LIVE RPSC-AE (DLB) Full Length Test Series

Civil Engineering

Full Length Paper - 4

Answer Key & Detailed Solution

Test Id - 504 **Date:- 02/04/2023**

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

35. (b)

36. (a)

37. (a)

38. (c)

39. (b)

40. (c)

41. (b)

As per clause 31.6.3 of IS 456 : 2000.

$$\tau_c = 0.25\sqrt{f_{ck}} \text{ in LSM}$$

$$= 0.16\sqrt{f_{ck}} \text{ in WSM}$$

42. (d)

Since, criteria for minimum area of tension reinforcement is

$$\frac{A_{st}}{bd} = \frac{0.85}{f_y}$$

$\because \quad f_y = 415 MPa$

$$\Rightarrow \frac{A_{st}}{bd} \times 100 = \frac{0.85}{415} \times 100 = 0.2\%$$

43. (a)

Environment	Exposure condition	Minimum Nominal cover (mm)
Mild (Normal)	Concrete protected against weather or aggressive conditions	20
Moderate	Concrete continuously under water	30
Severe	Concrete completely immersed in sea water	45
Very severe	Concrete exposed to sea water spray	50
Extreme	Concrete members in tidal zone	75

Here, for concrete totally immersed in sea water, minimum cover = 45 mm

Cover in normal condition (mild) = 20 mm

Hence, additional cover to be provided = 45 - 20 = 25 mm

44. (d)

The torsional effect is considerable in L -beam and beam around stairs because these beam receives their loads from one side only so these beams will be subjected to significant amount of torsional moments.

45. (a)

As per IS 800:2007, Clause no. 7.6.5.1 -

Slenderness ratio of component column i.e. λ

$$\lambda \nless \begin{cases} 50 \\ 0.7 \times \text{slenderness ratio of member as a whole} \end{cases}$$

46. (a)

As per clause 22.2 of IS: 456 - 2000, for simply supported beam or slab, the effective span of a member that is not built integrally with its supports shall be taken as clear span plus the effective depth of slab or beam or centre to centre of supports, whichever is less.

$$\text{Hence, Effective span} = \text{Min}^{m} \text{ of } \begin{cases} 5000 + d = 5400 \\ 5000 + w = 5300 \end{cases}$$

$\therefore$ Effective span = 5300 mm

47. (c)

As per IS 14458 (Part-2): 1997, Cl: 5.2, retaining wall for hill area, the following are the design requirements.

1. Retaining wall shall be designed as rigid wall.
2. **The minimum value of factor of safety against overturning and sliding are 2 and 1.5** respectively in case of static loads. However, these values are 1.5 and 1 respectively when subjected to earthquake forces.
3. The maximum base pressure at toes shall be less than the allowable bearing capacity of soil, but it shall be increased by 33% in case of earthquake forces.
4. The minimum base pressure recommended is zero.

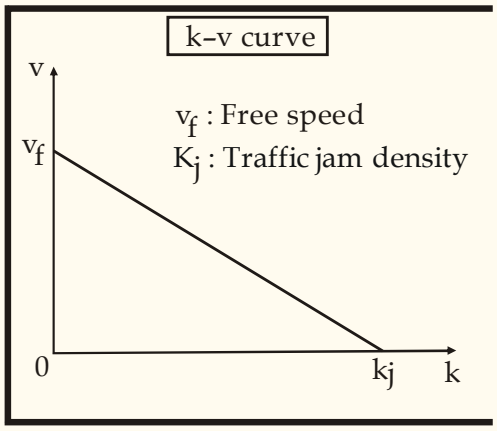
48. (b)

The **penetration test** determines the hardness or softness of bitumen by measuring the depths in tenths of a millimetre to which a standard loaded needle will penetrate vertically in five seconds. The sample is maintained at a temperature of 25°C.

49. (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.

50. (c)

As we know that -

$$e + f = \frac{V^2}{127\,R}$$

$$\Rightarrow (R)_{Min} = \frac{V^2}{(0.07+0.15)127}$$

For NH in plain areas, $V = 100$ kmph

So, $(R)_{Min} = \frac{(100)^2}{0.22 \times 127} = 357.90 \approx 360$ m

51. (c)

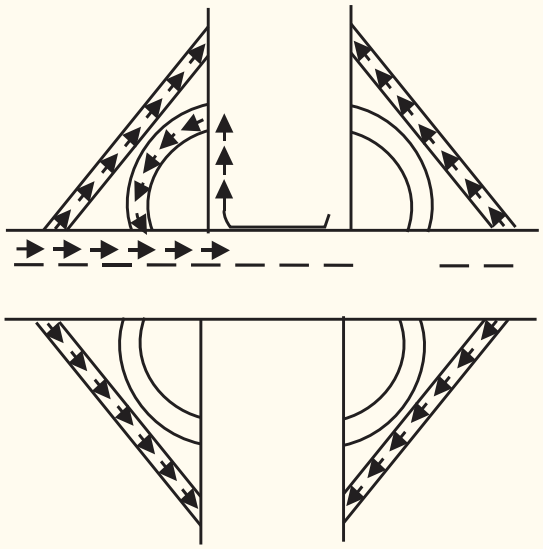
A viaduct is a specific type of bridge that consists of a series of arches, piers or columns supporting a long elevated railway or road. Typically a viaduct connects two points of roughly equal elevation, allowing direct overpass across a wide valley, road, river, or other low-lying terrain features and obstacles.

