GATE - 1998

CE : Civil Engineering

Time Allowed : 3 Hours *Maximum Marks : 150*

Section A
(100 Marks)

1. For each subquestion given below four answers are provided out of which only one is correct. Indicate in the answer book the correct or most approprite answer by writing the letter A, B, C or D against the subquestion number. (31×1=31)

1.1. If A is a real square matrix, then AA^T is

(a) unsymmetric (b) always symmetric
(c) skew symmetric (d) sometimes symmetric

1.2. In matrix algebra AS = AT (A, S, T, are matrices of appropriate order) implies S=T only if

(a) A is symmetric (b) A is singular
(c) A is non singular (d) A is skew symmetric

1.3. A discontinuous real function can be expressed as

(a) Taylor's series and Fourier's series
(b) Taylor's series and not by Fourier's series
(c) neither Taylor's series nor Fourier's series
(d) not by Taylor's series, but by Fourier's series

1.4. The Laplace Transform of a unit step function $u_a(t)$, defined as

$$U_a(t) = \begin{cases} 0 \text{ for } t < a \\ 1 \text{ for } t > a \end{cases} \text{ is}$$

(a) e^{-as}/s (b) se^{-as}
(c) $s-u(0)$ (d) $se^{-as}-1$

1.5. The continuous functions $f(x,y)$ is said to have saddle point at (a, b) if

(a) $f_x(a,b) = f_y(a,b) = 0$; $f_{xy}^2 - f_{xx}f_{yy} < 0$ at (a,b)
(b) $f_x(a,b) = 0; f_y(a,b) = 0$; $f_{xy}^2 - f_{xx}\cdot f_{yy} > 0$ at (a, b)
(c) $f_x(a,b) = 0; f_y(a,b) = 0$; f_{xx} and $f_{yy} < 0$ at (a, b)
(d) $f_x(a,b) = 0; f_y(a,b) = 0$; $f_{xy}^2 - f_{xx}\cdot f_{yy} = 0$ at (a, b)

Where the subscripts x,y etc, denote partial derivatives.

1.6. The Taylor's series expansion of sin x is

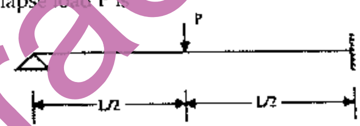
(a) $1-\frac{x^2}{2!}+\frac{x^4}{4!}$ (b) $1+\frac{x^2}{4!}+\frac{x^4}{4!}$

(c) $x+\frac{x^3}{3!}+\frac{x^5}{5!}$ (d) $x-\frac{x^3}{3!}+\frac{x^5}{5!}$

1.7. A three hinged arch shown in Figure is quarter of a circle. If the vertical and horizontal components of reaction at A are equal, the value of θ is

(a) 60°
(b) 45°
(c) 30°
(d) None in (0°, 90°)

1.8. A propped cantilever beam is shown in Figure. The plastic moment capacity of the beam is M_0. The collapse load P is

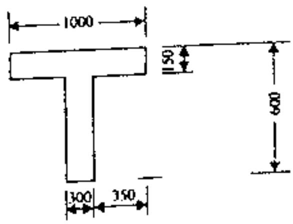


(a) $4M_0/L$ (b) $6M_0/L$
(c) $8M_0/L$ (d) $12M_0/L$

1.9. The maximum permissible deflection for a gantry gride, spanning over 6m, on which an EOT (electric overhead travelling) crane of capacity 200 k.N is operating, is

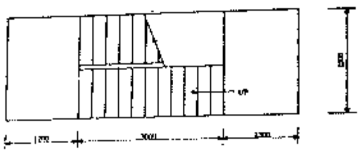
(a) 8 mm (b) 10mm
(c) 12 mm (d) 18 mm

1.10. An isolated T beam is used as a walkway. The beam is simply supported with an effective span of 6m. The effective width of flange, for the cross-section shown in Figure, is



(a) 900 mm
(b) 1000 mm
(c) 1259 mm
(d) 2200 mm

1.11. The plane of stairs supported at each end by landings spanning parallel with risers is shown in Figure. The effective span of staircase slab is



(*a*) 3000 mm (*b*) 4600 mm
(*c*) 4750 mm (*d*) 6400 I

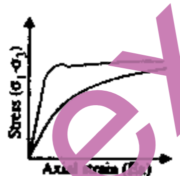
1.12. Some of the structural strength of a clayey material that is lost by remoulding is slowly recovered with time. This property of soils to undergo an isothermal gel-to sol-to -gel transformation upon agitation and subsequent rest is termed

