DETAILED SOLUTIONS

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ESE 2023 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

1. (d)	26. (d)	51. (d)	76. (d)	101. (a)	126. (c)
2. (d)	27. (d)	52. (b)	77. (d)	102. (c)	127. (c)
3. (c)	28. (b)	53. (b)	78. (d)	103. (a)	128. (d)
4. (b)	29. (a)	54. (b)	79. (d)	104. (c)	129. (b)
5. (b)	30. (a)	55. (d)	80. (d)	105. (c)	130. (c)
6. (d)	31. (c)	56. (c)	81. (b)	106. (a)	131. (a)
7. (d)	32. (a)	57. (b)	82. (a)	107. (c)	132. (c)
8. (b)	33. (c)	58. (c)	83. (b)	108. (b)	133. (a)
9. (d)	34. (c)	59. (a)	84. (d)	109. (c)	134. (a)
10. (b)	35. (b)	60. (d)	85. (d)	110. (b)	135. (d)
11. (b)	36. (c)	61. (c)	86. (c)	111. (a)	136. (b)
12. (b)	37. (a)	62. (d)	87. (d)	112. (c)	137. (b)
13. (a)	38. (d)	63. (b)	88. (d)	113. (b)	138. (c)
14. (c)	39. (c)	64. (b)	89. (b)	114. (c)	139. (d)
15. (c)	40. (c)	65. (b)	90. (b)	115. (c)	140. (d)
16. (c)	41. (b)	66. (a)	91. (d)	116. (a)	141. (c)
17. (b)	42. (b)	67. (c)	92. (d)	117. (d)	142. (c)
18. (d)	43. (b)	68. (a)	93. (d)	118. (c)	143. (a)
19. (d)	44. (d)	69. (c)	94. (b)	119. (a)	144. (a)
20. (c)	45. (b)	70. (a)	95. (b)	120. (a)	145. (c)
21. (c)	46. (c)	71. (b)	96. (c)	121. (d)	146. (a)
22. (b)	47. (c)	72. (b)	97. (d)	122. (a)	147. (c)
23. (b)	48. (a)	73. (a)	98. (c)	123. (c)	148. (d)
24. (b)	49. (d)	74. (c)	99. (d)	124. (d)	149. (d)
25. (c)	50. (a)	75. (a)	100. (a)	125. (a)	150. (a)

DETAILED EXPLANATIONS

1. (d)

Mango is found almost everywhere in India. The wood from this tree is of inferior quality. This has a lot of sap and moisture. It is a relatively cheap quality of timber. It is used for making low quality doors and windows and in packaging industries.

Note:

Deodar: These trees found in the Himalayan region are straight and tall with short branches. Timber from these trees has well defined grains and is very strong. This timber is used for railway sleepers, bridges and piles.

Sal: This is found in the foot hills of Himalayas. This provides a very good variety of timber. It is hard, coarse grained, heavy and durable. It is used for bridges, piles, railway sleepers. Since it is very hard and difficult to work, it is not suited for ornamental work.

Teak: This is very popular in South India. It provides a strong durable timber with a dark brown colour. It is light and can be easily worked. It can take fine polish. It is a very valuable and costly variety of timber. It is used for furniture, radio and television cabinets and decorative pieces of works.

Shisham: This is found generally in Central India, Punjab and Uttar Pradesh. These trees are found on the road sides generally. It is coarse grained and heavy and strong. This timber is very satisfactory for making furniture. It is also used for piles, cart wheels, railway sleepers.

Kail: This is found in the Himalayas. It is hard, durable and coarse grained. It is used for furniture, railway sleepers.

Sisso: This is found in Maharashtra, Bengal, Punjab and Uttar Pradesh. Timber from this tree is strong and durable. It has a reddish brown colour. It is used for making furniture.

2. (d)

Knot is an assembly of roots of small branches. A knot breaks the continuity of fibres, causing reduction of strength.

3. (c)

Bethell's process (creosoting): Creosote oil is the best preservative which can destroy the wood attacking fungi. Creosote oil is obtained by distillation of coal tar. Well seasoned timber is dried for 24 hours and is kept in an air chamber. The air is exhausted and creosote is pumped into the chamber at a pressure of 0.8 N/mm^2 to 1 N/mm^2 at 50°C for a duration of 90 minutes. After this, the timber is removed out of the chamber.

5. (b)

Refer Table 2 (common types of bonds for brick work and situations of their use) of IS 2212 : 1991 Brick works - Code of practice.

6. (d)

The edge of a good brick should be sharp.

7. **(d)**

Harmful ingredients of in brick earth:

1. **Excess of lime:** Excess of lime results in melting of bricks and bricks will lose their shape.
2. **Iron pyrites** Presence of iron pyrites will produce crystallization of bricks leading to disintegration during burning.
3. **Alkalies** Alkalies act as flux. Excess of alkalies results in the melting of the clay and the bricks will lose their moulded shape. Alkalies absorb moisture from the surroundings producing efflorescence in the bricks. This results in a powdery precipitate on the bricks, affecting their appearance.
4. **Pebbles:** Mixing the clay will be affected by the presence of pebbles, gravel, grit etc. They produce pores in bricks making them weak.
5. **Organic matter and vegetation:** Organic matter assists in burning. If organic matter present is not fully burnt, then it will result in pores in bricks rendering them weak.

8. **(b)**

- Plutonic rocks are formed when magma solidifies at great depths below the earth's surface.
- Hypabyssal rocks are formed when magma solidifies at small depths below the earth's surface.
- When an igneous intrusion has a surface area more than 100 square km, then it is called as a batholith. A batholith which generally has a dome like extension into rocks above is called a cupola. There are also downward projections of the rock into a batholith called roof pendants.

9. **(d)**

Hydraulic lime	Fat lime
1. This is obtained by calcination of raw lime stone containing impurities like silica, alumina and iron oxide	1. This is obtained by calcination of pure limestone.
2. This lime slakes slowly. Minimal heat is evolved while slaking very slowly.	2. This lime slakes very vigorously with water giving out a lot of heat with a hissing sound.
3. This lime does not absorb carbon dioxide. The slaking process continuous for a very long period and absorbs moisture from the atmosphere.	3. This lime when exposed to the atmosphere, absorbs carbon dioxide in the presence of moisture and becomes an inert carbonate losing the cementing properties.
4. This lime does not undergo shrinking.	4. This lime shrinks and also cracks as it dries.
5. This can set even in the absence of air.	5. This lime needs the presence of carbon dioxide to set.
6. This is most suitable where strength is required. This is not suitable for white wash work.	6. This does not provide strength. This is most suitable for plaster work and white washing.

10. **(b)**

For plastering walls to prevent weathering, 1 : 3 or 1 : 4 mortar is used.
For masonry work at super structure, 1 : 3 or 1 : 4 is used.
For masonry work at sub structure, 1 : 5 or 1 : 6 is used.
For pointing work, 1 : 1 or 1 : 2 mortar may be used.

11. (b)

With fine ground cement, workability is increased, especially in harsh mixes, making the concrete more cohesive and decreasing the tendency of segregation. A coarse ground cement reduces stickiness.

12. (b)

Degree of workability for different placing conditions:

Placing conditions	Degree of workability	Slump (mm)
Blinding concrete, shallow sections; pavement using pavers	Very low	**Note 1**
Mass concrete; lightly reinforced sections in slabs, beams, walls, columns, floors, hand placed pavements, canal lining, strip footings.	Low	25 – 75
Heavily reinforced sections in slabs, beams, walls, columns Slip from work, pumped concrete	Medium Medium	50 – 100 75 – 100
Trench fill, in-situ piling	High	100 – 150
Tremie concrete	Very high	**Note 2**

Note 1: In the 'very low' category of workability where strict control is necessary, for example pavement quality concrete, measurement of workability in terms of compacting factor will be more appropriate than slump value and a value of compaction factor of 0.75 to 0.80 is suggested.
Note 2: In the 'very high' category of workability, measurement of workability by determination of flow value will be the most appropriate.

