BYJU'S EXAM PREP

GATE 2023

Civil Engineering

Shift-2

Question & Solution

Memory Based

GATE 2023 Civil Engineering Shift-2: Major Highlights

- **Overall Difficulty Level:** Easy to Moderate
- **MSQ weightage:** 11 Qs
- **NAT weightage:** 21Qs
- **MCQ weightage:** 33 Qs
- **Zero marks from Fluid Mechanics, CPM, Railway & Airport.**
- **Easy level Questions from DSS, Engg. Mechanics & Highway.**
- **High Weightage for Geotech (16 Marks) and Environment (13 Marks).**

GATE 2023 Civil Engineering Shift-1
Comparison with last 3 Years' Data

S.No.	Subjects	2023	2022		2021	
		Set 1	Set 1	Set 2	Set 1	Set 2
1	Engineering Mathematics	**13**	13	12	11	13
2	Strength of Materials	**7**	2	7	4	6
3	Engineering Hydrology	**5**	2	4	9	4
4	Engineering Mechanics	**1**	2	2	2	5
5	Geotechnical Engineering	**16**	13	12	13	14
6	Structural Analysis	**5**	8	5	6	2
7	Surveying	**4**	3	2	4	4
8	Building Materials	**1**	1	1	1	1
9	Construction Planning Management	**0**	2	2	2	2
10	Design of Steel Structures	**3**	2	2	2	1
11	Irrigation Engineering	**2**	3	2	2	2
12	Highway Engineering	**6**	11	10	11	9
13	Open Channel Flow	**5**	3	4	2	1
14	Environmental Engineering	**11**	14	13	8	5
15	Fluid Mechanics	**2**	3	3	4	5
16	Railways and Airport	**0**	0	1	0	2
17	General Aptitude	**15**	15	15	15	15
18	Design of Concrete Structures	**4**	3	3	4	9
	Total	**100**	**100**	**100**	**100**	**100**

GATE 2023 Civil Engineering: Shift-1
Subject-Wise Marks Distribution

Subjects	Questions		Total Marks
	1 Mark	2 Marks	
Engineering Mathematics	5	4	**13**
Strength of Materials	1	3	**7**
Engineering Hydrology	1	2	**5**
Engineering Mechanics	1	0	**1**
Geotechnical Engineering	4	6	**16**
Structural Analysis	1	2	**5**
Surveying	2	1	**4**
Building Materials	1	0	**1**
Construction Planning Management	0	0	**0**
Design of Steel Structures	1	1	**3**
Irrigation Engineering	0	1	**2**
Highway Engineering	2	2	**6**
Open Channel Flow	1	2	**5**
Environmental Engineering	3	4	**11**
Fluid Mechanics	0	1	**2**
Railways and Airport	0	0	**0**
General Aptitude	5	5	**15**
Design of Concrete Structures	2	1	**4**
Total	**30**	**35**	**100**

Engineering Mathematics

1. Cholesky decomposition is carried out on the following

$$A = \begin{bmatrix} 8 & -5 \\ -5 & a_{22} \end{bmatrix}$$

Let L_{ij} & a_{ij} be the $(i.j)^{th}$ element of matrix [L] & [A]. If the element L_{22} of the decomposed lower triangular matrix [L] is 1.968. What is the value of element a_{22} ?

A. 11 B. 7

C. 5 D. 9

[MCQ]

Ans. B

Sol. Cholesky decomposition

A = LL*

Where,

L = Lower triangular matrix with real & positive diagonal elements.

L* = Transpose of conjugate

LL* = A

$$\begin{bmatrix} L_{11} & 0 \\ L_{21} & L_{22} \end{bmatrix}\begin{bmatrix} L_{11} & L_{12} \\ 0 & L_{22} \end{bmatrix} = \begin{bmatrix} 8 & -5 \\ -5 & a_{22} \end{bmatrix}$$

L_{11} & L_{22} $\rightarrow$ is positive

and L_{22} = 1.968 (given)

(i) $L_{11}^2 = 8 \Rightarrow L_1 = \sqrt{8}$

(ii) $L_{11}\,L_{21} = -5 \Rightarrow L_{21} = \dfrac{-5}{\sqrt{8}}$

(iii) $L_{21}^2 + 1.968^2 = a_{22}$

$$\Rightarrow a_{22} = \frac{25}{8} + 1.968^2 \cong 7$$

2. Solution of DE:

$$\frac{d^3y}{dx^3} - 5.5\frac{d^2y}{dx^2} + 9.5\frac{dy}{dx} - 5y = 0$$

is expressed as

$$y = c_1e^{2.5x} + c_2e^{\alpha x} + c_3e^{\beta x}$$

where c_1, c_2, c_3, α & β are constant, with $\alpha + \beta$ being distinct and not equal to 2.5. α & β ?

A. −2, −3 B. 2, 3

C. 1, 2 D. −1, −2

Ans. C

Sol. A.E.

$m^3 - 5.5\,m^2 + 9.5\,m - 5 = 0$

Roots are = 2.5, α, β

sum of roots, $2.5 + \alpha + \beta = -(-5.5) = 5.5$

or

$\alpha + \beta = 3$

Only option (1, 2) satisfies this condition.

3. Given $A = \begin{bmatrix} 1 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix}$

Find number of linearly independent eigen vectors.

Ans. 3

Sol. No. of linearly independent eigen vector = No. of distinct eigen values

Characteristics equation, $|A - \lambda I| = 0$

$$\lambda^3 - \beta_1\lambda^2 + \beta_2\lambda - \beta_3 = 0$$

β_3 → det A = 0

β_2 → 1 + 1 + 1 = 3

β_1 → Trace = 4

OR

$\lambda^3 - 4\lambda^2 + 3\lambda = 0$

$\lambda(\lambda^2 - 4\lambda + 3) = 0 \Rightarrow \lambda = 0, 1, 3$

No. of distinct eigen values = 3

4. Two vectors $\begin{bmatrix}2 & 1 & 0 & 3\end{bmatrix}^T$ & $\begin{bmatrix}1 & 0 & 1 & 2\end{bmatrix}^T$ belong to Null space of a 4 × 4 matrix of rank 2. Which of the following vectors also belong to Null space ?

