LIVE RPSC-AE (DLB) Full Length Test Series

Civil Engineering
Full Length Paper - 2
Answer Key & Detailed Solution

Test Id - 502 **Date:- 19/03/2023**

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

37. (a)

38. (b)

39. (a)

40. (c)

41. **(d)**

Footing is at surface,

Hence, $D_f = 0$

$q_u = CN_c + \gamma D_f N_q + 0.5\ B\gamma N_\gamma$

$\Rightarrow$ For clay

$N_\gamma = 0,\ N_q = 1$

$\therefore\ q_u = CN_c$

As per Terzaghi,

$N_c = 5.7$

and as per Meyerhoff and Prandtl,

$N_c = 5.14$

$q_u = 5.14\ C_U$

$q_u = (3.14 + 2)C_U$

$q_u = (\pi + 2)C_U$

42. (c)

Discharge velocity i.e. $v = 6\times 10^{-7}$ m/sec

Void ratio i.e. $e = 0.50$

So, porosity i.e. $n = \frac{e}{1+e} = \frac{0.50}{1+0.50} = \frac{1}{3}$

As we know that,

Seepage velocity i.e. $V_s = \frac{V}{n.S}$

Where,

V = Discharge velocity = 6×10^{-7} m/sec

S = Degree of saturation = 80% = 0.8

$n = \text{Porosity} = \frac{e}{1+e} = \frac{0.50}{1+0.50} = \frac{1}{3}$ (Given e=0.5)

Hence, $V_s = \frac{6\times 10^{-7}}{\frac{1}{3}\times 0.8}$

$= 22.5\times 10^{-7}$ m/sec

43. (c)

$\gamma_{b_1} = 2.10\ \text{gm/cm}^3$

$w_1 = 15\%$

$\gamma_{b_1} = \frac{W_1}{V_1}$

$\because\ W_1 = 2.10\,V_1$

$\gamma_{b_2} = 1.95\ \text{gm/cm}^3$

$w_2 = ?$

$\gamma_{b_2} = \frac{W_2}{V_2}$

$\because\ W_2 = 1.95\,V_2$

(Weight of solids is constant in both cases)

So, $W_{S_1} = W_{S_2}$

$$\frac{W_1}{1+w_1} = \frac{W_2}{1+w_2}$$

$$\frac{2.10\,V}{1+0.15} = \frac{1.95\,V}{1+w_2}$$

(Volume of soil remain same in both cases)

Hence, $w_2 = 6.8\%$

44. (c)

In a saturated clay layer undergoing consolidation with single drainage at its top the pore water pressure could be the maximum at its bottom while in double drainage pore water pressure is maximum at its middle.

45. (d)

- **Unconsolidated undrained test :** In unconsolidated undrained test drainage of water is not allowed in cell pressure stage and deviator stage.
- **Consolidated undrained test :** In consolidated undrained test drainage of water is allowed in cell pressure stage but not in deviator stage.
- **Consolidated drained test :** In consolidated drained test drainage of water is allowed in cell pressure stage and deviator stage.

46. (d)

Height of unsupported vertical cut i.e. H_C is

$$H_C = \frac{4C}{\gamma\sqrt{K_a}}$$

Where, $K_a = \cot^2\left(45+\frac{\phi}{2}\right)$

Hence, $H_C = \frac{4C}{\gamma}\tan\left(45+\frac{\phi}{2}\right)$

47. **(b)**

Given,

$c = 24\ \text{kN/m}^2,\ \phi = 25^0,\ \gamma = 18\ \text{kN/m}^3$

$N_c = 25.1,\ N_q = 12.7,\ N_\gamma = 9.7$

$N_c' = 14.8$, $N_q' = 5.6$, $N_\gamma' = 3.2$

Square footing B = 2m, L = 2m, $D_f = 0$ (Surface footing)

Since, $\phi = 25^0 < 28°$

Assume local shear failure.

Hence, $c_m = \frac{2}{3}c = \frac{2}{3} \times 24 = 16\ \text{kN/m}^2$

$N_c' = 14.8$, $N_q' = 5.6$, $N_\gamma' = 3.2$

Ultimate bearing capacity of square footing

$q_u = 1.3c_m N_c' + \gamma D_f N_q' + 0.4\gamma B N_\gamma'$

$q_u = 1.3 \times 16 \times 14.8 + 0 + 0.4 \times 18 \times 2 \times 3.2$

$q_u = 307.84 + 46.08$

$q_u = 353.92\ \text{kN/m}^2$

48. (b)

- **Pile foundation** is used for isolated or group of columns.
- **Combined footing** is used for two or more columns.
- **Isolated footing** is used for individual column.
- **Mat foundation** is used for supporting all columns of structure.

49. (a)

GI value $= 0.2a + 0.005\ ac + 0.01\ bd$

$a = p - 35 \ngtr 40$

$b = p - 15 \ngtr 40$

$c = W_L - 40 \ngtr 20$

$d = I_p - 10 \ngtr 20$

Where, p = % fraction pass through 75 μ sieve i.e. 35%

W_L = Liquid limit of soil i.e. 40%

I_P = Plasticity index i.e. 10%

So, a = 0, b = 20, c = 0, d = 0

Hence,

$GI = 0.2 \times 0 + 0.005 \times 0 \times 0 + 0.01 \times 20 \times 0$
$= 0$

50. **(b)**

As we know that

$S_r + S_y = n$

where,

S_r = Specific retention

S_y = specific yield

n = porosity

$\therefore 0.15 + S_y = 0.35$

$\therefore S_y = 0.20$ ...(i)

Change in volume of storage in aquifer,

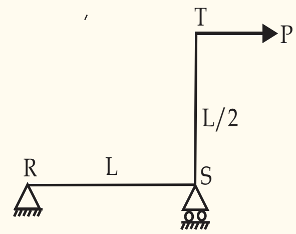
$\Delta V = S_y \times A \times d$

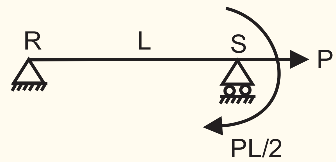
where, d = drop

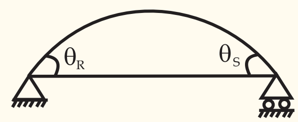
$\therefore \Delta V = 0.20 \times 200 \times 10^4 \times 4$

