All India Mock GATE Test Series
Test series 4
Civil Engineering

Answer Keys and Explanations

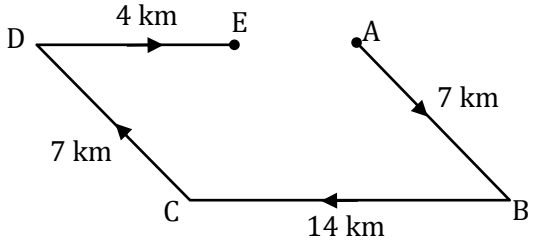
General Aptitude:

1. **[Ans. A]**
Meaning: slow to move or act
Part of Speech: Adjective

2. **[Ans. *] Range: 9 to 9**
Clearly $5 \times 2 = 10, 10 \times 2 = 20, 20 \times 2 = 40, \ldots$
So, the series is a G.P. in which $a_1 = 5$ and $r = 2$
To find the n^{th} term of a Geometric progression, the formula is $a_n = a_1 r^{n-1}$
Let 1280 be the n^{th} term of the series
Then, $5 \times 2^{n-1} = 1280 \Leftrightarrow 2^{n-1} = 256 = 2^8 \Leftrightarrow n - 1 = 8 \Leftrightarrow n = 9$

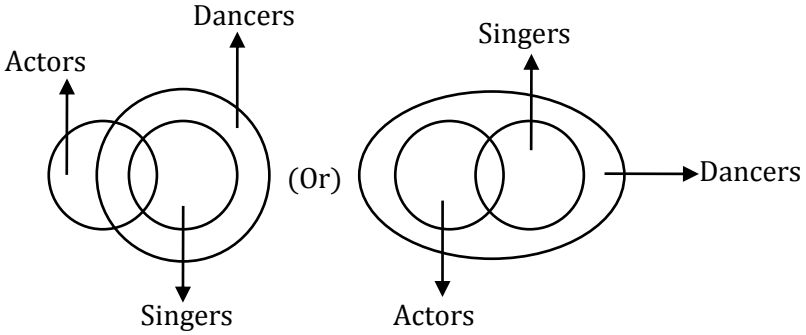
3. **[Ans. A]**
For this type of question take the LCM of speeds and assume the LCM as the distance
Then the time taken at speed of 60 km/hr $= \frac{300}{60} = 5$ hrs
Again the time taken at speed of 50 km/hr $= \frac{300}{50} = 6$ hrs
Thus we see that in place of 5 hrs trains take 6 hrs. Its means train takes 1 hr extra and this one hour is stopping period in the total time of 6 hrs. Thus in 6 hrs train halts for 1 hr. so in 1 hr train will stop for $1/6$ hours or 10 minutes.

4. **[Ans. *] Range: 10 to 10**
Let assume, Radha is at Point 'A'



Required distance = AE = AD − DE
Since ABCD is a parallelogram
AD= BC
∴ AE = BC − DE
= 14 − 4 = 10

5. **[Ans. A]**



Only (1) Follows

6. **[Ans. *] Range: 6 to 6**

Given:

$$\begin{matrix} R \to x+10 \\ L \to x+6 \\ B \to x+5 \\ H \to x+4 \\ A \to x \end{matrix}\Bigg]\begin{matrix} x \\ x \\ x+ \\ x \\ x \end{matrix} \quad 25 \quad \Bigg]\begin{matrix} x+5 \\ x+5 \\ x+5 \\ x+5 \\ x+5 \end{matrix}\Bigg]\begin{matrix} \textcircled{5}^{+} \\ \textcircled{1}^{+} \\ \textcircled{1}^{-} \\ \textcircled{5}^{-} \end{matrix}$$

Thus total 6 coins have to be transferred.

7. **[Ans. B]**

The numbers are given in pair of 4 and 9.

The unit digit of each pair is 4, and there are 50 such pairs which are mutually multiplied together.

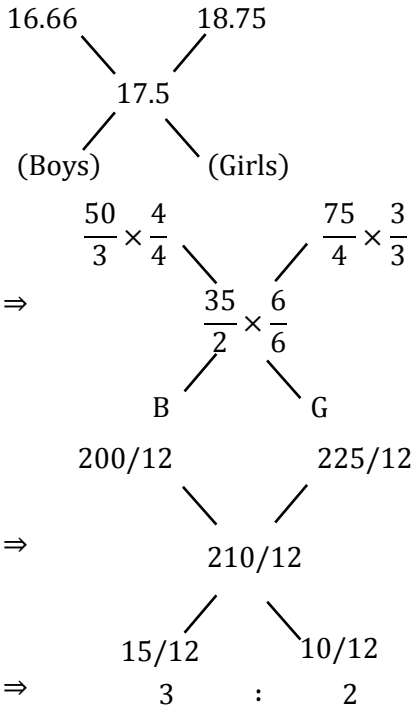
Unit digit $\underbrace{4 \times 9^2}_{4} \times \underbrace{4^3 \times 9^4}_{4} \times \underbrace{4^5 \times 9^6}_{4} \times \ldots . \underbrace{4^{99} \times 9^{100}}_{4}$

