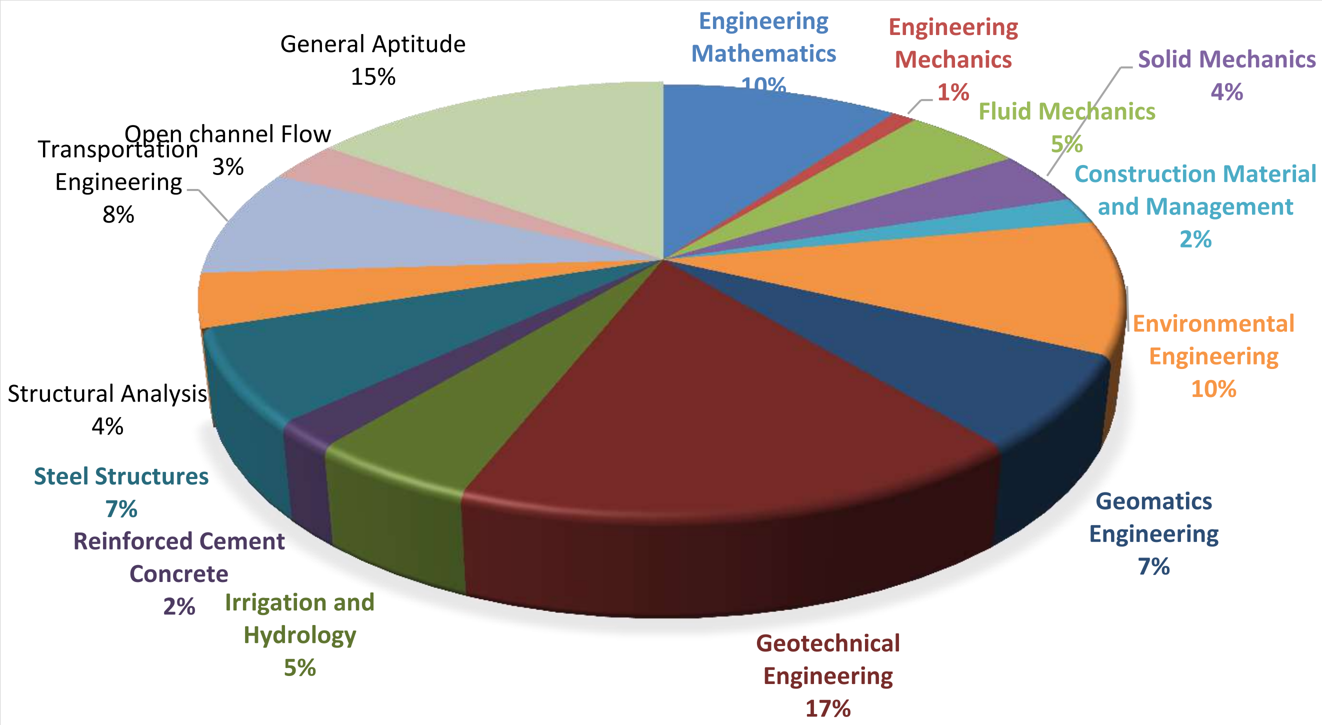
ANALYSIS OF GATE 2019

Civil Engineering



CE ANALYSIS-2019_Feb-10_Morning

SUBJECT	No. of Ques.	Topics Asked in Paper(Memory Based)	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 2 2 Marks: 4	Calculus, Differential equations	Moderate	10
Engineering Mechanics	1 Marks: 1 2 Marks: 0	Trusses and frames	Easy	1
Fluid Mechanics	1 Marks: 1 2 Marks: 2	Boundary layer	Moderate	5
Solid Mechanics	1 Marks: 2 2 Marks: 1	Simple stress and strain	Moderate	4
Construction Material and Management	1 Marks: 0 2 Marks: 1	Building materials	Easy	2
Environmental Engineering	1 Marks: 2 2 Marks: 4	Filtration, Disinfection, Air pollution, Sedimentation(Stokes law)	Tough	10
Geomatics Engineering	1 Marks:1 2 Marks: 3	Levelling, Curve, Triangulation survey, Chain survey	Moderate	7
Geotechnical Engineering	1 Marks: 5 2 Marks: 6	Bearing Capacity	Tough	17
Irrigation and Hydrology	1 Marks: 3 2 Marks: 1	Direct Run off	Moderate	5
Reinforced Cement Concrete	1 Marks: 2 2 Marks: 0	Singly reinforced beam	Moderate	2
Steel Structures	1 Marks: 3 2 Marks:2	Welding	Moderate	7
Structural Analysis	1 Marks: 0 2 Marks:2	Slope and Deflection	Moderate	4
Transportation Engineering	1 Marks: 2 2 Marks:3	Geometric design , Traffic design	Moderate	8
Open channel Flow	1 Marks: 1 2 Marks:1	Manning's formula, Critical analysis	Moderate	3
General Aptitude	1 Marks: 5 2 Marks:5	Data interpretation, Height and distance, Grammar, Blood relation, Percentage	Moderate	15
Total	65			100
Faculty Feedback	Overall paper was medium level difficulty.			

GATE 2019 Examination*

Civil Engineering

Test Date: 10-FEB-2019

Test Time: 9.30 AM to 12:30 PM

Subject Name: Civil Engineering

General Aptitude

Q.1 - Q.5 Carry One Mark each.

1. If $E = 10; J = 20; O = 30;$ and $T = 40.$ Which will be $P + E + S + T$?
(A) 51
(B) 82
(C) 120
(D) 164
[Ans. C]
The numbering of E in alphabet is 5 and double of 5 is 10.
Similarly for J, O and T
So, P→16→32; E→5→10, S→19→38, T→20→40
So, 32 + 10 + 38 + 40 = 120

2. The lecture was attended by quite _________students, so the hall was not very________
(A) A few, quite
(B) Few, quiet
(C) A few, quiet
(D) Few, quite
[Ans. C]
Few is used as 'very few' i.e. in negative sense.
A few is used as 'not all' and used in positive sense.

3. The CEO's decision to quit was as shocking to the board as it was to ________
(A) Myself
(B) Me
(C) My
(D) I
[Ans. B]
'Me' is a relative pronoun for I.

4. Aon a horizontal ground, the base of a straight ladder is 6m away from the base of a vertical pole. The ladder makes an angle od 45° to the horizontal. If the ladder is resting at appoint located at one-fifth of the height of the pole from the bottom, the height of the pole is ________ meters
(A) 15
(B) 25
(C) 30
(D) 35
[Ans. C]

$$\tan 45° = 1 = \frac{\frac{H}{5}}{6}$$

$$\frac{H}{5} = 6 \quad => \quad H = 30\text{m}$$

5. They have come a long way in_________ trust among the users
(A) Creating
(B) Created
(C) Create
(D) Creation
[Ans. A]
They have come a long way in creating trust among the users.
Creating has been used because it's a continuous process to develop trust.

Q.6 - Q.10 Carry Two Mark each.

6. A square has side 5cm smaller than the sides of a second square. The area of the larger square is four times the area of the smaller square. The side of the larger square is _________
(A) 18.50
(B) 15.10
(C) 10.00
(D) 8.50

[Ans. C]

Let the size of the larger square be 's'

Means, the size of smaller square '(s − 5)'

Area of larger square = $s \times s$

Area of smaller square = $(s-5) \times (s-5)$

According to question;

$s^2 = 4(s-5)^2$

$s^2 = 4s^2 + 100 - 40s$

$3s^2 - 40s + 100 = 0$

$(s-10)(3s-10) = 0$

$s = 10;\ s = \frac{10}{3}$

$s = \frac{10}{3}$ will be neglected because size of smaller square then comes out to be $\left(\frac{10}{3} - 5\right)$ i.e. negative

so, size of larger square = s = 10 cm

7. In a sports academy of 300 people. 105 play only cricket, 70 play only hockey. 50play only football. 25 play both cricket and hockey, 15 play both hockey and football and 30 play both cricket and football. The rest of them play all three sports. What is the percentage of people who play at least two sports?

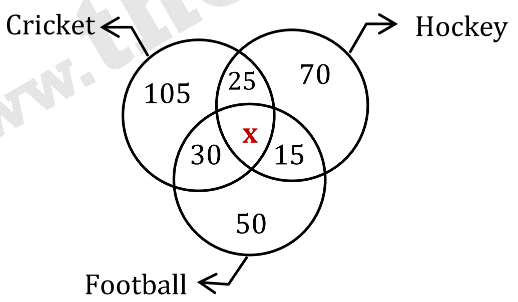
(A) 50.00

(B) 25.00

(C) 23.30

(D) 28.00

[Ans. B]



Number of students who play all the game= $300 - (105 + 70 + 70 + 30 + 25 + 15) = 5$

People who play at least two game = People who play 2 games + People who play all games

Percentage of people who play at least two game $= \frac{70+5}{300} \times 100 = 25\%$

8. The new cotton technology, bollgard II, with herbicide tolerant traits has developed into a thriving business in India, However, the commercial use of this technology is not legal in India. Notwithstanding that, reports indicate that the herbicide tolerant Bt cotton had been purches by farmers at an average of farmers at an average of Rs 200 more than the control price of ordinary cotton, and planted in 15% of the cotton growing area in the 2017 Kharif season

Which one of the following statements can be inferred from the given passage?

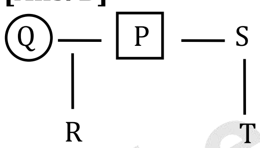
(A) Farmers want to access the new technology if India benefits from it
(B) Farmers want to access the new technology even if it is not legal
(C) Farmers want to access the new-technology for experimental purposes
(D) Farmers want to access the new technology by paying high price

[Ans. B]

9. P, Q, R, S and T related and belong to the same family. P is the brother of S. Q is the wife of P. R and T are the children of the siblings P and S respectively. Which one of the following stamens in necessarily FALSE?