(*a*) Isotropy (*b*) Anisotropy
(*c*) Thixotropy (*d*) Allotropy

1.13. If soil is dried beyond its shrinkage limit, it will show

(*a*) Large volume change
(*b*) Moderate volume change
(*c*) Low volume change
(*d*) No volume change

1.14. The stress-strain behaviour of soils as shown in the Figure corresponds to:



(*a*) Curve 1 : Loose sand and normally consolidated clay
Curve 2 : Loose sand and over consolidated clay
(*b*) Curve 1 : Dense sand and normally consolidated clay
Curve 2 : Loose sand and over consolidated clay
(*c*) Curve 1 : Dense sand and over consolidated clay
Curve 2 : Loose sand and normally consolidated clay
(*d*) Curve 1 : Loose sand and over consolidated clay
Curve 2 : Dense sand normally consolidated clay

1.15. In cohesive soils the depth of tension crack (Z_{cr}) is likely to be

(*a*) $Z_{cr} \geq \frac{2c}{\gamma}\sqrt{\tan\left(45° - \frac{\phi}{2}\right)}$

(*b*) $X_{cr} \geq \frac{2c}{\gamma}\sqrt{\tan\left(45° + \frac{\phi}{2}\right)}$

(*c*) $Z_{cr} \geq \frac{4c}{\gamma}\sqrt{\tan\left(45° - \frac{\phi}{2}\right)}$

(*d*) $Z_{cr} \geq \frac{4c}{\gamma}\sqrt{\tan\left(45° + \frac{\phi}{2}\right)}$

1.16. The settlement of prototype in granular material may be estimated using plate load test data from the following expression:

(*a*) $S_{prototype} = S_{plate} \times \left(\frac{B_{prototype}}{B_{plate}}\right)$

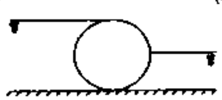
(*b*) $S_{prototype} = S_{plate} \times \left(\frac{B_{plate}}{B_{prototype}}\right)$

(*c*) $S_{prototype} = S_{plate} \times \left[\frac{2B_{prototype}}{B_{prototype} + B_{plate}}\right]^2$

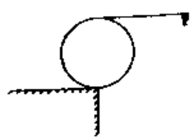
(*d*) $S_{prototype} = S_{plate} \times \left[\frac{B_{prototype} + B_{plate}}{2B_{prototype}}\right]^2$

1.17. In which one of the following arrangement would the vertical force on the cylinder due to water be the maximum?

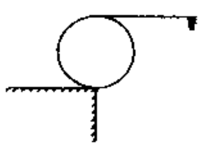
(*a*)



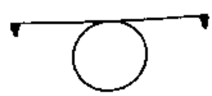
(*b*)



(*c*)



(*d*)

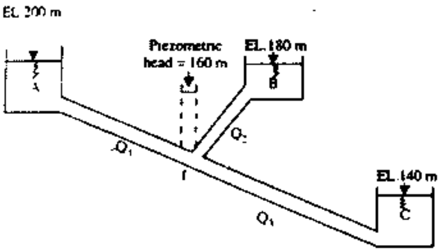


1.18. At the same mean velocity, the ratio of head loss per unit length for a sewer pipe flowing full to that for the same pipe flowing half full would be

(*a*) 2.0 (*b*) 1.63

(*c*) 1.00 (*d*) 0.61

1.19. Three reservoirs A, B and C are interconnected by pipes as shown in the Figure. Water surface elevations in the reservoirs and the Pirzometric head at the junction J are indicated in the Figure.



Discharge Q_1, Q_2 and Q_3 are related as

(*a*) $Q_1+Q_2 = Q_3$ (*b*) $Q_1 = Q_2+Q_3$

(*c*) $Q_2 = Q_1+Q_3$ (*d*) $Q_1+Q_2+Q_3 = 0$

1.20. The comparison between pumps operating in series and in parallel is

(*a*) Pumps operating in series boost the discharge, whereas pumps operating in parallel boost the head.

(*b*) Pumps operating in parallel boost the discharge, whereas pumps operating in series boost the head.

(*c*) In both cases there would be a boost in discharge only

(*d*) In both case there would be a boost in head only.

1.21. The Bowen ratio is defined as

(*a*) Ratio of heat and vapour diffusivities

(*b*) Proportionality constant between vapour heat flux and sensible heat flux.