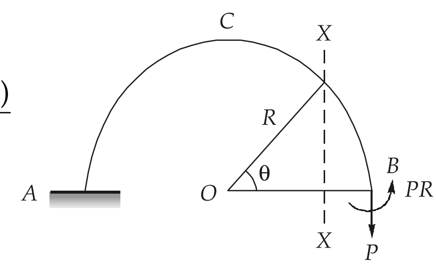
13. (a)

- **Table vibrator:** It is commonly used for vibrating concrete cubes. It is mostly adopted in the laboratories and in making small but precise prefabricated RCC members.
- **Internal vibrator:** Also called needle vibrator, immersion vibrator or poker vibrator. Useful in the case of mass concrete works like construction of dam.
- **Form vibrator:** Used for concreting columns, thin walls or in the casting of precast units. This method of vibrating concrete is particularly useful and adopted where reinforcement, lateral ties and spacers interfere too much with the internal vibrator.
- **Surface vibrator or Screed board vibrator:** Mostly, floor slabs and roof slabs are so thin that internal vibrator or any other type of vibrator cannot be easily employed. In such cases, the surface vibrator can be effectively used.

  In modern construction practices like vacuum dewatering technique, or slip-form paving technique, the use of screed board vibrators are a common feature.

14. (c)

At any section 'X' whose radius vector makes an angle 'θ' with OB,



$$BM = PR - PR(1 - \cos\theta) = PR\cos\theta$$

$$U = \int \frac{M^2 ds}{2EI} = \int_0^{\pi} \frac{P^2R^2\cos^2\theta(R\,d\theta)}{2EI}$$

$$\Rightarrow \quad U = \frac{P^2R^3}{2EI}\int_0^{\pi}\cos^2\theta \cdot d\theta$$

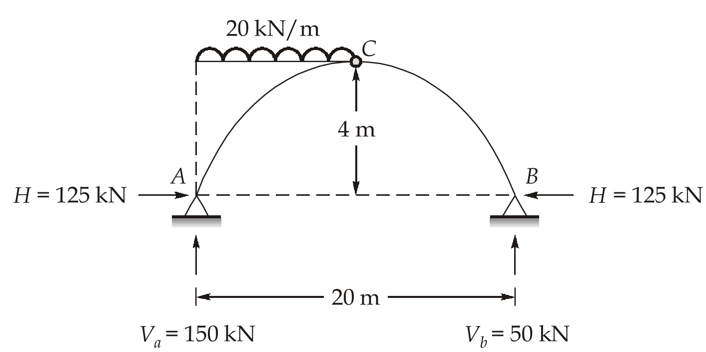
$$\Rightarrow \quad U = \frac{P^2R^3}{2EI}\int_0^{\pi}\left(\frac{1+\cos 2\theta}{2}\right)d\theta$$

$$\Rightarrow \quad U = \frac{P^2R^3}{4EI}\left[\theta + \frac{\sin 2\theta}{2}\right]_0^{\pi}$$

$$= \frac{P^2R^3}{4EI}\left[(\pi+0)-(0+0)\right] = \frac{P^2\pi R^3}{4EI}$$

$\therefore$ Vertical deflection of load, $\delta = \dfrac{\partial U}{\partial P} = \dfrac{P\pi R^3}{2EI}$

15. (c)



$$V_b \times 20 = 20 \times 10 \times 5$$

$$\Rightarrow \quad V_b = 50 \text{ kN}$$

$$\therefore \quad V_a = 150 \text{ kN}$$

$$\Sigma M_C = 0 \text{ (right side of } C)$$

$$\Rightarrow \quad 50 \times 10 = H \times 4$$

$$\Rightarrow \quad H = 125 \text{ kN}$$

At any section 'x' from A or B

$$y = \frac{4h}{l^2}x(l-x) = \frac{4\times 4}{20^2}\times x(20-x) = \frac{1}{25}x(20-x)$$

At any section distant 'x' from B, the bending moment is given by

$$M_x = 50x - 125 \times \frac{1}{25} x(20 - x)$$
$$= 50x - 100x + 5x^2$$
$$= -50x + 5x^2$$

For condition of maximum bending moment,

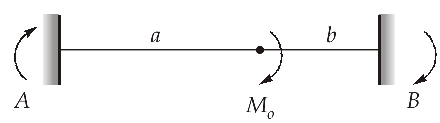
$$\frac{dM_x}{dx} = 0$$

$\Rightarrow$ $$-50 + 10x = 0$$

$\Rightarrow$ $$x = 5 \text{ m}$$

$\therefore$ $$M_{max} = -50 \times 5 + 5(25) = -125 \text{ kN-m}$$

16. (c)



$$M_{ab} = \frac{M_o b(3a - l)}{l^2}$$

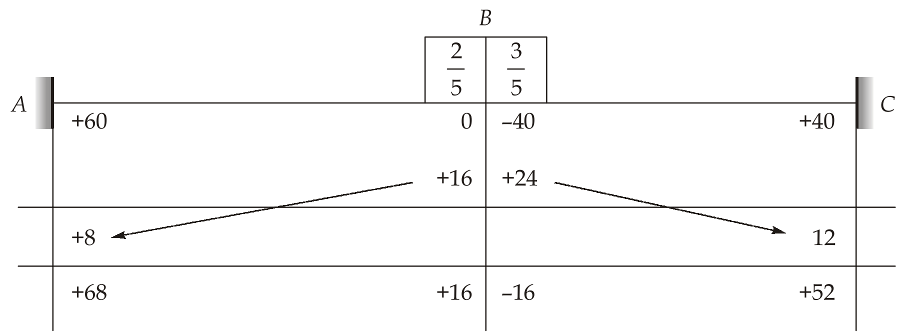
$\therefore$ $$M_{ab} = \frac{180 \times 2(3 \times 4 - 6)}{6^2} = +60 \text{ kN-m}$$

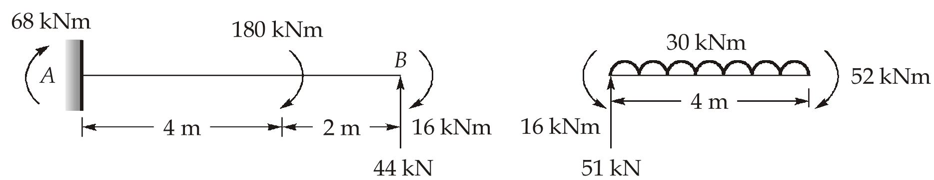
$$M_{ba} = \frac{180 \times 4(3 \times 2 - 6)}{6^2} = 0 \text{ kN-m}$$

$$M_{bc} = \frac{-30 \times 4^2}{12} = -40 \text{ kN-m}$$

$$M_{cb} = \frac{+30 \times 4^2}{12} = +40 \text{ kN-m}$$

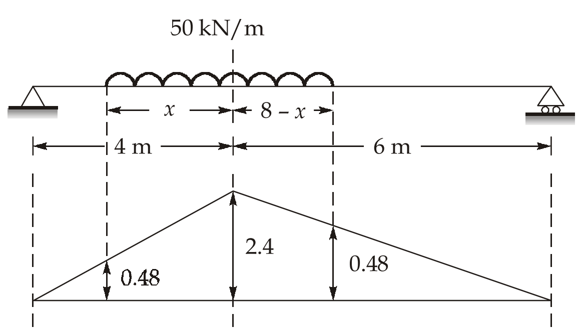
Joint	Member	Relative stiffness	Total relative stiffness	D.F.
B	BA	$\frac{I}{6} = \frac{2I}{12}$	$\frac{5I}{12}$	$\frac{2}{5}$
	BC	$\frac{I}{4} = \frac{3I}{12}$		$\frac{3}{5}$





$\therefore \quad V_B = 44 + 51 = 95 \text{ kN}$

17. (b)



$$\frac{x}{8-x} = \frac{4}{6}$$

$\Rightarrow \quad 3x = 16 - 2x$

$\Rightarrow \quad 5x = 16$

$\Rightarrow \quad x = 3.2 \text{ m}$

$$\text{Maximum bending moment} = \left[\frac{0.48+2.4}{2}\times 3.2+\frac{0.48+2.4}{2}\times 4.8\right]\times 50$$

$$= \frac{0.48+2.4}{2}(3.2+4.8)\times 50 = 576 \text{ kN-m}$$

18. **(d)**

For cantilever beam, stiffness is,

$$k_b = \frac{3EI}{L^3} = \frac{3 \times 200 \times 10^9 \times 1.6 \times 10^{-5}}{4^3} = 1.5 \times 10^5 \text{ N/m}$$

Now the cantilever beam and spring k_1 are acting in parallel.

