LIVE RPSC-AE (DLB) Full Length Test Series

Civil Engineering

Full Length Paper - 10

Answer Key & Detailed Solution

Test Id - 510 **Date:- 14/05/2023**

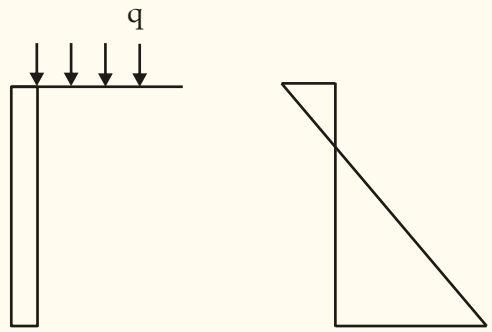
1. (a)
2. (a)
3. (c)
4. (d)
5. (b)
6. (d)
7. (a)
8. (c)
9. (d)
10. (d)
11. (b)
12. (d)
13. (a)
14. (a)
15. (b)
16. (a)
17. (c)
18. **(d)**
19. **(b)**
20. **(d)**
21. **(d)**
22. **(d)**
23. **(a)**
24. **(c)**
25. **(c)**
26. **(b)**
27. **(b)**
28. **(a)**
29. **(c)**
30. **(a)**
31. **(a)**
32. **(a)**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

38. (c)

39. (c)

40. (c)

41. (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

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

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

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

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

$$= 2C\tan\alpha$$

42. (a)

Ultimate bearing capacity: Maximum gross pressure that can be apply at the base of foundation without shear failure or it may also be defined as minimum gross pressure at which soil fails in shear.

Net safe bearing capacity: Net ultimate bearing capacity divided by factor of safety

Safe bearing capacity: Maximum gross pressure which soil can carry safely at the base of foundation without risk of shear failure

Allowable bearing pressure: Maximum net pressure that can be applied on the soil safely without the possibility of shear failure or settlement failure.

43. (b)

Energy provided in IS light compaction test (E_L),

$$E_L = \frac{(mgh)N}{V}$$

$$E_L = \frac{2.6\times 9.81\times 0.31\times 25\times 3}{10^3\times\left(10^{-2}\right)^3\times 10^3}\text{kJ/m}^3$$

$$E_L = 593.0145\ \text{kJ/m}^3$$

Energy provided in IS heavy compaction test (E_H),

$$E_H = \frac{(mgh)N}{V}$$

$$E_H = \frac{4.9\times 9.81\times 0.45\times 25\times 5}{10^3\times\left(10^{-2}\right)^3\times 10^3}\text{kJ/m}^3$$

$$E_H = 2703.88\ \text{kJ/m}^3$$

$$\therefore \frac{E_H}{E_L} = \frac{2703.88}{593.0145} = 4.56$$

44. (c)

Given -

$$w = 30\%$$
$$w_L = 60\%$$
$$w_P = 28\%$$

So, $$I_C = \frac{w_L - w}{w_L - w_P}$$

$$= \frac{60-30}{60-28} = \frac{30}{32} = 0.9375$$

I_c	Description of Soil
>1	Very stiff to very hard
1-0.75	**Stiff**
0.75-0.5	Medium stiff
0.5-0.25	Soft
0.25-0	Very soft
<0	Liquid

45. (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.

46. (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

47. (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

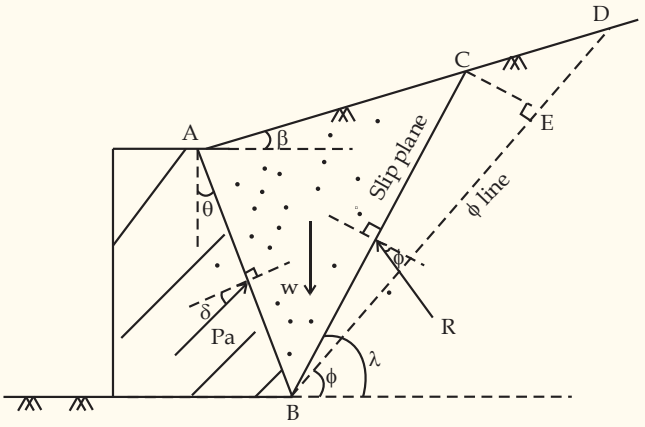
n = Porosity = $\frac{e}{1+e} = \frac{0.50}{1+0.50} = \frac{1}{3}$ (Given e=0.5)

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

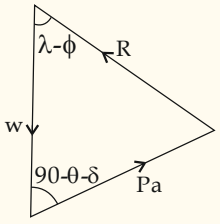
$= 22.5 \times 10^{-7}$ m/sec

48. (d)

The force acting on the wedge of soil are as follows:
1. Weight of soils wedge 'w' acting vertically downward.
2. Resultant thrust 'Pa' between the soil and wall acting at downward angle 'δ' with the normal to the inclined face of wall.
3. Resultant soil reaction 'R' acting at downward acting of 'ϕ' with the normal to slip plane.