(*c*) Ratio of actual evapotranspiration and potential evapotranspiration.

(*d*) Proportionality constant between heat energy used up in evaporation and the bulk radiation from a water body.

1.22. The microbial quality of treated piped water supplies is monitored by

(*a*) Miroscopic examination

(*b*) Plate count of heterotrophic bateria

(*c*) Coliform MPN test

(*d*) Identification of all pathogens

1.23. Excessive fluoride in drinking water causes

(*a*) Alzheimer's disease

(*b*) Mottling of teeth and embrittlement of bones

(*c*) Methemoglobinemia

(*d*) Skin cancer

1.24. Coagulation-flocculation with alum is performed

(*a*) immediately before chlorination

(*b*) immediately after chlorination

(*c*) after rapid sand filtration

(*d*) before rapid sand filtration

1.25. Sewage treatment in an oxidation pond is accomplished primarily by

(*a*) alga-bacterial symbiosis

(*b*) algal photosynthesis only

(*c*) bacterial oxidation only

(*d*) chemical oxidation only

1.26. An inverted siphon is a

(*a*) device for distributing septic tank effluent to a soil absorption system

(*b*) device for preventing overflow from elevated water storage tank

(*c*) device for preventing crown corrosion of sewer

(*d*) section of sewer which is dropped below the hydraulic grade line in order to avoid an obstacle.

1.27. Water distribution systems are sized to meet the

(*a*) maximum hourly demand

(*b*) Average hourly demand

(*c*) maximum daily demand and fire demand

(*d*) average daily demand and fire demand.

1.28. At highway stretches where the required overtaking sight distance cannot be provided, it is necessary to incorporate in such sections the following

(*a*) at least twice the stopping sight distance

(*b*) half of the required overtaking sight distance

(*c*) one third of the required overtaking sight distance

(*d*) three times the stopping sight distance

1.29. The modulus of subgrade reaction is obtained from the plate bearing test in the form of load-deformation curve. The pressure corresponding to the following settlement value should be used for computing modulus of subgrade reaction

(*a*) 0.375 cm (*b*) 0.175 cm

(*c*) 0.125 cm (*d*) 0.250 cm

1.30. In the plate bearing test, if the load applied is in the form of an inflated type of wheel, then this mechanism corresponds to

(*a*) rigidplate (*b*) flexible plate

(*c*) semi-rigid plate (*d*) semi-elastic plate

1.31. Base course is used in rigid pavements for

(*a*) prevention of subgrade settlement

(*b*) prevention of slab cracking

(*c*) prevention of pumping

(*d*) prevention of thermal expansion

2. For each subquestion given below four answers are provided out of which only one is correct. Indicate in the answer book the correct or most appropriate answer by writing the letter A, B, C or D against the subquestion number. $(22 \times 2 = 44)$

2.1. The infinite series $1+\frac{1}{2}+\frac{1}{3}+........$

(*a*) converges.. (*b*) diverges

(*c*) oscillates (*d*) unstable

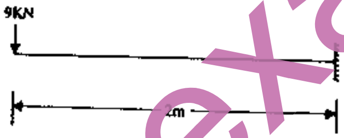
2.2. The real symmetric matrix C corresponding to the Quadratic form

$$Q = 4x_1x_2 - 5x_{22}, \text{ is}$$

(*a*) $\begin{bmatrix} 1 & 2 \\ 2 & -5 \end{bmatrix}$ (*b*) $\begin{bmatrix} 2 & 0 \\ 0 & -5 \end{bmatrix}$

(*c*) $\begin{bmatrix} 1 & 1 \\ 1 & -2 \end{bmatrix}$ (*d*) $\begin{bmatrix} 0 & 2 \\ 1 & -5 \end{bmatrix}$

2.3. A cantilever beam is shown in the Figure. The moment to be applied at free end for zero vertical deflection at that point is



(*a*) 9 kN.m clockwise

(*b*) 9 kN.m anti-clockwise

(*c*) 12kN.m clockwise

(*d*) 12 kN.m anti-clockwise

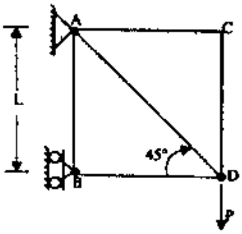
2.4. The strain energy stored in member AB of the pin-jointed truss is shown in Fig.2.4, when E and A are same for all members, is