$$k_{e_1} = k_b + k_1$$

$$= (1.5 \times 10^5) + (7.5 \times 10^5) = 9 \times 10^5 \text{ N/m}$$

This combination (i.e., k_{e_1}) is in series with k_2.

$$\therefore \quad \frac{1}{k_{e_2}} = \frac{1}{9 \times 10^5} + \frac{1}{3 \times 10^5}$$

$$\Rightarrow \quad k_{e_2} = 2.25 \times 10^5 \text{ N/m}$$

This combination (i.e., k_{e_2}) is in parallel with k_3 and k_4.

$$\therefore \quad k_e = (2.25 + 4 + 6) \times 10^5 \text{ N/m} = 12.25 \times 10^5 \text{ N/m}$$

$\therefore$ Natural frequency,

$$\omega_n = \sqrt{\frac{k_e}{m}} = \sqrt{\frac{12.25 \times 10^5}{250}} = 70 \text{ rad/sec}$$

19. **(d)**

Refer IS 800 : 2007 Clause 10.2.5 (Tacking fasteners)

20. **(c)**

Refer IS 800 : 2007, Clause 10.5.1.1 (End returns), 10.1.2 (Lap joint), 10.5.5 (Intermittent welds)

22. **(b)**

Angle	60° – 90°	91° – 100°	101° – 106°	107° – 113°	114° – 120°
k	0.70	0.65	0.60	0.55	0.50

23. **(b)**

There will be only torsional shear and no direct shear stress.

$$r = \sqrt{50^2 + 50^2} = 50\sqrt{2} \text{ mm}$$

Shear force in bolt 'A' is given by

$$F_s = \frac{Mr}{\Sigma r^2} = \frac{50 \times 10^6 \times 50\sqrt{2}}{4 \times \left(50\sqrt{2}\right)^2} \times 10^{-3} \text{ kN} = 176.78 \text{ kN} \simeq 176.8 \text{ kN}$$

24. **(b)**

Refer IS 800 : 2007, Clause 8.6.1 (Minimum web thickness)

Also Refer Clause 8.6.1.2 (Compression flange buckling requirement)

25. **(c)**

$$\text{Applied shear force} = 180 \text{ kN}$$

$$\text{Factored shear force} = 1.5 \times 180 = 270 \text{ kN}$$

$$0.6V_d = 0.6 \times 300 = 180 \text{ kN}$$

Since, 270 kN > 180 kN ⇒ High shear case

$$\therefore \quad \beta = \left(\frac{2V}{V_d} - 1\right)^2 = \left(\frac{2\times 270}{300} - 1\right)^2 = 0.64$$

26. (d)

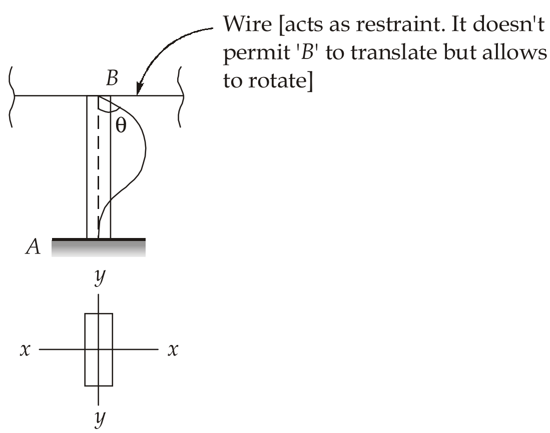
When the angles are not tack-riveted, both the angles will act individually.

$$A_{net} = 2[A_1 + kA_2]$$

where, $$k = \frac{3A_1}{3A_1 + A_2} = \frac{3(600)}{3(600)+900} = \frac{1800}{2700} = \frac{2}{3}$$

$$\therefore \quad A_{net} = 2\left[600 + \frac{2}{3}\times 900\right] = 2400 \text{ mm}^2$$

27. (d)



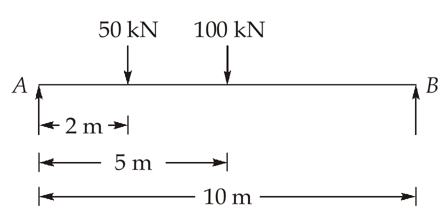
$$\therefore \quad l_{yy} = 0.8l = 0.8 \times 6 = 4.8 \text{ m}$$

But in the direction perpendicular to wire.

$$l_{xx} = 2l = 2 \times 6 = 12 \text{ m}$$

28. (b)

Capacity of crane + Weight of trolley = 40 + 10 = 50 kN



$$V_A \times 10 = 100 \times 5 + 50 \times 8$$

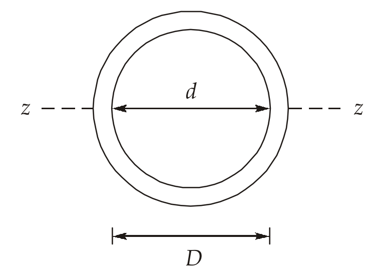
$$V_A = 90 \text{ kN}$$

Maximum static wheel load = Maximum reaction exerted by each wheel on the rail when crab is nearer to the girder

$$= \frac{90}{2} = 45 \text{ kN}$$

29. (a)

Moment of inertia about *zz*-axis



$$I_z = \frac{\pi}{64}(D^4 - d^4)$$

Elastic section modulus, $$Z_{e_z} = \frac{\pi}{32}\left(\frac{D^4 - d^4}{D}\right)$$

Plastic section modulus, $$Z_{p_z} = \frac{A}{2}(\bar{y}_1 + \bar{y}_2)$$

$$\bar{y}_1 = \bar{y}_2 = \frac{\frac{\pi D^2}{4}\left(\frac{2}{3}\times\frac{D}{\pi}\right) - \frac{\pi d^2}{4}\left(\frac{2}{3}\times\frac{d}{\pi}\right)}{\frac{\pi}{4}(D^2 - d^2)}$$

$\Rightarrow$ $$\bar{y}_1 = \bar{y}_2 = \frac{2}{3\pi}\frac{(D^3 - d^3)}{(D^2 - d^2)}$$

$\therefore$ $$Z_{p_z} = \frac{1}{2}\times\frac{\pi}{4}(D^2 - d^2)\left[2\times\frac{2}{3\pi}\times\frac{D^3 - d^3}{D^2 - d^2}\right] = \frac{1}{6}(D^3 - d^3)$$

$\therefore$ Shape factor, $$\text{S.F.} = \frac{\frac{1}{6}(D^3 - d^3)}{\frac{\pi}{32}\left(\frac{D^4 - d^4}{D}\right)} = \frac{32}{6\pi}\times\left[\frac{1 - \left(\frac{d}{D}\right)^3}{1 - \left(\frac{d}{D}\right)^4}\right] = \frac{16}{3\pi}\left[\frac{1 - \left(\frac{d}{D}\right)^3}{1 - \left(\frac{d}{D}\right)^4}\right]$$

32. (a)

Various mechanical devices used for removal of particulate matters:

Name of device	Minimum particle size (μm)	Efficiency of removal
1. Gravitational settling chamber	> 50	< 50%
2. Centrifugal collectors including cyclone collectors and dynamic precipitator	5 – 25	30 – 90%
3. Wet scrubbers of collectors including spray towers	> 10	< 80%
4. Cyclonic scrubbers	> 2.5	< 80%
5. Venturi scrubbers (Also used for gaseous pollutants)	> 0.5	< 99%
6. Electrostatic precipitator	> 1	95 – 99%
7. Fabric filters	< 1	> 99%

33. (c)

$$L_P = 20\log_{10}\left(\frac{P}{P_0}\right)$$

where, $P_0 = 20\ \mu$ Pa

$$\therefore \quad L_P = 20\log_{10}\left(\frac{2000\times10^5}{20}\right) = 140 \text{ decibel}$$

34. (c)

Specific yield: Volume of water drained by gravity per unit volume of aquifer.

Specific retention: Volume of water retained against gravity per unit volume of aquifer.

Storativity / Specific storage / Coefficient of storage: Volume of water drained from aquifer (by any means i.e., not only by gravity) per unit volume of aquifer.

In case of unconfined aquifer, specific storage is equal to specific yield.

In case of confined aquifer, water is drained because of compression of aquifer and expansion of water. Hence incase of confined aquifer specific storage is defined as volume of water released from unit volume of aquifer per unit decline in piezometric head.

Specific capacity: Discharge obtained per unit area per unit drawdown of a well. The performance of a well is measured by its specific capacity.