(A) S is the sister –in-law of Q
(B) S is the aunt of T
(C) S is the brother of P
(D) S is the aunt of R

[Ans. B]



□ indicates husband
○ indicates wife

10. "The increasing interest in tribal characters might be a mere coincidence, but the timing is of interest. None of this , through, is to say that the tribal hero has arrived in Hindi cinema, or that the new crop of characters represents the acceptance of the tribal character in the industry. The films and characters are too few to be described as a pattern"

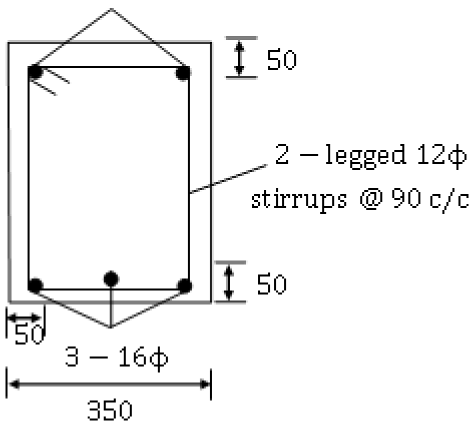
(A) Went to a place
(B) Reached a terminus
(C) Attained a status
(D) Came to a conclusion

[Ans. C]

Technical

Q.1 - Q.25 Carry One Mark each.

1. In the reinforced beam section shown in the figure(not drawn to scale), the nominal cover provided at the bottom of the beam as per IS 456-2000, is



All dimenstion are in mm

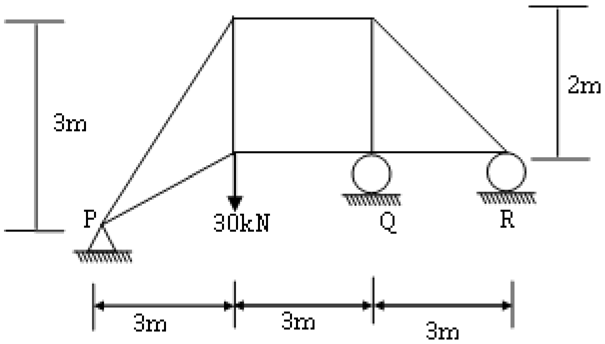
(A) 30mm
(B) 50mm
(C) 42mm
(D) 36mm

[Ans. A]

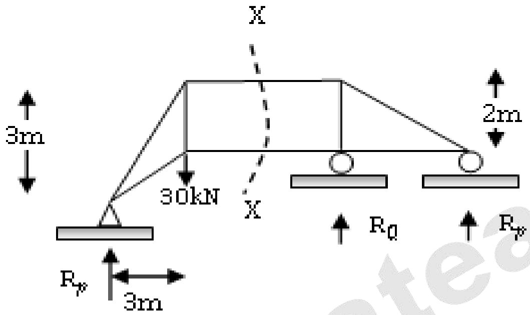
$= 50 - \left(\frac{16}{2} + 12\right)$

$= 30$ mm

2. Consider the pin-joined plane truss shown in the figure(not drawn to scale) Let $R_P, R_Q,$ and R_R denote the vertical reactions(upward positive) applied by the supports at P, Q, and R respectively , on the truss . The correct combination of (R_P, R_Q, R_R) is represented by



(A) $(30, -30, 30)$kN
(B) $(20, 0, 10)$kN
(C) $(0, 60, -30)$ kN
(D) $(10, 30, -10)$ kN
[Ans. A]



Using, $\sum F_V = 0$
$R_P + R_R + R_Q = 30\text{kN}$
Taking moment about P_1 $\sum M_p = 0$
$\Rightarrow (30 \times 3) - R_Q \times 6 - R_R \times 9 = 0$
$\Rightarrow 2R_Q + 3R_R = 30$
$\sum F_V = 0$
$\therefore$ $R_R = -R_Q$
Using (i), (ii) and (iii) $R_P = 30\text{kN}$
$R_Q = -30\text{kN}$
$R_R = +30\text{kN}$

3. The probability that the annual maximum flood discharge will exceed $25000\text{m}^3/\text{s}$, at least once in next 5 years is found to be 0.25. the return period of this flood event (in years, round off to 1 decimal place) is________
[Ans. *]Range: 17.8 to 18.0
$(1 - q^5) = 0.25$
$q = 0.944 = 1 - p$
$p = 1 - 0.944 = 0.056$

Return period , $T = \frac{1}{P} = \frac{1}{0.056} = 17.8$ years

4. Which one of the following is correct?

(A) $\lim_{x\to 0}\left(\frac{\sin 4x}{\sin 2x}\right) = 2$ and $\lim_{x\to 0}\left(\frac{\tan x}{x}\right) = 1$

(B) $\lim_{x\to 0}\left(\frac{\sin 4x}{\sin 2x}\right) = 1$ and $\lim_{x\to 0}\left(\frac{\tan x}{x}\right) = 1$

(C) $\lim_{x\to 0}\left(\frac{\sin 4x}{\sin 2x}\right) = \infty$ and $\lim_{x\to 0}\left(\frac{\tan x}{x}\right) = 1$

(D) $\lim_{x\to 0}\left(\frac{\sin 4x}{\sin 2x}\right) = 2$ and $\lim_{x\to 0}\left(\frac{\tan x}{x}\right) = \infty$

[Ans. A]

5. An element is subjected to biaxial normal tensile strains of 0.0030 and 0.0020. The normal strain in the plane of maximum shear strain is

(A) Zero
(B) 0.0050
(C) 0.0025
(D) 0.0010

[Ans. C]

$\epsilon_x = 0.003$

$\epsilon_y = 0.002$

Normal strain $= \frac{00.003 + 0.02}{2}$

$= 0.0025$

6. For small value of h, the Taylor series expansion for $f(x + h)$is

(A) $f(x) + hf'(x) + \frac{h^2}{2!}f''(x) + \frac{h^3}{3!}f''(x) + \cdots\infty$

(B) $f(x) + hf'(x) + \frac{h^2}{2}f''(x) + \frac{h^3}{3}f''(x) + \cdots\infty$

(C) $f(x) - hf'(x) + \frac{h^2}{2}f''(x) - \frac{h^3}{3!}f''(x) + \cdots\infty$

(D) $f(x) - hf'(x) + \frac{h^2}{2}f''(x) - \frac{h^3}{3}f''(x) + \cdots\infty$

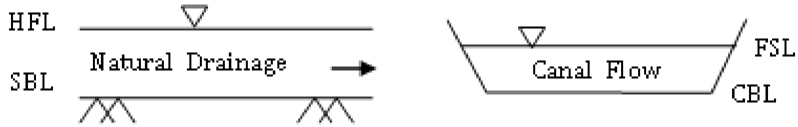
[Ans. A]

7. If the path of an irrigation canal is below the bed level of a natural stream, the type of cross drainage structure provided is

(A) Aqueduct
(B) Level crossing

(C) Sluice gate
(D) Super passage

[Ans. D]



HFL: High Flood Level of Drain
SBL: Stream Bed Level
FSL: Full Supply Level of Canal
CBL: Canal Bed Level
Super passage, as the given elevation condition suits CDW (as shown in diagram).

8. Consider a two dimension flow through isotropic soil along x direction and z direction . If h is the hydraulic head, the Laplace's equation of continuity is expressed as

(A) $\frac{\partial h}{\partial x}+\frac{\partial h}{\partial x}\frac{\partial h}{\partial z}+\frac{\partial h}{\partial z}=0$

(B) $\frac{\partial h}{\partial x}+\frac{\partial h}{\partial z}=0$

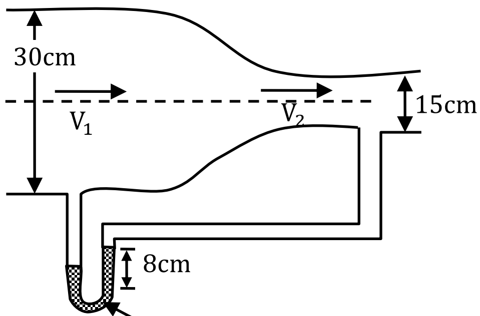
(C) $\frac{\partial^2 h}{\partial x^2}+\frac{\partial^2 h}{\partial z^2}=0$

(D) $\frac{\partial^2 h}{\partial x^2}+\frac{\partial^2 h}{\partial x\ \partial z}+\frac{\partial^2 h}{\partial z^2}=0$

[Ans. C]

$$\frac{\partial^2 h}{\partial x^2}+\frac{\partial^2 h}{\partial z^2}=0$$

9. A circular duct carrying water gradually contracts from a diameter of 30cm to 15cm.The figure (not drawn to sale) shows the arrangements of differential manometer attached to the duct



When the water flows, the differential manometer shows a deflection of 8cm of mercury (Hg). The values of specific gravity of mercury and water are 13.6 and 1.0, respectively.