52. (a)

The planting of the trees along the road side is called as arboriculture, in few cities like Visakhapatnam, Andhra Pradesh a green belt is maintained and garden is also provided but the planting of trees is called arboriculture.

53. **(b)**

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



54. **(c)**

$\because \frac{a}{h} = 2 \Rightarrow a = 2h$ (where $a > 1.724\ h$)

So

$b = a = 2h = 2 \times 20$

$b = 40$ cm

b is the equivalent radius of resisting section

55. **(d)**

Major developments	Year
Jayakar Committee	1927
Central road fund	1929
Indian road congress	1934
Motor vehicle act	1939
Nagpur road plan	1943
Central road research institute	1950
National highway act	1956

56. (c)

Ravelling: It is characterised by progressive disintegration of the surface due to the failure of the binder to hold the material together.

The following are the causes of ravelling:

1. **Insufficient binder in the mix.**
2. Inadequate compaction during construction.
3. Construction during wet weather leads to the stripping of binder from aggregate.
4. Construction during cold weather results in fracture, crushing and opening of new faces.
5. Over-heating of mix or the binder.
6. Improper coating of aggregates by binder.

57. (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

58. (c)

Aggregates retained on 4.75 mm sieve are identified as coarse while aggregates passed from 4.75 mm sieve are identified as fine aggregates. Thus IS sieve 4.75 mm are used for the grading of both coarse aggregates and fine aggregates.

59. (d)

According to IS : 4031 (Part 5) - 1988,

In order to find initial setting time, final setting time, soundness and strength characteristics of cement a parameter called standard consistency is used. Test for it is performed at 27 ± 2°C and relative humidity of 65±5%

60. (a)

Following are the principal techniques that have been used for placing concrete underwater:

- Tremie method
- Placing in de-watered caissons or cofferdams
- Bucket placing
- Placing in bags
- Prepacked concrete

61. (c)

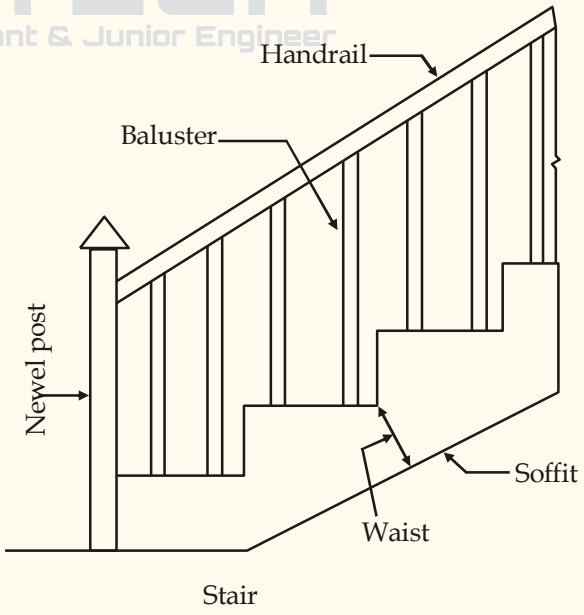
The aspect of the house should be such that it enables the family members to live comfortably and it should ensure proper ventilation and lighting conditions.

- The aspect is concerned with the orientation of building
- The arrangement of the doors and windows in the outside walls of the house should be in such a way that plenty of sun rays, the breeze can enter into the house.

Some common aspects of typical Indian building:

Room	**Orientation**
Kitchen	East
Bedroom	**South-east / South-west**
Living room	North-east / South-east

62. (a)



63. (b)

Collapse slump: In this case, fresh concrete collapses completely. The mix is too wet or high workability mix, slump test isn't appropriate for such mix.

Shear slump: If one-half of the cone slides down in an inclined plane, it is called a shear slump. It is an indication of the lack of cohesion of the mix. Again perform the experiment to avoid a shear slump.

True slump: Mix has high stiff consistency. In a true slump concrete just subsides shortly and more or less maintain the mould shape. This type of slump is most desirable.

Zero slump: If concrete maintains the actual shape of the mould, it is called zero slumps which represent stiff, consistent and almost no workability.

64. (a)

Jamb of Door Frame :

The door jamb is the **vertical wall face of a door opening** that supports the door frame. In the door frame, the jamb is the **vertical portion of the door frame** in which a door is secured. If you want to open and lock your door properly, door jamb is important.

65. (b)

(a) Coriolis force : Coriolis force is force caused by the earth's rotation. It can cause a small imbalance in velocity distribution such that velocity on one bank is higher than on the other end. This can generate erosion on one bank and deposition of sediment on opposite bank. This result in river meandering.

(b) Khosla's curve / khosla's theory : Khosla's curve is used for design of weir & barrages.

(c) Gumbel's method : Gumbel's method is used for estimation of design flood for a particular return period.

(d) Manning's equation : Manning's equation is used for measurement of velocity in open channel flow.

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Where

V = Average velocity of flow

n = Roughness co-efficient known as Manning's coefficient

R = Hydraulic radius of channel section

S = Channel slope

66. (a)

Type of channel	Non-scouring velocity (m/sec)
Earthen channels	0.6-1.2
Ordinary brick-lined channels	1.5-2.5
Cement concrete channel	2.5-3.0

67. (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.