(*a*) $\frac{2P^2L}{AE}$

(*b*) $\frac{P^2L}{AE}$

(*c*) $\frac{P^2L}{2AE}$

(*d*) Zero



2.5. The stiffness matrix of a beam element is given as $(2EI/L)\begin{bmatrix} 2 & -1 \\ 1 & 2 \end{bmatrix}$. Then the flexibility matrix is

(*a*) $\left(\frac{L}{2EI}\right)\begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$ (*b*) $\left(\frac{L}{6EI}\right)\begin{bmatrix} 1 & -2 \\ -2 & 1 \end{bmatrix}$

(*c*) $\left(\frac{L}{3EI}\right)\begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix}$ (*d*) $\left(\frac{L}{5EI}\right)\begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix}$

2.6. The plastic modulus of a section is 4.8×10^{-4} m³. The shape factor is 1.2. The plastic moment capacity of the section is 120 kN.m. The yield stress of the material is

(*a*) 100MPa (*b*) 240 MPa

(*c*) 250 MPa (*d*) 300MPa

2.7. A reinforced concrete wall carrying vertical loads is generally designed as per recommendations given for columns. The ratio of minimum reinforcements in the vertical and horizontal directions is

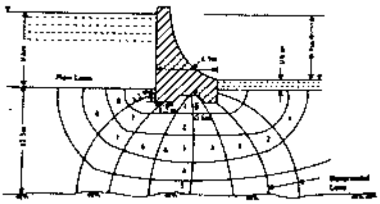
(*a*) 2 : 1 (*b*) 5 : 3

(*c*) 1 : 1 (*d*) 3 : 5

2.8. The proposed dam shown in the figure is 90 m long and the coefficient of permeability of the soil is 0.0013mm/second. The quantity of water (m³) that will be lost per day be seepage is (rounded to the nearest number):

(*a*) 55 (*b*) 57

(*c*) 59 (*d*) 61



2.9. The time for a clay layer to achieve 90% consolidation is 15 years. The time required to achieve 90% consolidation, if the layer were twice as thick, 3 times more permeable and 4 times more compressible would be :

(*a*) 70 years (*b*) 75 years

(*c*) 80 years (*d*) 85 years

2.10. The total active thrust on a vertical wall 3m high retaining a horizontal sand backfill (unit weight γ_t = 20 kN/m³, angle of shearing resistance ϕ' = 30°) when the water table is at the bottom of the wall, will be:

(*a*) 30 kN/m (*b*) 35 kN/m

(*c*) 40 kN/m (*d*) 45 kN/m

2.11. A 40° slope is excavated to a depth of 10 (d) depth of 10 m is a deep layer of saturated clay of unit weight 20 kN/m³; the relevant shear strength parameters are c_u = 72 kN/m² and ϕ_u = 0. The rock ledge is at a great depth. The Taylor's stability coefficient for ϕ_u = 0 and 40° slope angle is 0.18. The factor of safety of the load is:

(*a*) 2.0 (*b*) 2.1

(*c*) 2.2 (*d*) 2.3

2.12. A point load of 700 kN is applied on the surface of thick layer of saturated clay. Using Boussinesq's elastic analysis, the estimated vertical stress (σ_v) at a depth of 2 m and a radial distance of 1.0 m from the point of application of the load is:

(*a*) 47.5 kPa (*b*) 47.6 kPa

(*c*) 47.7 kPa (*d*) 47.8 kPa

2.13. A nozzle discharging water under head H has an outlet area "*a*" and discharge coefficient c_d = 1.0. A vertical plate is acted upon by the fluid force F_j when held across the free jet and by the fluid force F_n when held against the nozzle to stop the flow. The ratio $\frac{F_j}{F_n}$ is

(*a*) 1/2 (*b*) 1

(*c*) $\sqrt{2}$ (*d*) 2

2.14. A body moving through still water at 6m/sec produces a water velocity of 4m/sec at a point 1m ahead. The difference in pressure between the nose and the point 1m ahead would be

(*a*) 2,000N/m² (*b*) 10,000N/m²

(*c*) 19,620N/m² (*d*) 98,100 N/m²

2.15. The return period for the annual maximum flood of a given magnitude is 8 years. The probability that this flood magnitude will be exceeded once during the next 5 years is