Consider the acceleration due to gravity $g = 9.81\ m/s^2$.Assuming frictional flow, the flow rate (in m^3/s , round off to 3 decimal places)throught the duct is ________

[Ans. *]Range: 0.078 to 0.085

$$Q_T = \frac{q_1 q_2\sqrt{2gh}}{\sqrt{q_1^2 - q_2^2}}$$

$$h = \Delta h\left(\frac{s_m}{s_f} - 1\right) = 8 \times 10^{-2}\left(\frac{13.6}{1} - 1\right)$$

$$= 8 \times 10^{-2}(12.6) = 1.008m$$

$$Q_T = q_1 = \frac{\pi}{4}(0.3)^2 = 0.070m^2$$

$$q_2 = \frac{\pi}{4}(0.15)^2 = 0.017m^2$$

$$Q_T = \frac{0.07 \times 0.017 \times \sqrt{2 \times 9.81 \times 1.008}}{\sqrt{(0.07)^2 - (0.017)^2}}$$

$$Q_T = 0.077\ m^3/sec$$

10. For a given loading on a rectangular plain concrete beam with an overall depth of 500mm, the compressive strain and tensile strain developed at the extreme fibers are of the same magnitude of 2.5×10^{-4}. The curvature in the beam cross-section (in m^{-1}, round off to 3 decemial places), is ________

[Ans. *]Range 0.001 to 0.001

Given D=500m

$$\text{Strain} = \frac{\text{Stress}}{E} = \frac{f}{E}$$

$$\frac{M}{I} = \frac{E}{R} = \frac{f}{y}$$

$$\Rightarrow \frac{E}{R} = \frac{F}{y}$$

$$\Rightarrow \frac{1}{R} = \frac{\frac{f}{y}}{y} = \frac{\epsilon}{y} = 2.5 \times \frac{10^{-4}}{250} = 1 \times 10^{-6} = 0.001$$

11. The maximum number of vehicles observed in any five minute period during the peak hour is 160. If the total flow in the peak hour is 1000 vehicles, the five minute peak hour factor (round off to 2 decimal places) is _______

[Ans. *]Range: 0.51 to 0.53

$$\text{Peack hour factor} = \frac{1000}{\left(\frac{60}{5}\right) \times 160}$$

$$= 0.5208$$

12. Assuming that there is no possibility of shear bucking in the web, the maximum reduction permitted by IS-800-2007 in the (low-shear) design bending strength of semi-compact steel section due to high shear is ________
(A) Zero
(B) Governed by the area of the flange
(C) 25%
(D) 50%
[Ans. A]

13. A concentrated load 500kN is applied on an elastic half space. The ratio of the increase in vertical normal stress at depths of 2m and 4m along the point of the loading, as per boussineq's theory, would be _______
[Ans. *]Range: 4 to 4

$$\sigma \,\alpha \frac{1}{z^2}$$

$$\frac{\sigma_1}{\sigma_2} = \frac{z_2^2}{z_1^2}$$

$$\frac{\sigma_1}{\sigma_2} = \frac{4^2}{2^2} = 4$$

14. Which one of the following is a secondary pollutant?
(A) Ozone
(B) Hydrocarbon
(C) Carbon Monoxide
(D) Volatile Organic Carbon(VOC)
[Ans. A]

15. A soil has specific gravity of its solids equal to 2.65. The mass density of water is 1000kg/m^3. Considering zero air voids and 10% moisture content of the soil sample, the dry density (in kg/m^3, round off to 1 decimal place) would be _________
[Ans. *]Range: 2086. 6 to 2095.0

$$\gamma_d = \frac{(1 - h_a)\, G\gamma w}{1 + \frac{wG}{s}}$$

$$\gamma_d = \frac{(1 - 0) \times 2.65 \times 1000}{1 + \frac{0.10 \times 2.65}{1}}$$

$$\gamma_d = 2094.86 \text{ kg/m}^3$$

16. The interior angles of four triangles are given below;

Triangle	Interior Angles
P	85°, 50°, 45°
Q	100°, 55°, 25°
R	100°, 45°, 35°
S	130°, 30°, 20°

Which of the triangle are ill-conditioned and should be avoided in triangulation surveys?

(A) Both P and R

(B) Both P and S

(C) Both Q and R

(D) Both Q and S

[Ans. D]

Triangulation survey, for well-conditioned angle should be between 30° to 20° so the answer is triangle Q and S because both contain angle less that 30°

17. The coefficient of average rolling friction of a road is f_r and its grade is +G%. If the grade of this road is doubled, what will be the percentage change in the braking distance (for the design vehicle to come to stop) measured along the horizontal (Assume all other parameters are kept un changed)?

(A) $\frac{0.01G}{f_r + 0.02\ G} \times 100$

(B) $\frac{f_r}{f_{r+0.02G}} \times 100$

(C) $\frac{2f_r}{f_r + 0.01G} \times 100$

(D) $\frac{0.02G}{f_r + 0.01G} \times 100$

[Ans. A]

breaking distance $= \frac{v^2}{2g(f + G)}$

take $v = \frac{5m}{s}$

$f = 0.35$

G=0.02

$\therefore$ breaking dist $= \frac{5^2}{2 \times 9.81(0.35 + 0.02)} = 3.44m$

now take

$v = 5m/s$

$f = 0.35$

$G = 2 \times 0.02 = 0.04$

Breaking dist $= \dfrac{5^2}{2 \times 9.81\,(0.35 + 0.04)} = 3.267\text{m}$

% increment $= \dfrac{3.44 - 3.26}{3.44} = 5.02\%$

Only option B is matching with and by putting

G=2 and f=0.35

18. A simple mass-spring oscillatory system consists of a mass m, suspended from a spring of stiffness k. Considering as the displacement of the system at any time t, the equation of motion for the free vibration of the system is $mz + kz = 0$. The natural frequency of the system is

(A) $\dfrac{m}{k}$

(B) $\sqrt{\dfrac{k}{m}}$

(C) $\dfrac{k}{m}$

(D) $\sqrt{\dfrac{m}{k}}$

[Ans. B]

$m\ddot{z} + kz = 0$

$\Rightarrow \quad \ddot{z} + \dfrac{k}{m} z = 0$

Comparing with $\ddot{z} + \omega_n^2 Z = 0$

We get $\omega_n = \sqrt{\dfrac{k}{m}}$

19. In a soil specimen, the total stress, hydraulic gradient and critical hydraulic gradient are σ, σ', i and i_c respectively. For initiation of quick's and condition, which one of the following statements is TRUE?

(A) $\sigma' \neq 0$ and $i \neq i_c$

(B) $\sigma' = 0$ and $i = i_c$

(C) $\sigma = 0$ and $i = i_c$

(D) $\sigma' \neq 0$and $i = i_c$

[Ans. B]

For quick sand condition

(i) Effective stress $(\overline{\sigma})$= 0

(ii) $i = i_c$

i - Hydraulic gradient

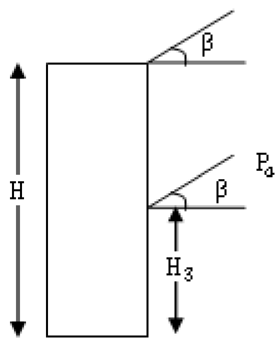
i_c - Critical hydraulic gradient

$$i_c = \frac{\gamma_{sub}}{\gamma_w} = G_s - \frac{1}{1+e}$$

20. In a rectangular channel, the ratio of the velocity head to the flow depth for critical flow condition is
(A) 1/2
(B) 3/2
(C) 2
(D) 2/3
[Ans. A]

$$\frac{Q^2}{g} = \frac{A^3}{T}$$
$$\frac{Q^2}{g} = \frac{(b \times y)}{b}$$
$$\frac{V^2}{g} = \frac{b \times y}{b}$$
$$\frac{V^2}{2g} = \frac{y}{2}$$
$$\frac{V^2/2g}{y} = 1/2$$

21. A retaining wall of height H with smooth vertical backface supports a backfill inclined at an angle β with the horizontal. The backfill consists of cohesion less soil having angle of internal friction ϕ. If the active lateral thrust acting on the wall is P_a, which of the following statements is
(A) P_a acts at a height $\frac{H}{3}$ from the base of the wall and at an angle ϕ with the horizontal
(B) P_a acts a height $\frac{H}{2}$ from the base of the wall and at angle β with the horizontal
(C) $P_a$acts at a height $\frac{H}{3}$ from the base of the wall and at an angle βwith the horizontal
(D) $P_a$acts at a heigh $\frac{H}{2}$ from the base of the wall and at ann angle ϕ with the horizontal
[Ans. C]



P_a will act at $\frac{H}{3}$ from base, at an angle of $'\beta'$ with horizantal.

22. A completely mixed dilute suspension of sand particles having diameters 0.25, 0.35 0.40 0.45 and 0.50 mm are filled in a transparent glass column of diameter 10cm and height 2.50m . The suspension is allowed to settle without ant disturbance. It is observed that all particles of diameter 0.35mm settle to the bottom of the column in 30s. For the same period of 30s the percentage removal (round off to integer value) of particles of diameters 0.45 and 0.50mm from the suspension is ________

[Ans. *]Range: 100 to 100

Since sand particle of size 0.35mm settles to the bottom of the column is 30sec particles having size grater than 0.35mm i.e. 0.45mm and 0.5mm will also settle is suspension at the bottom of column by 100% is 30sec, in fact these beggar sized particle will settle by 100% is fees than 30 second . so answer is 100%

23. An isolated concrete pavement slab of length L is resting on a frictionless base. The temperature of the top and bottom fiber of the slab are T_t and T_b respectively . Given the coefficient of thermal expansion = α and the elstic moduls =E Assuming $T_t > T_b$ and the unit weight of concrete as zero, the maximum thermal stress is calculated as

(A) $E_\alpha(T_t - T_b)$

(B) $\frac{E\alpha(T_t - T_b)}{2}$

(C) $L\alpha(T_t - T_b)$

(D) Zero

[Ans. D]

Frictionless base,

$\sigma_{thermal} = 0$

24. A catchment may be idealized as a rectangle. There are three rain gauges located inside the catchment at arbitrary locations. The average precipitation over the catchment is estimated by two methods (i) Arithmetic mean (P_A) and (ii) Thiessen polygon (P_r). Which one of the following statements is correct?