68. (a)

Yield of reservoir : The amount of water that can be supplied from a reservoir during specific period of time.

Safe yield : The maximum quantity of water guaranteed during a critical dry period, also called as firm yield.

Secondary yield : The yield which is in excess of firm yield.

Average yield : The arithmetic average of firm and secondary yield.

69. (d)

Given -

Actual depth of watering = 16 cm

Irrigation efficiency = 80% or 0.8

Conveyance losses = 20% or 0.2

So, Conveyance efficiency = 1 – Conveyance losses = 1 – 0.2 = 0.8

Hence, Depth of water required at the canal outlet

$$= \frac{\text{Actual depth of watering}}{\text{Irrigation efficiency} \times \text{Conveyance efficiency}}$$

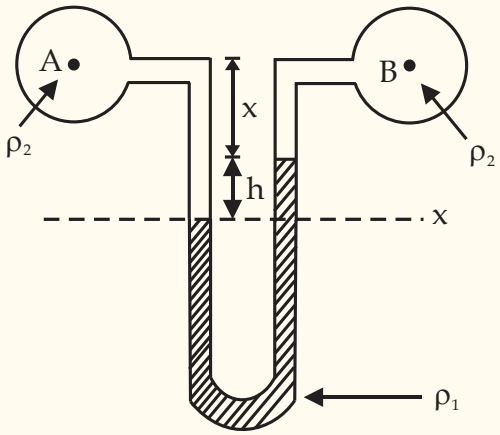
$$= \frac{16}{0.8 \times 0.8} = 25 \text{ cm}$$

70. (b)

Difference in pressure head in given by

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

Proof:



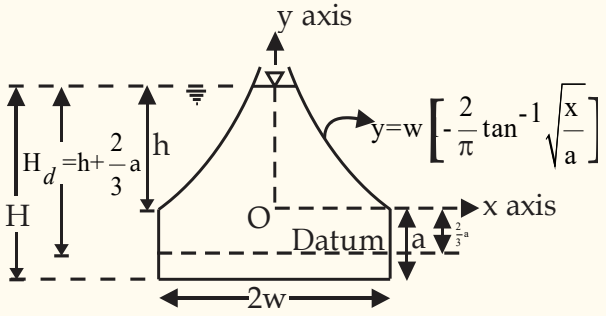
Pressure at section x-x

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

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

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

71. (d)



The discharge equation for the sutro weir is given by:

$$Q = b\left(h + \frac{2}{3}a\right) = b\left(H - \frac{a}{3}\right) = bH_d$$

h = Head measured from the top of the rectangular base weir.

H_d = Depth of water over the datum

b = Constant of proportionality

The sharp edged sutro weir is found to have an average coefficient of discharge of 0.62.

72. (a)

A hydraulically equivalent pipe is the one which can replace existing compound pipe while carrying same dischrage under same losses.

In general,

$$d = \frac{D}{n^{2/5}}$$

where n = no. of pipes in parallel

Here, n = 3

$$\therefore \quad d = \frac{D}{3^{2/5}}$$

73. (b)

- The depth of same specific energy is called "Alternate depth".
- The depths of same specific force is called "conjugate depths or sequent depths".

74. (b)

A π parameter is constant and has zero dimensional unit i.e. $M^0L^0T^0$.

Out of the given options only '$\frac{\mu}{\rho DV}$' has zero dimensional unit i.e. $M^0L^0T^0$.

Proof,

$$\frac{\mu}{\rho DV} = \frac{\left[M^1L^{-1}T^{-1}\right]}{\left[M^1L^{-3}T^0\right]\left[M^0L^1T^0\right]\left[M^0L^1T^{-1}\right]} = \left[M^0L^0T^0\right]$$

75. (b)

Given, $\frac{h_1}{h_2} = \frac{9}{16}$

For venturimeter,

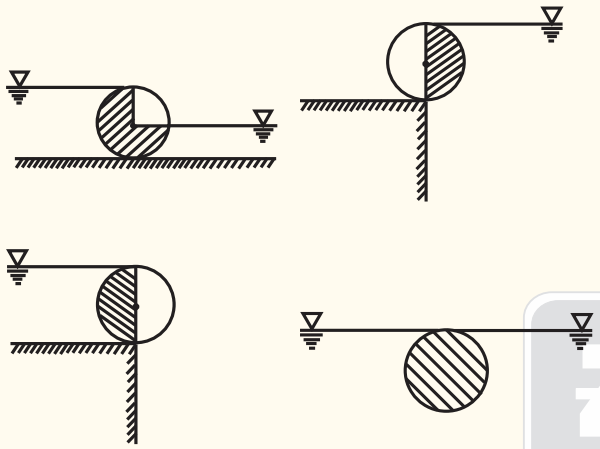
$$Q = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$
$$Q \propto \sqrt{h}$$
$$\frac{Q_1}{Q_2} = \sqrt{\frac{h_1}{h_2}} = \sqrt{\frac{9}{16}} = \frac{3}{4}$$
$$= 0.75 : 1$$

76. (b)
For GVF, Dynamic equation is given as

$$\frac{dy}{dx} = \frac{S_0 - S_e}{1 - F_r^2}$$

Where, S_0 = Bed slope
S_e = Energy line slope
F_r = Froude number

77. **(d)**
Vertical component of hydrostatic force is equal to the weight of liquid of shaded portion in figure given below:



So it clear that maximum force is experienced in (d).