$\Delta V = 1.6 \times 10^6\ \text{m}^3$

51. **(d)**







$$\theta_R = \frac{(PL/2)L}{6EI}$$

$$\theta_R = \frac{PL^2}{12EI}$$

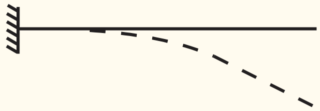
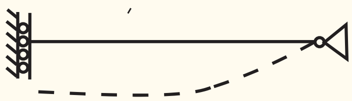
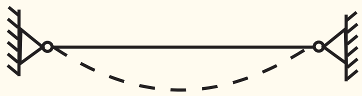
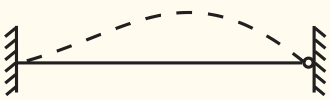
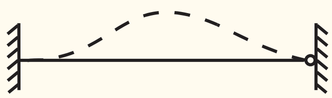
52. **(d)**

Statement 1: Correct

Because, $f_{CD} \propto \frac{1}{\lambda}$

Statement 2: Correct

Because

Boundary conditions	Effective length
	2.0L
	2.0L
	1.0L
	1.2L
	0.8L
	0.65L

Statement 3: Incorrect

Because, $f_{cr} = \frac{\pi^2 E}{\lambda^2}$,

where λ = slenderness ratio of compression member.

Statement 4: Correct

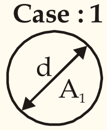
Because, $\lambda = \frac{kL}{r}$

kL = effective length

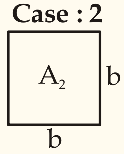
r = radius of gyration

53. (d)

Case : 1



Case : 2



$\text{Area} = \frac{\pi}{4} d^2$ $\qquad$ $\text{Area} = b^2$

$\because \quad A_1 = A_2 \text{ (given)}$

$$\frac{\pi}{4} d^2 = b^2$$

$$b = \sqrt{\frac{\pi}{4}} d \qquad \text{... (i)}$$

Now, I_{NA} = Moment of Inertia about neutral axis.

$$(I_{NA})_{Circular} = \frac{\pi d^4}{64}; \quad y_{max} = \frac{d}{2}$$

$$(Z)_{Circular} = \frac{I_{NA}}{y_{max}} = \frac{\pi d^4/64}{d/2}$$

$$= \frac{\pi d^3}{32} = 0.0982 d^3$$

$$(I_{NA})_{Square} = \frac{b^4}{12}; \quad y_{max} = \frac{b}{2}$$

$$(Z)_{Square} = \frac{I_{NA}}{y_{max}} = \frac{b^4/12}{b/2} = \frac{b^3}{6} \qquad \text{...(ii)}$$

Using equation (i) in (ii),

$$(Z)_{Square} = \frac{\left(\sqrt{\frac{\pi}{4}} d\right)^3}{6} = \frac{\left(\frac{\pi}{4}\right)^{3/2} d^3}{6}$$

$$= 0.116 d^3$$

$$\boxed{Z_{Square} > Z_{circular}}$$

Hence, square section is more economical.

54. (b)

$$\frac{TL}{GJ} = \phi$$

For, $\quad L = 1, \ \phi = 1$

$T = GJ$

Here, $\quad GJ$ = Torsional rigidity

EA = Axial rigidity

EI = Flexural rigidity

55. (a)

Ductility:- It is a measure of the amount by which a material can be drawn out in wire by tension before it fractures.

Brittleness:- A material breaks with little elastic deformation and without significant plastic deformation, such type of sudden failure without warning is cause due to the brittleness of material.

Toughness:- Ability to absorb mechanical energy up to failure is called toughness, it is desirable against impact loading.

Malleability:- Malleability is the ability of a material to be deformed or spread in different direction, this is usually caused by compressive forces during rolling, pressing and hammering action.

56. **(a)**

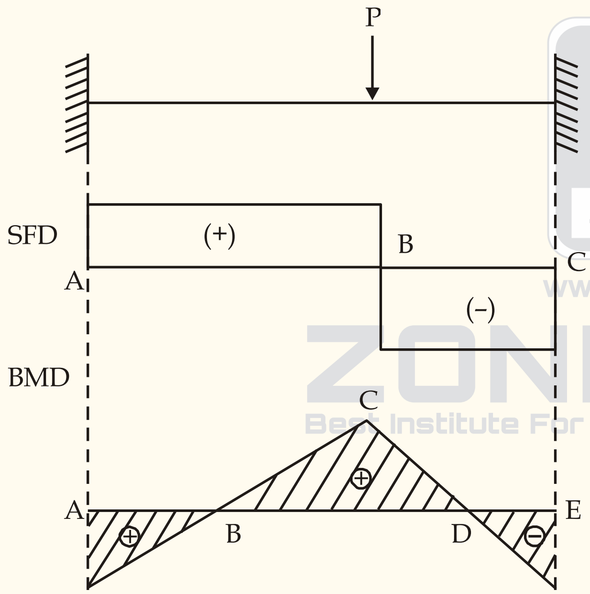
- Bending moment is linear so shear force distribution is constant.

$\because$ Shear force, $V = \dfrac{dM}{dx}$

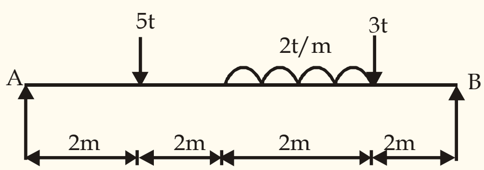
where, M = Bending moment

- +ve bending moment is maximum at C and -ve bending moment is maximum at A and E. So, option (a) is correct.

Note:-



57. (d)



Taking moment about B,

$$R_A = (6/8) \times 5 + \frac{3}{8} \times 4 + 3 \times \frac{2}{8}$$

$$= 3.75 + 1.5 + 0.75 = 6.0t$$

Taking moment about A,

$$R_B = \left(\frac{2}{8}\right) \times 5 + \frac{5}{8} \times 4 + 3 \times \frac{6}{8}$$

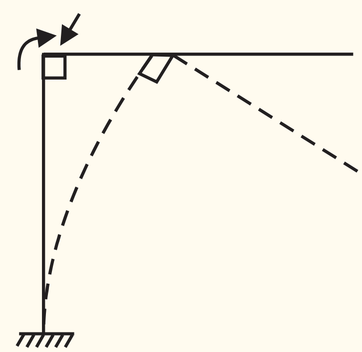
$$= 1.25 + 2.5 + 2.25 = 6.0t$$

$$\therefore \quad \frac{R_A}{R_B} = 1.0$$

58. **(a)**

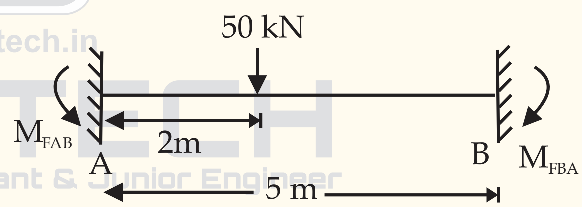
- A rigid joint will have translation and rotation as a whole.