(A) P_A is always equal tp P_T

(B) P_A is always greater than P_T

(C) P_A is always smaller than P_T

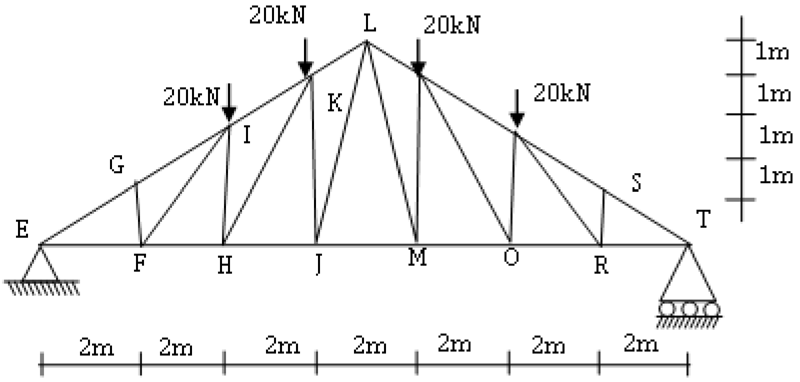
(D) There is no definite relationship between P_A and P_T

[Ans. D]

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

∴ There is no any relation between P_A and P_T

25. A plane truss is shown in the figure (not drawn to scale)



Which one of the options contains ONLY zero force members in the truss?

(A) FG, FI, HI, RS

(B) FG, FH, HI, RS

(C) FI, HI, PR, RS

(D) FI, FG, RS, PR

[Ans. D]

Q.26 - Q.55 Carry Two Mark each.

26. Traffic on a highway is moving at rate of 360 vehicles per hour at a location . If the number of vehicles arriving on this highway follows poisson distribution, the probability (round off to 2 decimal places) that the headway between successive vehicles lies between 6 and 10 seconds is ________

[Ans. *]Range: 0.17 to 0.19

$Q = 360\ \text{veh/hr}$

$\therefore$ arrival rate $\lambda = \dfrac{360}{3600} = 0.1$ veh/s

$\because p(\geq t) = e^{-\lambda t}$

$p(6 \leq t \leq 10) = 1 - [p(\leq 6) + p(\geq 10)]$

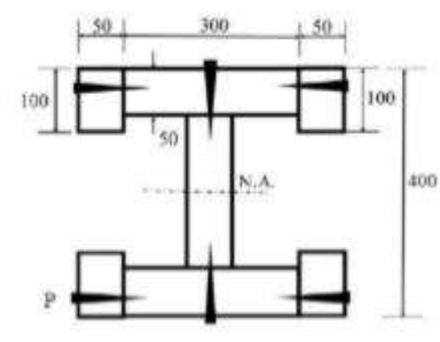
$= 1 - [1 - e^{-0.1\times 6} + e^{-0.1\times 10}]$

$= 1 - [0.4511 + 0.3767]$

$= 1 - 0.8189$

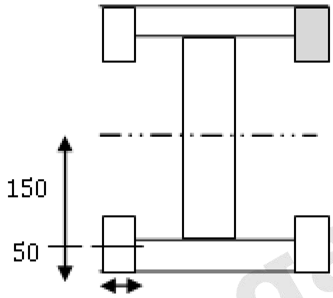
$= 0.1810$

27. The cross section of a built –up wooden beam as shown in the figure (not drawn to scale) is subjected to a vertical shear force of 8kN. The beam is symmetrical about the netural axis(N.A) shown and the moment of inertia about N.A. is $1.5 \times 10^9\ \text{mm}^4$. Considering that the nails at the location P are spaced longitudinally (along the length of the beam) at 60mm, each of the nails at P will be subjected to the shear force of



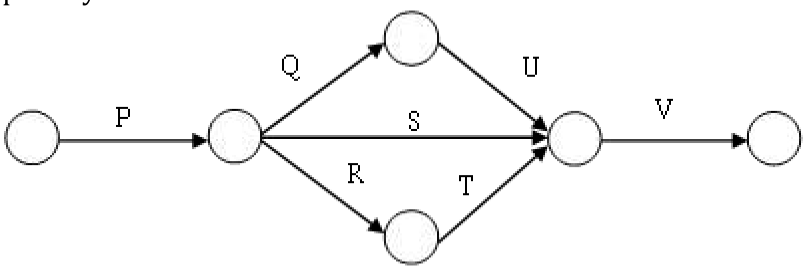
All dimensions are in *mm*

(A) 120N
(B) 60N
(C) 240N
(D) 480N
[Ans. C]



Sher flow, $q = \frac{SA\bar{y}}{I} = \frac{8000\times50\times100\times150\times}{1.5\times10^{9}} = 4\ N/mm$
Distance between two nails l = 60 mm
$\therefore$ S. F. resisted by each nail $= q \times l = 240$ N

28. The network of a small construction project awarded to a contractor is shown in the following figure. The normal duration , crash duration normal cost and crash cost of all the activates are shown in the table. The indirect cost incurred by the contractor is INR 5000 per day

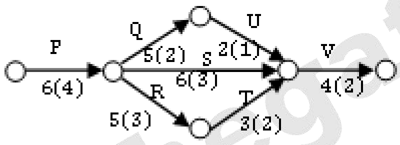


Activity	Normal Duration(days)	Crash Duration (days)	Normal Cost (days)	Crash cost (INR)
P	6	4	15000	25000
Q	5	2	6000	12000
R	5	3	8000	9500
S	6	3	7000	10000
T	3	2	6000	9000
U	2	1	4000	6000
V	4	2	20000	28000

If the project is targeted for completion in 16 days, the total cost (in INR) to be incurred by the contractor would be ________

[Ans. *] Range: 149500 to 149500

Activity	t_n(days)	t_c(days)	C_n(INR)	C_c(INR)	Cost slope $= C_s = \frac{C_n - C_n}{t_n - t_c}$
P	6	4	15000	25000	INR 5000/d
Q	5	2	6000	12000	INR 2000/d
R	5	3	8000	9500	INR 750/d
S	6	3	7000	10000	INR 1000/d
T	3	2	6000	9000	INR 3000/d
U	2	1	4000	6000	INR 2000/d
V	4	2	20000	28000	INR 4000/d



Considering normal durations, the total cost of the project

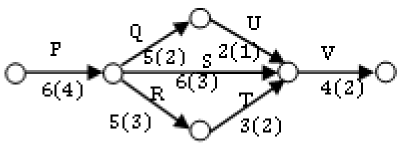
TC = Dc + IC

$= \text{INR } 66000 + \text{INR } 5000 \times 18$

$= \text{INR } 156000$

Stage-I: Crash activity R by 1 day

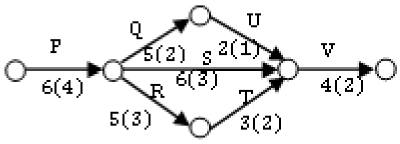
∴ Project becomes



$TC = (\text{INR } 6600 + \text{INR}750) + \text{INR } 5000 \times 17$

$= 151750$

Stage-II: Crash activity Q&R (or U&R) by 1 day
∴ Project becomes



TC = (INR 6670 + INR 2000 + INR 750) + (INR 5000 × 16)
=149500

29. A square footing of 4 m side is placed at 1m depth in a sand deposit. The dry unit weight (γ) of sand is $15 kN/m^3$. This $d_q = d_{(\gamma)} = 1.0$ and the bearing capacity factor $N_\gamma = 18.25$. This footing is placed at a depth of 2m in the same soil deposit. For a factor of safety of 3.0 as per terzaghi's theory, the safe bearing capacity (n kPa) of this footing would be _______

[Ans. *]Range: 250 to 250 OR 270 to 270

$Q_u = \gamma D_f N_q + 0.4\gamma\beta N_\gamma$

$600 = 15(1)(N_q) + (0.4)(15)(4)(18.75)$

$N_q = 10$

For 2m depth

$$q_{safe} = \frac{q_u - \gamma D_f}{Fos} + \gamma D_f$$

$$q_{safe} = \frac{(\gamma D_f N_q + 0.4\gamma\beta N_\gamma) - \gamma D_F}{Fos} + \gamma D_f$$

$$q_{safe} = \frac{15(2)(10) + 0.4(15)(4)(18.75) - 15(2)}{3} + 15(2)$$

$= 270\ kN/m^2$

30. A 0.80m deep bed of sand filer (length 4m and width 3m) is made of uniform particles (diameter=0.40mm specific gravity =2.65. shape factor =0.85) with bed porosity of 0.4. The bed has to be backwashed at a flow rate of $3.60 m^3/min$. During backwashing , if the terminal settling velocity of sand particles is .0.05m/s, the expanded bed depth (in m, round off to 2 decimal places is) ________

[Ans. *]Range: 1.15 to 1.25

$$V_B = \frac{Q_B}{L \times W} = \frac{3.6/60}{4 \times 3} = 5 \times 10^{-3}\ m/sec$$

$V_B = V_5(ne)^{4.5}$

$5 \times 10^{-3} = 0.05(ne)^{4.5}$

$ne = 0.6$

$$\frac{Ze}{Z} = \frac{1-n}{1-ne}$$

$$\Rightarrow Ze = \frac{Z(1-n)}{1-ne} = \frac{0.8 \times (1-0.4)}{(1-0.6)}$$

$Ze = 1.2m$

31. Which one of the following is NOT a correct statement?
(A) The function $\sqrt[x]{x}, (x > 0)$, has the global minima nor global maxima
(B) The function $\sqrt[x]{x}, (x > 0)$, has the global minima at x=e
(C) The function x^3has neither global minima nor global maxima
(D) The function |x| has the global minima at x=0
[Ans. B]
Let $y = x^{1/x}$

$$\log y = \frac{\log x}{x}$$

$$y = e^{\frac{\log x}{x}}$$

y maximum (or) minimum when,

$$f(x) = \frac{\log x}{x} \text{ is maximum (or)minimum}$$

(1) $f'(x) = \dfrac{x\left(\frac{1}{x}\right) - \log x}{x^2} = \dfrac{1-\log x}{x^2}$