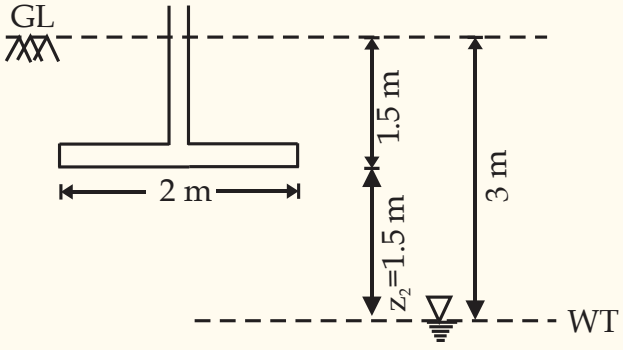


Using the properties of vector, we can resolve the forces as follows:



Where,
β = Surcharge angle
θ = Angle made by inclined face of wall with vertical.
δ = Angle of friction between wall and soil
ϕ = Friction angle of soil
λ = Angle made by slip plane with horizontal
Hence, the resultant active earth pressure 'Pa' inclined to the vertical 'w' at an angle of,
= 90 - θ - δ
= 90 - 6 - 8 = 76°

49. (a)



$$R_\gamma = \frac{1}{2}\left(1+\frac{z_2}{B}\right)$$

$$= 0.5 + 0.5 \times \frac{1.5}{2} = 0.875$$

50. (a)

Given that:

Design speed (v) = 20 m/sec

Acceleration (a) = 0.25 m/sec^2

$$\frac{\text{Centrifugal force}}{\text{Weight of vehicle}} = \frac{1}{4}$$

$$\frac{\text{Centrifugal force}}{\text{Weight of vehicle}} = \frac{mv^2}{R \times mg} = \frac{1}{4}$$

$$\frac{V^2}{gR} = \frac{1}{4}$$

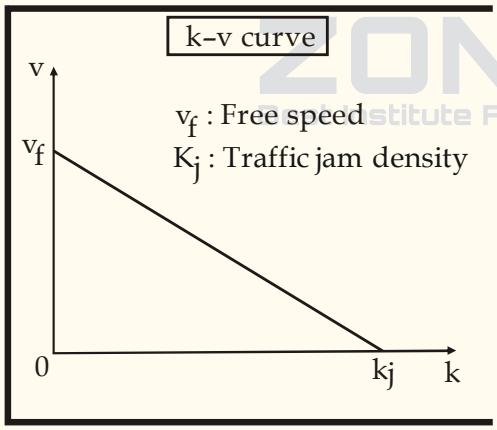
$$R = \frac{4V^2}{g} = \frac{4 \times (20)^2}{10}$$

$$R = 160 \text{ m}$$

51. (d)

Traffic volume = Traffic density × Traffic speed

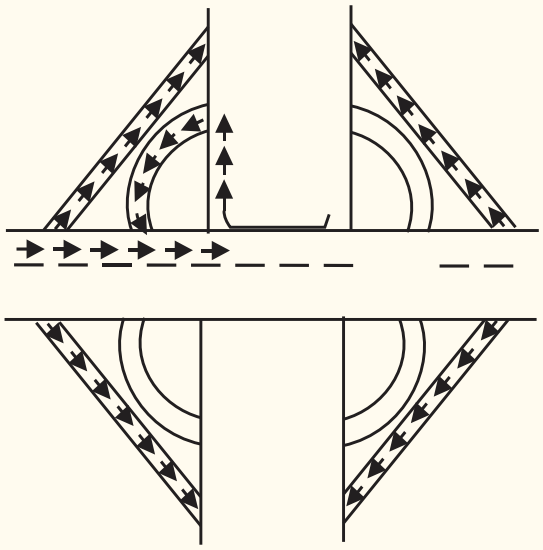
$$q = K \times V$$



So from above figure we can say that if speed of the traffic flow is zero then traffic volume is also zero and traffic density is maximum.

52. (b)

Merging from left is done using a clover left and diverging to left is done using indirect ramp.



53. (d)

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

54. (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.

55. (b)

Method-I

$$W_{me,60} = \frac{nl^2}{2R} = \frac{2\times5^2}{2\times50} = 0.5\text{ m}$$

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

$$W_{me,80} = \frac{nl^2}{2R} = \frac{2\times5^2}{2\times50} = 0.5\text{ m}$$

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

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.

56. (a)

30th highest hourly volume is exceeded 29 hrs in a year i.e. $\frac{29}{365\times24}\times100\%$ of time i.e. 0.33%

57. (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.

58. (c)

Difference between English and Flemish Bond

ENGLISH BOND	FLEMISH BOND
Bond pattern with alternate header and stretcher course.	Bond pattern with each course having alternate header and stretcher.
Less pleasing apperance	Apperance is more attractive and pleasing
Expensive	Economical
No strict supervision and skill is demanded.	Requires good workmanship and careful supervision.

Note : For walls having a thickness greater than 1.5 brick thick, an English bond is found to be stronger than a Flemish bond.

59. (d)

Boucherie process is used to preserve the timber.