(*a*) 0.625 (*b*) 0.966

(*c*) 0.487 (*d*) 0.529

2.16. Two completely penetrating wells are located L (in meters) apart, in a homogeneous confined aquifer. The drawdown measured at the mid point between the two wells (at a distance of 0.5L from both the wells) is 2.0 m when only the first well is being pumped at the steady rate of Q_1 m³/sec. When both the wells are being pumped at identical steady rate of Q_2 m³/sec, the drawdown measured at the same location is 8.0m. It may be assumed that the drawdown at the wells always remains at 10.0 m when being pumped and the radius of influence is larger than 0.5L $\frac{Q_1}{Q_2}$ is equal to

(*a*) $\frac{8}{5}$ (*b*) $\frac{4}{3}$

(*c*) $\frac{5}{8}$ (*d*) $l_n\left(\frac{L}{2}\right)$

2.17. In connection with the design of a barrage, identify the correct matching of the criteria of design with the items of design

	Item of design		Criteria of design
(i)	Width of waterway	(A)	Scour depth and exit gradient
(ii)	Level and length of downstream floor	(B)	Lacey's formula for wetted perimeter and discharge capacity of the barrage as computed by weir equations
(iii)	Depth of sheet piles and total length of barrage floor	(C)	Uplift pressure variation
(iv)	Barrage floor thickness	(D)	Hydraulic jump considerations

Codes:

	(i)	(ii)	(iii)	(iv)
(*a*)	A	B	C	D
(*b*)	D	C	B	A
(*c*)	B	A	D	C
(*d*)	B	D	A	C

2.18. In a BOD test using 5% dilution of the sample (15 ML of sample and 285 mL of dilution water), dissolved oxygen values for the sample and dilution water blank bottles after five days incubation at 20°C were 3.80 and 8.80 mg/L, respectively. Dissolved oxygen originally present in the undiluted sample was 0.80 mg/L. The 5-day 20°C BOD of the sample is

(*a*) 116 mg/L (*b*) 108 mg/L

(*c*) 100 mg/L (*d*) 92 mg/L

2.19. For a flow of 5.7 MLD (million litres per day) and a detention time of 2 hours, the surface area of a rectangular sedimentation tank to remove all particles have settling velocity of 0.33 mm/s is

(*a*) $20 m^2$ (*b*) $100 m^2$

(*c*) $200 m^2$ (*d*) $400 m^2$

2.20. For a highway with design speed of 100 kmph, the safe overtaking sight distance is (assume acceleration as $0.53 m/sec^2$)

(*a*) 300 m (*b*) 750 m

(*c*) 320 m (*d*) 470 m

2.21. What is the equivalent single wheel load of a dual wheel assembley carrying 20,440 N each for pavement thickness of 20 cm? Centre to centre spacing of tyres is 27 cm and the distance between the walls of tyres is 11 cm.

(*a*) 27600N (*b*) 32300N

(*c*) 40880N (*d*) 30190N

2.22. Plate bearing test with 20 cm diameter plate on soil subgrade yielded a pressure of $1.25 \times 10^5 N/m^2$ at 0.5 cm deflection. What is the elastic modulus of subgrade?

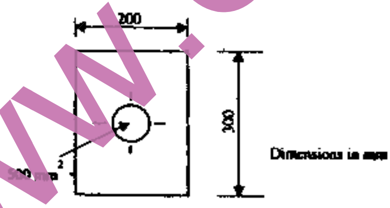
(*a*) $56.18 \times 10^5 N/m^2$ (*b*) $22.10 \times 10^5 N/m^2$

(*c*) $44.25 \times 10^5 N/m^2$ (*d*) $50.19 \times 10^5 N/m^2$

3. Solve the following set of simultaneous equations by Gauss elimination method. (5)

$$x - 2y + z = 3 \quad ......(1)$$
$$x + 3z = 11 \quad ......(2)$$
$$-2y + z = 1 \quad ......(3)$$

4. The cross-section of a pretensioned prestressed concrete beam is shown in Figure. The reinforcement is placed concentrically. If the stress in steel at transfer is 1000 MPa, compute the stress in steel immediately after transfer. The modular ratio is 6. (5)



5. An ISMS 400, with a flange width of 140 mm is subjected to an axial compressive load of 750 kN. Design the slab base resting on concrete of grade M15. The slab base available are 600 × 350 × 20 mm, 650 × 325 × 28 mm, and 700×2300×32 mm. Select one of these. (5)

6. The total unit weight of the glacial outwash soil is $6 kN/m^3$. The specific gravity of the solid particles of the soil is 2.67. The water content of the soil is 17% Calculate (5)