(2) $f'(x) = 0$

$\Rightarrow \quad 1 - \log x = 0$

log x =1

x = e

(3) $f''(x) = \dfrac{x^2 - \left(\frac{1}{x}\right) - 2x(1-\log x)}{x^4} = \dfrac{-3x + 2x\log x}{x^4}$

(4) $f''(e) = -\dfrac{e}{e^4} < 0(\max)$

$\therefore y = \sqrt[x]{x}$ is maximum at $x = e$

32. A rectangular open channel has a width of 5m and abed slope of 0.001 for a uniform flow of depth 2m, the velocity is 2m/s. The manning's roughness coefficient for the channel is
(A) 0.002
(B) 0.017
(C) 0.050
(D) 0.033
[Ans. B]
B=5m
S=0.001
Y=2m
V=2m/5

$$V = \frac{1}{n}(R)^{\frac{2}{3}}(5)^{\frac{1}{2}}$$

$$2 = \frac{1}{n}\left(\frac{5 \times 2}{pq}\right)^{\frac{2}{3}}(0.001)^{1/2}$$

n=0.017

33. Consider a laminar flow in the x-direction between two infinite parallel plates (Couette flow). The lower plate is stationary and the upper plate is moving with a velocity of 1cm/s in the x-direction. The distance between the plates is 5mm and the dynamic viscosity of the fluid is $0.01\ N - s/m^2$. If the shear stress on the lower plate is zero, the pressure gradiet ∂_y/∂_x, (in N/m^2)per m, round off 1 decimal place) is ______

[Ans. *]Range: 7.9 to 8.1

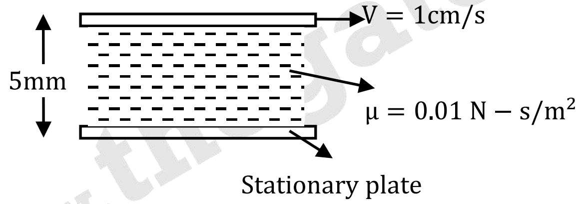
$$\tau = \frac{dp}{dx} \times y/2$$

$$\tau = \mu\frac{dv}{dy}\ \tau = 0.01 \times 1 \times \frac{10^{-2}}{5 \times 10^{-3}}$$

$$\tau = 0.02\frac{N}{m^2}$$

$$\tau = \frac{dp}{dx} \times \frac{15 \times 0^{-3}}{2}$$

$$\frac{dp}{dx} = \frac{0.02 \times 2}{5 \times 10^{-3}} = 8\ N/m^2 m$$



$$\frac{dp}{dx} = 8N/m^2\ /m$$

34. Average free flow speed and the jam density observed on a road stretch are 60km/h and 120 vehicles/km, respectively. For a liner speed-density relationship , the maximum flow on the road stretch (in vehicles/h) is ________

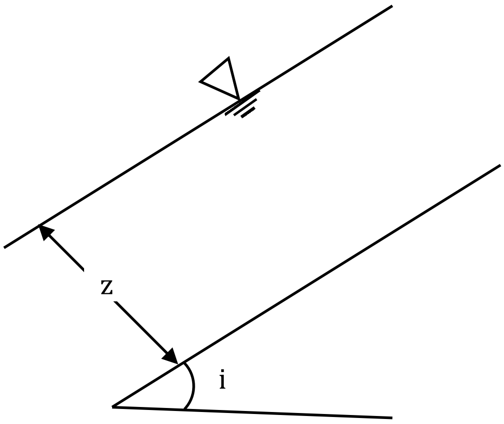
[Ans. *]Range: 1800 to 1800

$$q_{max} = \frac{V_{sf}k_s}{G} = \frac{60 \times 120}{4}$$

$$= 1800Ven\ /hr$$

35. A granular soil has a saturated unit weight of $20 kN/m^3$ and an effective angle of shearing resistance of 30°. The unit weight of water is $9.81 kN/m^3$. A slope is to be made on this soil deposit in which the seepage occurs parallel to the slope up to the free surface . Under this seepage condition for a factor of safety of 1.5, the safe slope angle (in degree, round off to 1 decimal place) would be ________

[Ans. *]Range: 10.8 to 11.3



$$Fos = \left(\frac{1-\gamma_{wh}}{V_{sat}z}\right)\frac{\tan\phi}{\tan i}$$

here $h = z$, so

$$Fos = \left(1-\frac{\gamma_w}{\gamma_{sat}}\right)\frac{\tan\phi}{\tan i}$$

$$1.5 = \left(1-\frac{9.81}{20}\right)\frac{\tan 30}{\tan i}$$

$i = 11.1$

36. A one – dimensional domain is discretization into N sub-domain of which Δx with node numbers $i = 0, 1, 2, 3 \dots\dots, N$. If the time scale is discretized in steps of Δt, te forward-time and centered-space finite difference approximation at i^{th} node and n^{th} time step, for the partial differential equation $\frac{\partial v}{\partial t} = \beta\frac{\partial^2 v}{\partial x^2}$ is

(A) $\dfrac{v_i^{(n+1)} - v_i^{(n)}}{\Delta t} = \beta\left[\dfrac{v_{i+1}^{(n)} - 2v_i^{(n)} + v_{i-1}^{(n)}}{(\Delta x)^2}\right]$

(B) $\dfrac{v_{i+1}^{n+1} - v_i^{(n)}}{\Delta t} = \beta\left[\dfrac{v_{i+1}^{(n)} - 2v_i^{(n)} + v_{i-1}^{n}}{2\Delta x}\right]$

(C) $\dfrac{v_i^{(n)} - v_i^{(n-1)}}{\Delta t} = \beta\left[\dfrac{v_{i+1}^{(n)} - 2v_i^{(n)} + v_{i-1}^{(n)}}{(\Delta x)^2}\right]$

(D) $\dfrac{v_i^{(n)} - v_i^{(n-1)}}{2\Delta t} = \beta\left[\dfrac{v_{i+1}^{(n)} - 2v_i^{(n)} + v_{i-1}^{(n)}}{(\Delta x)^2}\right]$

[Ans. A]

37. Consider the ordinary differential equation $x^2\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + 2y = 0$. Given the values of $y(1) = 0$ and $y(2) = 2$ the value of $y(3)$ (round off to 1 decimal place) is________

[Ans. *]Range: 5.9 to 6.1

$[xD^2 - 2xD + 2]y = 0$

Put, $x = e^z$

$xD = D_1$

$x^2D^2 = D_1(D_1 - 1)$

$[D_1(D_1 - 1) - 2D_1 + 2]y = 0$

$[D_1^2 - 3D_1 + 2]y = 0$

AE : $m^2 - 3m + 2 = 0$

m=1, 2

$y = C_1e^z + C_2e^{2z}$

$e^2 = x$

$y = C_1x + C_2x^2$

$y(1) = 0 \;\; y(2) = 2$

$y(1) = C_1 + C_2 = 0$

$y(2) = 2C_1 + 4C_2 = 2$

$C_1 = -1, C_2 = 1$

$y = x^2 - x$

$y(3) = 6$

38. Sedimentation basin in a water plant is designed for a flow rate of $0.2m^2/s$. The basin is rectangular with a length of 32m. Width of 8m, and depth of 4m. Assume that the settling velocity of these particles is governed by the stoke's law. Given: density of the gravitational acceleration= $980cm/s^2$. If the incoming water contains particles of diameter 25μm(sphertical uniform), the removal efficiency of these particles is

(A) 100%

(B) 65%

(C) 78%

(D) 51%

[Ans. B]

Flow rate , $Q_0 = 0.2\ m^3/sec$

Plan area, (PA) $= LB = 32 \times 8 = 256\ m^2$

(OFR)over flow rate $= \frac{Q_0}{PA} = \frac{0.2}{256} = 7.8125 \times \frac{10^{-4}m}{sec}$

Now, settling velocity of particle of size 25 μm be U_s

$$U_s = \frac{(G-1)\gamma_w d^2}{18\mu} = (2.5-1)9.81 \times \frac{10^{-3}(25 \times 16^{-6})^2}{18 \times 0.01 \times 13^{-3} \times 10^2}$$

$= 5.10 \times 10^{-4}\frac{\text{m}}{\text{sec}}$

$\eta_{\text{removal}} = \frac{u_s}{\text{OFR}} \times 100 = \frac{5.10 \times 10^{-4}}{7.8125 \times 10^{-4}} \times 100$

65.28%~65%

39. A wastewater is to be disinfected with 35mg/L of chlorine to obtain 99% kill of micro-organisms. The number of micro-organisms remaining alive (N_t) at time t, is modeled by $N_t = N_o\, e^{-kt}$, where N_0 is number of micro-organisms at t=0, and k is the rate of kill. The wastewater flow rate is $36\text{m}^3/\text{h}$ and $k = 0.23\,\text{min}^{-1}$. If the depth and width of the chlorination tank are 1.5m and 1.0m, respectively , the length of the tank (in m, round off to 2 decimal places) is ________

[Ans. *]Range 7.95 to 8.15

$M_t = Me^{-kt}$

$n = \left(1 - e^{-kt}\right)$

$\Rightarrow \frac{99}{100} = (1 - e^{-0.23\times t})$

$t = 20.02\text{min}$

$Q = 36\text{m}^3/\text{hr}$

$\omega = 1\text{m}$

$\text{depth} = 1.5\text{m}$

$V = \frac{Q}{\omega \times d} = \frac{36}{1.5 \times 1}$

$V = 0.\frac{4\text{m}}{\text{sec}}$

$L = V \times t$

0.4×20.02

$L = 8.008\text{m}$

40. Tie bar of 12mm diameter are to be provided in a concrete pavement slab. The working tensile stress of the tie bars is 230MPa, the average bond strength between a tie bar and concrete is 2MPa, and the joint gap between the slabs is 10mm. Ignoring the loss of bond and the tolerance factor, the design length of the tie bars (in mm, round off to the nearest integer)is _________