35. (b)

$$u = \frac{r^2S}{4Tt}$$

$$r = \frac{0.6}{2} = 0.3 \text{ m}$$

$$u = \frac{(0.3)^2\times3.6\times10^{-4}}{4\times3\times10^{-3}\times3000\times3600} = 2.5\times10^{-10}$$

From the table, $W(u) = 21.5323$

$$\text{Drawdown, } r = \frac{Q}{4\pi T}\times W(u) = \frac{3.14\times10^{-2}}{4\times3.14\times3\times10^{-3}}\times21.5223 = 17.94 \text{ m}$$

36. (c)

A geological formation which is highly porous and permeable → Aquifer

A geological formation through which only seepage is possible and thus the yield is insufficient compared to an aquifer → Aquitard

A geological formation which is highly porous but impermeable → Aquiclude

38. (d)

Valve	Function	Location of installation
Sluice / gate/ shut off valve	Regulates the flow of water through the pipe by dividing the mainline into several sections. (Used for isolation)	Placed at entry, exit and summit of the pressure conduits where the pressure is low.
Air relief valve	To release the air pressure.	Provided at the summit point on upstream of gate valve.
Air inlet / admittance valve	→ Allows air into the system to prevent a vacuum. → Used where gravity flow is required through pipeline.	Provided on the downstreams side of gate valve.
Check valve/ Reflux / non-returning valve	Allows water to flow in one direction only.	Provided on delivery and suction side of pump.
Scour valve / Blow-off / Drain / Wash-out valve	Avoids sediment accumulation, removes sand, silt etc.	Provided at the dead end of the pipeline and at low level points.
Pressure relief valve	To reduce water hammer pressure in pipes.	Usually provided in small pipelines.

39. (c)

Water borne diseases:

Micro-organisms	Disease
Bacteria	Typhoid, cholera, dysentery
Virus	Jaundice (Hepatitis) → leads to inflammation of liver Polio (Poliomyelitis)
Protozoa	Amoebic dysentery, gastroenteritis
Helminths	Worms

40. (c)

- Asbestos cement sewers are not strong enough to bear heavy compressive load.
- They are susceptible to hydrogen sulphide corrosion at crown.
- Due to these drawbacks, they are used as verticals or to carry less foul sewage from kitchen and bathroom.

41. (b)

Year	Population	Increase in population (x)
1970	25000	
1980	27000	2000
1990	33000	6000
2000	40000	7000
2010	45000	5000
Total		**20000**

$$\text{Average increase per decade } (\bar{x}) = \frac{20000}{4} = 5000$$

$$\therefore \quad P_3 = 45000 + 3(5000) = 60000$$

42. (b)

$$C_6H_6 + 7.5O_2 \rightarrow 6CO_2 + 3H_2O$$

$$\text{Theoretical oxygen demand} = \frac{240}{78} \times 25 = 76.92 \text{ mg/lit}$$

43. (b)

$$\text{Piezometric head} = \frac{P}{\gamma} + z = 15 \text{ m}$$

$$\Rightarrow \quad \frac{P}{\gamma} = 15 - 3 = 12 \text{ m}$$

Let the area of floor be A. So, by force balance,

$$\text{Weight of floor + Weight of water} = \text{Uplift force}$$

$$\Rightarrow \quad (t \times A \times G \times \gamma_w) + (2 \times A \times \gamma_w) = 12\gamma_w \times A$$

$$\Rightarrow \quad (t \times G) + 2 = 12$$

$$\Rightarrow \quad t = \frac{10}{2.5} = 4 \text{ m}$$

44. (d)

Volume of water actually stored in the root zone = $10 \times 10^4 \times 0.1 = 10^4$ m^3

$$\text{Volume of water supplied} = 6 \times 8 \times 3600 = 172800 \text{ m}^3$$

$$\text{Field application efficiency} = \frac{\text{Volume of water actually stored in the root zone}}{\text{Volume of water delivered to the field}}$$

$$= \frac{10^4}{172800} \times 100 = 5.79\%$$

45. (b)

Base period = 100 days

Water is required at an average interval of 20 days.

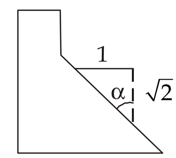
$\therefore$ Number of waterings required $= \frac{100}{20} = 5$

Total depth of water required each time = 5 cm

$\therefore$ Total depth of water = 5 × 5 = 25 cm

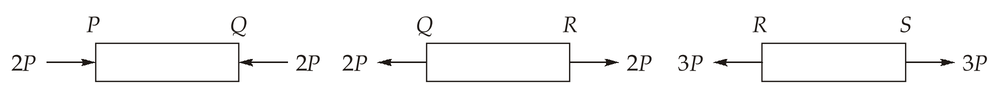
Hence, delta for wheat = 25 cm

46. (c)



$$\sigma_{max} = (p_{max\ toe}) \sec^2 \alpha$$
$$= p_{max\ toe}(1 + \tan^2 \alpha)$$
$$= 2.4\left(1+\left(\frac{1}{\sqrt{2}}\right)^2\right)$$
$$= 2.4 \times \frac{3}{2} = 3.6 \text{ N/mm}^2$$

47. (c)



$$\sigma_{bronze} = \frac{2P}{400} = 0.005P$$
$$\sigma_{steel} = \frac{3P}{300} = 0.01P$$
$$\sigma_{Al} = \frac{2P}{600} = 0.0033P$$
$$\therefore \quad \sigma_{steel} > \sigma_{bronze} > \sigma_{Al}$$

48. (a)

$$\sigma_x = \frac{(\epsilon_x + \mu \epsilon_y)E}{1-\mu^2}$$
$$= \frac{(0.4 \times 10^{-3} + 0.35 \times 0.3 \times 10^{-3}) \times 110 \times 10^3}{1 - 0.35^2} = 63.3 \text{ MPa}$$

49. (d)

$$\text{Buckling load} = F\cos\theta = F\cos 45° = \frac{F}{\sqrt{2}}$$
$$\therefore \quad \frac{F}{\sqrt{2}} = \frac{\pi^2 EI}{l^2} \qquad (l_{eff} = l)$$
$$\Rightarrow \quad F = \frac{\sqrt{2}\,\pi^2 EI}{l^2}$$

50. (a)

$$\text{Radius of Mohr's circle} = \left(\frac{\gamma_{xy}}{2}\right)_{max}$$

$$\Rightarrow \quad \frac{1000}{2} = \sqrt{\left(\frac{\epsilon_{xx}-\epsilon_{yy}}{2}\right)^2+\left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$\Rightarrow \quad 500^2 = \left(\frac{1000-200}{2}\right)^2+\left(\frac{\gamma_{xy}}{2}\right)^2$$

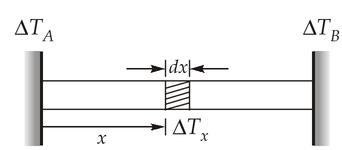
$$\Rightarrow \quad \gamma_{xy} = 600\mu$$

51. (d)

$$\frac{\Delta T_B-\Delta T_A}{L} = \frac{\Delta T_x-\Delta T_A}{x}$$

$$\Rightarrow \quad \Delta T_x = \Delta T_A+\frac{\Delta T_B-\Delta T_A}{L}x$$

Now, $d\delta = \alpha(dx)\ (\Delta T_x)$



$$\Rightarrow \quad d\delta = \alpha(dx)\left[\Delta T_A+\frac{\Delta T_B-\Delta T_A}{L}x\right]$$

$$\therefore \quad \delta = \int_0^l \alpha\, dx\left[\Delta T_A+\frac{\Delta T_B-\Delta T_A}{L}x\right]$$

$$\Rightarrow \quad \delta = \alpha\,\Delta T_A L+\frac{\alpha}{L}\frac{L^2}{2}(\Delta T_B-\Delta T_A)$$

$$\Rightarrow \quad \delta = \alpha\,\Delta T_A L+\frac{\alpha L}{2}(\Delta T_B-\Delta T_A)$$

$$\Rightarrow \quad \frac{\delta}{L} = \frac{\alpha}{2}[\Delta T_B+\Delta T_A]$$

$$\therefore \quad \sigma = \frac{E\delta}{L}=\frac{\alpha E}{2}[\Delta T_B+\Delta T_A]$$