Rigid Joint



- In a rigid joint, angle between two members does not change.

59. **(d)**



Fixed end moment,

$$M_{FAB} = \frac{Pab^2}{l^2} = \frac{50 \times 2 \times 3^2}{5^2} = 36 \text{ kNm}$$

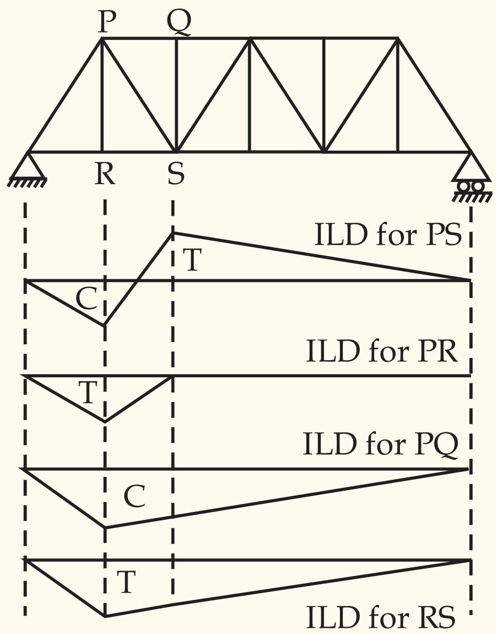
$= 36$ kNm (anticlockwise)

Fixed end moment,

$$M_{FBA} = \frac{Pa^2b}{l^2} = \frac{50 \times 3 \times 2^2}{5^2}$$

$= 24$ kNm (clockwise)

60. (a)



61. (b)

PQ is a horizontal stiffener in the given plate girder. Horizontal stiffeners are also called longitudinal stiffeners. The horizontal stiffener are provided in the compression zone of the web. The first horizontal stiffener is provided at one-fifth of the distance from the compression flange to the tension flange. If required another stiffener is provided at the neutral axis. Horizontal stiffeners are not continuous and are provided between vertical stiffeners.

RS is a vertical stiffener in the given plate girder. Vertical stiffeners are also called transverse stiffeners. It is assumed that the vertical stiffener is not subjected to any load and is selected to provide necessary lateral stiffness only and can therefore, be crimped or joggled for tight fittings. Such stiffeners increase the buckling resistance of the web caused by shear.

62. (c)

At one end		At other end		Effective length
Translation	Rotation	Translation	Rotation	
Restrained	Restrained	Free	Free	2.0 L
Free	Restrained	Free	Restrained	2.0 L
Restrained	Free	Restrained	Free	1.0 L
Restrained	Restrained	Free	Restrained	1.2 L
Restrained	Restrained	Restrained	Free	0.8 L
Restrained	Restrained	Restrained	Restrained	0.65 L

63. (a)

The minimum size of fillet weld should not be less than 3mm and not more than thickness of thinner plate jointed.

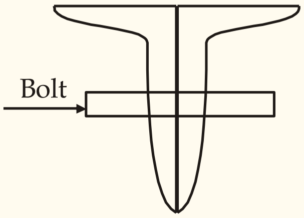
64. (b)

Double angle section : When two angle sections are connected with each other in any configuration is termed as double angle section.

- **Equal angles on the same side of the gusset plate :** It has a very low radius of gyration about the axis parallel to gussel plate and it acts as weak axis for buckling, hence least preferred.
- **Equal angles on the opposite side of the gusset plate :** It is good compared to equal angles on the same side as no weak axis with respect to radius of gyration. But its axial capacity is less compared to unequal double angles.
- **Unequal angles with short legs back to back :** It has slightly improved axial capacity compared to equal sections but has a low radius of gyration about the axis perpendicular to the short edges, hence not preferred.
- **Unequal angles with long legs back to back :** It has slightly improved axial capacity compared to equal sections and does not have weak axis for bucking, hence it is best preferred section among the double angles sections. It has larger value of radius of gyration.

Note :

Unequal legged angles with long legs back to back



Maximum strain in tension reinforcement (Fe-415 and E_S = 200 kN/mm²) $= \frac{0.87\ f_y}{E_S} + 0.002$

$$= \frac{0.87 \times 415}{200 \times 10^3} + 0.002$$

$$= 0.0038$$

65. (d)

Perry Robertson formula,

$$f_{cd} = \frac{f_y / \gamma_{m_0}}{\phi + \left[\phi^2 - \lambda^2\right]^{0.5}}$$

$$\phi = 0.5[1 + \alpha(\lambda - 0.2) + \lambda^2]$$

From above formula, it is clear that for less value of 'α' f_{cd} is more.

Buckling class	Imperfection	α	Example
a	Least imperfection	0.21	Hot rolled I section
b	Medium imperfection	0.34	Welded I-section with thin flange, box section
c	Lots of imperfection	0.49	Channel, angles, tee shape, thick box section, I section about minor axis
d	Maximum imperfection	0.76	Hot rolled I section very thick flange, thick I section buckling about minor axis

66. (a)

$$\text{Nominal cover} = \text{Effective cover} - \frac{\phi_m}{2} - \phi_{st}$$

$$= 50 - \frac{16}{2} - 12 = 30 \text{ mm}$$

67. (a)

Maximum strain in an extreme fibre of concrete = 0.0035

68. (c)

As per **IS 456 : 2000, Table 9** (Proportions for nominal Mix concrete)

Grade of concrete	Total Quantity of dry aggregates by Mass per 50 kg of cement, to be taken as the sum of the individual masses of fine and coarse aggregates (kg), max	Quantity of water per 50 kg of cement (*l*), max
M 5	800	60
M 7.5	625	45
M 10	480	34
M 15	330	32
M 20	250	30

69. (b)

As per **IS 456 : 2000 clause 10.2.2,** the accuracy of measuring equipment shall be within ± 2% of quantity of cement being measured & within ± 3% of quantity of aggregate, admixture & water being measured.