A. $\begin{bmatrix}0 & -2 & 1 & -1\end{bmatrix}^T$

B. $\begin{bmatrix}1 & 1 & -1 & 1\end{bmatrix}^T$

C. $\begin{bmatrix}2 & 0 & 1 & 2\end{bmatrix}^T$

D. $\begin{bmatrix}3 & 1 & 1 & 2\end{bmatrix}^T$

Ans. B

Sol. Nullity of matrix

= No. of variables (n) – rank of A

= 4 – 2 = 2

and

Nullity is no. of linearly independent vectors in the null space.

After seeing the given matrix, these two vectors are already independent.

i.e. $\begin{bmatrix}2\\1\\0\\3\end{bmatrix}$ & $\begin{bmatrix}1\\0\\1\\2\end{bmatrix}$

Any other vectors in null space

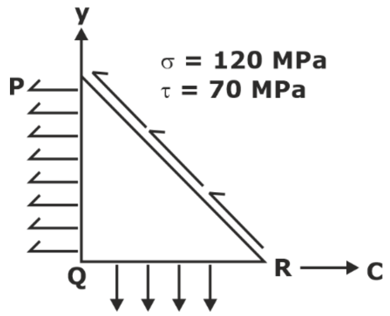
$z = \alpha x + \beta y$

where, α, β can be any real value

Option B is correct because (x – y).

Strength of Materials

5. In a two-dimensional stress analysis the stale of stress at a point is shown in the figure. The value of length of PQ, QR, RP are 4, 3 & 5 units respectively the principal stresses are ________.



A. σ_x = 54 MPa σ_y = 128.5 MPa

B. σ_x = 26.7 MPa σ_y = 172.5 MPa

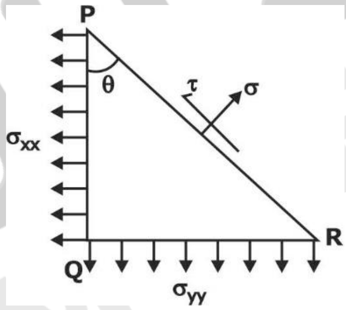
C. σ_x = 16 MPa σ_y = 138.5 MPa

D. σ_x = 67.5 MPa σ_y = 213.3 MPa

[MCQ 2 Marks]

Ans. D

Sol. Given,



PQ = 4 QR = 3 PR = 5

From fig. $\sin\theta = \frac{3}{5}$, $\cos\theta\ \frac{4}{5}$

σ = 120 MPa

τ = 70 MPa

We have,

$\sigma_\theta = \sigma_{xx}\cos^2\theta + \sigma_{yy}\sin^2\theta + 2\tau_{xy}\sin\theta\cos\theta$

$$120 = \sigma_{xx}\left[\frac{4}{5}\right]^2 + \sigma_{yy}\left(\frac{3}{5}\right)^2 + 0$$

$$120 = \frac{16}{25}\sigma_{xx} + \frac{9}{25} \times \sigma_{yy} \quad ...(i)$$

$$\tau_\theta = -\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$70 \times 2 = -(\sigma_{xx} - \sigma_{yy}) \times 2\sin\theta\cos\theta$$

$$= -(\sigma_{xx} - \sigma_{yy}) \times 2 \times \frac{3}{5} \times \frac{4}{5}$$

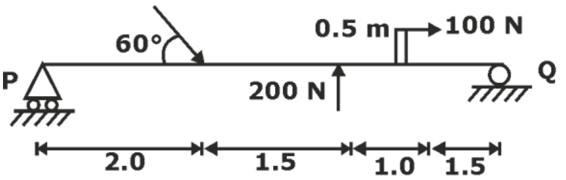
$$12\sigma_{xx} - 12\sigma_{yy} = -70 \times 25 \ ....(ii)$$

Giving equation (i) and (ii)

σ_{xx} = 67.5 MPa

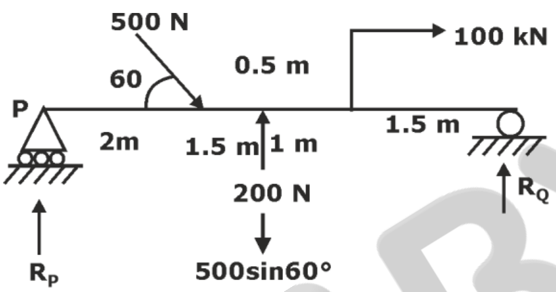
σ_{yy} = 213.33 MPa

6. A beam is subjected to a system of coplanar forces of shown in the fig. the magnitude of vertical reaction support P is _____ N.



Ans. 197.06 kN

Sol.