Again $4 \times 4 \times 4 \times 4 \ldots 4$(upto 50 times)

i.e., the unit digit of 4^{50}, which is 6

[Since unit digit of 4^{2n} is 6 for n = 1, 2, 3, ...etc]

8. **[Ans. B]**



⇒ … … (Making Denominator equal)

⇒

⇒

$\therefore$ Boys $= 3x$; Girls $= 2x$

Given $3x - 2x = 8$

$\therefore x = 8$

Thus the number of Girls $= 16$ and number of Boys $= 24$

9. **[Ans. D]**

Let there be x voters and k votes goes to loser then

$0.8x - 120 = k + (k + 200)$ … … . ①

Also, $k + 200 = 0.41x$ … … . ②

From equation ① and ②

$0.8x - 120 = 0.41x - 200 + 0.41x$

$0.02x = 80$

$x = 4000$

$\therefore k = 0.41 \times 4000 - 200$

$\Rightarrow k = 1440$

And $(k + 200) = 1640$

Number of voters voted $= x - 0.2x$

$0.8x = 0.8 \times 4000 = 3200$

Therefore, percentage of votes for defeated candidates $= \frac{1440}{3200} \times 100 = 45\%$

10. **[Ans. *] Range: 40 to 40**

Given

$W_2 = 1.5\ W_1$ ……. (50% Increase in walk)

$D_1 = D_2$

$\because \dfrac{M_1 \times D_1}{W_1} = \dfrac{M_2 \times D_2}{W_2}$

$\therefore M_2 = 1.5\ M_1$

$\therefore$ If the efficiency of M_1 and M_2 is same, then 50% more work force is required.

But it is given the productivity of new labour is 25% more (i.e., 5/4 times efficient)

$\therefore$ Actual % increase in work force required $= \dfrac{50\%}{5/4} = 40\%$

Technical:

1. **[Ans. *]Range: 20 to20**

As we know,

If $A = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 1+a & 1 & 1 \\ 1 & 1 & 1+b & 1 \\ 1 & 1 & 1 & 1+c \end{pmatrix}$

Then $|A| = a \times b \times c$

Given

Method-1

$A = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 5 & 1 & 1 \\ 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 6 \end{pmatrix}$

Re-write the matrix

$A = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 1+4 & 1 & 1 \\ 1 & 1 & 1+1 & 1 \\ 1 & 1 & 1 & 1+5 \end{pmatrix}$

So,

$|A| = 4 \times 1 \times 5 = 20$

Method-2

$A = \begin{vmatrix} 1 & 1 & 1 & 1 \\ 1 & 5 & 1 & 1 \\ 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 6 \end{vmatrix}$

$|A| = \begin{vmatrix} 1 & 1 & 1 & 1 \\ 1 & 5 & 1 & 1 \\ 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 6 \end{vmatrix}$

$R_2' ; R_2 - R_1; R_3' ; R_3 - R_1; R_4' ; R_4 - R_1$

$|A| = \begin{vmatrix} 1 & 1 & 1 & 1 \\ 0 & 4 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 5 \end{vmatrix}$

For triangular matrix

$|A|$ = Product of PD elements

$= 1 \times 4 \times 1 \times 5 = 20$

2. **[Ans. D]**

Continuity $\lim_{x\to 2} f(x) = f(a)$

$\lim_{x\to 2^-} f(x) = \lim_{x\to 2^-} x^2 + 1 = 5$

$\lim_{x\to 2^+} f(x) = \lim_{x\to 2^+} x - x^2 = -2$

Clearly $\lim_{x\to 2^-} f(x) \neq \lim_{x\to 2^+} f(x)$

The given function is not continuous at $x = 2$.

If a function is not continuous at $x = 0$ then it cannot be differentiable.

3. **[Ans. B]**

Since no y-derivation occur, we can solve the given PDE like $u'' - u = 0$

The solution for $u'' - u = 0$ is given by $u = Ae^x + Be^{-x}$ with constant A and B

Here A and B may be function of y so the answer is

$u(x, y) = A(y)e^x + B(y)e^{-x}$

4. **[Ans. B]**

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

$$f(x) = \frac{1}{x} - N = 0. \quad f'(x) = -\frac{1}{x^2}$$

$$\therefore x_{n+1} = x_n - \frac{1/x_n - N}{-1/x_n^2}$$

$$= x_n + x_n - Nx_n^2$$

$$= x_n[2 - Nx_n]$$

5. **[Ans. C]**

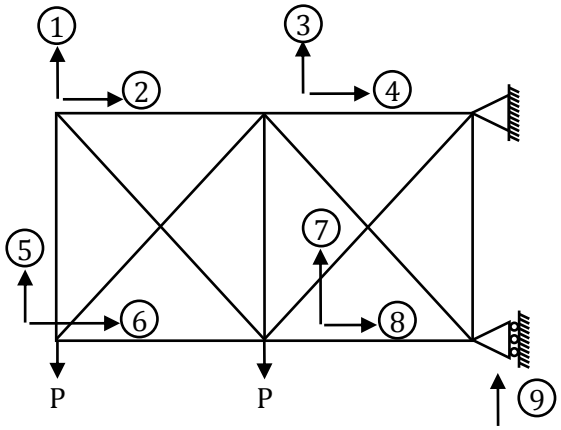
Maclaurin Series is given by

$$f(0) + \frac{f'(0)}{1!} + \frac{x^2 f''(0)}{2!} + \frac{x^3 f'''(0)}{3!}$$

$$-1 + \frac{x(6)}{1!} + \frac{x^2\left(\frac{2}{3}\right)}{2!} + \frac{x^3(-6)}{3!}$$

$$-1 + 6x + \frac{x^2}{3} - x^3$$

6. **[Ans. *]Range: 9 to 9**



The truss can go two displacements at each joint. Although rotations can take place on each joint, since movements cannot be sustained at truss joints, rotations have no physical significance in this problem.
So, the truss is Kinematically Indeterminate to the ninth degree.