70. (d)

As per **IS 456 : 2000 clause 31.7.1,** Spacing of bars in non-celluar, non-ribbed flat slab shall not exceed 2 times slab thickness

71. (d)

As per **IS 456 : 2000 clause 15.2.2,**

Quantity of Concrete (m^3)	Number of Samples
1 - 5	1
6 - 15	2
16 - 30	3
31 - 50	4
51 & above	4 + 1 additional sample for each additional 50 m^3 or its part

Hence, for 101 m^3 of concrete work
Number of samples = 4 + 1 + 1 = 6

72. (d)
As per **IS 456 : 2000 clause 35.3.2,**

Width of crack	Conditions
≤ 0.3 mm	In members where cracking is not harmful
≤ 0.2 mm	In members where cracking in tensile zone is harmful because they are continuously exposed to ground water (moderate category)
≤ 0.1 mm	Members subjected to aggressive environment (Severe category)

73. (c)
As per **IS 456 : 2000, Clause 26.2.3.2**, the shear at cut-off point should not exceed two thirds that permitted that means:

$$\text{Shear capacity} = \frac{3}{2}\text{(applied shear)}$$

74. (a)
A beam is considered to be deep beam when

$$\frac{\text{Effective span } (l)}{\text{Overall depth (D)}} < 2 \text{ (For simply supported beam)}$$

$$\frac{\text{Effective span } (l)}{\text{Overall depth (D)}} < 2.5 \text{(For continuous beam)}$$

75. (d)
As per **IS 456 : 2000 clause 26.5.2,**
- Minimum flexural reinforcement of Fe250 steel in slabs = 0.15% of gross cross-sectional area.
- Minimum flexural reinforcement of Fe415 steel in slabs = 0.12% of gross cross-sectional area.

As per **IS 456 : 2000 clause 26.5.1.1,**
- Minimum flexural steel reinforcement in beams is as follows

$$\frac{A_{st,min}}{bd} \geq \frac{0.85}{f_y}$$

76. (d)
According to Newton's second law of motion, the net force $\vec{F}$ acting on a fluid element is equal to mass M of the fluid element multiplied by the acceleration $\vec{a}$. Thus mathematically,

$$\vec{F} = M\vec{a}$$

In the fluid flow various forces acting are
(a) Gravity Force $(\vec{F_g})$
(b) Pressure Force $(\vec{F_p})$
(c) Viscous Force $(\vec{F_v})$
(d) Force due to compressibility $(\vec{F_c})$
(e) Force due to turbulence $(\vec{F_t})$
(f) Minor forces like surface tension $(\vec{F_\sigma})$

- When all forces are taken into account the equation of motion is called newton's equation of motion.
- When compressibility and other minor forces are neglected, it is called Reynold's equation of motion

$$\vec{F_g} + \vec{F_p} + \vec{F_v} + \vec{F_t} = M\vec{a} \quad \text{.. (i)}$$

- When compressibility, turbulence and minor forces are neglected and only gravity, pressure and viscosity is taken into account, the equation of motion is called Navier-stokes equation of motion

$$\vec{F_g} + \vec{F_p} + \vec{F_v} = M\vec{a} \quad .. (ii)$$

- When only gravity and pressure force are considered the equation of motion is called Euler's equation of motion

$$\vec{F_g} + \vec{F_p} = M\vec{a} \quad .. (iii)$$

From equation (ii) we can say that Navier-Stokes equation are useful for the analysis for viscous flow while from equation (iii) we can say that Euler's equation are not applicable for viscous flow.

77. (b)

Following point are needed in selecting repeating variables.

- They must have amongst themselves all the basic dimensions involved in the problem
- The dependent variable must not be chosen as repeating variable.

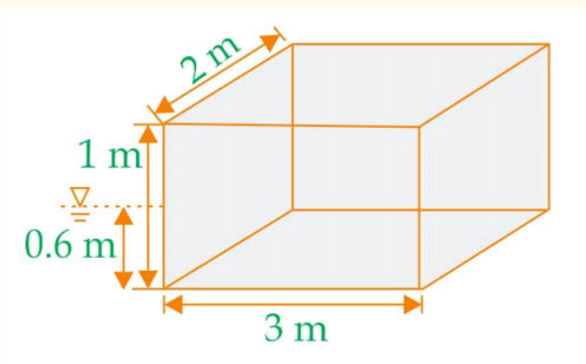
78. (d)

As we know that, Buoyancy force on any body is equal to the weight of the fluid displaced by the body.

And according to Law of Floatation, when a body floats in a fluid, the weight of the fluid displaced by its immersed part is equal to the total weight of the body. So, we can say that when a body floats, Buoyancy force is equal to the Weight of the body.

Weight of body (W) = Buoyancy force = Submerged volume of body x Unit weight of water

Given,



L = 3 m, B = 2m and H = 1m & Submerged depth = 0.6 m

So, Submerged volume of body,

= 3 × 2 × 0.6 = 3.6 m^3

& Unit weight of water = 10 kN/m^3 (as given in question)

Hence, W = Submerged volume of body × Unit weight of water

W = 3.6 m^3 × 10 kN/m^3 = 36 kN

79. (a)

In Fluid Mechanics, the matter of concern is the general state of motion at various points in the fluid system (as in Eulerian approach) rather than the motion of each particle (as in Lagrangian approach). Hence, the Eulerian method is extensively used in Fluid Mechanics.

80. (d)

When horizontal and vertical scales are different, then model is said to be distorted.

$$(L_r)_H = \left(\frac{1}{1000}\right)$$

$$(L_r)_V = \left(\frac{1}{100}\right)$$

$$Q_m = 0.1\ m^3/s$$

As we know that,

$$Q_r = A_r \times V_r$$

$$\frac{Q_m}{Q_p} = \left(\frac{L_m}{L_p}\right)_H \left(\frac{L_m}{L_p}\right)_v \sqrt{\left(\frac{L_m}{L_p}\right)_v}$$

$$\frac{Q_m}{Q_p} = \frac{1}{1000} \times \frac{1}{100} \times \frac{1}{10}$$

$$\frac{0.1}{Q_p} = \frac{1}{10^5 \times 10}$$

$$\therefore \quad Q_p = 10^5\ m^3/s$$

81. (d)

$y_1 = 1m$

$y_2 = 2m$

Head loss due to hydraulic jump i.e. E_L is

$$E_L = \frac{(y_2 - y_1)^3}{4y_1y_2} = \frac{(2-1)^3}{4 \times 1 \times 2} = 0.125\,m$$

82. (b)

$\therefore$ The force exerted by the jet in the direction of motion of plate,

F_x = Mass per second [Initial velocity - Final velocity]