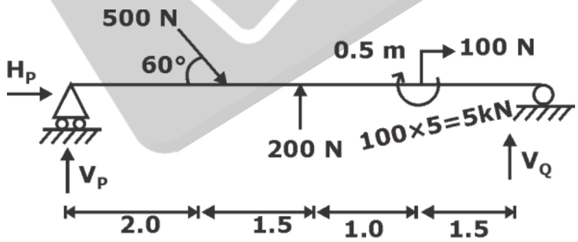
$\Sigma MQ = 0$

R_P =

$$\frac{500\times\sin 60\times 4}{6}-\frac{200\times 2.5}{2}-\frac{100\times 0.5}{6}$$

R_P = 197.06 kN

Alternate Method



$\Sigma V = 0$

$V_P + V_Q$ = 500 sin60° – 200 N

$V_P + V_Q$ = 2330.01 N ...(i)

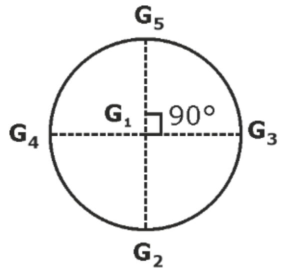
$\Sigma M_Q = 0$

V_P × 6 + 200 × 2.5 – 500sin60° × 4 + 50 = 0

$\boxed{V_P = 197.06\ \text{N}}$

Engineering Hydrology

7. A circle radius 30 km, 5 rain gauges

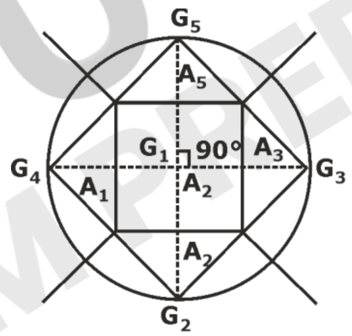


Gauge	G_1	G_2	G_3	G_4	G_5
Rain fall (mm)	910	930	925	895	905

Using Thiessen polygon method, what is the average rainfall over the catchment in that year.

Ans. 912.55 mm

Sol.



A_1 = 30 × 30 = 900 km^2

$$A_2 = A_3 = A_4 = A_5 = \left(\frac{\pi + 30^2 - 900}{4}\right)$$

= 481.85 km^2

$$P_{avg} = \left(\frac{P_1A_1 + P_2A_2 + P_3A_3 + P_4P_4 + P_5P_5}{A_1 + A_2 + A_4 + A_5}\right)$$

$$\frac{900\times 910\times 930\times 481.85 + 925\times 481.85 + 895 + 481.85 + 905\times 481.89}{900 + 4\times 481.85}$$

= $\boxed{P_{avg} = 912.55\ \text{mm}}$

8. Match the column

Column 1

P. Horton equation

Q. Muskingum method

R. Penman method

Column 2

1. Precipitation

II. Flood frequency
III. Evapotranspiration
IV. Infiltration
V. Channel Routing

[NTA-1 Mark]

A. P-III, Q-IV, R-I
B. P-III, Q-I, R-IV
C. P-IV, Q-V, R-III
D. P-IV, Q-II, R-III

Ans. C

Sol. Harton's equation → infiltration
Muskingum method → channel routing
Penman's equation → Evapotranspiration

9. C/O of on small river is sub-divided of into seven segments of width 1.5 m each. The average depth, velocity at different depth's were measured during a field carriage at the middle of each segment width Q by velocity are method for given data is m^3/s (in decimal) _____ .

[NTA]

Segment	Average depth (0)	V(m/s)		
1	0.4	–	0.4	–
2	0.7	0.76	–	1.10
3	1.2	1.19	–	1.13
4	1.4	1.25	–	1.10
5	1.1	1.13	–	1.09
6	0.8	0.09	–	0.05
7	0.45	–	0.42	–

Ans. 7.8235 m^3/sec

Sol.

Segment	Depth (y)	Average width	$V_{0.2}$	$V_{0.6}$	$V_{0.8}$	Q
1	0.40	1.6875		0.4		1.6875×0.4×.4 = 27
2	0.70	1.5	0.76		1.10	$0.70\times1.5\times\left[\frac{0.76+1.10}{2}\right] = 0.7665$
3	1.20	1.5	1.19		1.13	$1.20\times1.5\times\left[\frac{1.19+1.13}{2}\right] = 2.088$
4	1.40	1.5	1.25		1.10	$1.40\times1.5\times\left[\frac{1.25+1.10}{2}\right] = 2.467$
5	1.10	1.5	1.13		1.09	$1.10\times1.5\times\left[\frac{1.13+1.09}{2}\right] = 1.8315$
6	0.80	1.5	0.09		0.05	$0.80\times1.5\times\left[\frac{0.09+0.05}{2}\right] = 0.084$
7	0.45	1.6876		0.42		0.45 × 1.6875 × 0.42 = 0.319

$$(W_2)_{avg.} = \frac{1.5}{2} + \frac{1.5}{2} = 1.5$$

$W_2 = W_3 = W_4 = W_5 = W_6 = 1.5$

$$W_{avg.} = \frac{W_1 + \frac{W_2}{2}}{2W_1} = \frac{1.5 + \left(\frac{1.5}{2}\right)^2}{2\times1.5} = 1.6875$$

$W_{avg} = 1.6878$ m

Discharge = Area × Velocity

$= y \times W_{avg} \times V_{avg}$

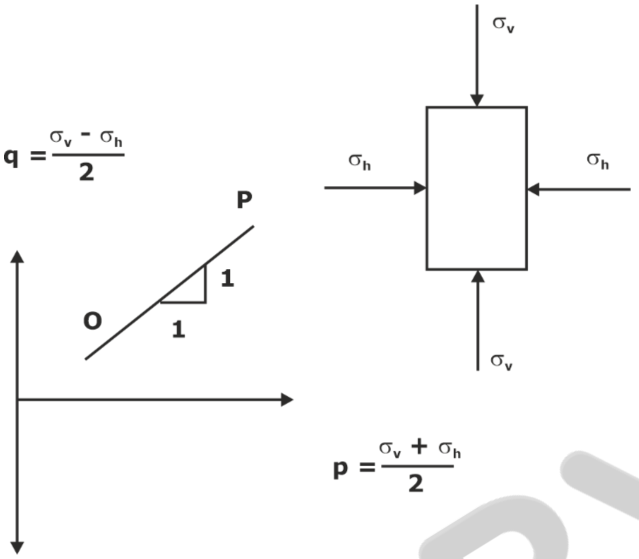
From last column, total discharge

= 7.8235 m^3/sec

Geotechnical Engineering

10. In the given figure point O indicates the stress point of soil element at initial non-hydrostatic stress condition. For the stress path (OP) which of the following coding condition is correct?