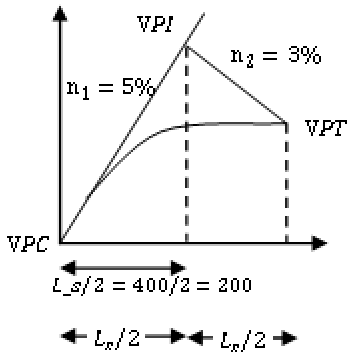
[Ans. *]Range 700 to 700

$L_T = \frac{\emptyset\sigma_{st}}{2\tau_{bd}} = \frac{12\text{mm} \times 230\text{MPa}}{2 \times 2\text{ MPa}} = 690\text{mm}$

The design length of tie bar $= 690 + 10 = 700$ mm

41. A parabolic vertical curve is being designed to join a road of grade +5% with a raod of grade −3%. The length of the vertical curve is 400m measured along the horizontal. The vertical point of curvature (VPC) is located on the road of grade +5%. The difference in height between VPC and vertical point of intersection(VPI) (in m, round off to the nearest integer) is ________

[Ans. *]Range 10 to 10



$$\tan\theta = 5\% = \frac{5}{180} = \frac{x}{200}$$

$$\frac{5}{100} = \frac{x}{200}$$

$\Rightarrow$ x=10m

42. A box measuring 50cm × 50cm × 50*cm* is filled to the top with dry coarse aggregate of mass 187.5kg. The water absorption and specific gravity of the aggregate are 0.5% and 2.5. respectively . The maximum quantity of water (in kg round off to 2 decimal places) required to fill the box completely is ________

[Ans. *]Range: 50.50 to 51.20

$$G = \frac{m_d}{(m_u - m_3) + m_d}$$

$m_d = 187.5\text{kg}$ $G = 2.5$

$m_u = V \times \gamma_w = (0.50)^3 \times 1000 = 125\text{kg}$

$$2.5 = \frac{187.5}{(125 - m_3) + 187.5}$$

$$2.5 = \frac{187.5}{312.5 - m_3}$$

$312.5 - m_3 = 75$

$m_3 = 237.5$

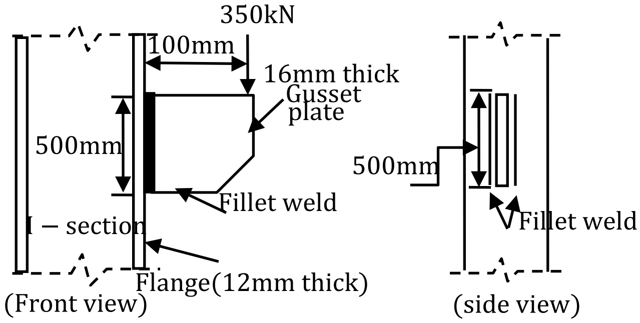
= wt of water + coarse aggregate

wt of water = 50kg

now water absorption = 0.5% = 0.25 kg

So we need to maximum water =50.25 kg

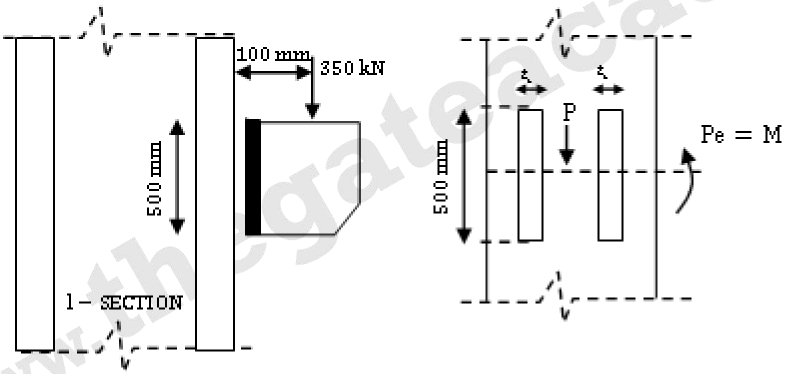
43. A 16mm thick gusset plate is connected to the 12mm thick flange plate of an I-section using fillet welds on both sides as shown in the figure (not drawn to scale) . The gusset plate is subjected to a point load of 350kN acting at a distance of 100mm from the flange plate. Size of fillet weld is 10mm.



The maximum resultant stress (in MPa, round off to 1 decimal place) on the fillet weld along the vertical plane would be ________

[Ans. *]Range : 78.10 to 78.10

The maximum resultant stress (in MPa, round off to 1 decimal place) on the fillet weld along the vertical plane would be ________



P = 150 kN, e = 100 mm

t_t = Effective throat thickness

$t_t = 0.7S$

S = Size of weld = 10 mm

$\therefore t_t = 0.7 \times 10 = 7\text{mm}$

Shear stress due to direct force, $q = \frac{350\times10^3}{2\times500\times7}$ MPa = 50MPa

Normal stress due to bending, $f_b = \frac{My}{I}$

$$f_b = \frac{Pe \times \frac{d}{2}}{2 \times \frac{t_1 d^3}{12}} = \frac{250 \times 10^3 \times 100 \times \frac{500}{2}}{2 \times 7 \times \frac{500^3}{12}} \text{MPa}$$

=60MPa

Resultant stress, $f_\theta = \sqrt{f_b^2 + q^2} = \sqrt{60^2 + 50^2}$

=78.10MPa

44. Consider two functions; $x = \psi \ln \phi$ and $y = \phi \ln \psi$. Which one of the following is the correct expression for $\frac{\partial \psi}{\partial x}$?

(A) $\frac{\ln \psi}{\ln \phi \ln \psi - 1}$

(B) $\frac{\ln \phi}{\ln \phi \ln \psi - 1}$

(C) $\frac{x \ln \phi}{\ln \phi \ln \psi - 1}$

(D) $\frac{x \ln \psi}{\ln \phi \ln \psi - 1}$

[Ans. D]

$x = \varphi \text{In}\emptyset, \quad y = \emptyset \text{in}\varphi$

Partially differentiating w.r.t x

$$1 = \varphi_x \text{In}\emptyset + \frac{\varphi}{\emptyset}\emptyset_x$$

$$0 = \emptyset_x \text{In}\varphi + \frac{\emptyset}{\varphi}\varphi_x$$

$$\Rightarrow \quad \frac{\emptyset}{\varphi} = \frac{-\emptyset \text{In}\varphi}{\varphi_x}$$

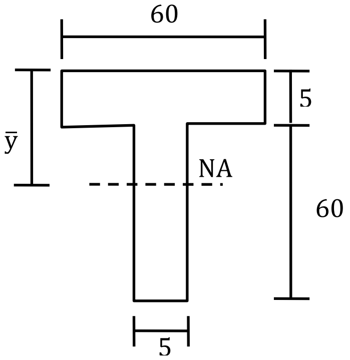
$$\Rightarrow \quad \frac{\emptyset}{\varphi \emptyset_x} = \frac{-\text{In}\varphi}{\varphi_x}$$

Put (ii) in (i)

$$1 = \varphi_x \text{In}\emptyset - \frac{\varphi_x}{\text{In}\varphi} = \varphi\left[\frac{\text{In}\emptyset\text{In}\varphi - 1}{\text{In}\varphi}\right]$$

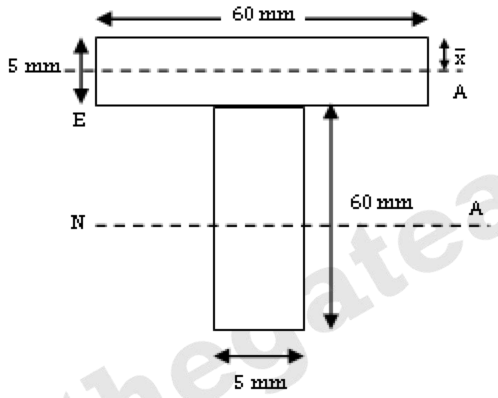
$$\varphi_x = \left[\frac{\text{In}\varphi}{\text{In}\emptyset\text{In}\varphi - 1}\right]$$

45. If the section shown in the figure turns from fully-elastic , the depth of neutral axis (N. A). $\bar{y}$, decreases by



(A) 10.75mm
(B) 15.25
(C) 13.75
(D) 12.52

[Ans. C]



$$\bar{y} = \frac{A_1\bar{y_1} + A_2\bar{y_2}}{A_1 + A_2}$$

$$= \frac{60 \times 5 \times \frac{60}{2} \times 60 \times 5 \times \left(60 + \frac{5}{2}\right)}{60 \times 5 + 60 \times 5} = 46.25\text{mm}$$

NA - Neutral axis

The section is unsymmetrical about the NA and hence the equal area axis (EA) has to be located

Let, $\bar{x} \leq 5\text{mm}$

$60 \times \bar{x} = \frac{(60\times5)+60\times5}{2}$

$\bar{x} = 5\text{mm}$

$\therefore$ NA shifts by, $60 - \bar{y} = 60 - 46.25$

$= 13.75\text{mm}$

46. A sample of air analyzed at 0°C and 1atm pressure is repoted to contain 0.02 ppm (parts per million) of NO_2. Assume the gram molecular mass of NO_2 as 46 and its volume at 0°C and 1 atm pressure as 22.4 liters per mole. The equivalent NO_2 concentration (in microgram per cubic meter. Round off to 2 decimal places) would be ________

[Ans. *]Range: 41.00 to 41.10

$1\mu g/m^3 = \frac{K}{M} \times 10^3 PPm$

$1PPM = \frac{M}{K} \times 10^3\ \mu g/m^3$

$= \frac{46}{22.11} \times 10^3\ \mu g/m^3$

$K = \frac{RT}{P} \times 10^3$

$= 82.05 \times 10^{-6} \times 213.15$

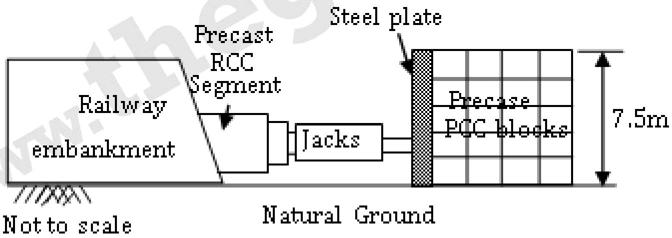
$K = 22.11$

$1PPm = 46 \times \frac{10^3}{22.11} \mu g/m^3$

$0.02PPm = 46 \times \frac{10^3}{22.11} \times 0.02$

$= 41.61\ \mu g/m^3$

47. A 3m × 3m square precast reinforced concrete segments to be installed by pushing them through an existing railway embankment for making an underpass as shown in the figure. A reaction arrangement using precast PCC blocks placed on the ground is to be made for the jacks.