78. **(d)**
In closed uniform conduit, velocity head remains constant, thus flow will be from higher to lower Piezometric head.

$$\text{Piezometric head} = \frac{p}{\rho g} + z$$

79. (a)
Sand is the cheapest filter material followed by anthracite whereas Garnet sand is the costliest among them and is not used as a sole filter material but used as a constituent in mixed media filter.

80. (b)
The tolerance limit of oil and grease of sewage to be disposed on land is 30ppm while on sea water is 20ppm.

81. (c)
The usual routine tests on water are conducted to detect and count the presence of Coliforms. Coliform called **bacteria coli (B coli or E coli)** are important harmless aerobic microorganism. These bacteria live longer in water than pathogenic bacteria. Hence if coliform is absent, pathogens will also be absent. Hence they are used as indicator organism for probable presence of pathogens.

82. (d)

$$\text{Recirculation factor (RF)} = \frac{1+R}{(1+0.1R)^2}$$

Where,
R = Recirculation ratio = 1

So, $RF = \frac{1+1}{(1+0.1)^2} = 1.65$

83. (a)
Given,

$$L_1 = 2L_0$$

$$\text{Rate of filtration} = \frac{Q}{L^2} = \text{constant}$$

Hence, $\frac{Q_0}{L_0^2} = \frac{Q_1}{L_1^2}$

$$\Rightarrow \quad \frac{Q_0}{L_0^2} = \frac{Q_1}{4L_0^2}$$

$$\Rightarrow \quad 4Q_0 = Q_1$$

The amount of water filtered would become 4 times

84. **(b)**
- Rate of filtration in 'slow sand filter' is 100 - 200 *l*/hr/m² or 2.4 m³/m²/day - 4.8 m³/m²/day
- Effective size of sand :

Slow sand filter	Rapid sand filter
(0.2-0.3)mm	(0.45-0.7)mm

- Period of cleaning is several years.
- 'Backwashing' is done in rapid sand filter to expand the granular base.
  Time taken for backwashing is 15 minutes.
  Amount of water required for backwashing is 2-5%.
- Uniformity coefficient = D_{60}/D_{10}

Filter	Slow sand filter	Rapid sand filter
D_{60}/D_{10}	1.8 - 3	1.3 - 1.7

85. (b)

Activated sludge process is designed primarily for satisfaction of carbonaceous BOD which is done by heterotrophs.

86. (d)

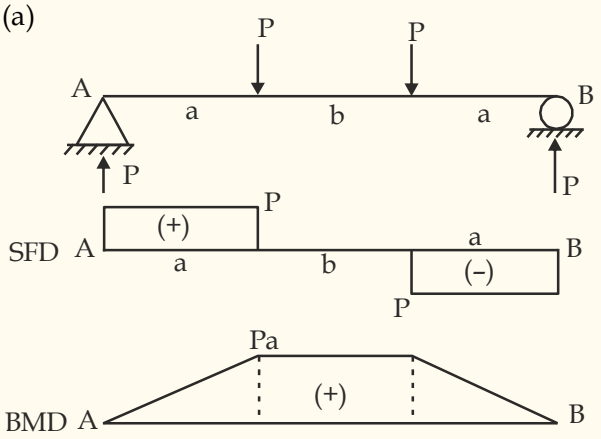
Size of Sewer	Recommended spacing of manholes on straight reaches of sewer line as per IS 1742:1960
Diameter upto 0.3 m	45 m
Diameter upto 0.6 m	75 m
Diameter upto 0.9 m	90 m
Diameter upto 1.2 m	120 m
Diameter upto 1.5 m	250 m
Diameter greater than 1.5 m	300 m

87. (a)

As per IS 1172, the domestic demand water per day per capita under normal conditions is 135 liter/capita/day

Hence for family of 4 members water demand is = 135 × 4 = 540 liter/day

88. (a)



For rectangular cross-section -

$$\text{Maximum shear stress} = \frac{3}{2}\text{Average shear stress}$$

$$\because \quad \tau_{max} = \frac{3}{2}\tau_{avg}$$

As we know that -

$$\tau_{avg} = \frac{P}{bd} \text{ (For rectangular cross-section)}$$

Where,

P = Maximum shear force

$$\text{Hence, } \tau_{max} = \frac{3}{2}\cdot\frac{P}{bd}$$

& Maximum bending stress i.e. $\sigma_{max} = \frac{BM_{max}}{Z}$

Where,

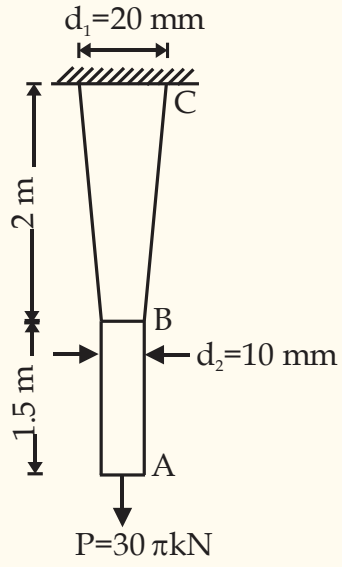
$$BM_{max} = Pa$$

$$Z = \frac{bd^2}{6}$$

$$\text{Hence, } \sigma_{max} = \frac{Pa}{\left(\frac{bd^2}{6}\right)} = \frac{6Pa}{bd^2}$$

$$\therefore \quad \frac{\tau_{max}}{\sigma_{max}} = \frac{(3P/2bd)}{(6Pa/bd^2)} = \frac{d}{4a}$$