[MCQ-1 Mark]



A. σ_v is decreasing & σ_h is increasing

B. σ_v is increasing & σ_h is decreasing

C. σ_v is constant & σ_h is increasing

D. σ_v is increasing & σ_h is constant

Ans. D

Sol.

$$q = \frac{\sigma_v - \sigma_h}{2}$$

$$p = \frac{\sigma_v + \sigma_h}{2}$$

When σ_V increasing, σ_h is constant, then y axis

is increasing as well as x-axis. Then required.

stress path will be made so option d is correct.

11. An unconfined compressive strength test was conducted on a cohesive soil. The test specimen failed at an axial stress of 76 kpa. The undrained cohesion (in kPa) of the soil is _________

[NAT 1 Mark]

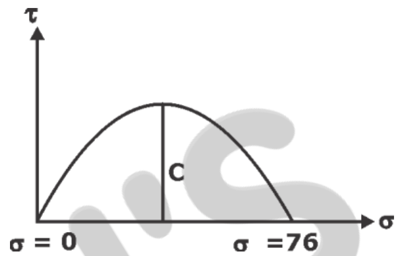
Ans. 76

Sol.

Test done on soil – UCS

axial stress =76 kPa

For UCS test



$$C = \text{Radius} = \frac{76}{2} = 38 \text{ kPa}$$

12. A circular pile of diameter 0.6m and length 8 m was constructed in a cohesive soil stratum having the following properties γ_b= 19 kN/m^3, ϕ = 0° & C = 25 kPa. The allowable load the pile can carry with FOS = 3 is _____kN (α = 1.0 N_C = 9.0)

[NAT 2 Mark]

Ans. 146.5- 146.9

Sol.

$Q_{up} = q_s A_s + q_b A_b$

$Q_{up} = \bar{\alpha}\bar{C}(\pi d L) + CNc\frac{\pi}{4}d^2$

$Q_{up} = (1 \times 25 \times \pi \times 0.6 \times 8) + (25 \times 9 \times \frac{\pi}{4} \times 0.6^2)$

Q_{up} = 440.60 kN

$Q_{allowable} = Q_{up}/$ FOS =440.60/3=146.87kN

13. A square footing is to be designed to carry a column load of 500 kN which is resting on a soil stratum having the following average properties γ_b = 19 kN/m^3 angle of internal friction ϕ = 0° & C = 25 kPa.

Considering the depth of footing in m and adopting meyerhof method, the bearing capacity theory with a FOS = 3, the width of footing in m is ________

[NAT - 2 Mark]

Ans. 3- 3.2

Sol.

As per meyerhoff

$Q_u = CN_C d_C s_C i_c + \gamma D_f N_q d_q s_q i_q + 0.5 B \gamma N_\gamma d_\gamma s_\gamma i_\gamma$

$N_q = 1,\ N_\gamma = 0,\ N_c = 5.7$

$C = 25$ kPa, $\phi = 0,\ \gamma = 19$ kN

Putting the value in question

$$\text{Area} = \frac{\text{load} \times \text{FOS}}{q_u} = \frac{500 \times 3}{147.5} \quad ...(i)$$

Since it's a square footing

Area = $(\text{width})^2$...(ii)

By (i) and (ii)

Width = 3.18 m

14. A vertical sheet pile was installed in an anisotropic soil having coefficient of permeability, k_h & kv. In order to draw the flow net for the isotropic condition, the embedment depth of the wall should be scaled by a factor of ________ without changing the horizontal scale.

[MCQ-1 Mark]

A. 1.0

B. $\sqrt{\frac{k_h}{k_v}}$

C. $\sqrt{\frac{k_v}{k_h}}$

D. k_h/k_v

Ans. C

Sol.

As we know to change the horizontal scale we have to use the factor

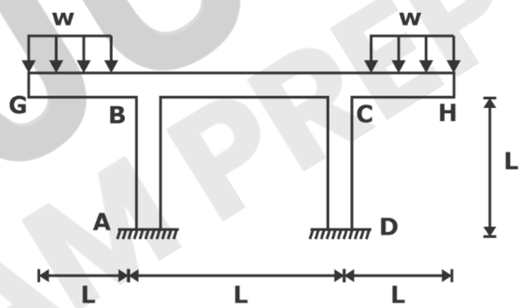
$$X = X_T\sqrt{\frac{k_h}{k_v}}$$

But as per question we cannot change the horizontal scale, hence we have to change the vertical length. So the we have to multiply wit

$\sqrt{\frac{k_v}{k_h}}$ so get the desired result

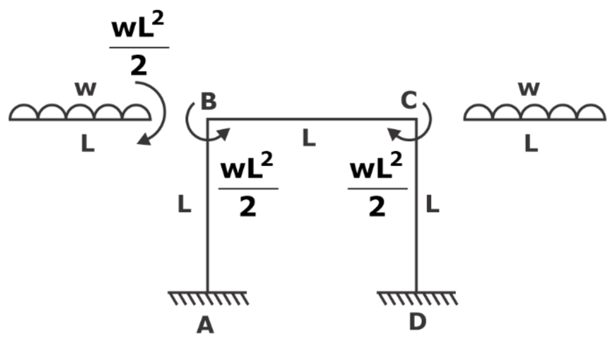
Structural Analysis

15. For the frame shown in the figure, all members AB, BC, CD, GB and CH have the same length L and flexural rigidity EI. B and C are rigid joints, and A and D are fixed supports. Beam GB and CH carry UDL and the moment of reaction at A is wL^2/K. K is ____



Ans.

Sol.