(*a*) dry unit weight (*b*) porosity

(*c*) void ratio (*d*) degree of saturation

Assume that unit weight of water (γ_w) is $10 kN/m^3$

7. An overflow spillway is 40 m high. Water flows down the spillway with a head of 2.5 m over the spillway crest. The spillway discharge coefficient cd = 0.738. Show that the water depth at the toe of the spillway would be 0.3 m. Determine the sequent depth required for the formation of the hydraulic jump and the loss of head in the jump. (5)

SECTION-B

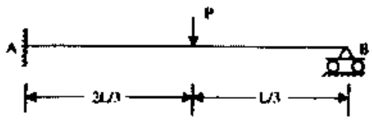
(50 Marks)

Answer and TEN question from this section. All questions carry equal marks.

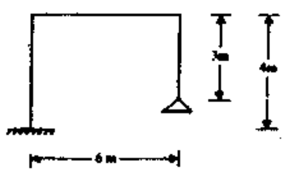
8. Solve $\frac{d^4y}{dx^4} - y = 15\cos 2x$ (5)

9. Obtain the eigen values and eigen vectors of the matrix $\begin{bmatrix} 8 & -4 \\ 2 & 2 \end{bmatrix}$ (5)

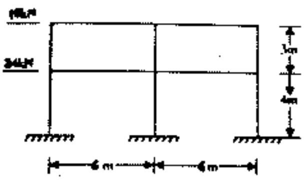
10. Using the Force Method, computer the slope at the support B of the propped cantilever beam shown in Fig.10. The value of EI is constant. (5)



11. The steel portal frame shown in Figure is subjected to an imposed service load of 15 kN. Compute the required plastic moment capacity of the members. All the members are of the same cross-section. Draw the collapse mode. (5)



12. Compute the bending moments at the top of the columns in the upper storey of the multi-storey frame shown in Figure, by the cantilever and portal methods of analysis. Indicate tension face of columns, the area of cross-section of all columns is same. (5)



13. The cross-section of a simply supported plate girder is shown in Figure. The loading on the girder is symmetrical. The bearing stiffeners at supports are the sole means of providing restraint against torsion. Design the bearing stiffeners at supports, with minimum moment of inertia about the centre line of web plate only as the sole design criterion. The flat section available are: 250 × 25, 250 × 32, 200×28, and 200 × 32 mm. Dray a sketch (5)

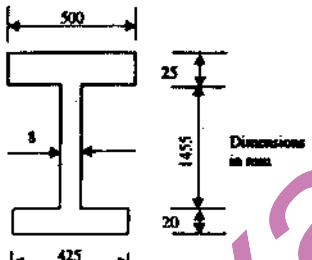


Fig. 18.

14. The diameter of a ring beam in water tank is 7.8 m. It is subjected to an outward raidal force of 15 kN/m. Design the section using M 25 grade concrete and Fe 415 reinforcement. Sketch the cross-section. (5)

15. For general $c-\phi$ soil, cohesion c is 50 kPa, the total unit weight γ is 20 kN/m³ and the bearing capacity factors are $N_q = 3$ and $N_r = 2$. Using Terzaghi's formula, calculate the net ultimate bearing capacity for a strip footing of width B = 2m at depth z = 1 m. Considering shear failure only, estimate the safe total load on a footing 10 m long by 2 m wide strip footing using a factor of safety of 3. (5)

16. A soft normally consolidated clay layer is 20 m thick with a moisture content of 45%. The clay has a saturated unit weight of 20 kN/m³, a particle specific gravity of 2.7 and a liquid limit of 60%. A foundation load will subjected the centre of the layer to a vertical stress increase of 10 kpa. Ground water level is at the surface of the clay. Estimate

(a) The initial and final effective stresses at the centre of the layer

(b) The approximate value of the compression index (C_c)

(c) The consolidation settlement of the foundation if the initial effective stress at the centre of the soil is 100kPs.

Assume unit weight of water to be 10kN/m³

17. Estimate the safe load carrying capacity of a single bored pile 20 m long, 500 mm diameter. The adhesion coefficient (d) is 0.4. Take a factor of safety of 2.5. The soil strata is as follows.