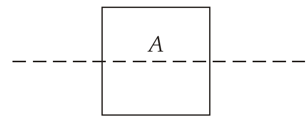
52. (b)

$$\tau = \frac{T}{2A_0 t}$$

$$A_0 = 80\times 30 = 2400\ \text{mm}^2$$

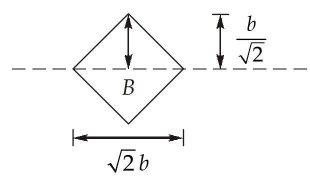
$$\therefore \quad t = \frac{T}{2A_0\tau}=\frac{960\times 10^3}{2\times 2400\times 100}=2\ \text{mm}$$

53. (b)



$$Z_A = \frac{I}{y_{max}} = \frac{\frac{b \times b^3}{12}}{\frac{b}{2}}$$

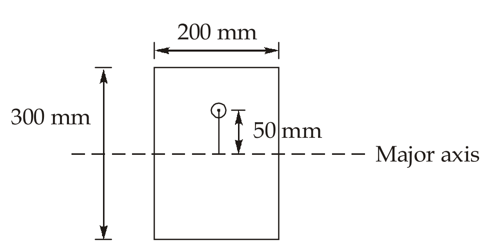
$$\Rightarrow \quad Z_A = \frac{b^3}{6}$$



$$Z_B = \frac{I}{y_{max}} = \frac{\frac{2 \times (\sqrt{2}\,b) \times \left(\frac{b}{\sqrt{2}}\right)^3}{12}}{\frac{b}{\sqrt{2}}} = \frac{b^4}{12} \times \frac{\sqrt{2}}{b} = \frac{b^3}{6\sqrt{2}}$$

$$\therefore \quad \frac{Z_A}{Z_B} = \frac{\frac{b^3}{6}}{\frac{b^3}{6\sqrt{2}}} = \sqrt{2}$$

55. (d)



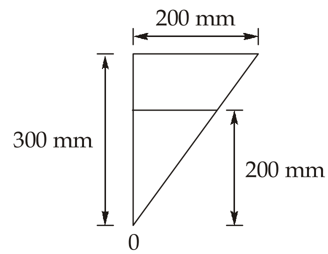
$$\sigma_{max} = \frac{P}{A} + \frac{M}{Z}$$

$$= \frac{240 \times 10^3}{200 \times 300} + \frac{240 \times 10^3 \times 50 \times 6}{200 \times 300^2} = 4 + 4 = 8 \text{ MPa}$$

$$\sigma_{min} = \frac{P}{A} - \frac{M}{Z} = 4 - 4 = 0$$

$\because \quad \sigma_{min}$ = 0 and thus whole column section is under compression

Stress diagram,



$$\therefore \qquad \frac{8}{300} = \frac{x}{200} \Rightarrow x = \frac{16}{3}\text{ MPa}$$

56. (c)

Deflection at C due to M, $\delta_C = \frac{Ml^2}{2EI} + \frac{Ml}{EI} \times l = \frac{3Ml^2}{2EI}$

Deflection at C due to prop, $\delta_C' = \frac{R(2l)^3}{3EI} = \frac{8Rl^3}{3EI}$

But $\delta_C = \delta_C'$ (Compatibility condition)

$$\Rightarrow \qquad \frac{3Ml^2}{2EI} = \frac{8Rl^3}{3EI}$$

$$\Rightarrow \qquad R = \frac{9M}{16l}$$

57. (b)

$$\Sigma M_A = 0$$

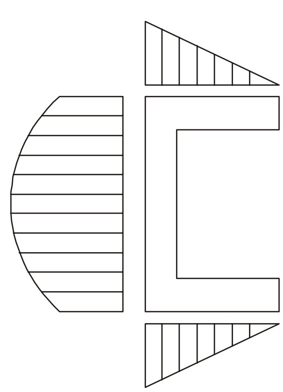
$$\Rightarrow \qquad R_C \times 5 = \frac{1}{2} \times [400 + 1000] \times 3 \times \left[2 + \frac{2 \times 1000 + 400}{400 + 1000} \times \frac{3}{3}\right]$$

$$\Rightarrow \qquad R_C \times 5 = \frac{1}{2} \times 1400 \times 3 \times \left[2 + \frac{12}{7}\right] = 700 \times 3 \times \frac{26}{7}$$

$$\Rightarrow \qquad R_C = 1560\text{ N}$$

$$\therefore \qquad R_A = \frac{1}{2} \times (400 + 1000) \times 3 - 1560 = 540\text{ N}$$

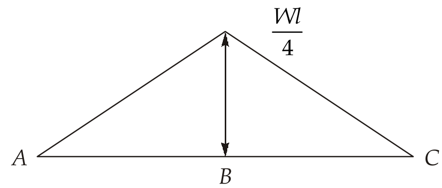
58. (c)



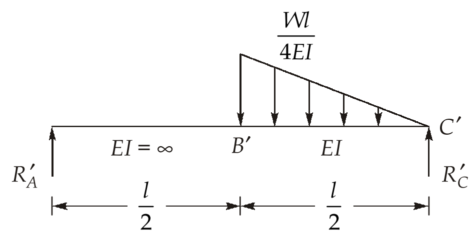
59. (a)

Using conjugate beam method:

Real beam BMD:



Conjugate beam:



$$\Sigma M_C' = 0$$

$$\Rightarrow \quad R_A' \times l = \frac{1}{2} \times \frac{Wl}{4EI} \times \frac{l}{2} \times \frac{2}{3} \times \frac{l}{2}$$

$$\Rightarrow \quad R_A' \times l = \frac{Wl^3}{48EI}$$

$$\Rightarrow \quad R_A' = \frac{Wl^2}{48EI}$$

$$\therefore \quad SF_B' = \frac{Wl^2}{48EI}$$

$\therefore$ Slope at mid-span in the real beam $= \dfrac{Wl^2}{48EI}$

60. (d)

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

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

$$= \sqrt{\frac{1}{8}\left[4\left(\frac{y_2}{y_1}\right)^2 + 1 + \frac{4y_2}{y_1} - 1\right]}$$

$$= \sqrt{\frac{4}{8}\left[\left(\frac{y_2}{y_1}\right)^2 + \left(\frac{y_2}{y_1}\right)\right]} = \sqrt{\frac{1}{2}\left[\left(\frac{y_2}{y_1}\right)^2 + \frac{y_2}{y_1}\right]}$$

62. (d)

$$F_B = \rho_{fluid} \cdot V_{immersed} \cdot g_{eff}$$

As the block is dropped, the effective acceleration due to gravity is constant (g). The density of fluid also remains same (ρ).
Thus, the buoyant force acting on it will also remain same.

63. (b)

$$w_Z = \frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)$$

$\because$ $$v = 3x - 5y + 9$$

$\therefore$ $$\frac{\partial v}{\partial x} = 3$$

Also, $$u = 2x + 3y + 6$$

$\therefore$ $$\frac{\partial u}{\partial y} = 3$$

$\therefore$ $$w_Z = \frac{1}{2}(3-3) = 0$$

64. (b)

Gradient of a scalar function gives a vector quantity but potential function is scalar quantity. Velocity can be written as gradient of potential function (scalar function).

$$\text{Velocity} = \nabla\phi$$

If $\phi = 2x + 5y$ is a potential function, then it must satisfy Laplace equation

$\therefore$ $$\phi = 2x + 5y$$

$\therefore$ $$\frac{\partial\phi}{\partial x} = 2 \text{ and } \frac{\partial^2\phi}{\partial^2 x} = 0$$

and $$\frac{\partial\phi}{\partial y} = 5 \text{ and } \frac{\partial^2\phi}{\partial^2 y} = 0$$

Laplace equation: $$\frac{\partial^2\phi}{\partial^2 x} + \frac{\partial^2\phi}{\partial^2 y} = 0$$

65. (b)

$$\tau = \mu\left(\frac{d\phi}{dt}\right)$$

$\Rightarrow$ $$\tau = \nu\rho \times 10^4$$

$\Rightarrow$ $$\tau = 18 \times 10^{-4} \times 1260 \times 10^4 \text{ Pa}$$

$\Rightarrow$ $$\tau = 22.68 \text{ kPa}$$

66. (a)

For rotational flow, Bernoulli's equation cannot be applied on two different streamlines.