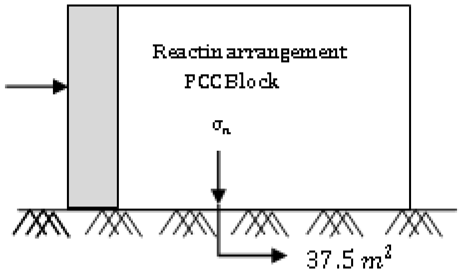


At each stage, the jacks are required apply a force of 1875kN to push the segment . The jacks will react against the rigid steel plate placed against the reaction arrangement. The footprint area of reaction arrangement on natural ground are

$o = 17kPa: \phi = 25°$ and $\gamma = 18\ kN/m^3$. Assuming that the reaction arrangement has rough interface and has the same properties that of soil , the factor of safety (round off to 1 decimal place) against shear failure is ________

[Ans. *]Range 1.8 to 2.1

$FOS = \frac{S}{\tau} = \frac{c + \overline{\sigma_n}\tan\emptyset}{\tau}$



$$\tau = \frac{\text{Jackforce}}{\text{Area}} = \frac{1875}{37.5} = 50\frac{\text{kN}}{\text{m}^2}$$

Shear strength of soil

$$\delta = c + \sigma_n \tan\phi$$

$$\sigma_n = \frac{\text{load}}{\text{area}} = \frac{\gamma 7.5 \times 37.5 \times_{\text{concrete}}}{37.5}$$

$$\sigma_n = \frac{7.5 \times 37.5 \times 24}{37.5} = 180\ \text{kN/m}^2$$

$$\delta = c + \sigma_n \tan\phi$$

$$= 17 + 180 \tan 25°$$

$$= 100.935\ \text{kN/m}^2$$

$$\text{Fos} = \frac{\delta}{\tau} = \frac{100.935}{50} = 2.018$$

48. For the following statements:

P-The lateral stress in the soil while being tested in an odometer is always at -rest

Q- For a perfectly rigid strip footing at deeper depths in a sand deposit , the vertical normal contact stress at the footing edge is greater that that at its center.

R- The corrections for overburden pressure and dilitancy are not applied to measured SPT-N values in case of clay deposits

The correct combination of the statements is

(A) P-TRUE ; Q-TRUE; R-TRUE
(B) P-TRUE; Q-TRUE; R-FALSE
(C) P-FALSE; Q-FALSE ; R-FALSE
(D) P-FALSE ; Q-FALSE; R-TRUE

[Ans. A]

For rigid footings resting on a surface of cohesionless soil the settlement must be uniform and the pressure distribution is zero at the edges and maximum at the centre but for very deep rigid footing on sand the contact pressure distribution may be more like that of rigid footing on cohesive soil i.e., more at edges than at center.

Hence statement Q is true.

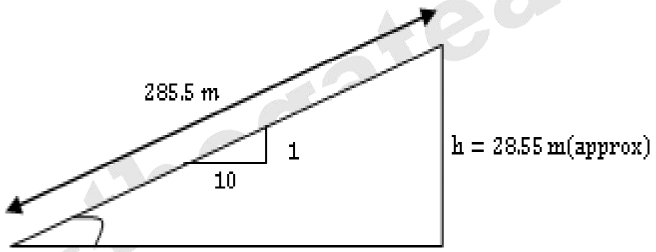
49. A survey line was measured to be 285.5m with a tape having a nominal l length of 30m. On checking the true length of the tape was found to be 0.05m too short. If the line lay on a slope of in 10, the reduced length (horizontal length) of the line for plotting of survey work would be

(A) 283.6m
(B) 285.0m
(C) 285.6m
(D) 284.5m

[Ans. A]

Given
Measured length = 285.5 m
Designated tape length = 30 m
Actual tape length = 30 – 0.05 = 29.95 m
Slope along measurement = 1 in 10.

1. Standardization correction,
   Actual tape length $l' < l$ (hence negative correction)
   Correction per tape length = 29.95 – 30 = –0.05 m
   $\text{Total correction} = \frac{285.5}{30} \times 0.05 = 0.4758(\text{negative})$
2. Slope correction:

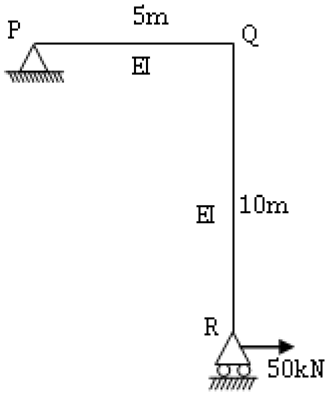


$$\text{Approximate slope correction} = \frac{h^2}{2l} = \frac{28.55^2}{285.5 \times 2} = 1.4275(\text{negative})$$

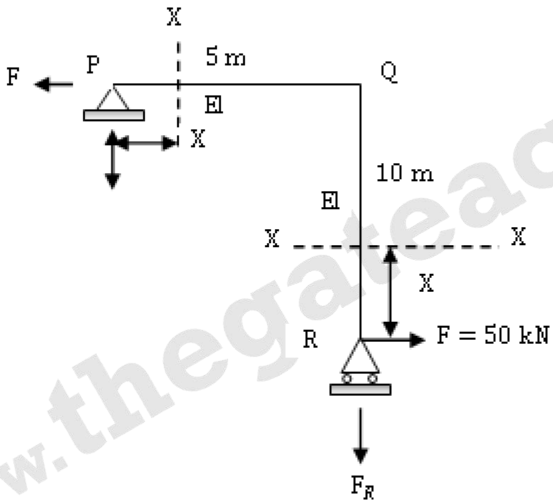
$$\text{Total correction} = -(1.4275 + 0.4758)$$
$$= -1.9033$$

Correct length = Measured length – Correction
$= 285.5 - 1.9033 = 283.596 = 283.6 \text{ m}$

50. A portal frame shown in figure (not drawn to scale) has a hinge support at joint P and a roller support at joint R. A point load of 50kN is acting at joint R in the horizontal direction. The flexural rigidity. EI. Of each member is $10^6 kN/m^2$. Under the applied load, the horizontal displacement (in mm. round off to I decimal place) of joint R would be ________



[Ans. *]Range 24.9 to 25.1



$\sum M_p = 0$

$F \times 10 = F_R \times 5 = 0$

$F_r = 2F = F_p$

$\Delta_R = \frac{\partial U}{\partial F} = \frac{\partial U_{PQ}}{\partial F} + \frac{\partial U_{QR}}{\partial F}$

$= \frac{1}{EI}\int M_{xPQ} \times \frac{\partial M_{xPQ}}{\partial F} dx + \frac{1}{EI}\int M_{xQR} \times \frac{\partial M_{xQR}}{\partial F} dx$

$M_{xPQ} = F_p \times x = 2F.x$

$= 2x$

$M_{x_{QR}} = Fx$

$\frac{\partial M_{x_{QR}}}{\partial F} = x$

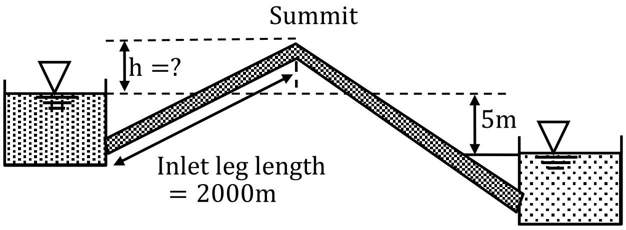
$$\therefore\ \Delta R = \frac{1}{EI}\int_0^5 4Fx^2dx + \int_0^{10} Fx^2dx$$

$$= \frac{4F}{EI}\left[\frac{x^3}{3}\right]_0^5 + \frac{F}{EI}\left[\frac{x^3}{3}\right]_0^{10}$$

$$= \frac{200}{EI}\times\frac{125}{3} + \frac{50}{EL}\times\frac{1000}{3} = \frac{25000}{EI}$$

$$= \frac{25000}{10^6}m = 25mm$$

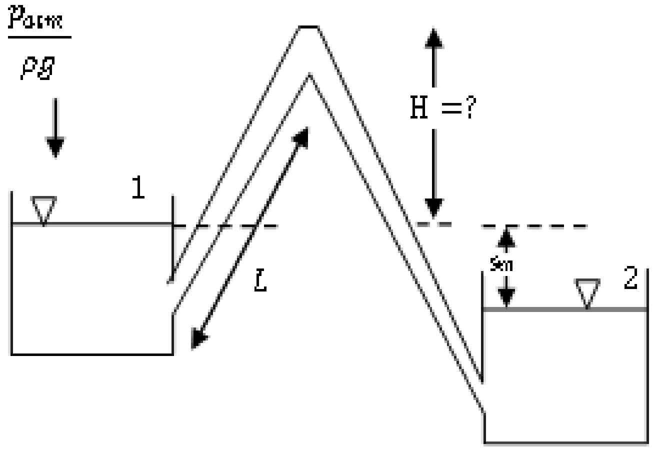
51. Two water reservoirs are connected by a siphon (running full) of total length 5000m and diameter of 0.01m as shown below (figure not drawn to scale).