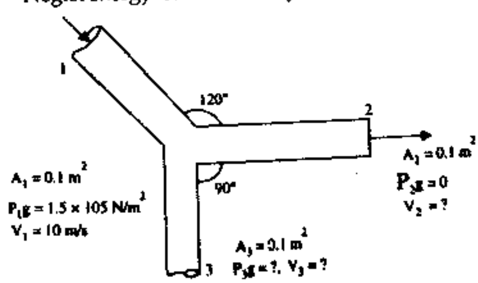
Depth (*m*)	Soil deposit	Undrained shear strength (S_u)kPa
0–5	Loose fill	50
5–10	Weathered over consolidate clay	70
10–15	Over consolidated clay	100
15–30	High over-consolidated clay	200

Assmne, $\phi_n = 0$ is valid and $N_c = 9$, for deep fomadations. (5)

18. (a) What is the shear strength in terms of effective stress on a plane within a saturated soil mass at a point where the total normal stress is 295 kPa and the pore water pressure 120 kPa? The effective stress shear strength parameters are c' = 12 kPa and ϕ' = 30° (2)

(b) In a falling head permeameter test on a silty clay sample, the following results were obtained; sample length 120 mm; sample diameter 80 mm; initial head 1200 mm, final head 400 mm; time for fall in head 6 minutes stand pipe diameter 4 mm. Find the coefficient of permeability of the soil in mm/ second.

19. Water flows through the Y-joint as shown in figure. Find the horizonal and vertical components of the force acting on the joint because of the flow of water. Neglet energy losses and body force.



20. Water flows in a rectangular channel at depth of 1.20 m and a velocity of 2.4 m/sec. What would be the effect of a local rise in the channel bed of 0.60 m on the water surface? (5)

21. A reservoir is proposed to be constructed to command an area of 1,20,000 hectares . The area has a monsoon rainfall of about 100cm per year. It is anticipated that sugar and rice would each be equal to 20% of the command area and wheat equal to 50% of the command area, making a total of annual irrigation equal to 90% of the command area.

(i) Work out the storage required for the reservoir, assuming the water requirements given below, canal losses as 25% of the head discharge and reservoir evaporation and dead storage losses as 20% of the gross capacity of the reservoir.

(ii) Derermine also the full supply discharge of the canal at the head of the canal.

Crop	Transplanted Rise	Sugar Cane	Wheat
Sowing time	July	Feb-Mar	October
Harvesting Time	November Next year	Dec-March	Mar-Apr
Total Water Depth in cm	150	90	37.5
"Kor" period in weeks	2.5	4	4
"Kor" watering in cm	19.0	16.5	13.5

Note that $\Delta = \frac{864B}{D}$ in which Δ = Depth of water in cm, B = base period in days, and D = duty of water in hectares/ cumec. (5)

22. The following rainfall hyetograph and the corresponding direct run off are recorded in a watershed. Compute the one-hour unit hydrography ordinates for the first four hours. Assume ϕ index = 0.50 cm/hr (5)

Time (hrs)	Rainfall (cm)	Direct Run Off (m^3/sec)
1	2.8	64.2
2	5.2	288.4
3	4.7	794.5
4	0.0	1369.6
5	0.0	1593.7
6	0.0	1175.1
7	0.0	588.1
8	0.0	286.9
9	0.0	170.5
10	0.0	110.0

23. A dual-media rapid sand filter plant is to be constructed for treatment of 72 million litres of water per day. A pilot plant study indicated that a filtration rate of 15m/h would be acceptable. Allowing one unit out of service for backwashing, how many 5m × 8 m filter units will be required? Determine the net production in million litres per day of each filter unit if backwashing is done at 36 m/h for 20 minutes and the water is wasted for the first 10 minutes of each filter run. (5)

24. The minimum flow of a river is 50m^3/s having a dissolved oxygen (DO) content of 7.0 mg/L (80% saturation) and BOD_5 of 8.0 mg/L. It receives a waste water discharge of 5m^3/s with BOD_5 of 200 mg/L and no DO. If the rate constants for deoxygenation and reaeration (both base e) are 0.5/d and 1.0/d, respectively and the velocity of river flow is 0.8 m/s, calculate the distance in kilometre downstream from the point of waste water discharge where the minimum DO occurs. (5)

25. An activated sludge aeration tank (length 30.0m; width 14.0m; effective liquid depth 4.3 m) has the following parameters:

flow 0.0796 m3, soluble BOD_5 after primary settling 130 mg/L; mixed liquor suspended solids (MLSS) 2100 mg/L; mixed liquor volatile suspended solids (MLVSS) 1500 mg/L; 30 minute settled sludge volume 230 mL/L; and return sludge concentration 9100 mg/L. Determine the aeration period, food to micro-organsims (F.M) ratio, sludge volume index (SVI), and return sludge rate. (5)

26. There is a horizontal curve of radius 360 m and length 180m. Calculate the clearance required from the central line on the inner side of the curve, so as to provide an overtaking sight distance of 250 m. (5)

27. The width of expansion joint gap is 2.5 cm in a cement concrete 20 cm thick pavement. If the laying temperature is 15° C and the maximum slab temperature in the summer is 55° C, calculate

(i) the spacing between expansion joints, and

(ii) the spacing between contraction joints.