7. **[Ans. *] Range: 187.65 to 188.05**

$b = 200$ mm

$d = 400 - 35 = 365$ mm

$T_u = 6$ kN-m

$V_u = 50$ kN

$\tau_c = 0.76$ N/mm^2

Equivalent Shear Force:

$$V_{ueq} = V_u + 1.6\frac{T_u}{b} = 50 + \frac{1.6 \times 6}{0.2}$$

$V_{ueq} = 98$ kN

Equivalent Shear Stress:

$$\tau_{veq} = \frac{V_{ueq}}{bd} = \frac{98 \times 10^3}{200 \times 365} = 1.342 \text{ N/mm}^2$$

$\tau_{veq} = 1.342$ N/mm^2

$\therefore \tau_{veq} < \tau_c$, therefore provide minimum shear reinforcement.

$$\frac{A_{sv}}{b_{sv}} \geq \frac{(\tau_{veq} - \tau_c)}{0.87 f_y}$$

$$\frac{2 \times \frac{3.14}{4} \times (8)^2}{200 \times s_v} = \frac{(1.342 - 0.76)}{0.87 \times 250}$$

$s_v = 187.84$ mm

8. **[Ans. D]**

In method of joints, necessary reactions are worked out first. Then taking each joint, the forces acting on it will be external forces including reactions if any and the forces in various members.

9. **[Ans. A]**
As per IS 3495 (Part 2) 1992 procedure for water absorption, when bricks are immersed in water for 24 hours, water absorption shall not be more than 20% by weight up to class 12.5 (Class designation i.e., 12.5 N/mm^2 compressive strength) and 15% by weight for higher classes.

10. **[Ans. C]**
As if F< 0 then the activity is super critical and so there is no freedom or flexibility, so requires special attention.
If $F > 0 =$ sub-critical
Flexibility or freedom to delay the activity is there, so require normal attention.

11. **[Ans. *]Range: 10 to 10.5**
Volume of soil $= 1m^3$
$y_{sat} = 20kN/m^3$
Hydraulic gradient $i = 0.25$
$F_H = iy_\omega \times$ volume
$= 0.25 \times 10 \times 1 = 2.5kN$
$F_v = y' \times$ Volume
$= (20 - 10) \times 1 = 10kN$
$F_R = \sqrt{F_{H^2} + F_{v^2}} = \sqrt{(2.5)^2(10)^2}$
$=10.31kN$

12. **[Ans. D]**
$e_o = 0.8\,, e_f = 0.72$
$\Delta\sigma_o = (2 - 1) = 1\ kg/cm^2$
$\Delta_e = (0.80 - 0.72) = 0.08\,, k = 3.2 \times 10^{-4} cm/s$
$$m_v = \frac{\Delta_e}{1 + e_o} \times \frac{1}{\Delta\sigma_o} = \frac{0.08}{1 + 0.80} \times \frac{1}{1} = 0.044\ cm^2/kg$$
$\therefore$ Coefficient of consolidation,
$$C_R = \frac{k}{m_v \cdot y_\omega} = \frac{3.2 \times 10^{-4}}{0.044 \times 10^{-3} \times 1}$$
$= 7.27\ cm^2/s$
$\simeq 7.3\ cm^2/s$

13. **[Ans. C]**
$$\sigma_z = \frac{3Q}{2\pi z^2}\left[\frac{1}{1 + \left(\frac{r}{z}\right)^2}\right]^{5/2}$$
$$= \frac{3 \times 20}{2\pi \times 16}\left[\frac{1}{1 + \left(\frac{2}{4}\right)^2}\right]^{5/2} = 0.342\ kN/m^2$$

14. **[Ans. *]Range: 72 to73**

$V_k = 0.55mD^{0.64}$

$V_k = 0.55 \times 0.85 \times 2^{0.64}$

$V_k = 0.7285$ m/s

$=72.85$ cm/s

15. **[Ans. D]**

16. **[Ans. *]Range: 2 to 5**

For couette flow (No pressure gradient) velocity profile is

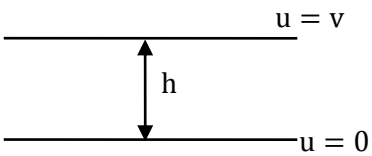
$u = v\frac{y}{h}$

Considering the fluid to be Newtonian

So,

$\frac{F}{A} = \mu\frac{du}{dy}$

$\because u = v\frac{y}{h}$



$\frac{du}{dy} = \frac{v}{h}$

$\therefore \frac{F}{A} = \mu\frac{v}{h} = \frac{8}{10} \times \frac{100}{20} = 4$ Pa

17. **[Ans. A]**

Ambient Lapse rate $= \frac{19.42 - 16.72}{305 - 5} \times 1000 = 9°C/km$ [$< 9.8°C/km$]

When ambient lapse rate is less than adiabatic lapse rate, the ambient lapse rate is said to be sub adiabatic.