Stiffness of BC = $\frac{2EI}{L}$

(Since, beam is bending in a symmetrical mode)

Stiffness of BA = $\frac{4EI}{L}$

$$\text{D.F. for BA} = \frac{\frac{4EI}{L}}{\frac{4EI}{L} + \frac{2EI}{L}} = \frac{2}{3}$$

$$M_{BA} = \frac{wL^2}{2} \times \frac{2}{3} = \frac{2wL^2}{6}$$

Carry over moment at A, $M_{AB} = \frac{1}{2} \times \frac{2wL^2}{6}$

$$= \frac{wL^2}{6}$$

$\Rightarrow K = 6$

16. Muller-Breslau principle is used in analysis of structure for

A. Drawing an ILD for any force response in the structure.

B. Writing the virtual work expression to get the equilibrium equation.

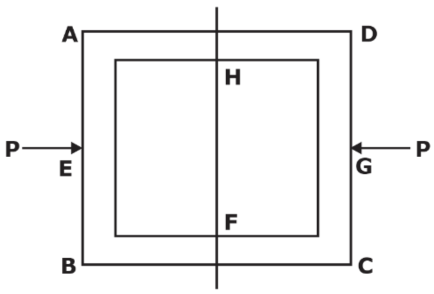
C. Superposing the load effects to get the total force response in the structure.

D. Relating the deflection between two points in a member with the curvature diagram in between.

Ans. A

Sol. Muller-Breslau principle is used to draw ILD for any force response in the structure.

17. All 4 members (AB, BC, CD AD) have same L and EI. All joints A, B, © and D are rigid. Midpoint of AB, BC, CD and AD are denoted by ©, F, G, H. Frame is in unstable condition. Under the shown force of magnitude P acting at © + G, which of the following statements are true?



A. SF @ H and F = 0

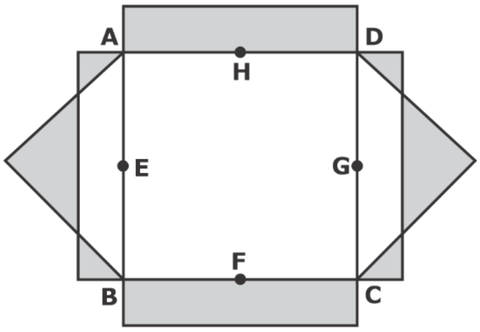
B. δ_V @ H + F = 0

C. θ @ E/F/G/H = 0

D. δ_H @ H + F = 0

Ans. A, © and D

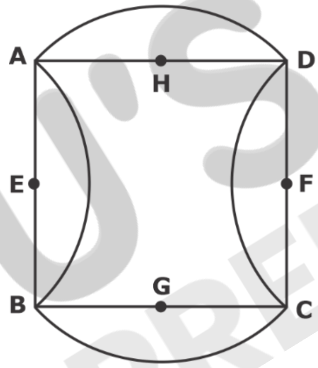
Sol. BMD for symmetrical box frame–



At H and F, BM is constant.

$\Rightarrow$ SF = 0 (option A is correct)

Deflection diagram for symmetrical box frame



From the diagram, it is clear that-

→ δ_V at H and F ≠ 0 (option B is incorrect)

→ θ at ©, F, G, H = 0 (option © is correct)

→ δ_H at H and F = 0 (option D is correct)

Surveying

18. A delivery agent is at a location R. To deliver the order, she is instructed to travel to location P along the straight line paths of RC, CA, AB & BP of 5 km each. The direction of each path is given in the table below as WCB. Assume latitude L & departure D of R is (0, 0) km. What is L & D of P in km.

Path	RC	CA	AB	BP
Direction	120	0	90	240

A. - L = 0.0, D = 5.0 B. L = 0.0, D = 0.0

C. L = 2.5, D = 5.0 D. L = 5.0, D = 2.5

Ans. A

Sol. Latitude and departure of starting point,

R= (0, 0)km

Latitude of location P = Latitude of R + ΣLatitude for each line

= 0 + 5 cos 120 + 5 cos 0 + 5 cos 90 + 5 cos 240 = 0

Departure of location P = Departure of R + ΣDeparture for each line

= 0 + 5 sin 120 + 5 sin 0 + 5 sin 90 + 5sin240

= 5 km

L = 0 km, D = 5 km

19. If the size of the ground area is 6 km × 3 km and the corresponding photo size in the arial photograph is 30 cm × 15 cm then the scale of photograph is 1:_________ (in integer).

Ans. 20000

Sol. Ground area = 6 km ×3 km

Photograph size = 30 cm × 15 cm

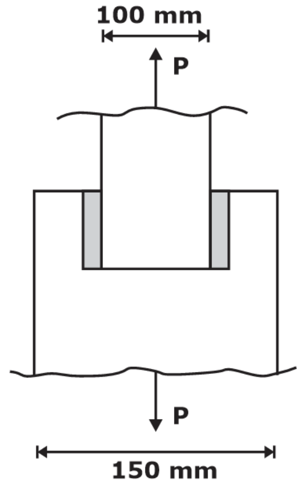
$$\text{Scale} = \sqrt{\frac{\text{photograph size}}{\text{ground size}}}$$

$$= \sqrt{\frac{30 \times 15}{6 \times 3 \times (10^5)^2}}$$

= 1 : 20000

Design of Steel Structures

20. Two plates are connected by fillet welds of size 10 mm and subjected to tension, as shown in the figure. The thickness of each plate is 12 mm, the yield stress and ultimate stress of steel under tension are 250 MPa and 410 MPa, respectively. The welding is done in the workshop □MW = 1.25. As per limit state method of IS 800 : 2007, what is the minimum length required of each weld to transmit a factored force P = 275 kN?

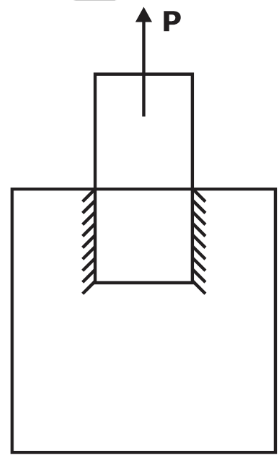


A. 115 B. 100

C. 105 D. 110

Ans.