The inlet leg length of the siphon to its summit is 2000m. The difference in the water surface levels of the two reservoirs is 5m. Assume the permissible minimum absolute pressure at the summit of siphon to be 2.5m of water when running full. Given, friction factor f = 0.02 throughout, atmospheric pressure = 10.3m of water and acceleration due to gravity $g = 9.81 m/s^2$. Considering only major loss using Darcy-Weisbach equation, the maximum height of the summit of siphon from the water level of upper reservoir h (in m, round off to 1 decimal place) is ______________

[Ans. *]Range 5.7 to 5.9

water reservoirs are connected



Given : $L = 5000\ \text{m}, D = 0.1\ \text{m}, L' = 2000\ \text{m}, \frac{P_s}{\rho g} = 2.5 \text{mofH}_2\text{O}, f = 0.02,$

$\frac{P_{atm}}{\rho g} = 10.3 \text{mofH}_2\text{O}, g = 9.81\ \text{m/s}^2$

Consider only major losses

Apply energy equation between (1) and (2)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_{f(1-2)}$$

$$5 = h_{f(1-2)}$$

$$5 = \frac{fLV^2}{2gD} = \frac{(0.02) \times (5000)}{0.1} \frac{V^2}{2g}$$

$$\frac{V^2}{2g} = 0.005\text{m}$$

Apply energy equation between (1) and (S)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_s}{\rho g} + \frac{V_s^2}{2g} + z_S + h_{f(1-S)}$$

$$10.3 + 0 + 0 = 2.5 + 0.005 + H + \frac{fL'}{D} \frac{V_S^2}{2g}$$

$$10.3 = 2.505 + H + \frac{(0.02)(2000)}{0.1} \times (0.005)$$

$$10.3 = 2.505 + H + 2$$

H = 5.795

H = 5.8 m (up to 1 decimal place)

52. A reinforced concrete circular pile of 12m length and 0.6m diameter is embedded in stiff clay which has an undrained unit cohesion of $110 kN/m^2$. The adhesion factor is 0.5. The Net Ultimate Pullout (uplift) Load for the pile (in kN, round off to 1 decimal place) is ______

[Ans. *]Range: 1240.0 to 1250.0

pallout load = Frictional load + W

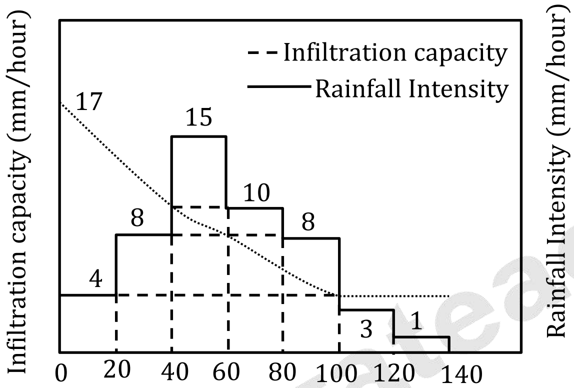
$= \alpha \bar{C} A_s + (\gamma_{concrete})(V)$

$= (0.5 \times 110 \times \pi \times 0.6 \times 12) + \left(25 \times \frac{\pi}{4} \times 0.6^2 \times 12\right)$

$= 1244.07 + 84.78$

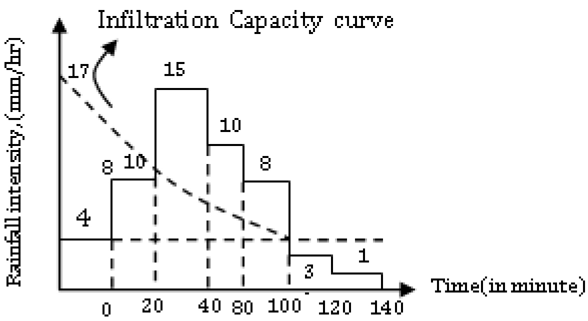
$= 1328.85$ kN

53. The hyetograph of a storm event of duration 140minutes is shown in the figure.



The infiltration capacity at the start of this event (t =0) is 17mm/hour, which linearly decreases to 10mm/hour after 40 minutes duration. As the event progresses, the infiltration rate further drops down linearly to attain a value of 4mm/hour at t = 100 minutes and remains constant thereafter till the end of the storm event. The value of the infiltration index, φ (in mm/hour, round off to 2 decimal places) is ______

[Ans. *]Range 7.20 to 7.30



$P = (4 + 8 + 15 + 10 + 8 + 3 + 1) \times \frac{20}{60} = 16.33$ minutes

$$Q = (15-10)\times\frac{20}{60} + (10-8)\times\frac{20}{60} + (8-6)\times\frac{20}{60} + \frac{1}{2}\times 2\times\frac{20}{60} + \frac{1}{2} + \frac{1}{2}2\times\frac{20}{60} + \frac{1}{2}\times 2 \times\frac{20}{60} = 4\text{ mm}$$

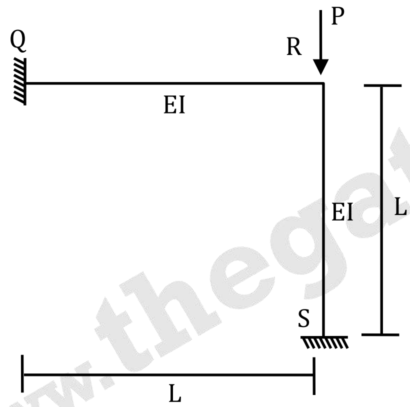
$$W-\text{index} = \frac{P-Q}{t} = \frac{16.33-4}{\frac{140}{60}} = \frac{5.28\text{mm}}{\text{hr}}$$

Since, $\emptyset \geq W$

Assume, $\emptyset = 5.28\frac{\text{mm}}{\text{hr}}$

$$\Rightarrow \quad \text{Corrected}, \emptyset = \frac{16.33-4-4\times\frac{20}{60}-1\times\frac{20}{60}}{140-30-20-\frac{20}{60}} = 7.2475\text{ mm/hr}$$

54. The rigid-jointed plane frame QRS shown in the figure is subjected to a load P at the joint R. Let the axial deformations in the frame be neglected. If the support S undergoes a settlement of $\Delta = \frac{PL^3}{\beta EI}$, the vertical reaction at the support S will become zero when β is equal to:



(A) 0.1
(B) 48.0
(C) 7.5
(D) 3.0

[Ans. C]

Assume ‘R’ sinks by Δ

Sway analysis:

$$M_{F_{QR}} = -\frac{6EI\delta}{l^2}$$

$$M_{F_{RQ}} = -\frac{6EI\delta}{l^2}$$

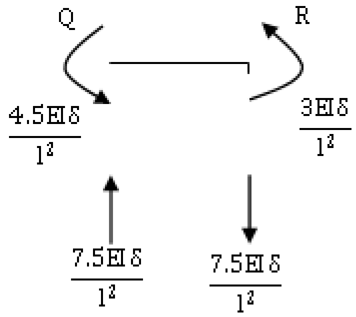
$$M_{F_{RS}} = M_{F_{SR}} = 0$$

D.F. at R

0.5	0.5

End moment distribution

FEM	$-\frac{6EI\delta}{l^2}$	$-\frac{6EI\delta}{l^2}$	0	0
Balance		$\frac{3EI\delta}{l^2}$	$\frac{3EI\delta}{l^2}$	
COM	$\frac{1.5EI\delta}{l^2}$			$\frac{1.5EI\delta}{l^2}$
Final end moments	$-\frac{4.5EI\delta}{l^2}$	$-\frac{3EI\delta}{l^2}$	$\frac{3EI\delta}{l^2}$	$\frac{1.5EI\delta}{l^2}$

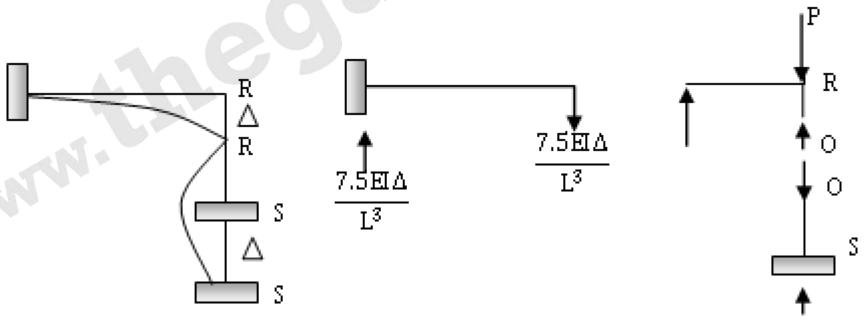


Sway force

So, Sway force $P = \frac{7.5EI\delta}{l^3}$

So, $\delta = \frac{Pl^3}{7.5EI}$

$\therefore\ \beta = 7.5$



$\sum F_v = 0$(At joint R)

$$\therefore\ P = \frac{7.5EI\Delta}{L^3}$$

$$\therefore\ \Delta = \frac{PL^3}{7.5EI}$$

55. A staff is placed on a benchmark (BM) of reduced level (RL) 100.000m and a theodolite is placed at a horizontal distance of 50m from the BM to measure the vertical angles. The measured vertical angles from the horizontal at the staff readings of 0.400m and 2.400m are found to be the same. Taking the height of the instrument as 1.400m, the RL (in m) of the theodolite station is ___________

[Ans. *]Range 100 to 100

HI = RL of BM + BS

$= 100 + (0.4 + 1)$

$=101.4$

RL of Theodolite station

$= \text{HI} - \text{height}$

$= 101.4 - 1.4$

$=100\text{m}$