18. **[Ans. B]**

$V_s = \frac{(\gamma_s - \gamma_w)d^2}{18\,\mu} = \frac{(20 - 9.81) \times 10^3 \times (1.2 \times 10^{-3})^2}{18 \times 10.19 \times 10^{-3}} = 0.08$ m/s

Over flow rate $= \frac{Q}{B.H} = \frac{5}{50} = 0.1$ m/s

$\therefore \eta = \frac{0.08}{0.1} \times 100 = 80\%$

19. **[Ans. *] Range: 75 to 75**

Total Hardness $= 6 \times 50 = 300$ mg/l as $CaCO_3$

Alkalinity $= 4.5 \times 50 = 225$ mg/l as $CaCO_3$

Temporary hardness or Carbonate hardness (CH) = Less of Total Hardness (TH) or alkalinity =225 mg/l as $CaCO_3$

So, Non carbonate Hardness (NCH)= TH − Alkalinity $= 300 - 225 = 75$ mg/l

20. **[Ans. C]**

$$\widehat{L_{eq}} = 10\log\sum_{i=1}^{n} 10^{\frac{Li}{10}} \times t_i$$

$$= 10\log\left[10^{\frac{72}{10}} \times \frac{15}{90} + 10^{\frac{55}{10}} \times \frac{70}{90} + 10^{\frac{50}{10}} \times \frac{5}{90}\right]$$

$$= 10\log\left[10^{7.2} \times \frac{1}{6} + 10^{5.5} \times \frac{7}{9} + 10^{9} \times \frac{1}{8}\right]$$

$$= 10\log_{10}[5844\ 2999.139] = 77.67\ \text{dB}$$

21. **[Ans. *]Range: 30 to 30**

$$L = \frac{\delta'}{100 \times \alpha \times \Delta T}$$

$\Delta\tau = 60 - 10 = 50°C$

$\delta' = \frac{3}{2}1.5$ cm

$$L = \frac{1.5}{100 \times 10 \times 10^{-6} \times 50} = 30\ \text{cm}$$

22. **[Ans. C]**

$$t = \sqrt{P}\left[\frac{1.75}{CBR} - \frac{1}{p\pi}\right]^{\frac{1}{2}}$$

$$= \sqrt{4100} \times \left[\frac{1.75}{5} - \frac{1}{6\pi}\right]^{\frac{1}{2}} = 35.5\ \text{cm}$$

23. **[Ans. C]**

24. **[Ans. A]**

25. **[Ans. A]**

Trunnion axis not perpendicular to the vertical axis by a small amount is also an example of error in horizontal circle bearing

26. **[Ans. *] 166.5 to 166.7**

Parabola intersects the x-axis at -6 and 4 also at $x = 0, y = 24$.

$y = x^2 + 2x + 24$ is the equation of the given curve.

$$\int_{-6}^{4} y\,dx = \int_{-6}^{4} x^2 + 2x + 24 = \frac{x^3}{3} + x^2 + 24x\Big|_{-6}^{4}$$

$$= \frac{500}{3} = 166.666$$

27. **[Ans. C]**

$$\oint \frac{\sin z}{z^2 - 2iz}\,dz = \frac{1}{2i}\left(\oint \frac{\sin z}{z - 2i} - \oint \frac{\sin z}{2}\right)$$

$$= \frac{1}{2i}\, 2\pi i\,[\sin 2i - 0]$$

$$= \pi \sin 2i = \pi \frac{e^{i(2i)} - e^{-i(2i)}}{2i}$$

$$= \frac{\pi . e^{-2} - e^{2}}{2i}$$

$$= \frac{\pi}{2} i\,(e^2 - e^{-2})$$

28. **[Ans. C]**

Put $\sin x = 1$ so that $\cos x\,dx = dt$

$$\int \sin^{3/4} x \cos^3 x\,dx = \int t^{\frac{3}{4}}(1 - t^2)dt$$

$$= \int \left(t^{3/4} - t^{11/4}\right)dt$$

$$= \frac{4}{7}\, t^{7/4} - \frac{4}{15} t^{15/4}$$

$$= \frac{4}{7} \sin^{7/4} x - \frac{4}{15} \sin^{15/4} x$$

29. **[Ans. B]**

The characteristic equation of the homogenous ODE is given by

$\lambda^3 - 2\lambda^2 - 9\lambda + 18 = 0$

Verification of the options

(A) Roots are $-4, 2, 4$ which do not satisfy

(B) Roots are $-3, 2, 3$ which satisfy

(C) Roots are $-1, 1, 2$ which do not satisfy

(D) Roots are $1, 1, 2$ which do not satisfy

30. **[Ans. C]**

$$\text{Average rate of change} = \frac{f(b) - f(a)}{b - a}$$

$f(2) = 2^2 + 5(2) + 1 = 15$

$f(0) = 0^2 + 5(0) + 1 = 1$

$$\frac{f(2) - f(0)}{2 - 0} = \frac{15 - 1}{2} = 7$$

31. **[Ans. C]**

$$\sigma_x = \left(\frac{P}{A}\right) = \frac{4P}{\pi d^2} = \frac{4 \times 20 \times 10^3}{\pi \times (50)^2}$$