Sol.



Fillet weld

Size = 10 mm

Fusion angle = 90°

Throat thickness = 0.7 × size

t_e = 7 mm

Design strength of fillet weld

$$P_{dw} = \frac{f_u}{\sqrt{3} \cdot \gamma_{mw}} \times l_e \times t_e$$

Let's take limiting condition:

$$P_{dw} = 275 \times 10^3 N = \frac{410}{\sqrt{3} \times 1.25} \times 7\,mm \times l_e$$

l_e = 207.45 mm

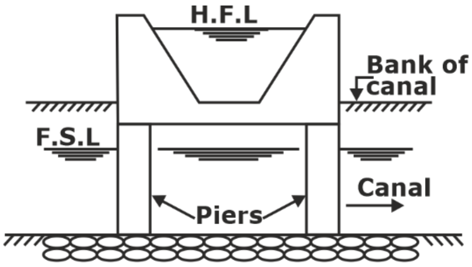
So, the required length on each side =

$$\frac{l_e}{2} = \frac{207.45}{2}$$

= 103.72 mm

Irrigation Engineering

21. Identing the CD works in the fig.



Super passage

A. Level crossing   B. Siphon aqueduct
C. Super passage   D. Aqueduct

[MCQ - 1 Mark]

Ans. C

Sol. Cross drainage works where bed level of stream is sufficiently above FSL of canal is called super-passage.

Highway Engineering

22. SSD equal to the ________

A. Brake distance
B. Brake distance + distance travelled during reaction time
C. ______________
D. Distance only during reaction time

Ans. B

Sol. (1) SSD is

SSD = Lag distance + Braking distance

Lag distance = distance covered during reaction time

23. As per IRC guidelines (IRC 86 : 2018) extra widening depends on which of the following parameters?

A. No. of lanes
B. Longitudinal gradient
C. Super elevation
D. Horizontal curve radius

[MSQ]

Ans. A and D

Sol. Extra widening = $\frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$

So extra widening depends on number of lane and radius.

24. In respect to Marshall test and Bitumen content, which are true?

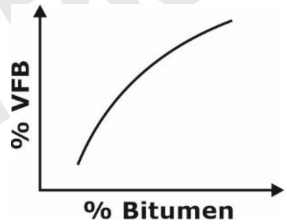
A. The air sides increase initially and then decreases.
B. The VFB increase monotonically.
C. The stability decreases initially and then decreases.
D. The flow decreases monotonically.

[MSQ - 2 Marks]

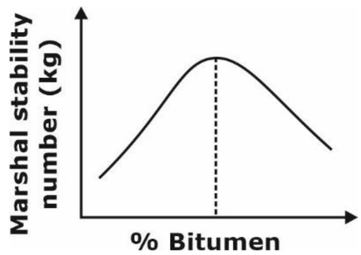
Ans. B and D

Sol.

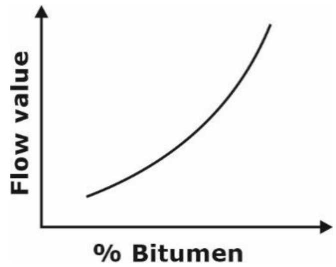
- With increase with Bitumen content, Air voids decreases.
- With increase with Bitumen content, VFB increases.



- As Bitumen content increases, the stability increases initially then decreases.



- As Bitumen content increases, the flow will increase.



- Hence B, D are correct.

Open Channel Flow

25. The critical flow condition in a channel is given by, a = kinetic energy correction factor

A. $\frac{aQ^2}{g} = \frac{A_c^3}{T_c}$

B. $\frac{aQ}{g} = \frac{A_c^3}{T_c}$

C. $\frac{aQ}{g} = \frac{A_c^3}{T_c^2}$

D. $\frac{aQ^2}{g} = \frac{A_c^3}{T_c^2}$

[MCQ - 2 Marks]

Ans. A

Sol. For critical flow condition in channel of any shape

$$\frac{Q^2T_c}{gA_c^3} = 1$$

If kinetic energy factor a is considered.

$$\frac{aQ^2T_c}{gA_c^3} = 1$$

$$\frac{aQ^2}{g} = \frac{A_c^3}{T_c}$$

ENVIRONMENTAL ENGINEERING

26. For the elevation and temperature data given in the table the existing lapse rate in the environment is ______ °C/100 m. (round off two)

Elevation from ground level	Temperature
5 m	14.2°C
325 m	16.9°C

[NAT - 1 Marks]

Ans. 0.84

Sol.

Elevation above ground level	Temperature
5 m	14.2°C
325 m	16.9°C

$$ELR = \frac{16.9 - 14.2}{(325 - 5)}$$

= 0.00843 °C/m

= 0.84 °C/100 m

27. Match the column

Air pollutants

P. Aromatic Hydrocarbons

Q. Carbon monoxide

R. Sulphur oxides

S. Ozone

Health effect on humans and animals

I. Reduce the capacity of the blood to carry oxygen

II. Bronchitis and pulmonary emphysema

III. Damages chromosomes

IV. Carcinogenic effect

A. P-IV, Q-I, R-II, S-III

B. P-IV, Q-I, R-III, S-II

C. P-III, Q-I, R-II, S-IV

D. P-II, Q-I, R-IV, S-III

Ans. B

Sol. Aromatic hydrocarbon – Carcinogenic effect

Carbon monoxide – Reduce capacity of blood to carry oxygen.