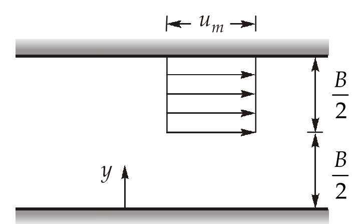
67. (c)

$$P_{generated} = \gamma Q(H - h_L)$$
$$= 10 \times 3 \times (28) = 840 \text{ kW}$$
$$P_{extracted} = 750 \text{ kW}$$
$$\therefore \quad P_{remaining} = 840 - 750 = 90 \text{ kW}$$
$$\therefore \quad \text{Residual head} = \frac{P_r}{\gamma Q} = \frac{90 \times 10^3}{10000 \times 3} = 3 \text{ m}$$

68. (a)

$$B = \frac{1}{AV^2}\int u^2\, dA$$

Conservation of discharge



$$\bar{u} \times (B \times 1) = \int u\, dA$$
$$\Rightarrow \quad \bar{u} \times B = \int u(dy \times 1)$$
$$\Rightarrow \quad \bar{u} \times B = \int_{\frac{B}{2}}^{B} u_m\, dy$$
$$\Rightarrow \quad \bar{u} \times B = u_m \times \frac{B}{2}$$
$$\Rightarrow \quad \bar{u} = \frac{u_m}{2}$$
$$\therefore \quad \beta = \frac{1}{(B \times 1)(\bar{u})^2}\int_{\frac{B}{2}}^{B} u_m^2 (dy \times 1)$$
$$\Rightarrow \quad \beta = \frac{4}{B \times u_m^2}\, u_m^2 \times \frac{B}{2} = \frac{4}{2} = 2$$

69. (c)

$$L_H = \frac{1}{300}, \quad L_V = \frac{1}{30}$$
$$\text{Slope} = \frac{\text{Vertical distance}}{\text{Horizontal distance}}$$
$$\therefore \quad S_r = \frac{S_m}{S_p} = \frac{\frac{1}{30}}{\frac{1}{300}} = 10$$

70. (a)

Stoke's equation, $F = 3\pi D\mu V_0$

where, F = longitudinal force on sphere

D = diameter of sphere

μ = viscosity of fluid

71. (b)

$$\frac{\tau_0}{\frac{1}{2}\rho V^2} = \frac{f}{4}$$

$$\Rightarrow \quad f = \frac{8\tau_0}{\rho V^2} = \frac{8 \times 50}{1000 \times 2^2} = 0.1$$

72. (b)

Conditions favouring boundary layer separation:

1. Positive pressure gradient

2. Negative velocity gradient

73. (a)

Designing, tendering and construction fall under project phase.

75. (a)

Contract consists of

1. contract drawings

2. general conditions of contract

3. special conditions of contract

4. agreement

5. specification

6. bill of quantities (if applicable)

76. (d)

- Forward pass technique calculates earliest start time of an activity.
- Backward pass technique chooses minimum of all latest occurrence times at any node.

77. (d)

Scraper : Purposes
- Site stripping
- Levelling
- Loading
- Hauling
- Discharging

78. (d)

$$D_m = (C_i - C_s)\left[\frac{n-m+1}{\frac{n(n+1)}{2}}\right]$$

$$\therefore \quad D_1 = (1200 - 200)\left[\frac{4-1+1}{\frac{4(4+1)}{2}}\right]$$

$$\Rightarrow \quad D_1 = 1000\left[\frac{4}{2 \times 5}\right] = ₹400$$

79. (d)

Safety indices:

1. Frequency rate
2. Severity rate
3. Incidence rate
4. Experience modification rate
5. Loss ratio
6. Workmen's compensation claim frequency index

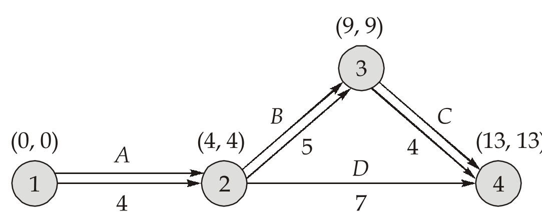
80. (d)

$$Z = \frac{T_m - T_s}{\sigma} = \frac{50-44}{\sqrt{9}} = 2$$

Z	P
0	50%
1	84.13%
2	97.72%

81. (b)

Critical path is 1 – 2 – 3 – 4 and the project duration 13 days



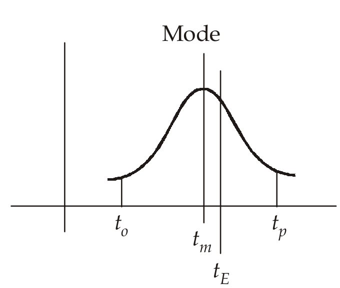
$$FF_D = (TF)_D - (Slack)_4$$
$$= (13 - 4 - 7) - 0 = 2 \text{ days}$$

82. (a)

During updating, activities and their inter-relationship is maintained. It means activities can neither be added nor be deleted from the network.

After project updating, project duration as well as critical path may change.

84. (d)



t_E = Expected time

t_m = Most likely time (occurring most of the time)

t_o = Optimistic time
t_p = Pessimistic time

85. (d)

$$\text{Correct length} = \frac{\text{RF (wrong scale)}}{\text{RF (correct scale)}} \times \text{Measured length}$$

$$= \frac{\frac{1}{500}}{\frac{1}{1000}} \times 200 = 400 \text{ m}$$

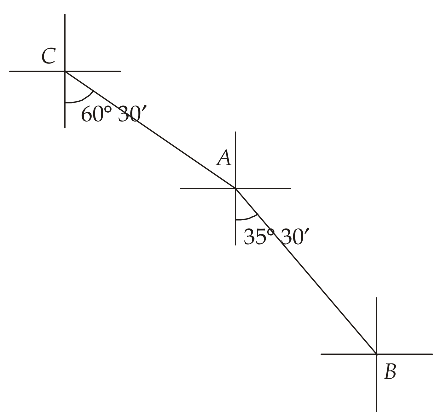
86. (c)

Only systematic errors follow some well-defined mathematical or physical law or system.

87. (d)

$$E_{90} = \pm 1.645\sigma$$
$$E_{99.9} = \pm 3.29\sigma$$
$$E_{95} = \pm 1.965\sigma$$
$$E_{95.5} = \pm 2\sigma$$
$$E_{99.7} = \pm 3\sigma$$

89. (b)



$$\text{Included angle} = 360° - [90° - 60° 30' + 90° + 35° 30']$$
$$= 360° - [155°] = 205°$$

90. (b)

$$\Delta H = \frac{1}{2}\left[(h_p - h_q) + (h_p' - h_q')\right]$$

$$= \frac{1}{2}[(2.845 - 2.523) + (1.090 - 1.765)]$$

$$= \frac{1}{2}[0.322 - 0.675]$$

$$= -\frac{0.353}{2} = -0.1765 \text{ m}$$

91. (d)

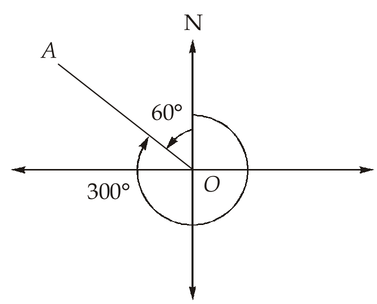
(a) The vernier reading does not change when upper clamp screw is tightened while the lower clamp screw is loose.

(c) Process of turning the telescope in horizontal plane is known as swinging the telescope.

(d) Face changing of telescope is done by transiting (moving in vertical plane).

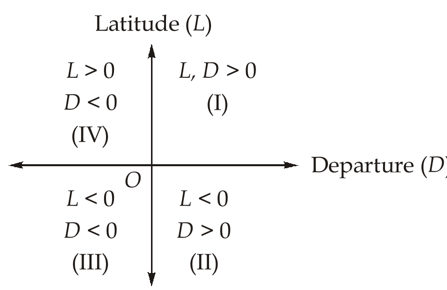
(b) When the lower clamp screw is tightened while the upper clamp screw is loose, the vernier readings change.

92. (d)



$$\text{Latitude} = (+)\, 100 \cos 60° = 50 \text{ m}$$

$$\text{Departure} = -100 \sin 60° = -50\sqrt{3} \text{ m}$$



93. (d)

$$S = \frac{f}{H-h}$$

$$\Rightarrow \quad \frac{1}{5000} = \frac{\frac{30}{100}}{H-1200}$$

$$\Rightarrow \quad H - 1200 = \frac{30}{100} \times 5000$$

$$\Rightarrow \quad H - 1200 = 1500$$

$$\Rightarrow \quad H = 2700 \text{ m}$$

96. (c)

- Under high pressure and temperature for a long time, schist can be transformed into gneiss.