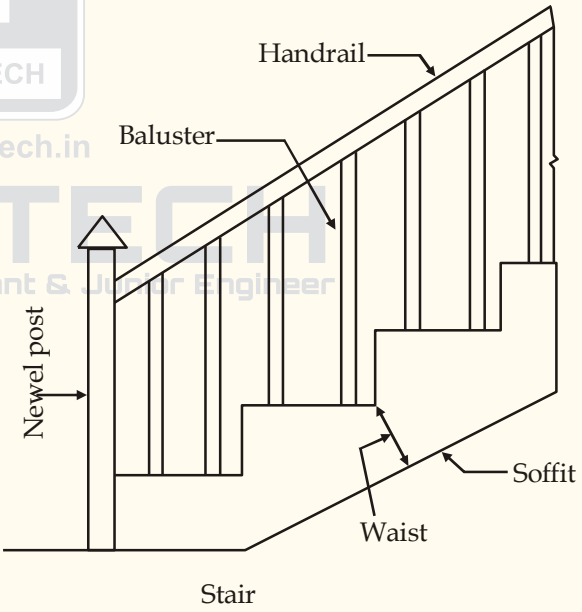
Note:

- The objective of preservation of timber is to increase the life of timber make it durable and protect the timber structure from the attack of fungi and insects.

Treatment methods of timber are:

- Surface application of brushing, spraying or dipping in preservative solution.
- Hot and cold process
- Boucherie process
- Diffusion process
- Bethel process
- Boulton process

60. (a)



61. (b)

The sieves that are to be used for the sieve analysis of the aggregate (coarse, fine or all-in-aggregate) for concrete as per IS:2386 (Part-I) - 1963 are, 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 m, 600 μm, 300 μm and 150 μm.

The fineness modulus can be regarded as a weighted average size of a sieve on which material is retained and the sieves being counted from the first sieve.

Fineness modulus of 3.3 indicates size between 3^{th} and 4^{th} sieve i.e., between 600 μm and 1.18 mm.

62. (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**.

63. (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.

64. (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.

65. (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.

66. (c)

IS 875 (part 1)-1987: Indian Standard Codes provides design dead loads (Unit weight of building material and stored materials) for buildings and structures.

IS 875 (part 2)-1987: Indian Standard Codes provides **conservatively imposed loads for buildings and structures.**

IS 875 (part 3)-1987: Indian Standard Codes provides design wind loads for buildings and structures.

IS 875 (part 4)-1987: Indian Standard Codes provides design snow loads for buildings and structures.

IS 875 (part 5)-1987: Indian Standard Codes provides design special loads (load combination) for buildings and structures.

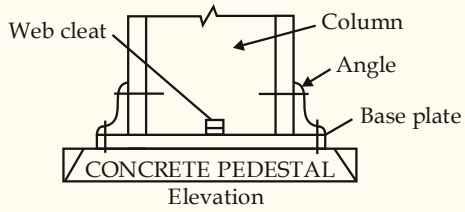
67. (c)

Explanation:

Column Base: It is used to transfer a load of steel columns to the concrete without any failure in the concrete.

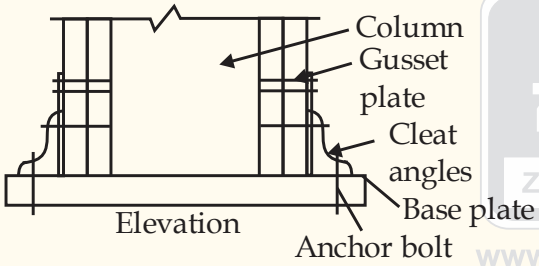
Types of column base:

1. **Slab base**: Slab base is generally used for axial loading.



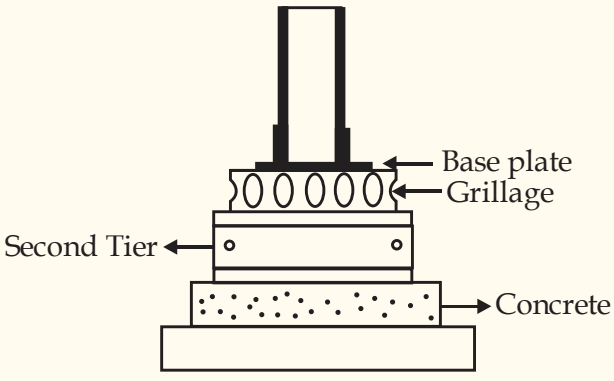
Slab Base

2. **Gusseted base**: Gusseted base is used for axial load and moment i.e. for eccentrically loaded steel column.



Gusseted Column Base

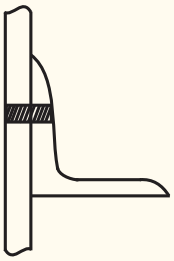
3. **Grillage foundation**: Grillage foundation is used when soil is very weak and load is to be transferred at shallow depth, it is also used for heavy-load steel columns to be rested on weak soil.



Grillage Foundation

68. (b)

For a single angle connected by one leg only,



$$A_{net} = A_1 + kA_2$$

where,

A_1 = Effective net cross-sectional area of connected leg.

