as shown in figure



Stiffened seat connections

2. **Unstiffened seated connection:**
   If packing stiffener is not provided with angle at top & bottom



Unstiffened seat connections