$= \rho aV[(V - u)-0] = \rho aV[V - u]$

Work done by the jet on the series of plates per second,

= Force × Distance per second in the direction of force

$= F_x \times u = \rho aV[V - u] \times u$

Kinetic energy of the jet per second

$$= \frac{1}{2} mV^2 = \frac{1}{2} (\rho aV) \times V^2 = \frac{1}{2} \rho aV^3$$

$$\therefore \text{Efficiency, } \eta = \frac{\text{Work done per second}}{\text{Kinetic energy per second}}$$

$$= \frac{\rho aV(V-u)\times u}{\frac{1}{2}\rho aV^3} = \frac{2u(V-u)}{V^2}$$

83. **(a)**

Hardness is due to multivalent metallic cations, i.e. Ca^{2+} and Mg^{2+}

Total hardness (mg/l as $CaCO_3$)

= (Total meq/l) × (eq. weight of $CaCO_3$ in mg)

= (4.1) × 50 mg/l as $CaCO_3$

= 205 mg/l as $CaCO_3$

Alkalinity is due to the presence of HCO_3^- in this case,

Alkalinity (mg/l as $CaCO_3$)

= 3.3 × 50 mg/l as $CaCO_3$

= 165 mg/l as $CaCO_3$

Now, non-carbonate hardness

= Total hardness in excess of alkalinity

= 205 - 165

= 40 mg/l as $CaCO_3$

84. (c)

In flocculation tanks, a certain element is mixed in the water to neutralize the charge on the surface of the small particles that do not settle in the sedimentation tank. As the charges get neutralized, the particles come in contact with each other, stick together and form a larger particle that can be settled easily. So, in the case of tapered flocculation, the initial velocity gradient is kept higher so that the mixing agent can be dispersed easily in the whole sample. Particles get mixed for two reasons: velocity gradient and due to the Brownian motion and their collision with each other. Now as the flocs are formed, the velocity gradient needs to be reduced, so that the flocs do not get bombarded by other particles and get reduced in size and along with it is also done to get in contact with other particles to make the flocs bigger. Hence, for tapered flocculation, the velocity gradient at the inlet needs to be higher and at the outlet, it needs to be lesser.

This type of flocculation greatly increases the efficiency and removes comparatively more particles than the conventional one.

85. (b)

Overflow rate = 17m³/day/m² = 17/86400 = m³/s/m² = 0.1967 mm/s

Settling velocity of particles to be removed = 0.1 mm/s

Percentage of particle's removal.

$$= \frac{0.1}{0.1967} \times 100 = 50.84\% \simeq 50\%$$

86. (b)

Detention time for different types of Treatment units are as follows:

Treatment Unit	Detention time
Grit chamber	30-60 second
Primary sedimentation	2-2.5 hour
Sludge digestion	20-30 days
Activated sludge	4-6 hour
Oxidation pond	2-6 weeks
Septic tank	12-36 hour

87. (c)

Given,

$$D_2 = 2D_1$$

As we know that

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

So, $$R_1 = \frac{A_1}{P_1} = \frac{\frac{\pi D_1^2}{4}}{2\pi D_1} = \frac{\pi D_1^2}{8\pi D_1} \quad \text{... (i)}$$

& $$R_2 = \frac{A_2}{P_2} = \frac{\pi D_2^2}{8\pi D_2} = \frac{\pi(2D)_1^2}{8\pi(2D)_1} = \frac{\pi D_1^2}{4\pi D_1} \quad \text{... (ii)}$$

Dividing equation (i) by (ii)

$$\therefore \frac{R_1}{R_2} = \frac{1}{2}$$

As we know that

$$\frac{V_1}{V_2} = \left(\frac{R_1}{R_2}\right)^{2/3}$$

Hence, $$\frac{V_1}{V_2} = \left(\frac{1}{2}\right)^{2/3}$$

88. (a)
- Sludge with poor settling characteristics is termed bulking sludge.
- Sludge bulking results in poor influent due to presence of excessive suspended solid and also in rapid loss of MLSS from tank.

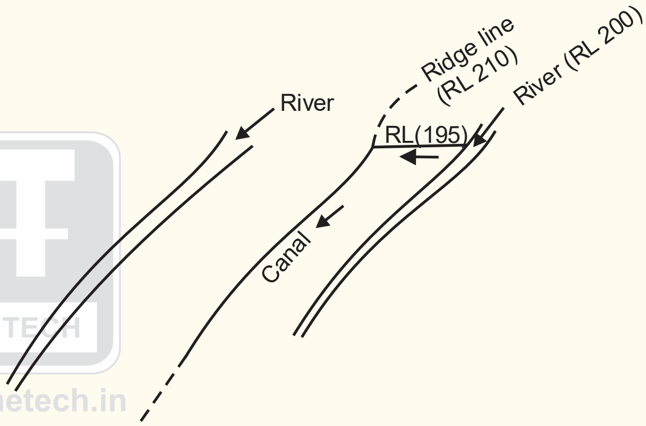
Sludge bulking can be reduced by
- Reducing sludge age
- Chlorination of returned activated sludge
- Addition of nutrient if it is less.

89. (d)
(i) The sources of supply (such as wells) may be designed for maximum daily consumption or some times for average daily consumption.
(ii) The pipe mains (to take water from source to service reservoir) and filter and other treatment units are designed for the maximum daily draft.
(iii) Pumps may be designed for maximum daily draft plus some additional reserve for break down and repair.
(iv) The distribution system (to carry water from service reservoir to water taps) should be designed for the maximum hourly draft of maximum day or coincident draft with fire, whichever is more.
(v) The service reservoir is designed to take care of hourly fluctuations, fire demands and emergency reserves.

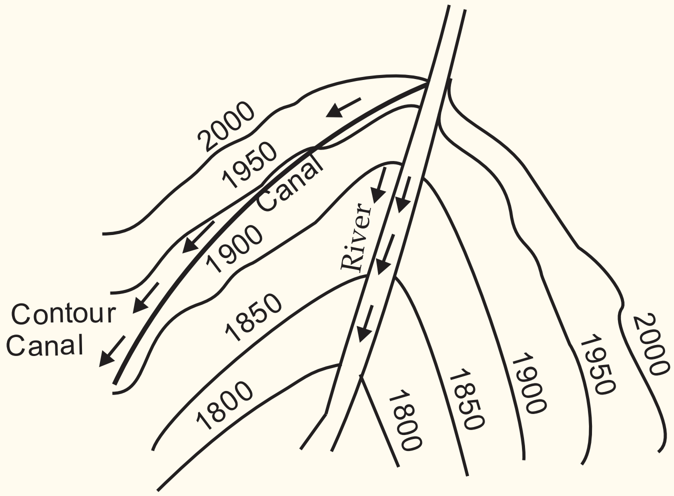
90. (b)
- **Arithmetic increase method :** Suitable for large and old city with considerable develop-ment. In it population is assumed to increase at a constant rate.
- **Geometric increase method :** Suitable for young and rapidly growing city
- **Incremental increase method :** Suitable for cities likely to grow progressively at a increasing rate rather than constant. It is a modification of arithmetic increase method.
- **Logistic method :** Suitable for cities wher growth is likely to reach an ultimate saturation limit because of local factors.