$$= 10.185 \text{ MPa}$$

$$\epsilon_v = \left(\frac{1 - 2\mu}{E}\right)(\sigma_x + \sigma_y + \sigma_z)$$

$$\left(\frac{\Delta v}{v}\right) = \epsilon_v = \left[\frac{1 - 2(0.25)}{200 \times 10^9}\right][10.185 \times 10^6]$$

$$\epsilon_v = 2.54 \times 10^{-5}$$

$$\frac{\Delta v}{v} \times 100 = 2.5 \times 10^{-3} = 0.00254\%$$

32. **[Ans. B]**

33. **[Ans. *]Range: 1.7 to 1.7**

Joints	Member	Relative stiffness	Total relative stiffness	Distribution factor
B	BA BC	$\frac{I}{2} = \frac{5I}{10}$ $\frac{I}{2.5} = \frac{4I}{10}$	$\frac{9I}{20}$	$\frac{5}{9}$ $\frac{4}{9}$
C	CB CD	$\frac{I}{2.5} = 0.40I$ $\frac{I}{3\sqrt{2}} = 0.2357I$	0.6357I	0.63 0.37

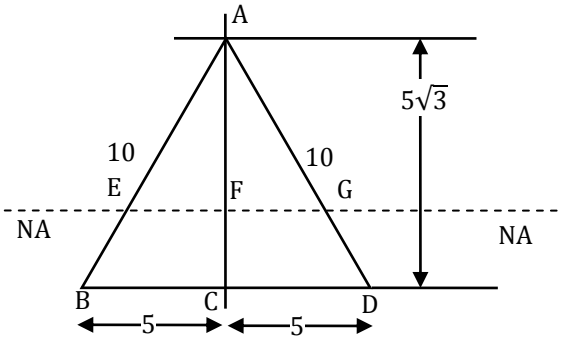
$$\therefore \frac{f_{CB}}{f_{CD}} = \frac{0.63}{0.37} = 1.70$$

34. **[Ans. A]**

The method of section can be more useful if one just wants to know the forces acting on a particular member close to the center of the truss.

35. **[Ans. *]Range: 60 to 62**

Given beam cross-section



AB=10cm

BC=5 cm

$\frac{BC}{AC} = \frac{EF}{AF}$

$\Rightarrow AC = 5\sqrt{3}$

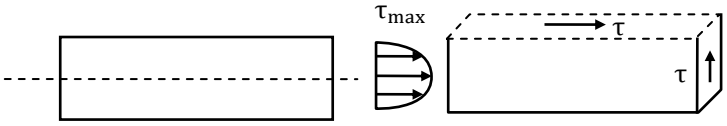
$\Rightarrow AF = \frac{2(AC)}{3} = \frac{10}{\sqrt{3}} \Rightarrow EF = \left(\frac{10}{3}\right)$

$\tau|_{at\ NA} = \left(\frac{VQ}{Ib}\right) = \left(\frac{V\vec{A}_y}{Ib}\right)$

$$= \frac{(200 \times 10^3) \times \left(\frac{1}{2} \times \frac{20}{3}\right)\left(\frac{10}{\sqrt{3}}\right)\left(\frac{10}{3\sqrt{3}}\right)}{10 \times \frac{(5\sqrt{3})^3}{36} \times \left(\frac{20}{3}\right)}$$

$= 61.58$ MPa

36. **[Ans. *] Range: 30 to 30**



$\tau_{avg} = \frac{200H}{10mm^2} = 20$ Mpa

τ_{max} occurs at Neutral axis

$\tau_{max} = \frac{3}{2}\tau_{avg} = 30$ MPa

Therefore, the shear stress shown is 30 Mpa

37. **[Ans. *]Range: 52 to 53**

Case: 1

$A_{net} = (70 - 2 \times 11.5) \times 6 = 282\ mm^2$

$T = (150 \times 282)N = 42.3\ kN$

But when plate will try to tear along section 1-2-3-4, the bolt at 6 will try to resist it with its shear capacity of 15 kN, hence effective tension for rupture will be $(42.3 + 15) = 57.3\ kN$

Case: 2

$A_{net} = (70 - 11.5) \times 6 = 351\ mm^2$

$\therefore T = (150 \times 351) = 52.65\ kN$

Case 3:

$$A_{net} = \left(b - n.d_n + \sum \frac{ps^2}{4g}\right) \times t$$

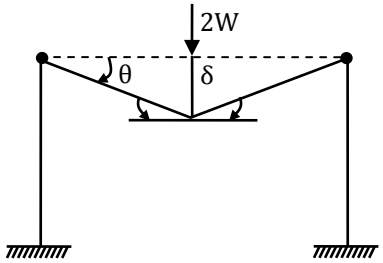
$$= \left\{70 - 3 \times 11.5 + \frac{2 \times (35)^2}{4 \times 20}\right\} \times 6 = 396.75\ mm^2$$