89. (c)



Total elongation,

AB is uniform

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

BC is tapered

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

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

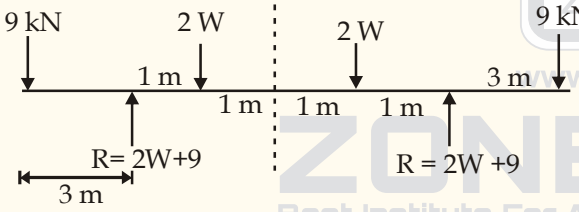
$$= \frac{PL}{AE} + \frac{4PL}{\pi d_1 d_2 E}$$

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

$= 9 + 6$ mm

$= 15$ mm

90. (a)



B.M. at support,

$BM_1 = -9 \times 3 = -27$ kN

B.M. at mid span,

$BM_2 = (2W + 9) \times 2 - 2W \times 1 - 9 \times 5$

$\because \quad |BM_1| = |BM_2|$

$27 = 4W + 18 - 2W - 45$

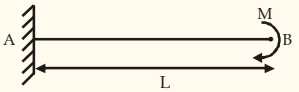
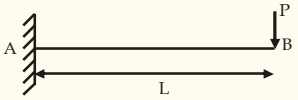
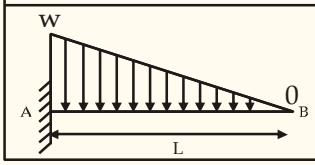
$\therefore W = 27$ kN

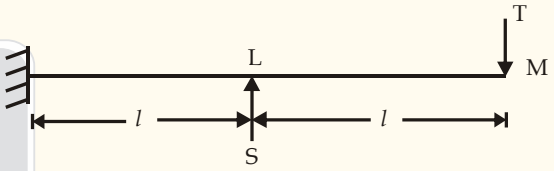
91. (a)

When the machine part is larger greater is the probability that a flaw exists somewhere in the component, the chances of fatigue failure originating at these flaws are more. The endurance limit, therefore, reduces with the increasing size of the component.

92. (c)

Deflection and slope of cantilever beams are given by:

Loading Condition	Deflection	Slope
	$y_B = \frac{ML^2}{2EI}$	$\theta_B = \frac{ML}{EI}$
	$y_B = \frac{PL^3}{3EI}$	$\theta_B = \frac{PL^2}{2EI}$
	$y_B = \frac{wL^4}{8EI}$	$\theta_B = \frac{wL^3}{6EI}$
	$y_B = \frac{wL^4}{30EI}$	$\theta_B = \frac{wL^3}{24EI}$



Given -

$\theta_M = 0$

$$\text{So, } \frac{T(2l)^2}{2EI} - \frac{Sl^2}{2EI} = 0$$

$$\frac{T}{S} = \frac{1}{4}$$

93. (c)

D'Alembert's principle states that for any body algebraic sum of externally applied forces and the forces resisting the motion i.e. reversed effective forces (internal forces) is zero for dynamic equilibrium of body.

i.e. $\sum F_x = 0$

$\sum F_y = 0$

$\sum M = 0$

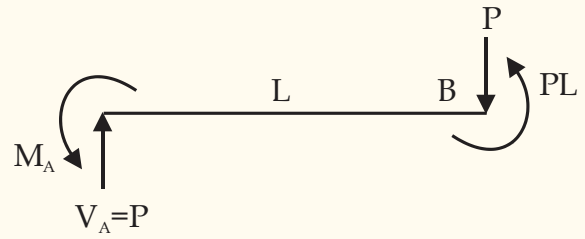
94. **(a)**

$\sigma_{xx} = 30$ MPa, $\sigma_{yy} = 50$ MPa, $\sigma_{zz} = 0$

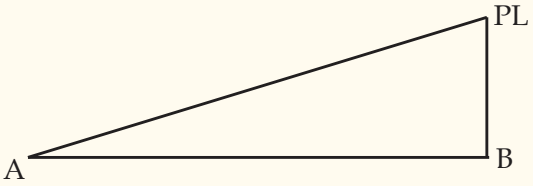
$$\varepsilon_{zz} = \frac{\sigma_{zz}}{E} - \mu\frac{\sigma_{xx}}{E} - \mu\frac{\sigma_{yy}}{E} = -\frac{\mu}{E}(\sigma_{xx} + \sigma_{yy})$$

$$= -\frac{0.3}{2 \times 10^5}(30 + 50) = -120 \times 10^{-6}$$

95. (a)

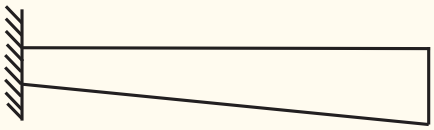


$$(-PL) + (PL) + (-M_A) = 0$$
$$M_A = 0$$



Bending moment diagram

For most economical,
Maximum cross-section is given where maximum bending moment occurs.