91. **(a)**
Irrigation canal can be aligned in any of the following three ways.

(i) Watershed canal or ridge canal
- Canal which is aligned along any natural watershed is called a watershed canal or ridge canal.
- Aligning the canal on the ridge ensures gravity irrigation on both sides of the canal.
- No cross-drainage work are required since the drainage flows away from the ridge.
- This type of canal is preferred in plain areas where land slopes are relatively flat and uniform.



(b) Contour canal
- Contour canals follow a contour, except for giving the required longitudinal slope.
- It irrigates only on one side because the areas on the other side is higher.
- This type of canal necessitate the construction of cross drainage works as the drainage flow is always at right angles to the ground contour.

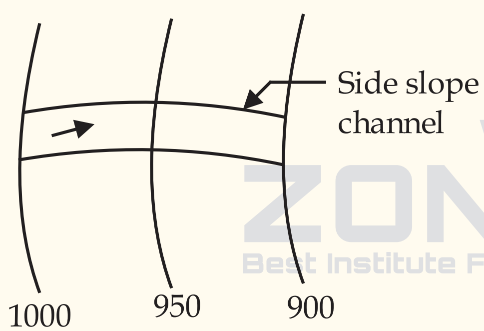


(c) **Side slope canal**

• A side slope canal is that which is aligned at right angles to the contour.

•In such canals, flow runs parallel to natural drainage.

•Usually, flow in such canals does not intercept the drainage channel thus avoid the construction of cross-drainage works.



92. (c)

Water Conveyance Efficiency: It is defined as the ratio of quantity of water delivered to the field or the irrigated land to the quantity of water diverted into the canal system.

Water Application Efficiency: It is defined as the ratio of the quantity of water stored in the root zone of the plants to the quantity of water delivered to the field.

Water Use Efficiency: It is defined as the quantity of water used beneficially including the water required for leaching to the quantity of water delivered.

Water Storage Efficiency: It is defined as the ratio of the quantity of water stored in the root zone during irrigation to the quantity of water needed to bring the moisture content of the soil to the field capacity.

93. (c)

Porous lining

1. If ground water table is higher than bed level of main canal the porous lining is advisable.
2. The porous lining allows water pressure to be released and occurance of back pressure is eliminated.
3. For porous lining, 15 cm inverted filter is spread evenly on the prepared subgrade and stone pitching is done by hand packing.
4. This lining does not provide any imperviousness but is used for the drainage of the banks.

94. (a)

As per IS 7112:2002 methods are used for design of unlined channels are as follows:

1. Lacey's Method (ANNEX-A, Clause 4.8, Note 2)
2. Regime Type Fitted Equations (ANNEX-B, Clause 4.8, Note 3)
3. Tractive Force Approach (ANNEX-D, Clause 4.8, Note 4)
4. Lacey's Modified Equations (ANNEX-C, Clause 4.8, Note 3)

95. (b)

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:

(a) to **minimize the seepage losses** through the bed and sides of the canal.

(b) 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.

(c) **increase the discharge** in the canal section by increasing the velocity.

(d) to **prevent the growth of weeds** along the bed and sides of the canal.

(e) to **increase the command area**.

96. (b)

If bed level of canal is sufficiently above the HFL of the drain, an **Aqueduct** may be constructed. Sometimes bed level of canal may be little below the HFL of drain so that water

flows under syphonic action. This structure is known as **Syphon Aqueduct**.
If bed level of the drain is sufficiently above the canal FSL, a **Super Passage** is the right choice.
If the canal FSL is little above bed level of drain to allow syphonic action, the structure is called **Canal Syphon**.
A level crossing is used when the canal water and drain water are allowed to intermingle with each other.

97. (c)

$$d_{min} = 11RS_0$$

where $R = \frac{By}{B+2y} \simeq y \left[\because B >> y\right]$

$$d_{min} = 11(0.8)0.0041$$
$$= 0.03608\,m$$
$$= 36\,mm$$

98. (a)
Probable Maximum Flood (PMF): This is the flood resulting from the most severe combination of critical meteorological and hydrological conditions that are reasonably possible in the region. The PMF is computed by using the Probable Maximum Storm (PMS) which is an estimate of the physical upper limit to storm rainfall over the catchment. This is obtained from the studies of all the storms that have occurred over the region and maximizing them for the most critical atmospheric conditions.

Standard Project Flood (SPF): This is the flood resulting from the most sever combination of meteorological and hydrological conditions considered reasonably characteristic of the region.The SPF is computed from the Standard Project Storm (SPS) over the watershed considered and may be taken as the largest storm observed in the region of the watershed.

Design Flood is the value of the instantaneous peak discharge adopted for the design of a particular project or any of its structures. In addition to the considerations of the flood characteristics, frequencies and potentiality of the contributing drainage area above the structure, social, economic and other non-hydrological considerations which are likely to have influence are considered in deriving a design flood.

The term **"design flood"** is used to denote the **"maximum flood"** flow that could be passed without damage or serious threat to the stability of engineering structures.

99. (a)
Evaporation is defined as the process in which the liquid changes to the gases state at the free surface, below the boiling point through the transfer of heat energy. It is a cooling process in which latent heat of vaporization is provided by the water body itself.
The rate of evaporation is dependent on the following factors -

1. The vapor pressure at water surface (Vapor Pressure $\uparrow \Rightarrow$ Evaporation $\downarrow$)
2. Air and water temperatures (Temperature $\uparrow \Rightarrow$ Evaporation$\uparrow$)
3. Wind speed (Wind Speed $\uparrow \Rightarrow$ Evaporation $\uparrow$ up to some extent after that evaporation rate became constant)
4. Atmospheric pressure (Atmospheric Pressure $\uparrow \Rightarrow$ Evaporation $\downarrow$)
5. Quality of water (Quality $\uparrow \Rightarrow$ Soluble Salts $\downarrow \Rightarrow$ Evaporation $\uparrow$)
6. Size of the water body (Size $\uparrow \Rightarrow$ Surface Area $\uparrow \Rightarrow$ Evaporation $\uparrow$)
7. Depth of water (During summer, Depth $\uparrow \Rightarrow$ Evaporation $\downarrow$, while during winter, Depth $\uparrow \Rightarrow$ Evaporation $\uparrow$)
8. For convex water surface, rate of evaporation is more while for concave water surface rate of evaporation is less

100. (a)
A. **Resonant frequency test** is used to determine dynamic modulus of elasticity whereas destructive test like cube test etc measures the static modulus of elasticity.
B. **Rebound hammer test** is a non-destructive test used for compressive strength of concrete.
C. **Split cylinder test** is used to determine the direct tensile strength of concrete.
D. **Compaction factor test** is used to measure workability of concrete.