$T = (150 \times 396.75)N = 59.5\ kN$

$\therefore T_{max} = \min\{57.3, 52.65, 59.5\} = 52.65\ kN$

38. **[Ans. B]**

(i) Beam mechanism



Internal work $= M_P\theta + M_P(\theta + \theta) + M_P\theta = 4M_P\theta$

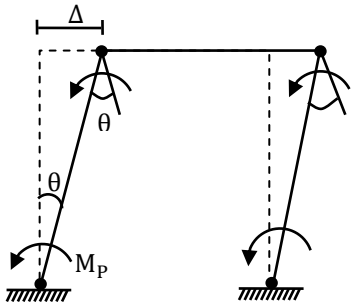
External work $= (2w) \times \delta$

$$= 2w \times \theta \times \left(\frac{L}{2}\right)$$

$$\therefore 2w \times \theta \times \frac{L}{2} = 4\ M_P\theta$$

$\Rightarrow W = 4M_{P/L}$

(ii) Sway mechanism



External work $= W \times 4$

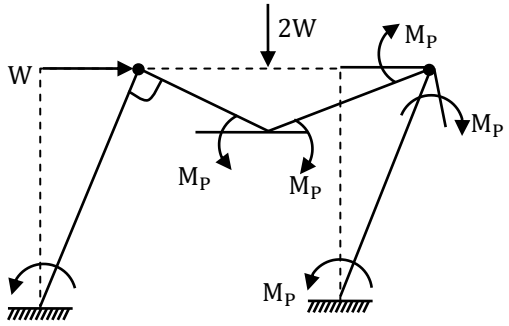
$= W \times \left(\frac{L}{2}\right) \times \theta$

internal work $= 4\ M_P\theta$

$\therefore W \times \left(\frac{L}{2}\right) \times \theta = 4\ M_P\theta$

$\Rightarrow W = \frac{8M_P}{L}$

(iii) Combined Mechanism



internal work $= 6\ M_P\theta$

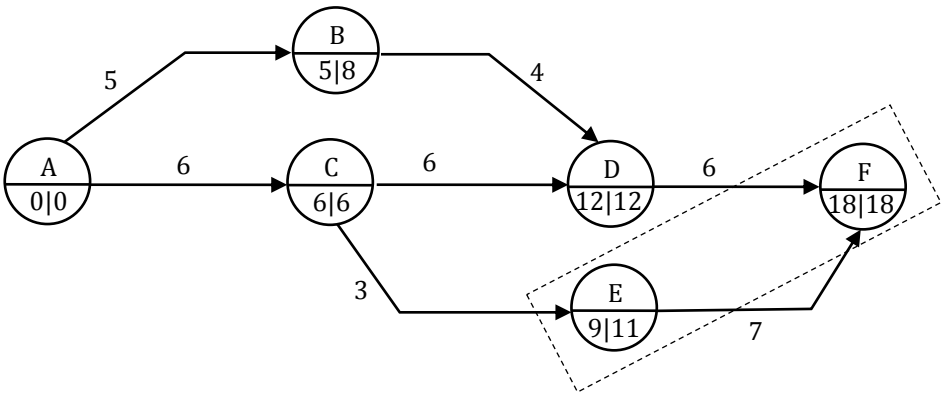
External work $= 2W \times \left(\frac{L}{2}.\theta\right) + W \times \left(\frac{L}{2}.\theta\right)$

$\Rightarrow 3W \times \frac{L}{2} \times \theta = 6\ M_P\theta$

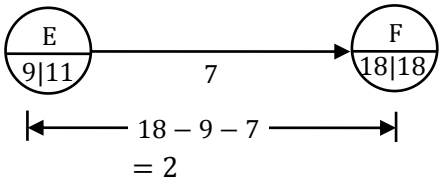
$\Rightarrow W = 4\ M_P/L$

Lowest value =Collapse load.

39. **[Ans. D]**

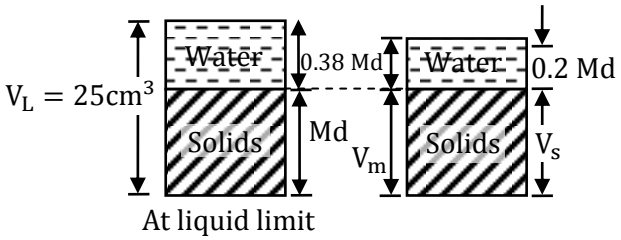


Free float for EF



40. **[Ans. *]Range: 18.5 to 19.5**

Soil specimen will attain minimum volume at shrinkage limit



At liquid limit

If Md is mass of solids, volume of water at liquid limit, $V_L = 0.38\ Md\ cm^3$

Volume of solids, $V_s = \frac{Md}{G\rho\theta} = \frac{Md}{2.6 \times 1} = \frac{Md}{2.6} cm^3 = 0.385\ Md\ cm^3$