Sulphur oxides – Damages chromosomes

Ozone – Bronchitis and pulmonary emphysema

28. Which of the following statements is/are true for aerobic composting of sewage sludge?

A. Bulking agent is added during the composting process to reduce the porosity of the solid mixture

B. In-vessel composting, systems cannot be operated in the plug flow mode

C. Antinomcytes are involved in the process

D. Leachate can be generated during compositing

Ans. C,D

Sol. Bulking agent is added to increase the volume, so statement 1 is incorrect.

- In vessel composting, systems can be operated in plug flow mode.

- Antinocytes are involved in the process.
- Leachate can be generated during compositing.

29. The theoretical aerobic oxidation of bio mass ($C_5H_7O_2N$) is given below.

$C_5H_7O_2N + 5O_2 \rightarrow 5CO_2 + NH_3 + 2H_2O$

The biochemical oxidation of biomass is assumed as first order reaction with a rate constant 0.23 per day at 20°C (base e). Neglecting the second stage oxygen demand from its biochemical oxidation, the ratio is BOD_5 at 20°C to total organic carbon (TOC) is biomass is __________. Atomic weight of C,H,& O are 12 g/mol, 1 g/mol, 16 g/mol and for N = 14 g/mol respectively.

[NAT]

Ans. 1.82

Sol. $C_5H_7O_2N = 5 \times (12) + 7 \times (1) + 2 \times (16) + 14 = 113$ g

113gm of $C_5H_7O_2N \rightarrow 5 \times 12$ gm carbon

1 mole of $C_5H_7O_2N \rightarrow$

$\frac{5 \times 12}{113} = 0.53$ gm carbon

BOD_5 at 20°C = $BOD_u\ [1 - e^{-KD \times t}]$

$= BOD_u\ (1 - e^{-0.23 \times 5})$

113 gm $C_5H_2O_2N$ required 5×32 gm of O_2

So 1 gm $C_5H_2O_2N$ required

$\frac{5 \times 32}{113} = 1.415$ gm of O_2

$BOD_u = 1.4159\ (1 - e^{-0.23 \times 5})$

= 0.9675 g/l

$\frac{BOD_{5,20°C}}{TOC} = \frac{0.9673}{0.53} = 1.82$

30. In the context of water and wastewater treatment the correct statements are

A. Ammonia decreases chlorine demand

B. Phosphorous stimulates algal and aquatic growth

C. Ca and Mg increase hardness and TDS

D. Particular matter may shield micro-organisms during disinfection

Ans. B, C, D

Sol. Ammonia increases chlorine demand so statement I is false. Rest all 3 statements are true.

31. Which of the following is/are not an active disinfectant of the water treatment plant?

A. Cl^- B. O_3

C. OCl^- D. OH

Ans. D

Sol. Active disinfectant used in plant.

1. Cl^-

2. O^3

3. OCl^-

Fluid Mechanics

32. Which of the following statements is/are true?

A. For a curved surface immersed in stationary liquid, the vertical component of the force of the curved surface is equal to the weight of liquid about it.

B. For flow through circular pipes, the momentum correction factor for laminar flow is larger than that for turbulent flow.

C. If the stream lines and equipotential lines of a source are interchanged with each other, resulting flow will be sink

D. The thickness of a turbulent boundary layer on a flat plate kept parallel to the flow direction is proportional to the square root of the distance from the leading edge.

[MSQ - 2 Marks]

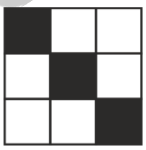
Ans. A and B

Sol.

1. Vertical component of force on curved surface immersed in stationary liquid is equal to the weight of liquid above the curved surface upto the free surface of the liquid. So, option (a) is true.
2. Momentum correction factor for circular pipe
   Laminar flow = 1.33
   Turbulent flow = 1.015
   So, option (b) is true.
3. Sink will form if you reverse the direction of the streamlines in the source. So, option (c) is false.
4. Turbulent boundary layer thickness δ relation with distance x from the leading edge of plate is given as
   $$\frac{\delta}{x} = \frac{0.376}{Re^{1/5}}$$
   where, $Re = \frac{\rho v x}{\mu}$
   So, from above equation, it is clear that δ is not proportional to $\sqrt{x}$. So, option (d) is false.

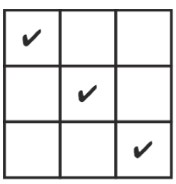
General Aptitude

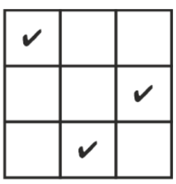
33. In how many ways can cells in a 3×3 grid be shaded, such that each row each column have exactly one shaded cell ?



Ans. 6

Sol. e.g.





$3 \times 2 \times 1 = 6$

34. If x satisfies the equation $4^{8^x} = 256$, then x is equal to _____.

[NAT]

Ans. $\frac{2}{3}$

Sol. $4^{8^x} = 256$

$4^{8^x} = 4^4$

or

$8^x = 4$

$(2^3)^x = 2^2$

$2^{3x} = 2^2$

or $3x = 2$

or $x = \frac{2}{3}$

35. Kind : _____ : : Often : Seldom

A. Kindred B. Type

C. Cruel D. Variety

Ans. C

Sol. Often means regular repetition.

Seldom means very rarely occurring.

Hence, often and seldom are opposite.

The correct opposite of kind is cruel.

Kindred mean similar or related.

36. The line ran _____ the page, right through the centre, and divided the page into two

A. between B. about

C. of D. across

[MCQ]

Ans. D

Sol. Across represent the motion

37. There are 4 Red, 5 Green and 6 Blue balls inside a Box.

If N number of balls are picked simultaneously. What is smallest N test guarantees there will at least balls of same color ?

A. 4 B. 5

C. 15 D. 2

Ans. A

Sol. 3 variety of balls i.e. R, G & B

If we pick up 4 balls, one ball will definitely repeated.