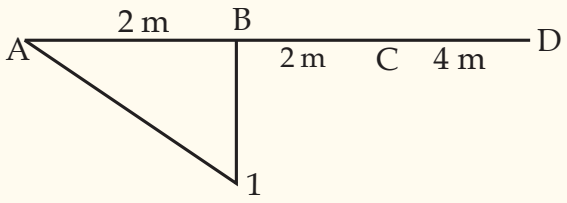
So, option (a) is correct.

96. (a)

- When all the forces in a structure can be determined strictly from equilibrium equations, the structure is referred to as **statically determinate**.
- If structure have more unknown forces than available equilibrium equation then, the structure is referred to as **statically indeterminate**.
- For a coplanar structure there are at most three equilibrium equations for each part, so that if there is a total of x parts and y no of forces and moment reaction components, we have
  $y = 3x$, statically determinate
  $y > 3x$, statically indeterminate
- If a structure is statically indeterminate, the additional equations needed to solve for the unknown reactions are obtained by relating the applied loads and reaction to the displacement or slope at different points of the structure. These equations are referred to as **compatibility equations**, must be equal in number to the degree of indeterminacy of the structure.

97. (c)

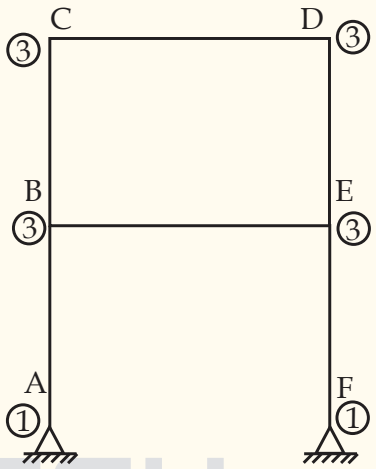
ILD for V_B



$$\text{Max. shear } V_B = \left[\left(\frac{1}{2}\times 2\times 1\times 10\right)+(60\times 1)\right]$$
$$= 70 \text{ kN}$$

98. (b)

Degree of Freedom (DOF) of Joints:



When all members are extensible,

$D_k = 3j - r_e - m'' = 3\times 6 - 4 - 0 = 14$

D_k (when **extensible**) $= 14$

D_k (when **inextensible**) $= D_k$(when extensible)- No. of axially rigid member
$= 14 - 6 = 8$

So, reduction in D_k is 6 (θ_A, θ_B, θ_C, θ_D, θ_E, θ_F)

Note: Shear deformation is not considered in calculation of D_k.

99. (b)

R.F. is ratio of two measurements with common unit.

$$\text{R.F.} = \left[\frac{1\text{cm}^2}{16\times(10^3)^2\times(10^2)^2\text{cm}^2}\right]^{1/2}$$
$$= \frac{1}{400000}$$

100. (d)

Magnetic Lines	Definition
Isogonic Line	The line joining points of equal declination at a time of observation.
Agonic Line	The line joining the places of zero declination.
Isoclinic Line	The line joining the places of the same dip
Aclinic Line	The line joining the places of zero dip

101. (a)
As we know that,
30 metre chain, contains 150 links.

So, length of one link $= \frac{30}{150} \times 100\,\text{cm}$

$= 20\,\text{cm}$

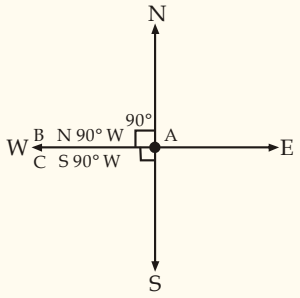
102. (b)
Functions of clamp screws :

- When the lower clamp screw is tightened, but the upper claim screw is loosened, the instrument rotates on the inner axis with a relative motion between the two plates. The vernier reading changes.
- When the **upper clamp screw is tightened** but **lower clamp screw is loosened**, the instrument rotates on outer axis without any relative motion between the plates. **The vernier reading do not change.**
- If both the clamps are tightened, the instrument cannot rotate at all.

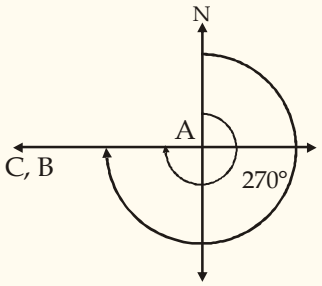
∴ If we don't want to change the readings, the lower clamp screw is loosened and upper clamp is tightened.

103. (c)
Trigonometric levellings cannot be done with a dumpy level. In Trigonometric levelling the difference in elevation is determined from the observed vertical angles and measured distances and the Dumpy level cannot measure angles.

104. (c)



AB & AC are parallel to each other and in same direction.
So, angle between them is 0°.
Alternative method:
Change bearing of line AB, from QB to WCB
AB = 360° – 90° = 270°



And bearing of line AC = 180° + 90° = 270°
The included equal BAC will be
270° – 270° = 0°

105. (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.

106. (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.