A_2 = Gross cross-sectional area of outstanding leg

$$k = \frac{3A_1}{3A_1 + A_2}$$

Here, $A_1 = a$, $A_2 = b$

$$\therefore \quad k = \frac{3a}{3a+b} = \frac{1}{1+0.33\frac{b}{a}}$$

Hence, $A_{net} = a + k \times b$

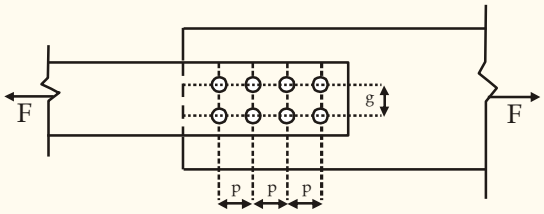
$$\therefore \quad A_{net} = a + \frac{b}{1+0.33\frac{b}{a}}$$

69. (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

70. (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.

71. (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

72. (d)

Grade	M15	M20	M25	M30	M35	M40
Bond stress	1	1.2	1.4	1.5	1.7	1.9

1. These are for plain mild steel bar.
2. For deformed bar, these values are increased by 60%.

   i.e. $\tau_{bd,deformed} = 1.6 \times \tau_{bd,plain}$

   $\tau_{bd,\ deformed} = 1.6 \times 1.2 = 1.92$ MPa

73. (b)

- While calculating the upward soil pressure the self weight of the footing is not considered.
- While calculating the area of footing required self weight of footing is considered.
- If self weight not given, it is assumed to be 10% of the service load on the footing.
- Area of footing required is found out on the basis of service load.

  For example

  P = Service load on footing (kN)

  Q = Allowable bearing pressure of soil (kN/m^2)

  Then area of footing required

$$= \frac{\text{Service load} + \text{Self weight of footing}}{\text{Allowable bearing pressure of soil}}$$

74. (a)

Depth of beam = 85 × 6 = 510 mm = 0.51 m

So, volume of beam = 0.51 × 6 × 0.23 = 0.7038 m^3

Weight of beam = Volume × Unit weight

= 0.7038 × 25 = 17.595 kN

Factored weight of beam = 1.5 × 17.595 = 26.39 kN

75. (c)

Effective width of Flange i.e. b_f is

$$b_f = \frac{l_o}{6} + b_w + 6d_f$$

Where,

l_o = Distance between points of zero moments (points of contraflexure) which may be taken as 0.7 times the effective span for continuous beams and for beams in frames.

b_w = Breadth of web

d_f = Thickness of flange

Hence,

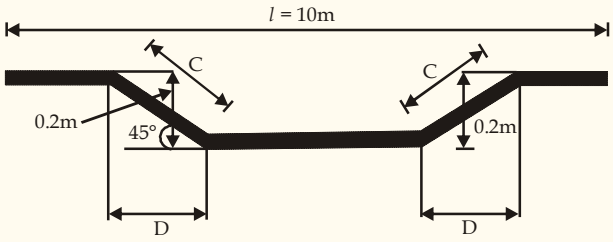
$$b_f = \frac{3600}{6} + 300 + 6 \times 100 = 1500$$

or b_f = C/C distance between beams
= 3000 mm

Take least value of above two,

$\therefore \quad b_f = 1500\,mm$

76. (a)



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

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

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

$= 10.1657\,m$

$= 10.17\,m$

77. (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

78. (a)

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

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

79. (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

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

80. (b)

Using Rise and Fall method,

$$\Sigma F.S. > \Sigma B.S.$$

$\therefore$ Fall = ΣF.S. - ΣB.S.

Fall = R.L. of first station - RL of last station
= 5.645 - 3.085 = 2.56 m

R.L. (last station) = R.L. (first station) - Fall
= 100 - 2.56 = 97.44 m

81. (d)

$$\text{Scale} = \frac{1}{4000} = \frac{\text{Distance on map}}{\text{Distance on ground}}$$

Distance on ground = 4000 × 10 = 40000 cm

$$= \frac{40000}{100 \times 1000} = 0.4\ km$$

82. (b)

Given,

Focal length of objective (f) = 20 cm = 200 mm

Stadia interval (i) = 4 mm = 0.4 cm

Staff intercept (S) = 1 m

Additive constant (C) = zero

So, Horizontal distance i.e. D = KS + C

Where, $K = \frac{f}{i} = \frac{20\,cm}{0.4cm} = 50$

Hence, D = KS + C = 50 × 1 + 0 = 50 m

83. (b)

Traversing:

Traversing is the type of survey in which a number of connected survey lines form the framework and the directions and lengths of the survey lines are measured with the help of an angle measuring instrument and tape or chain respectively.

Types of Surveying:

There are two types of traverse surveying. They are:

- **Closed traverse**: When the **lines form a circuit that ends at the starting point,** it known as a closed traverse. The closed traverse is suitable for locating the boundaries of lakes, woods, etc. and for survey of large areas.
- **Open traverse:** When the **lines form a circuit that ends elsewhere except the starting point,** it is said to be an open traverse. The open traverse is suitable for surveying a long narrow strip of land as required for a road of canal or the coast line.