$\therefore$ Total Volume $= 0.38Md + 0.385Md = 25$

$\Rightarrow Md = 32.68\ g$

At shrinkage limit, soil attains its minimum volume,

$V_m = V_s + 0.2Md = 0.385\ Md + 0.2Md$

$= 0.585\ Md$

$= 0.585 \times 32.68 = 19.12\ cm^3$

41. **[Ans. A]**

(i) N value increases with depth→ Correct

(ii) N=30 − 50 represents dense sand→ Incorrect

42. **[Ans. *]Range: 0.3 to 0.32**

$T_v = \frac{C_v \times t}{d^2}$

$\Rightarrow C_v = \frac{T_v \times d^2}{t} = \frac{0.196 \times \left(\frac{4}{2}\right)^2}{1}$

$= 0.784\ m^2/yr$

Now, $m_v = \frac{k}{C_v Y_\omega} = \frac{0.02}{0.784 \times 9.81} = 2.6 \times 10^{-3} m^2/kN$

Total settlement of clay layer:

$S_f = m_v \cdot \Delta\vec{\sigma} \cdot H_o$

$= 2.6 \times 10^{-3} \times 60 \times 4$

$= 0.624\ m$

Settlement after one year $= 0.50 \times 0.624$

$= 0.312\ m$

43. **[Ans. C]**

Apex angle $= 60°$, Base area $= 10cm^2$

44. **[Ans. *]Range: 8.1 to 8.3**

$\frac{D_f}{B} = \frac{1.5}{3} = 0.5 < 2.5$

So, it is a shallow foundation

$N_c = 6\left[1 + 0.2\left(\frac{D_f}{B}\right)\right]$

$= 6\left[1 + 0.2 \times \frac{1.5}{3}\right] = 6.6$

$\therefore q_{nv} = CNC \quad \left[\because C = \frac{90}{2} = \frac{5}{2} = 2.5\ t/m^2\right]$

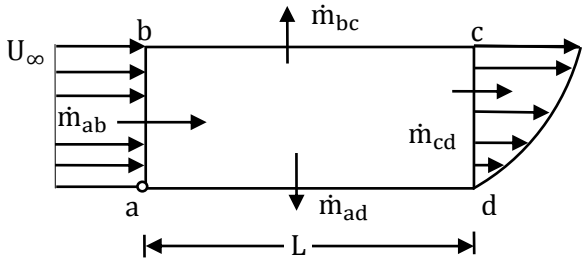
$= 2.5 \times 6.6 = 16.5\ t/m^2$

$\therefore q_s = \frac{q_{nv}}{FOS} + yD_f$

$= \frac{16.5}{3} + 1.8 \times 1.5$

$= 8.2\ t/m^2$

45. **[Ans. *]Range: 1.3000 to 1.5000**



Conservation of mass (steady state)

$\sum \dot{m}_i = \sum \dot{m}_{outlet}$ (i = inlet)

$\Rightarrow \dot{m}_{ab} = \dot{m}_{bc} + \dot{m}_{ad} + \dot{m}_{cd}$

$\Rightarrow \int_{c-s} \rho\, U_\infty (dy \times W) = \dot{m}_{bc} + \rho \times (L \times W)V_0 + \int_{c-s} \rho\ u(dy \times W)$

$\therefore \dot{m}_{bc} = \int_0^\delta \rho\, U_\infty W dy - \int_0^\delta \rho\, U_\infty \left\{3\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^{\frac{3}{2}}\right\} W\, dy - \rho L \times W \times V_o$

$= \rho W[U_\infty \delta - \left(\frac{3y^2}{2\delta} - \frac{2}{\frac{5}{2}} \times \frac{y^{\frac{5}{2}}}{\delta^{\frac{3}{2}}}\right)_0^\delta \times U_\infty - L \times V_0$

$= 999 \times 1.5\left[3 \times \frac{1.5}{1000} - \left(\frac{3}{2}\delta - \frac{4}{5}\delta\right) \times U_\infty - 2 \times 0.0002\right]$

$= 999 \times 1.5\left[3 \times \frac{1.5}{1000} - \left(\frac{3}{2} \times \frac{1.5}{1000} - \frac{4}{5} \times \frac{1.5}{1000}\right) \times 3 - 2 \times 0.0002\right]$

$= 999 \times 1.5 \times 9.5 \times 10^{-4}$

$= 1.423\ kg/s$

46. **[Ans. D]**

$$\therefore k = \frac{[HOCl]}{[H^+][OCl^-]}$$

$$\Rightarrow \frac{[HOCl]}{[OCl^-]} = k \times [H^+] = 10^{-7.6} \times 10^{7.6} = 1$$

$$\Rightarrow [HOCl] = [OCl]^-$$

Now free Chlorine residual=1.5 mg/l

$$= \frac{1.5 \times 10^{-3}}{2 \times 35.5} = 2.11 \times 10^{-5} \text{ mol/l}$$

$$[HOCl^-] + [OCl^-] = 2.11 \times 10^{-5}$$

$$\Rightarrow [OCl^-] = \frac{2.11 \times 10^{-5}}{2} = 1.055 \times 10^{-5} \text{ mol/l}$$