107. (d)

$$\text{Activity} = \left(\frac{\text{Plasticity Index}}{\text{\% by weight finer than } 2\mu}\right)$$

Activity based classification of clays :

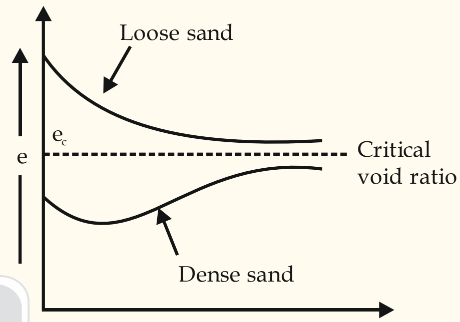
Activity	Classification
< 0.75	Inactive
0.75 - 1.25	Normal
> 1.25	Active

Note: Volume change during swelling or shrinkage in clays is the function of activity which in turn depends upon plasticity index (I_P) and percent of clay size particles.

108. (a)

Critical void ratio :

- In case of loose sand (at high initial void ratio), as the shear strain is increased, the void ratio decreases from an initial large value and in case of dense sand (at very low initial void ratio), the initial void ratio increases after a slight initial decrease.
- At large value of shearing strain, both the initially loose and initially dense sands approach a constant value of void ratio (i.e. change of volume remains constant during shearing), called critical void ratio.



Point of contraflexure : It is the point in bending moment diagram of a structure at which bending moment changes sign.

Bulking : Increase in volume of sand due to apparent cohesion.

109. (b)

Energy provided in IS light compaction test (E_L),

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

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

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

Energy provided in IS heavy compaction test (E_H),

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

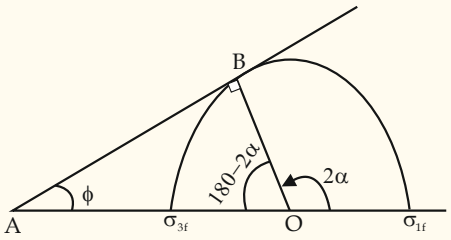
$$E_H = \frac{4.9 \times 9.81 \times 0.45 \times 25 \times 5}{10^3 \times (10^{-2})^3 \times 10^3} \text{kJ}/\text{m}^3$$

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

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

110. (c)

Mohr's circle for a c-ϕ soil is shown below,



As we know that any angle θ^0 on the horizontal plane becomes equal to $2\theta^0$ on Mohr's circle.

Hence, α° become 2α° on Mohr's circle.

Here,

σ_{1f} = Major Principal Stress, σ_{3f} = Minor Principal Stress, ϕ = Angle of internal friction of soil, and c = Cohesion.

In ΔAOB,

$\phi + (180 - 2\alpha^0) + 90° = 180°$

$\phi = (2\alpha^0 - 90°)$

$\phi = 2(\alpha^0 - 45°)$

111. (b)

Rankine's formula provides guidance on the minimum depth of foundation based on the bearing capacity of the soil.

$$q_u = \gamma D_f \left(\frac{1+\sin\phi}{1-\sin\phi}\right)^2$$

Therefore, the depth of the foundation can be expressed as

$$D_f = \frac{q_u}{\gamma}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2$$

Where,

D_f = minimum depth of foundation,

q_u = ultimate bearing capacity of the soil,

γ = unit weight of soil,

ϕ = angle of repose or internal friction angle of soil.

112. (d)

From Coulomb's theory, Karl Culmann (1866) devised his own Culmann's Graphical Method for calculating earth pressure. According to Coulomb's wedge theory, Culmann's method allows us to graphically calculate the magnitude of the earth pressure and locate the most dangerous rupture surface.

113. (c)

Given -

$q_{nu} = 25\ t/m$

$FOS = 2.5$

$\gamma = 1.7\ t/m^3$

So, $q_s = \frac{q_{nu}}{FOS} + \bar{\sigma}$

$$= \frac{25}{2.5} + 1.7 \times 1$$

$$= 10 + 1.7 = 11.7\ t/m^2$$

114. (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

Hence the soil has **'Stiff consistency'**

115. **(c)**

Seepage velocity,

$$V_s = \frac{v}{n} = \frac{\text{distance}}{\text{time}}$$

As per darcy,

$v = ki$

$$\frac{ki}{n} = \frac{100\,m}{100\,days}$$

$$i = \frac{\text{head difference}}{\text{length}} = \frac{5}{100}$$

$$\frac{k \times 5}{0.15 \times 100} = \frac{100}{100}\ m/day$$

$k = 3\ m/day$

116. (d)

Safe bearing pressure:

Safe bearing pressure (q_{ns}) is the maximum net intensity of loading that can be imposed on the soil without the settlement exceeding the permissible value.

Allowable bearing pressure:

Allowable bearing pressure (q_a) is the maximum net intensity of loading that can be imposed on the soil with no possibility of shear failure or the possibility of excessive settlement.