84. (a)

Contour Interval:

- A contour interval is a vertical distance or difference in elevation between contour lines.
- It is always kept the same or constant for a map.

The contour interval depends upon the following factors:

1. **The scale of the map**:
   The contour interval normally varies inversely to the scale of the map i.e, if the scale of the map is large, the contour interval is considered to be small and vice versa.

2. **Nature of ground**:
   For flat ground, a small contour interval is chosen whereas, for undulating and broken ground, a greater contour interval is adopted.

3. Purpose and Extent of survey:

Purpose and extent of survey affects the choice of contour interval, e.g. **small contour interval is used for a survey intended for detailed design work and for accurate earthwork calculations.** A large contour interval is used when the extent of survey is large, e.g. location surveys for communication lines, highways and railways.

4. **Time and Cost**:
   If the contour interval is small, greater time and funds will be required in the field survey, in reduction, and in plotting the map. If the time and funds available are limited, the contour interval may ke kept large.

85. (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

86. (b)

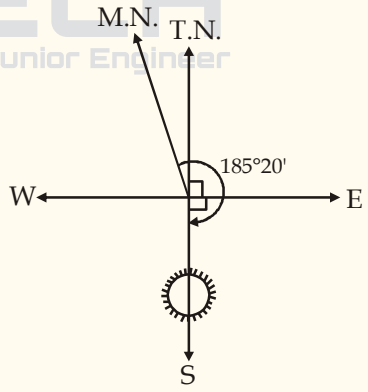
According to science, position and motion are relative terms.

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.

87. (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 :

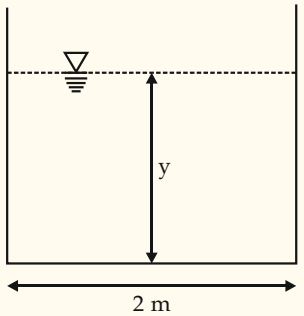
- The axis of plate level is perpendicular to the vertical axis.
- The horizontal axis is perpendicular to the vertical axis.
- The line of collimation axis at right angles to the horizontal axis.
- The axis of altitude level is parallel to the line of collimation when it is horizontal, and the vertical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

88. (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.

89. **(a)**



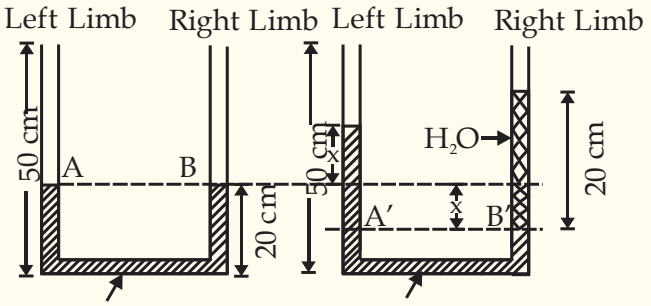
$S = \frac{1}{1000}, C = 50$

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

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

90. **(b)**

After addition of water in right limb, rise in left limb will be equal to fall in right limb due to conservation of volume.



$\rho_{Hg} = 13.6 \times 10^3 \text{ kg/m}^3$ $\rho_{Hg} = 13.6 \times 10^3 \text{ kg/m}^3$

Now equating pressure at section A' - B'

$$P_{A'} = P_{B'}$$

$$(13.6 \times 10^3)g \times (2x) = (10^3)\, g(20)$$

$$x = \frac{1.0}{3.6} = 0.735 \text{ cm}$$

So, the new height (in cm) of mercury in the left limb will be

= Initial height of mercury in left limb + x

$= 20 + 0.74 = 20.74$ cm

91. (b)

$$h_f = \frac{FLV^2}{2gD}$$

$\because$ $F = 4f$

where F = friction factor

f = coefficient of friction

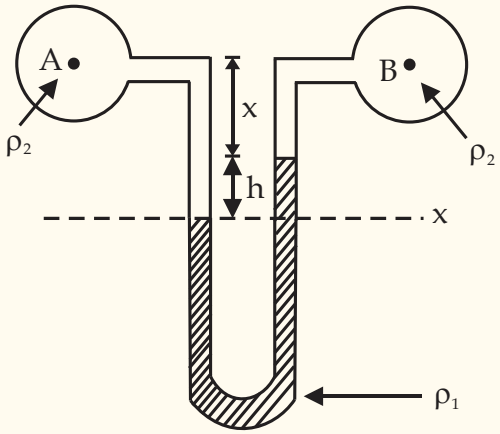
$$h_f = \frac{(4f)LV^2}{2gD} = \frac{2fLV^2}{gD}$$

92. **(b)**

Difference in pressure head in given by

$$h' = \left(\frac{\rho_1}{\rho_2} - 1\right)h$$

Proof:



Pressure at section x-x

$$P_A + \rho_2 g(x + h) = P_B + \rho_2 gx + \rho_1 gh$$
$$P_A - P_B = \rho_1 gh - \rho_2 gh$$
$$\rho_2 gh' = \rho_1 gh - \rho_2 gh$$
$$h' = \left(\frac{\rho_1}{\rho_2} - 1\right) h$$