101. (c)
The masonry work over the foundation lime concrete should be started only after 7 days.
Note:

- In case of cement concrete, however the masonry work over the foundation concrete may be started after 2 days of its laying.
- In case of lime concrete, the curing should start after 24 hours of its laying and should be continued for a minimum period of 7 days.

102. (d)

Bethel's process / Fuel cell process

- It is the method of treatment of timber in which preservatives is applied with pneumatic process.
- It is used when maximum absorption of preservative is desired.
- The timber charged into the cylinder and if needed spacers should be used to separate the pieces. The door is tightly closed and then a vacuum of atleast 560 mm of mercury is created and maintained for half an hour to remove as much air as possible from the wood cells. At the end of the vacuum period, the preservative is introduced into the cylinder, with the vacuum pump working. When the cylinder has been filled with the preservative , the vacuum pump is stopped and the cylinder is subjected to an antiseptic pressure of 0.35 to 1.25 N/mm^2 depending on the species, size and refractory nature of timber to inject the preservative into the timber. The pressure is held until the desired absorption is obtained.

103. (a)

Casement Windows:- Casement windows are the widely used and common windows nowadays. The shutters are attached to frame and these can be opened and closed like door shutters. Rebates are provided to the frame to receive the shutters. The panels of shutters may be single or multiple. Sometimes wired mesh is provided to stop entering of fly's.

Sliding Windows:- In this case, window shutters are movable in the frame. The movement may be horizontal or vertical based on our requirement. The movement of shutters is done by the provision of roller bearings. Generally, this type of window is provided in buses, bank counters, shops etc.

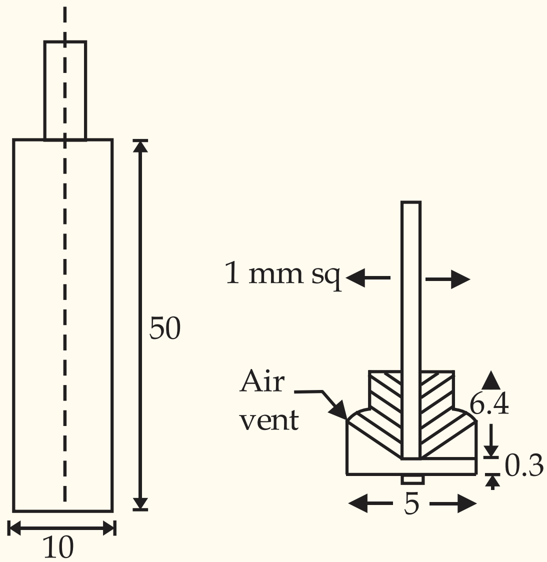
Bay Windows:- Bay windows are projected windows from wall which are provided to increase the area of opening, which enables more ventilation and light from outside. The projection of bay windows are of different shapes. It may be triangular or rectangular or polygonal etc. They give beautiful appearance to the structure.

Louvered windows:- Louvered windows are similar to louvered doors which are provided for the ventilation without any outside vision. The louvers may be made of wood, glass or metal. Louvers can also be folded by provision of cord over pulleys. We can maintain the slope of louvers by tilting cord and lifting cord. Recommended angle of inclination of louvers is about 45^0. The sloping of louvers is downward to the outside to run-off the rain water. Generally, they are provided for bathrooms, toilets and privacy places etc.

104. (c)

Diameter, length and shape of Vicat apparatus for different test:

S.No	Types of test	Diameter or size	Length	Shape
1.	Consistency	10 mm	Upto 50 mm & 40 mm	Solid circular
2.	Initial setting time	1 mm of square needle	Upto 50 mm & 40 mm	Square needle
3.	Final setting time	5 mm	Upto 50 mm & 40 mm	Annual ring



Plunger **Enlarged view of needle**

(All dimensions are in mm)

105. (b)

Following are the different underpinning methods used for foundation strengthening

- Mass concrete underpinning method (pit method)
- Underpinning by cantilever needle beam method
- Pier and beam underpinning method
- Mini piled underpinning
- Pile method of underpinning
- Pre test method of underpinning

106. (b)

Abram's Law (In 1919) : States that "Assuming full compaction, at a given age and normal temperature, the strength of concrete can be taken to be inversely proportional to the water-cement ratio."

The increase in water-cement ratio decreases the strength of mix.

Workability : Workability of concrete describes how easily freshly mixed concrete can be mixed, placed, consolidated and finished with minimal loss of homogeneity.

As water-cement ratio increases workability increases.

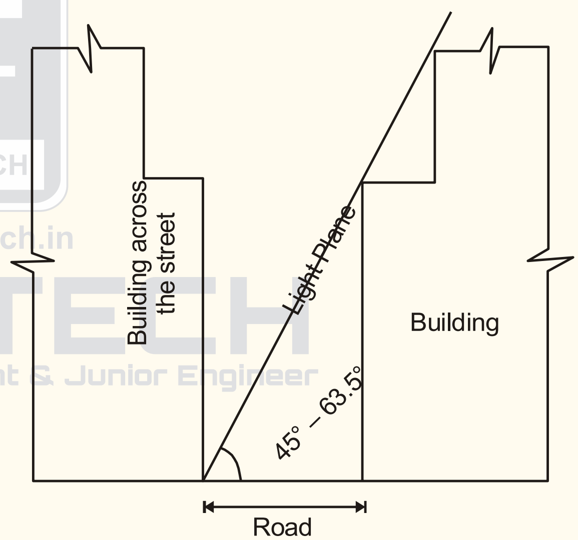
107. (a)

As per building bye-laws, $63\frac{1}{2}°$ Rule is generally used for fixing up the height of a building. It is related to the term 'light plane' in building bye-law.

Light Plane :

The light plane is the plane at which the light comes at a building the majority of the time in all weather. It means that the light plane is the angle at which the shadow of the building is going to appear.