Gross safe bearing capacity:

Gross safe bearing capacity (q_s) is the maximum gross intensity of loading that the soil can carry safely without failing in shear.

$$q_s = q_{ns} + \gamma D_f$$

where, q_{ns} = Net safe bearing capacity

γD_f = Overburden pressure

Net safe bearing capacity:

- Net safe bearing capacity (q_{ns}) is the maximum net intensity of loading that the soil can carry safely without the risk of shear failure.
- It is obtained by dividing q_{nu} by a factor of safety.

$$q_{ns} = \frac{q_{nu}}{F}$$

where,

q_{nu} = Net ultimate bearing capacity

F = Factor of safety

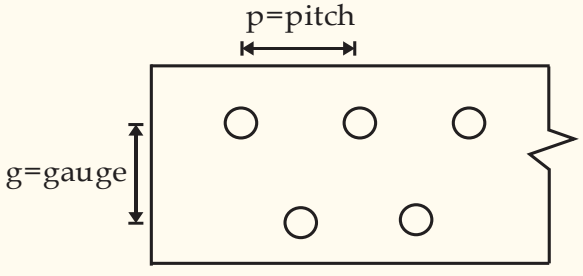
Net ultimate bearing capacity:

Net ultimate bearing capacity (q_{nu}) is the maximum net intensity of loading at the base of the foundation that the soil can support before failing (or failure) in shear.

$$q_{nu} = q_u - \gamma D_f$$

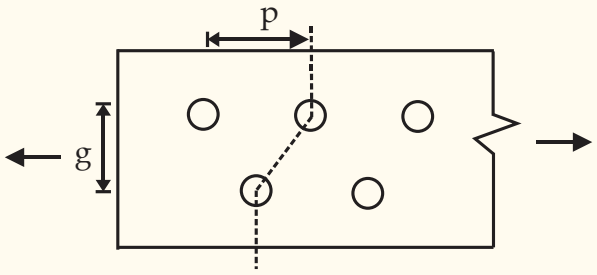
where q_u = ultimate bearing capacity.

117. (d)



Case I:

When g > p



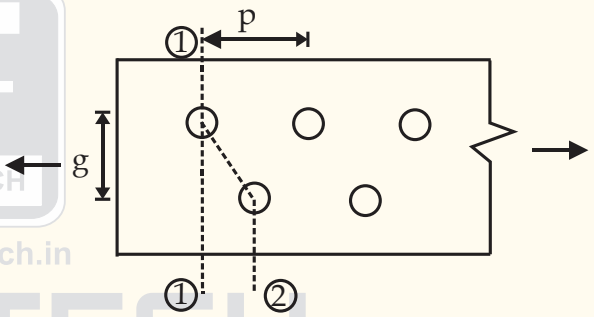
$$A_{net} = \left(b - nd' + \frac{p^2}{4g} \right) t$$

Here, A_{net} decreases.

Thus, failure may occur in zig-zag line.

Case II:

When g < p



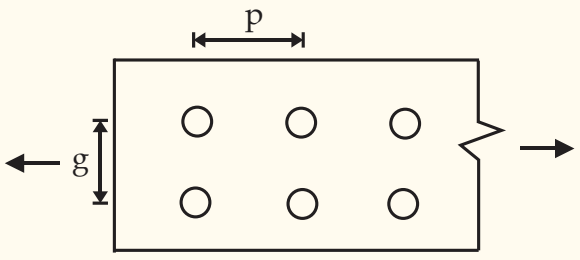
In this case, failure may occur in straight line through centre of rivet,

Usually in such cases,

$$A_{net(1)-(1)} < A_{net(1)-(2)}$$

Case III:

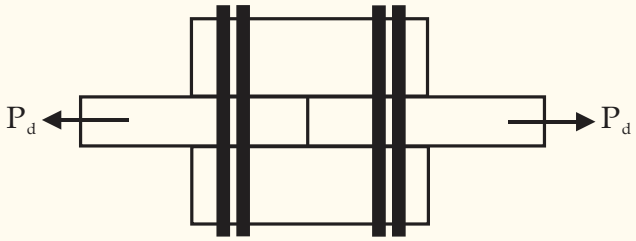
When g = p



In this case, as diameter increases, A_{net} decreases.

Thus failure becomes more likely.

118. (d)



Strength of joint per pitch length $= P_d$

So, the force carried by each shearing plane $= \frac{P_d}{2}$

The strength of one rivet in single shear $= P_s$

So, strength of two bolt in single shear $= 2P_s$

Strength of joint in single shear = Strength of bolt

So, $\frac{P_d}{2} = 2P_s$

$$\boxed{P_d = 4P_s}$$

119. (a)

Bearing strength of all bolts (P_b)

$P_b = 2.5 \times k_b \times (d \times t) \times f_u$

where 't' is the thickness of thinner main plate and

$$k_b = \min\left\{\frac{e}{3d_h}, \frac{P}{3d_h} - 0.25, \frac{f_{ub}}{f_u}, 1.0\right\}$$

Here we can see K_b depends upon

Edge distance, Pitch distance, Bolt hole diameter, Ultimate strength of the bolt and the Ultimate strength of the plate.

120. (c)

The design bending strength of such section is given by:

$$M_d = \beta_b Z_p f_y / Y_{mo}$$

where,

$\beta_b = 1.0$ (for plastic and compact section) or

Z_e / Z_p (for semi-compact section)

Z_e = Elastic section modulus of the cross section

Z_p = Plastic section modulus of the cross section

f_y = Yield stress of the material

$Y_{mo} = 1.1$, the partial safety factor

Hence,

$$M_d = \beta_b Z_p f_y / Y_{mo}$$

$$= \frac{(1) \times 11 \times 10^4 \times 250}{1.1} N - mm$$

$= 25 \times 10^6$ N-mm

$= 25$ kN-m