Hence, Difference in pressure head i.e. h'

$$h' = 20 \text{ cm } (13.6 - 1)$$
$$h' = 252 \text{ cm} = 2.52 \text{ m}$$

93. (d)

Size of Sewer	Recommended spacing of manholes on straight reaches of sewer line as per IS 1742:1960
Diameter upto 0.3 m	45 m
Diameter upto 0.6 m	75 m
Diameter upto 0.9 m	90 m
Diameter upto 1.2 m	120 m
Diameter upto 1.5 m	250 m
Diameter greater than 1.5 m	300 m

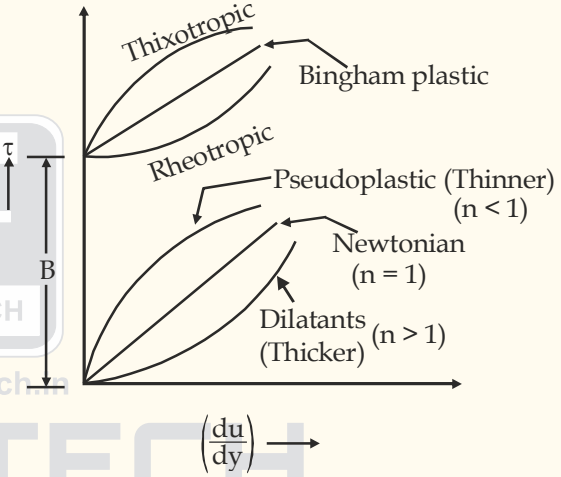
94. (b)

Cavitation is the formation of vapour bubbles in a flowing liquid in the region where the pressure falls below the vapour pressure and sudden collapsing of these vapour bubbles in a region of high pressure causes pitting

$$\because \quad \frac{p}{\gamma} + z + \frac{v^2}{2g} = C$$

If we reduce the velocity head then pressure head will increase, now chances of the pressure head falling below vapour pressure head will be less hence cavitation and pitting can be prevented.

95. (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 :-

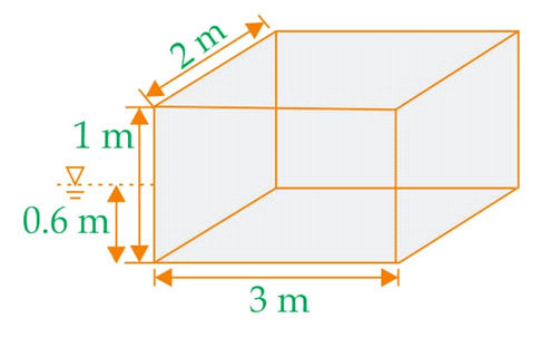
For pseudoplastic, B = 0 and n < 1

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

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

96. (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,
$= 3 \times 2 \times 0.6 = 3.6\ m^3$
& Unit weight of water = $10\ kN/m^3$ (as given in question)
Hence, W = Submerged volume of body × Unit weight of water
$W = 3.6\ m^3 \times 10\ kN/m^3 = 36\ kN$

97. **(b)**
As per IS 1742 : 1983 (Reaffirmed 2007) clause 4.6.1.2, the sewer shall be designed for discharging **three times** the dry-weather flow flowing half-full with a minimum self-cleansing velocity of **0.75 m/s**.

98. **(a)**

5% + 95% → 100%
Solid waste Water Wet sludge

5 kg solid waste make = 100 kg wet sludge

$$1 \text{ kg solid waste make} = \frac{100}{5} = 20 \text{ kg wet sludge}$$

210 kg solid waste make = 20 × 210 = 4200 kg wet sludge.
Density of wet sludge = 1.05 × 1000 = 1050 kg/m^3

$$\text{So, volume of wet sludge} = \frac{4200}{1050} = 4\ m^3$$

99. (d)

Measuring Compound	Indicator
Iron	1, 10 phenanthroline
Alkalinity	Methyl orange and phenolpthalein
Hardness	Erichrome black T
Chlorides	Potassium Chromate

100. **(d)**

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

$$= \frac{720}{12 \times 1.5} = 40\ m^3/hr/m^2$$
$$= 40{,}000\ \text{liter/hr/m}^2$$

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

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

101. **(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.

102. **(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 $CaCO_3$

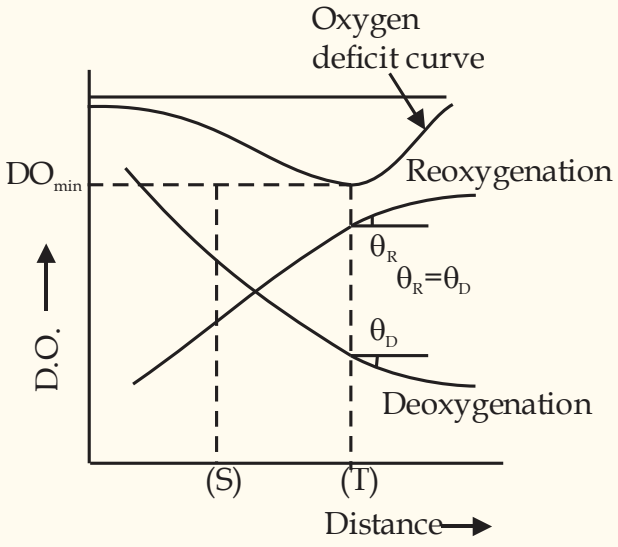
Alkalinity is due to the presence of HCO_3^- in this case,
Alkalinity (mg/l as $CaCO_3$)
= 3.3 × 50 mg/l as $CaCO_3$
= 165 mg/l as $CaCO_3$