97. (d)

$$A = \frac{h}{3}[O_1 + O_5 + 4(O_2 + O_4) + 2(O_3)]$$

$$\Rightarrow \quad A = \frac{10}{3}[3.2 + 8.6 + 4(5.6 + 6.6) + 2 \times 4.2]$$

$$\Rightarrow \quad A = \frac{10}{3}[11.8 + 48.8 + 8.4] = 230 \text{ m}^2$$

98. (c)

A strike is the direction which a rock layer takes along the horizontal stretch of the country.

100. (a)

Length of valley curve as per comfort condition,

$$L_V = 2\sqrt{\frac{NV^3}{C}}$$

Here, $N = |n_1 - n_2|$

$$= |-0.02 - 0.03| = 0.05$$

$$C = 0.5$$

$$V = 20 \text{ m/s}$$

$$\therefore \quad \text{Length of transition curve} = \frac{L_V}{2} = \sqrt{\frac{NV^3}{C}} = \sqrt{\frac{0.05 \times (20)^3}{0.5}} = 20\sqrt{2} \text{ m}$$

101. (a)

As per Burmister's method, (for sub grade $F = 1$)

$$\Delta = 1.18\frac{pa}{E} \cdot F$$

$$\Rightarrow \quad 0.5 = 1.18 \times \frac{1.25 \times 15}{E} \times 1$$

$$\Rightarrow \quad E = 44.25 \text{ kg/cm}^2$$

102. (c)

- WBM, WMM (wet mix macadam) and soil aggregate mixes belongs to granular base course.

104. (c)

$$\text{Optimum cycle time } (C_0) = \frac{1.5 \times L + 5}{1 - (y_A + y_B)} = \frac{1.5 \times 10 + 5}{1 - (0.20 + 0.40)} = 50$$

Now, $G_A = \frac{y_A}{y}[C_0 - L]$

$$= \frac{0.2}{0.6}[50 - 10] = 13.33$$

$$\text{Percentage of time for which there is flow on road } A = \frac{G_A}{C_0} \times 100 = \frac{13.33}{50} \times 100 = 26.67$$

105. (c)

- Bitumen is obtained from fractional distillation of petroleums.
- Ductility of bitumen is measured at 27°C.

106. (a)

Stress developed due to wheel load at interior is given by,

$$S_i = \frac{0.316P}{h^2}\left[4\log_{10}\left(\frac{l}{b}\right)+1.069\right]$$

$$= \frac{0.316\times 4500}{(15)^2}\left[4\log\left(\frac{90}{9}\right)+1.069\right] = 32 \text{ kg/cm}^2$$

108. (b)

Traffic capacity and traffic volume have same units.

109. (c)

$$\text{Relative density } (I_D) = \frac{V_{\max}-V_n}{V_{\max}-V_{\min}}\times 100$$

$$= \frac{1350-1200}{1350-990}\times 100 = 41.67\%$$

I_D	Description
0 – 15	Very loose
15 – 35	Loose
35 – 65	Medium
65 – 85	Dense
85 – 100	Very dense

110. (b)

$$\text{Hydraulic gradient } (i) = \frac{2}{6} = \frac{1}{3}$$

$$[\text{T.H}]_C = [\text{T.H}]_A + i \cdot Z$$

$$= [6+2] + \frac{1}{3}\times 2.5 = 8.83 \text{ m}$$

$$[\text{D.H}]_C = 6 - 2.5 = 3.5 \text{ m}$$

$$[\text{P.H}] = [\text{T.H}]_C - [\text{D.H}]_C$$

$$= 8.83 - 3.5 = 5.33$$

111. (a)

- Coulomb's theory assumes wedge failure.
- It is not preferred for passive earth pressure analysis.

112. (c)

$$\text{Ultimate load carrying capacity of piles} = 3 \times 5500 = 16500 \text{ kN}$$

$$\text{Load carrying capacity of single pile} = C_u \cdot N_c A_b + \alpha C_u A_s$$

$$= 100 \times 9 \times \frac{\pi}{4} \times 0.5^2 + 0.5 \times 80 \times 0.5 \times \pi \times 10 \simeq 805 \text{ kN}$$

$$\text{Number of piles required} = \frac{16500}{805} = 20.5 \simeq 21$$

113. (b)

- Inside clearance should be low.
- Area ratio should be less than 20%.

114. (c)

$$\text{Free swell (\%)} = \frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}} \times 100$$

$$= \frac{165 - 100}{100} \times 100 = 65\%$$

For Illite, possible range is 30% to 80%.

116. (a)

$$B = \frac{\Delta u_1}{\Delta \sigma_3} = \frac{545 - 450}{700 - 600} = 0.95$$

and $$\bar{A} = \frac{\Delta u_2}{\Delta \sigma_D} = \frac{745 - 545}{500} = 0.4$$

$\therefore$ $$\bar{A} = AB$$

$\Rightarrow$ $$A = \frac{\bar{A}}{B} = \frac{0.4}{0.95} = 0.42$$

117. (d)

$$R_h = (\rho - 1) \times 1000$$

$$= (1.015 - 1) \times 1000 = 15$$

Now, $$\%N = \frac{\frac{R_h}{1000} \times \frac{G}{G-1}}{\frac{M}{V}} \times 100$$

$$= \frac{\frac{15}{1000} \times \frac{2.6}{2.6-1}}{\frac{70}{1000}} \times 100 = 34.82\%$$

118. (c)

- Shape factor is ratio of number of flow channels to number of equipotential channels.
- Shape of flow field is square for isotropic medium and rectangle or curvilinear for non-isotropic medium.

119. (a)

The soil which has maximum plasticity index (I_P) will have maximum amount of clay.

Soil A : $I_P = 0.54 - 0.24 = 0.3$

Soil B : $I_P = 0.47 - 0.21 = 0.26$

Soil C : $I_P = 0.41 - 0.16 = 0.25$

Soil D : $I_P = 0.50 - 0.23 = 0.27$

120. (a)

- The contact pressure distributions under a rigid footing on a cohesionless soil would be maximum at centre and zero at the edges. The distribution is close to parabolic.
- The bearing capacity of footing not always gets affected by the location of ground water table.

121. (d)

$$\text{Minimum depth of ballast } (D_b) = \frac{S-W}{2}$$

$$\therefore \quad 20 = \frac{S-25}{2}$$

$$\Rightarrow \quad S = 65 \text{ cm}$$

122. (a)

The gate capacity for single gate is,

$$G_c = \frac{1}{\text{Weighted service time}}$$

$$= \frac{1}{0.45\times 25+0.55\times 50} = \frac{4}{155}\text{aircraft/min/gate}$$

$$\text{Capacity of all gates } (C) = G_c \times \text{Number of gate}$$

$$= \frac{4}{155}\times 12$$

$$= 0.31 \text{ aircraft/min} \simeq 18 \text{ aircraft/hour}$$

123. (c)

$$\text{Hydraulic efficiency} = \frac{\text{Energy head transferred to runner}}{\text{Water head}}$$

$$= \frac{36}{42} = 0.857$$

$$\text{Overall efficiency, } \eta_o = \eta_m \times \eta_h$$

$$= 0.9 \times 0.857 = 0.77$$

$$\text{Water power, } P = \eta_o \gamma Q H$$

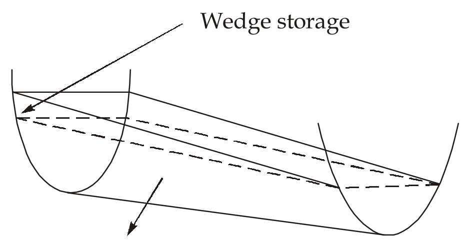
$$\Rightarrow \quad Q = \frac{45\times 10^3}{0.77\times 42\times 10^3\times 10} \simeq 0.14 \text{ m}^3/\text{sec}$$

124. (d)

$$\text{Average depth of flow} = 30 \text{ mm}$$
$$\text{Effective depth of flow} = \text{Average depth of flow} - \text{Losses}$$
$$= 30 - 0.25 \times 2 \times 10 = 25 \text{ mm}$$
$$\text{Peak flow for flood hydrograph} = 220 \text{ m}^3/\text{sec}$$
$$\text{Peak flow for direct runoff hydrograph} = 220 - 20 = 200 \text{ m}^3/\text{sec}$$
$$\text{Peak flow for unit hydrograph} = \frac{\text{Peak flow for DRH}}{\text{Effective depth of flow (cm)}}$$
$$= \frac{200}{25 \times 10^{-1}} = 80 \text{ m}^3/\text{sec}$$

125. (a)

- Prism storage: It is the volume that would exist if the uniform flow occurred at the down stream depth.
- Wedge storage: It is the volume formed between the actual water surface profile and surface parallel to bed of channel.