Coefficient of thermal expansion for concrete is 10×10^{-6} per degree centigrade. Ultimate stress in tension in cement concrete is 1.6×10^5 N/m^2. Ultimate tensile stress in steel is 1200× 10 N/m^2. Factor of safety is to be taken as 2. Assume the pavement width to be 3.5 m. Unit weight of steel is 75,000 N/m^3. Total reinforcement of 6kg/m^2 is provided in the slab. (5)

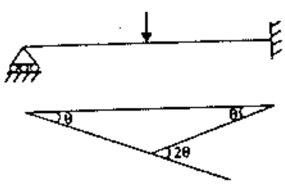
ANSWERS

1.1.(b)	1.2. (a)	1.3.(d)	1.4.(b)	1.5.(a)	1.6.(d)	1.7.(b)	1.8.(b)	1.9. (a)	1.10.(a)
1.11.(b)	1.12. (c)	1.13.(d)	1.14.(c)	1.15.(b)	1.16.(a)	1.17.(b)	1.18.(*)	1.19. (b)	1.20.(b)
1.21.(d)	1.22. (c)	1.23.(b)	1.24.(d)	1.25.(b)	1.26.(d)	1.27.(c)	1.28.(a)	1.29. (c)	1.30.(c)
1.31.(c)	2.1.(a)	2.2.(a)	2.3.(d)	2.4.(c)	2.5.(d)	2.6.(c)	2.7.(a)	2.8.(d)	2.9.(c)
2.10.(a)	2.11. (a)	2.12.(d)	2.13.(b)	2.14.(b)	2.15.(c)	2.16.(d)	2.17.(d)	2.18. (d)	2.19.(c)
2.20.(b)	2.21. (d)	2.22.(*)							

EXPLANATIONS

1.7. Values of horizontal and vertical components of reaction at A are equal at $\theta = 45°$. Since the vertical and horizontal components are given by $\sin\theta$ and $\cos\theta$ respectively, and $\sin\theta = \cos\theta$ at 45°, therefore the components are equal.

1.8. For kinematic equilibirium,



$$\frac{PL\theta}{2} = M_0 . \theta + M_0 (2\theta)$$

or $$P = \frac{6M_0}{L}$$

1.9 Maximum permissible deflection as per I.S code 800, 1984 for overhead travelling and electically operated crane up to capacity of 500 kN is given by

$$\frac{\text{span}}{750} = \frac{6 \times 1000}{750}$$

$= 8$ mm.

1.10. For isolated T-beam, $b_f = \frac{l_0}{(l_0 / b) + 4} + b_w$

where $l_0 = 6m$, $b = 1000$ mm

and $b_w = 300$ mm

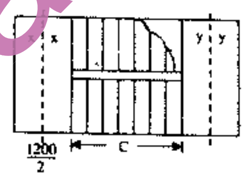
$$\therefore \quad b_f = \frac{6 \times 1000}{(6000 / 1000) + 4}$$

$= 300 = 900$ mm

1.11. $$x = \frac{1200}{2} = 600 \text{ mm.}$$

$$c = 3000 \text{ mm,}$$

$$y = \frac{1200}{2} = 1100$$



If $x < 1000$ mm and $y \geq 1000$ mm, then effective span of stair case slab

$= (x + c + 1000)$ mm

$= (600 + 3000 + 1000) = 4600$ mm

1.14. The stress strain curves for dense and loose sands are similar in shape to the stress-strain curve for overconsolidated and normally consolidated clays.

1.16. $$\frac{S_f}{S_p} = \frac{B_f}{B_p}$$

where, S_f = settlement of foundation

S_p = settlement of plate

B_f = width of foundation

B_p = width of place

$$\therefore \quad S_{(prototype)} = S_{(plate)} \times \left(\frac{B_{prototype}}{B_{plate}}\right)$$

1.17. Head loss per unit length is independent of sewer running full or half full condition.

2.1. The sum of the series will never tend to zero as n tends to infinity.