47. **[Ans. D]**

$$E_c = y_c + \frac{v_c^2}{2g}$$

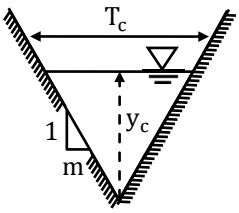
$$E_c = y_c + \frac{Q^2}{2gA_c^2}$$

But for critical flow, $\frac{Q^2 T_c}{gA_c^3} = 1$

Where $T_c \rightarrow$ Top width at critical flow

$$\Rightarrow E_c = y_c + \frac{A_c}{2T_c}$$

From Diagram,



$$T_c = 2my_c$$

$$A_c = \frac{1}{2} y_c T_c = my^2 c$$

$$\text{Now, } E_c = y_c + \frac{my_c^2}{2(2my_c)} = y_c + \frac{y_c}{4}$$

$$E_c = 1.25\, y_c \text{[For triangular channel]}$$

$$\text{i.e., } k = 1.25$$

48. **[Ans. *]Range: 4 to 4**

Power available from turbines

$P = \rho g Q H \times \eta_0$

$= 1000 \times 9.81 \times 34 \times 60 \times 0.85$

$= 1.701 \times 10^7 W$

$= 1.701 \times 10^4 kW$

Relation for specific speed

$N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$

Power available from a single turbine

$P = \left(\frac{N_s}{N}\right)^2 \times H^{\frac{5}{2}}$

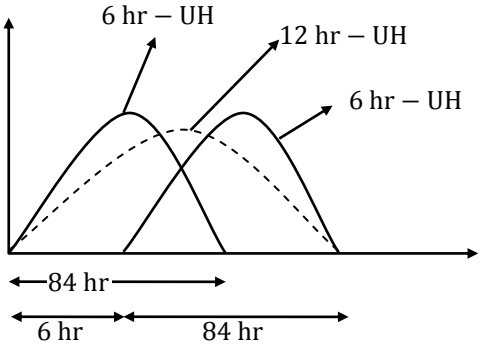
$= \left(\frac{215}{550}\right)^2 \times (60)^{\frac{5}{2}}$

$= 4261.17$ kW

$\therefore$ Required number of turbines

$= \frac{1.701 \times 10^4}{4261.17} \simeq 3.99 \simeq 4$

49. **[Ans. D]**



Base period of 6-hour unit hydrograph=84 hours

Then the base period of 12 hour unit hydrograph is

6+84 hour=90 hours as to obtain 12 hour UH by superposition method, the 6 hour UH is lagged by 6 hours, so the base period for 12 hr UH is 6+84=90 hours

50. **[Ans. *] Range: 0.30 to 0.30**

Since each household gets water=500 l/day

So, total treated water $= 500 \times 5 = 2500$ l/day

Let bypass flow rate is Ql/day

So, $60 = \frac{Q \times 500 + (2500 - Q) \times 0}{2500}$

$Q = 300$ l/day

$= 0.30\ m^3/day$

51. **[Ans. *] Range: 5 to 5.1**

Total area of settling tanks required

$$A = \frac{Q}{V_o} = \frac{600}{15} = 40\ m^2$$

Since number of tanks $= 2$

So, area of each tank $= \frac{40}{2} = 20\ m^2$

$$\frac{\pi d^2}{4} = 20$$

$$d = 5.04\ m$$

52. **[Ans. C]**

Volume of reaction tank,

$$V = \frac{Q_o(S_o - S)Q_c}{1 + k_{ER}Q_c} \cdot \frac{y}{x}$$

$$V = \frac{12000 \times (200 - 25) \times 10}{(1 + 0.05 \times 10)} \times \frac{0.5}{3000} = 2333.33\ m^3$$

53. **[Ans. *]Range: 715 to 716**

Total lost time, $t_L = 3 + 1 = 4$ seconds

Effective green time, $g_i = 30 + 5 - 4 = 31$ seconds

Saturation flow rate, $S_i = \frac{3600}{2.4} = 1500$ veh/hr

Capacity of the given phases $C_i = 1500 \times 31/65 = 715$ veh/hr/lane

54. **[Ans. *]Range: 67 to 67**

The weighted hourly capacity is WHC

For capacity of 130, percentage of maximum capacity(in operation/hr) $= \frac{130}{130} \times 100$

$= 100\%$

$\therefore$ weight $= 1$

For capacity of 70, percentage of maximum capacity $= \frac{70}{130} \times 100 = 53\%$

$\therefore$ weight $= 8$

For capacity of 80, percentage of maximum capacity $= \frac{80}{130} \times 100 = 61\%$

$\therefore$ weight $= 8$

$$\therefore \text{WHC} = \frac{(0.25 \times 8 \times 70) + (0.65 \times 1 \times 130) + (0.10 \times 8 \times 80)}{(0.25 \times 8) + (0.65 \times 1) \times (0.10 \times 8)}$$

$= 67$ operation/hr

55. **[Ans. *]Range: 136.10 to 136.15**

$R_1 = 200$ m $D = 18$m, $L = 110$m

$L = \sqrt{2D(R_1 + R_2)}$

$\Rightarrow R_2 = \frac{L^2}{2D} - R_1 = \frac{110^2}{2 \times 18} - 200 = 136.11$