126. (c)

The rainfall data are arranged in descending order:

Rainfall	Order
11	1
10	2
9.3	3
9	4
8.5	5
8	6
7	7
6	8

As per Weibull's method,

$$\text{Return period, } T_r = \frac{N+1}{m} = \frac{8+1}{3} = 3$$

$\therefore$ $$\text{Risk} = 1 - [1 - P]^2$$
$$= 1 - \left[1 - \frac{1}{T_r}\right]^2 = 1 - \left[1 - \frac{1}{3}\right]^2 = 0.55$$

127. (c)

- The maximum area of reinforcement (including both tension and compression reinforcement) shall not exceed 0.04 b.D.
- Minimum shear reinforcement in the form of stirrups shall be provided such that;

$$\frac{A_{sv}}{b \cdot S_v} \geq \frac{0.4}{0.87 f_y}$$

For Fe415, $$\frac{A_{sv}}{b \cdot S_v} \geq \frac{0.4}{0.87 \times 415}$$

$\Rightarrow$ $$A_{sv} \geq 0.0011 b.S_v$$

128. (d)

For single HYSD bar is compression,

$$L_d = \frac{\phi \times 0.87 f_y}{4 \cdot \tau_{bd} \times 1.6 \times 1.25} = 32.23\phi$$

For a bundle of four bars in contact, the development length of each bar shall be that for individual bar increased by 33 percent.

$\therefore$ $$L_d = 1.33 \times 32.23\phi \simeq 43\phi$$

129. (b)

Refer IS 1343 - 1980, Clause 19.6.1.1.(b)

130. (c)

$$M_{u\,\text{lim}} = 0.36 f_{ck} B \cdot x_{u\,\text{lim}} [d - 0.42 x_{u\,\text{lim}}]$$

For severe condition, $$d_{\text{eff}} = D - 45 \text{ mm}$$
$$= 450 - 45 \text{ mm} = 405 \text{ mm}$$

For Fe500, $$M_{u\,\text{lim}} = 0.133 f_{ck} \cdot B \cdot d^2$$
$$= 0.133 \times 20 \times 200 \times (405)^2 \times 10^{-6} \text{ kNm}$$
$$= 87.26 \text{ kN-m} \simeq 87 \text{ kN-m}$$

131. (a)

Side face reinforcement is provided when beam depth exceeds 750 mm.
The total area of such reinforcement shall not be less than 0.1 percent of the web area and shall be distributed equally on both the faces.

$\therefore$ $$[A_{st}]_{\text{side}} = 0.1\% \text{ of } B \times D$$
$$= \frac{0.1}{100} \times 350 \times 800 = 280 \text{ mm}^2$$

$\therefore$ Reinforcement on each side $$= \frac{280}{2} = 140 \text{ mm}^2$$

133. (a)

$$\text{Maximum working moment} = \frac{w \times l^2}{8} = \frac{4 \times 6^2}{8} = 18 \text{ kN-m}$$

Stress at bottom fiber at working load = 0 N/mm^2 (Given)

Stress corresponding to cracking at the bottom fiber = 5 N/mm^2

Extra moment required to develop this stress = 5 × 18 × 10^5

= 9 × 10^6 N-mm = 9 kN-m

∴ Cracking moment = 18 + 9 = 27 kN-m

$$\therefore \quad \text{Load factor against cracking} = \frac{\text{Cracking moment}}{\text{Working moment}} = \frac{27}{18} = 1.5$$

134. (a)

Loss due to creep in steel = $\phi \cdot f_c \cdot m$

where, m = Modular ratio

$$= \frac{E_s}{E_c}$$

135. (d)

Total area of steel in longer direction = $L_y \times A_{st}$

$\Rightarrow$ $(A_{st})_{\text{Total}}$ = 5.4 × 900 = 4860 mm^2

$$\text{Total number of 16 mm } \phi \text{ bars for full length } (n_T) = \frac{(A_{st})_{\text{total}}}{\frac{\pi}{4} \times \phi^2} = \frac{4860}{\frac{\pi}{4} \times (16)^2} \simeq 25 \text{ nos.}$$

$$\text{Number of bars in central band } (n_c) = n_T \times \frac{2}{1 + \left(\frac{L}{B}\right)}$$

$$= \frac{25 \times 2}{1 + \left[\frac{5.4}{3.5}\right]} = 19.66 \simeq 20$$

136. (b)

For axial loading;

$$P_u = 0.45 f_{ck} \cdot A_c + 0.67 f_y A_{sc}$$

$$\Rightarrow \quad 1800 \times 10^3 = 0.45 \times 20 \times [300 \times 350 - A_{sc}] + 0.67 \times 415 \times A_{sc}$$

$$\Rightarrow \quad A_{sc} = 3177.8 \text{ mm}^2 \simeq 3178 \text{ mm}^2$$

137. (b)

Cracks get developed when tensile stresses and strains are caused during shrinkage due to restraint. Thus shrinkage cause tension cracks.

138. **(c)**

The temperature contrast causes convection and air cools adiabatically to from the shape of the cloud which finally bursts into thunderstorm.

139. **(d)**

Self compacting concrete exerts high pressure on the from-work and accordingly while casting the rate of casting has to be slow.

140. **(d)**

False setting: Water of crystallization of gypsum ($CaSO_4.2H_2O$) vapourizes either partially or completely during manufacturing of cement. Hence when water is added in cement, it first reacts with gypsum to fulfill its water deficiency, during which it hardness and gives impression of false setting of cement. It can be removed by adding extra water.

Flash setting: It occurs due to more C_3 A and less gypsum. After flash setting, remixing is not possible.

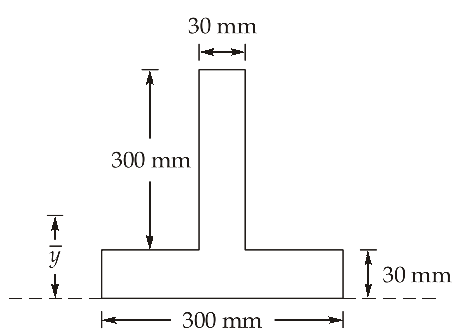
141. **(c)**

Viscous damping introduces a damping force which varies linearly with the relative velocity and the differential equation of motion becomes linear. On the otherhand, the damping force in Coulomb's damping is assumed to be constant and independent of relative velocity. Due to this resulting differential equation of motion becomes non-linear.

142. **(c)**

Triangular section is the most inefficient cross-section, because most of area lies near plastic neutral axis and thus plastic section modulus (z_p) is less.

145. **(c)**



$$\bar{y} \text{ (from bottom)} = \frac{300 \times 30 \times 15 + 300 \times 30 \times \left(30 + \frac{300}{2}\right)}{300 \times 30 + 300 \times 30} = 97.5 \text{ mm}$$

Distance of neutral axis from the junction of flange and web

$$= 97.5 - 30 = 67.5 \text{ mm}$$

146. (a)

At critical condition,

$$\frac{Q^2 T}{gA^3} = 1$$

$$\Rightarrow \quad \frac{Q^2}{g} = \frac{A^3}{T} \Rightarrow \frac{(VA)^2}{g} = \frac{A^3}{T}$$

$$\Rightarrow \quad \frac{V^2}{g} = \frac{A}{T} = D$$

$$\Rightarrow \quad \frac{V^2}{2g} = \frac{D}{2}$$

147. (c)

Project crashing is applied on critical activities with lowest cost slopes along a critical path.

148. (d)

IRC suggested that the maximum volume of traffic of 3000 veh/hr entering from all legs of the rotary intersection can be handled efficiently.

149. (d)

At the same void ratio desiccated clay is stronger than saturated clay. During drying due to rise in temperature, tension develops in pore water and effective stress increases.

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