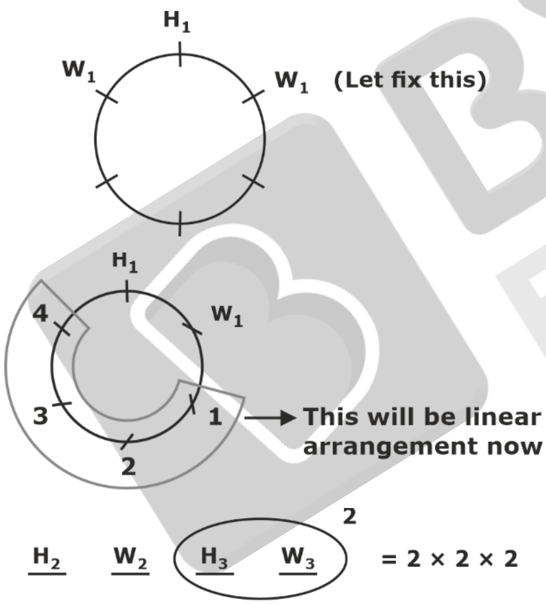
38. 3 Husband-wife pairs are to be seated at a circular table. How many seating arrangements are possible so that every husband sits next to his wife.

A. 720 B. 120

C. 16 D. 4

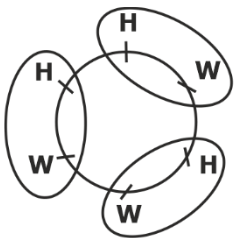
Ans. C

Sol.



So, total no. = 2 × 2 × 2 × 2

OR



= (3! – 1) × 2 × 2 × 2

= 16

Design of Concrete Structures

39. M20 concrete as per IS 456:2000 refers to the concrete with a design mix having

[1 Mark]

A. an average cylinder strength of 20 MPa

B. a 5 percentile cylinder strength of 20 MPa

C. a 5 percentile cube strength of 20 MPa

D. an average cube strength of 20 MPa

Ans. C

Sol. M20 concrete as per IS 456:2000 refers to the concrete with a design mix having a 5 percentile cube strength of 20 MPa

40. A reinforced beam has following data:

B = 300 mm

3 bar of 28 mm diameter is used.

Effective cover = 45 mm

Overall depth = 600 mm

M25 and Fe415

Find the value of MR.

Sol. B = 300 mm

A_{st} = 3 – 28 mm

Effective cover = 45 mm

D = 600 mm

d = 600 – 45 = 555 mm

$X_{u,lim}$ = kd {for Fe415 k = 0.48}

= 0.48 d

= 0.48 × 555

= 266.4 mm

C = T

$0.36\, f_{ck}\, Bx_u = 0.87\, f_{y}A_{st}$.

$0.36 \times 25 \times 300 \times X_u = 0.87 \times 415 \times \frac{\pi}{4} \times 28^2 \times 3$

X_u = 247 mm

So, it's an under-reinforced section.

$X_u < x_{ulim}$

$MR = 0.36\, f_{ck}\, Bx_u\, (d - 0.42\, x_u)$

= 0.36 × 25 × 300 × 247 (555 – 0.42 × 247)

= 300.9 kNm

41. Regarding shear design of RCC beams, which are true:

[MSQ - 1 Mark]

A. As per IS 456 : 2000, the nominal shear stress in beams of varying depth depends on both the design shear force value as well as design BM.

B. Beams without shear reinforcement, even if adequately designed for flexure, can have brittle failure.

C. The main (longitudinal) reinforcement plays no role in the shear resistance of beam.

D. Excessive shear reinforcement can lead to compression failure in concrete.

Ans. A, B, and D

Sol.

1. Nominal shear stress for beam of varying depth, $\tau_{v_u} = \dfrac{V_u + \dfrac{M_u}{d}\tan\beta}{B.d}$

   where, V_u = design shear force

   M_u = design bending moment

   So, option A is correct.

2. Beams need to be provided with minimum shear reinforcement to avoid brittle failure. So, option B is correct.

3. Design shear strength of concrete τ_c (without shear reinforcement) depends upon–

   (i) grade of concrete

   (ii) % main reinforcement

   So, option C is incorrect.

4. Excessive shear reinforcement can cause compressive failure in concrete. So, option D is correct.

***

Our Outstanding GATE Results

100+ Students under AIR-100 2021


Rank 02
Poojasree (EC)


Rank 03
Manoj (EC)


Rank 03
Munish (ME)


Rank 06
Parag (EC)


Rank 07
Vatsal (ME)


Rank 08
Rahul (CE)


Rank 08
Hemant (EE)


Rank 08
Rajat (ME)


Rank 09
Vamsi (EC)


Rank 13
Shashwat (CE)

50+ Students under AIR-100 2020


Rank 06
Ghanendra (EC)


Rank 09
Avinash (ME)


Rank 09
Himanshu (EE)


Rank 26
Kartikay (CE)


Rank 30
Raja (EC)


Rank 39
Akash Singh (CS)


Rank 39
Navneet (CS)


Rank 54
Rishi (EE)


Rank 56
Apurv Mittal (ME)


Rank 56
Nikhil (ME)

Our Success Stories

Our Outstanding GATE Results

80+
Students under AIR-100
2022


Rank 01
Ram (EC)


Rank 02
Amit (CE)


Rank 02
Vandit (EE)


Rank 03
Parvinder (ME)


Rank 06
Abhishek (ME)


Rank 06
Vivek (CE)


Rank 08
Kiran (CS)


Rank 09
Shivam (EC)


Rank 09
Tushar (EE)


Rank 10
Mitesh (CS)


Rank 11
Kaustav (ME)


Rank 11
Souvik (ME)


Rank 12
Himanshu (CE)


Rank 15
Surya (CS)


Rank 18
Swastik (CE)


Rank 20
Lakshay (ME)


Rank 21
Tathagata (CS)


Rank 22
Ayush (CE)


Rank 29
Piyush (EE)


Rank 38
Rajat (EE)