Now, non-carbonate hardness
= Total hardness in excess of alkalinity
= 205 - 165
= 40 mg/l as $CaCO_3$

103. (c)

- **Large floating matter :** Primary treatment removes material that will either float or readily settle out by gravity. It includes the physical processes of screening, comminution, grit removal, and sedimentation. Screens are made of long, closely spaced, narrow metal bars.
- **Suspended inorganic matter :** Grit Chambers are long narrow tanks that are designed to slow down the flow so that solids such as sand, coffee grounds, and eggshells will settle out of the water. Grit causes excessive wear and tear on pumps and other plant equipment. Suspended solids that pass through screens and grit chambers are removed from the sewage in sedimentation tanks.
- **Suspended organic matter :** Primary clarifiers are used to separate settleable solids from the raw incoming wastewater. These are located downstream of the plant. The major function of the primary clarifier is the removal of all settleable and suspended solids waste which has a high oxygen demand.
- **Dissolved organic matter :** Trickling filters are used to remove dissolved organic matter from wastewater. The trickling filter is an aerobic treatment system that utilizes microorganisms attached to a medium to remove organic matter from wastewater.

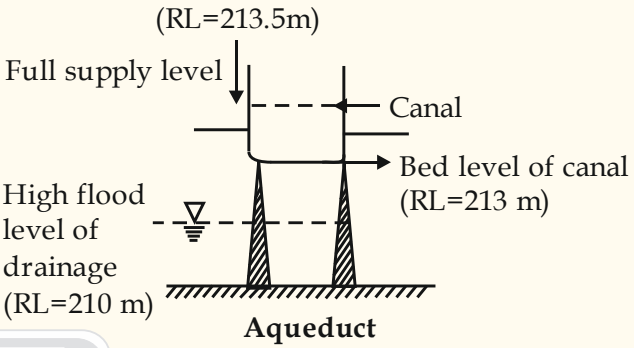
104. (d)



- Before point T, rate of aeration < rate of degradation, so DO continuously decrease from S till T.
- At point T, rate of aeration = rate of degradation. Hence DO is minimum at T.
- After point T, rate of aeration > rate of degration, so DO starts increasing.

Hence, DO is minimum at some point downstream of S.

105. (a)



Here the bed level of canal is above the top flood level of the drainage so the correct option will be **Aqueduct**.

106. (a)

Given -

Area of land i.e. A = 1200 hect.

Base period i.e. B = 140 days

Delta i.e. Δ = 134 cm = 1.34 m

So, Duty i.e. $D = 8.64 \frac{B}{\Delta}$

$$= 8.64 \times \frac{140}{1.34}$$

$$= 902.69 \text{ hect./cumec.}$$

$\therefore$ Dischrage required to irrigate 1200 hectare of land growing rice $= \frac{1200}{902.69} = 1.329$ cumec

This canal water (i.e. 1.329 cumec) is used to irrigate wheat of a base period i.e. B' = 120 days and Δ' = 52 cm or 0.52 m

So, duty i.e. $D' = 8.64 \times \frac{120}{0.52}$

$$= 1993.85 \text{ hect./cumes}$$

Hence, the area that can be irrigated with discharge 1.329 cumec,

$$= 1993.85 \times 1.329 = 2650 \text{ hect.}$$

107. (c)

The result from Thiessen polygon method is more accurate than arithmetic mean method. But there is no any close relationship between values obtained by Thiessen polygon method and Arithmetic mean method.

$\therefore$ There is no any relation between P_A and P_T.

108. (b)

Field capacity has two parts:

(1) Capillary or available water: It is attached to soil molecules due to molecular attraction and can be extracted by plants under the action of capillary and is available for plant growth.

(2) Hygroscopic water: It is attached to soil molecules by loose chemical forces and can't be extracted by capillarity and is not available for plant growth.

109. (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

110. (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.

111. (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)

112. (c)

Elastic recovery/strain: The strain recovered after the removal of the load is known as elastic strain.

Plastic strain: The permanent changes in dimension after the removal of load is known as plastic strain.

The load is removed when the stress was 200 MPa and the corresponding strain was 0.03

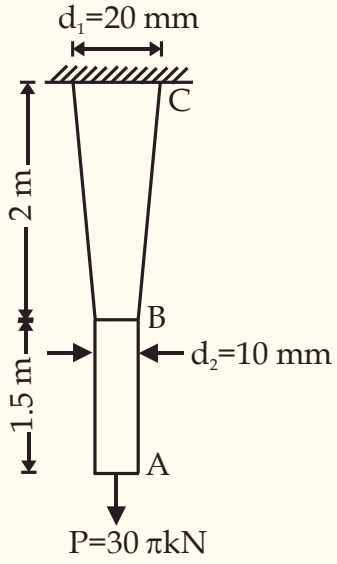
After the removal of load, the body recovered and the final strain found was 0.01.