- According to the building bye-law, the value of light plane varies from 45° to 63.5°
- It means the average value of the light plane is taken as 45° and it can go maximum up to a value of 63.5°
- This is selected in such a way so that the height of one building does not affect the lighting and ventilation of the building across the street.



108. (d)

S.No.	Occupancy classification	UDL (kN/m^2)	Concentrated load (kN)
1	**Residential Buildings**		
a)	All room & kitchens	2.0	1.8
b)	Toilet and bathroom	2.0	1.8
c)	Corridors, passage, Staircase including tire space and storeroom	3.0	4.5
d)	Balconies	3.0	1.5 per meter run concentrated at the outer edge
2	**Educational Buildings**		
a)	Classroom & lecture rooms	3.0	2.7
b)	Dining rooms, cafeterias, and restaurants	3.0	2.7
c)	Offices, lounges, and staff rooms	2.5	2.7
d)	Dormitories	2.0	2.7
e)	Toilets and bathrooms	2.0	4.5
f)	Corriodors, passages, lobbies, staircases including fire escapes-as per the floor serviced (without accounting for storage and projection rooms) but not less than	4.0	4.5

109. (b)

The errors that can be eliminated by changing face are as follows

1. Error due to the line of collimation not being perpendicular to the horizontal axis.
2. Error due to horizontal axis not being perpendicular to the vertical axis.
3. Error due to the line of collimation not being parallel to the axis of the altitude level.

110. (c)

As per trapezoidal method,

Volume of embankment i.e. V is

$$V = \frac{d}{2}[A_1 + A_3 + 2A_2]$$

Where,

d is the common interval i.e. 30 m

& A_1, A_2 and A_3 are the areas of sections i.e. 20 m^2, 40 m^2 and 50 m^2

Hence, $$V = \frac{30}{2}[20 + 50 + 2 \times 40]$$

$$V = 2250\,m^3$$

111. (b)

According to science, position and motion are relative terms.

As we know earth revolves around the Sun but we are on earth.

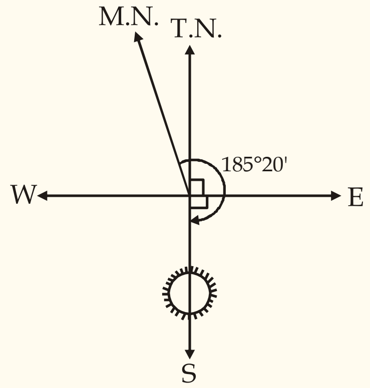
We see, Sun is changing direction from east to west in clocking direction.

So, if we keep the earth in centre the Sun will be move as-

In morning - In east

In noon - In south

In afternoon - In west



So, magnetic declination will be equal to

$= T_B - M_B$

$\because$ T_B of sun at noon = 180°

= 180° – 185°20'
= –5°20' {west}

Declination is measured from true north so, magnetic declination = 5°20' west.

112. (c)

The fundamental lines of theodolite :

1. Vertical axis
2. Horizontal axis (Trunnion axis)
3. Line of collimation (Line of sight)
4. Altitude level axis.
5. Plate level axis.

When the Theodolite is in proper adjustment, the following four conditions between fundamental lines are satisfied :

- The axis of plate level is perpendicular to the vertical axis.
- The horizontal axis is perpendicular to the vertical axis.
- The line of collimation axis at right angles to the horizontal axis.
- The axis of altitude level is parallel to the line of collimation when it is horizontal, and the vertical circle reads zero.

113. (a)

$$\text{Degree of accuracy} = \frac{\text{Probable error}}{\text{Measured distance}}$$

$$= \frac{0.05}{584.65}$$

$$= \frac{1}{11693} \approx \frac{1}{11700}$$

114. (a)

1) **IRC – 6: Standard specifications and code of practice of road bridges.**
2) IS: 875, Part – I: Code of practice for design loads for buildings and structures.
3) IS: 3370 – Code of practice for the concrete structures for storage of liquids
4) IRC – 38: Guidelines for design of horizontal curves.

115. (b)

Method-I

$$W_{me,60} = \frac{nl^2}{2R} = \frac{2 \times 5^2}{2 \times 50} = 0.5 \text{ m}$$

$$W_{ps,60} = \frac{V}{9.5\sqrt{R}} = \frac{60}{9.5\sqrt{50}} = 0.89 \text{ m}$$

$$W_{me,80} = \frac{nl^2}{2R} = \frac{2 \times 5^2}{2 \times 50} = 0.5 \text{ m}$$

$$W_{ps,80} = \frac{V}{9.5\sqrt{R}} = \frac{80}{9.5\sqrt{50}} = 1.19 \text{ m}$$

Method-II

As mechanical widening is independent of speed of the vehicle,

$$W_{me,60} = W_{me,80}$$

Hence options (a) and (d) are eliminated.

Now, as psychological widening is directly proportional to the speed of the vehicle.

$$W_{ps,60} < W_{ps,80}$$

Hence option (b) is the correct answer.

116. (d)

- IRC has fixed the maximum limit of superelevation in plain and rolling terrains and in snow-bound areas as 7.0% or 0.07 taking such mixed traffic into consideration.
- On hilly roads not bound by snow, a maxium superelevation up to 10% has been recommended.
- On urban road stretches with frequent intersections, it may be necessary to limit the maximum superelevation to 4.0%

117. (c)

Type of pavement	Camber	
	Heavy Rainfall	**Light Rainfall**
CC or thick bituminous	2%	1.7%
Thin bituminous	**2.5%**	2%
Gravel or WBM roads	3%	2.5%
Earthenware or kuchha road	4%	3%

118. (b)

Given -

Breaking distance i.e. S = 9.8m,

Final speed i.e. v = 0

$$\because \text{ Braking distance} = 9.8\text{m} = \frac{u^2}{2gf} \quad \text{... (i)}$$

Where,

u = Initial speed

As we know that,

$$v = u + at \quad ...(ii)$$

Putting 'v = 0' in equation (ii)

$$\because \quad 0 = u - fgt \quad (a = -fg)$$

$$u = fgt \quad ...(iii)$$

Using equation (iii) in equation (i)

$$\therefore \quad 9.8 = \frac{f^2g^2t^2}{2fg}$$

$$f = \frac{2 \times 9.8}{9.8 \times 2^2} = 0.5$$

119. (b)

The most convenient parking angle is 45 degree and the maximum number of vehicle can be parked in 90 degree angle.

120. (a)

30^{th} highest hourly volume is exceeded 29 hrs in a year i.e. $\frac{29}{365 \times 24} \times 100\%$ of time i.e. 0.33%