Hence,

Elastic strain = 0.03 - 0.01 = 0.02 and

Plastic strain = 0.01 respectively.

113. (c)



Total elongation,
AB is uniform

So, $\Delta = \frac{PL}{AE}$

BC is tapered

So, $\Delta = \frac{PL}{\frac{\pi}{4} d_1 d_2 E}$

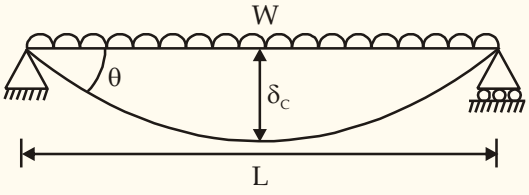
Hence, $\Delta = \Delta_{AB} + \Delta_{BC}$

$= \frac{PL}{AE} + \frac{4PL}{\pi d_1 d_2 E}$

$= \frac{30\pi \times 10^3 \times 1.5 \times 10^3}{\frac{\pi}{4} \times (10)^2 \times 2 \times 10^5} + \frac{4 \times 30\pi \times 10^3 \times 2 \times 10^3}{\pi \times 10 \times 20 \times 2 \times 10^5}$

$= 9 + 6$ mm
$= 15$ mm

114. (d)



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

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

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

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

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

Using equation (ii) in equation (i)

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

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

115. (c)

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

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

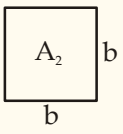
$\therefore \frac{\text{Flexural rigidity}}{\text{Torsional rigidity}} = \frac{E}{2 \times \frac{E}{2(1+v)}}$

$= 1 + v$

116. (d)

Case : 1

Case : 2



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

$\because \quad A_1 = A_2$ (given)

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

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

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

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

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

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

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

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

Using equation (i) in (ii),

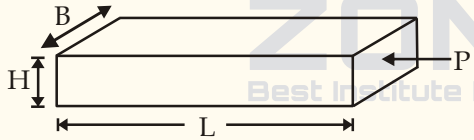
$$(Z)_{Square} = \frac{\left(\sqrt{\frac{\pi}{4}}d\right)^3}{6} = \frac{\left(\frac{\pi}{4}\right)^{3/2} d^3}{6}$$

$$= 0.116 d^3$$

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

Hence, square section is more economical.

117. (d)



Initial volume i.e. V is

$V = LBH$

$\because$ Applied load is compressible so length will decrease

So, final volume i.e. V_f is

$$V_f = (L - \Delta L)(B + \Delta B)(H + \Delta H)$$

$$\because \quad \frac{\Delta L}{L} = \varepsilon, \frac{\Delta H}{H} = \mu\varepsilon = \frac{\Delta B}{B}$$

Hence, $V_f = LBH\left(1 - \frac{\Delta L}{L}\right)\left(1 + \frac{\Delta B}{B}\right)\left(1 + \frac{\Delta H}{H}\right)$

$$V_f = V(1 - \varepsilon)(1 + \mu\varepsilon)(1 + \mu\varepsilon)$$

$$V_f = V(1 - \varepsilon)(1 + \mu\varepsilon)^2$$

118. (d)

Castigliano's First Theorem: The first partial derivative of the total internal energy (strain energy) in a structure with respect to any particular deflection component at a point is equal to the force applied at that point and in the direction corresponding to that deflection component i.e.

$$\frac{\partial U}{\partial d_i} = R_i$$

Castigliano's Second Theorem: The first partial derivative of the total internal energy (strain energy) in a structure with respect to the force applied at any point is equal to the deflection at the point of application of that force in the direction of its line of action i.e.

$$\frac{\partial U}{\partial R_i} = d_i$$

119. (a)

Distribution factor

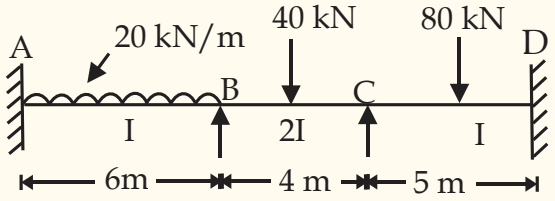
- The distribution factor at a joint for a particular member is defined as the ratio of the stiffness of that member to the total stiffness of all the members meeting at that joint.
- The summation of D.F. of all the members meeting at a joint is always one.
- D.F. is a property of rigid joint, it is not the property of hings joint.

$$\text{Distribution factor} = \frac{k_i}{\sum_{i=1}^{n} k_i}$$

Here,

k_i = Stiffness of i^{th} member meeting at the joint

Now,



Joint	Member	Member Stiffness	Joint Stiffness	D.F.
B	BA	$\frac{4EI}{6}$	$\frac{8EI}{3}$	1/4
	BC	$\frac{4E(2I)}{4}$		3/4

120. (a)