GATE-1997

CIVIL ENGINEERING

Duration : Three hours

Maximum marks : 150

SECTION A. (100 Marks)

1. For each subquestion given below, for answers viz A, B, C and D are provided, out of which only one is correct. Choose the correct answer from A, B, C or D

(10 × 1 = 10)

1.1. For the differential equation,

$$f(x,y)\frac{dy}{dx} + g(x,y) = 0 \text{ to be exact,}$$

(*a*) $\frac{\partial f}{\partial y} = \frac{\partial g}{\partial x}$ (*b*) $\frac{\partial f}{\partial x} = \frac{\partial g}{\partial y}$

(*c*) $f = g$ (*d*) $\frac{\partial^2 f}{\partial x^2} = \frac{\partial^2 g}{\partial y^2}$

1.2. The differential equation $\frac{dy}{dx} + Py = Q$, is a linear equation of first order only if

(*a*) P is a constant but Q is a function of y

(*b*) P and Q are functions of y or constants

(*c*) P is a function of y but Q is a constant

(*d*) P and Q are functions of x or constants

1.3. For real values of x, cos (x) can be written in one of the forms of a convergent series given below :

(*a*) $\cos(x) = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} \ldots\infty$

(*b*) $\cos(x) = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^5}{5!} \ldots\infty$

(*c*) $\cos(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} + \frac{x^7}{7!} \ldots\infty$

(*d*) $\cos(x) = x - \frac{x^2}{1!} + \frac{x^2}{2!} - \frac{x^3}{3!} \ldots\infty$

1.4. If A and B are two matrices and if AB exists, then BA exists

(*a*) only if A has as many rows as B has columns

(*b*) only if both A and B are square matrices

(*c*) only if A and B are skew matrices

(*d*) only if both A and B are symmetric

1.5. If the determinant of matrix $\begin{bmatrix} 1 & 3 & 2 \\ 0 & 5 & -6 \\ 2 & 7 & 8 \end{bmatrix}$ is 26, then the determinant of the matrix $\begin{bmatrix} 2 & 7 & 8 \\ 0 & 5 & -6 \\ 1 & 3 & 2 \end{bmatrix}$ is

(*a*) – 26 (*b*) 26

(*c*) 0 (*d*) 52

1.6. Inverse of matrix $\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$ is

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

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

1.7. Area bounded by the curve $y = x^2$ and lines $x = 4$ and $y = 0$ is given by

(*a*) 64 (*b*) $\frac{64}{3}$

(*c*) $\frac{128}{3}$ (*d*) $\frac{128}{4}$

1.8. The curve given by the equation $x^2 + y^2 = 3axy$, is

(*a*) symmetrical about x – axis

(*b*) symmetrical about y – axis

(*c*) symmetrical about line y = x

(*d*) tangential to x = y = a/3

1.9. e^x is periodic, with a period of

(*a*) 2π (*b*) $2i\pi$

(*c*) π (*d*) $i\pi$

1.10. $\underset{\theta\to 0}{\text{Lt}} \frac{\sin m\theta}{\theta}$, where m is an integer, is one of the following :

(*a*) m (*b*) $m\pi$

(*c*) $m\theta$ (*d*) 1

2. For each subquestion given below, four answer viz: A, B, C and D are provided, out of which only one is correct.

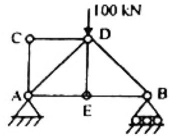
2.1. The force in the member DE of the truss shown in the figure is

(a) 100.0 kN

(b) zero

(c) 35.5 kN

(d) 25.0 kN



2.2. A propped cantilever beam of span L, is loaded with uniformly distributed load of intensity w/unit length, all through the span. Bending moment at the fixed end is

(a) $\frac{wL^2}{8}$ (b) $\frac{wL^2}{2}$

(c) $\frac{wL^2}{12}$ (d) $\frac{wL^2}{24}$

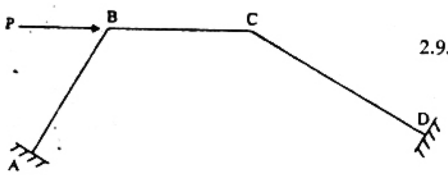
2.3. The degree of kinematic inderminacy of the rigid frame with clamped ends at A and D shown in the Figure 2.3. is,

(a) 4

(b) 3

(c) 2

(d) zero



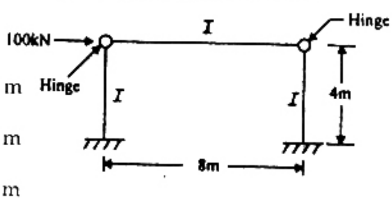
2.4. For the frame shown in the Figure 2.4, the maximum bending moment in the column is

(a) zero

(b) 400 kN m

(c) 100 kN m

(d) 200 kN m



2.5. The order or the flexibility matrix for a structure is

(a) equal to the number of redundant forces

(b) more than the number of redundant forces

(c) less than the number of redundent forces

(d) equal ot the number of redundant forces plus three

2.6. A cantilever beam of span 'L' is loaded with a concentrated load 'P' at the free end. Deflection of the beam at the free end is

(a) $\frac{PL^3}{48\ EI}$ (b) $\frac{5\ PL^3}{384\ EI}$

(c) $\frac{PL^3}{3\ EI}$ (d) $\frac{PL^3}{6\ EI}$

2.7. The cylinder strength of the concrete is less than the cube strength because of

(a) the difference in the shape of the cross section of the specimens

(b) the difference in the slenderness ratio of the specimens

(c) the friction between the concrete specimens and the steel plate of the testing machine

(d) the cubes are tested without capping but the cylinders are tested with capping

2.8. IS 459 - 1978 recommends to provide certain minimum steel in a RCC beam

(a) to ensure compression failure

(b) to avoid rupture of steel in case a flexural failure occurs

(c) to hold the stirrup steel in position

(d) to provide enough ductility to the beam

2.9. The permissible bending tensile stress in concrete for the vertical wall of an R.C. water tank made of M 25 concrete is

(a) 8.5 N/mm^2 (b) 6.0 N/mm^2

(c) 2.5 N/mm^2 (d) 1.8 N/mm^2

2.10. Permissible bending tensile stress in high yield strength deformed bars of grade 415 N/mm^2 in a beam is

(a) 190 N/mm^2 (b) 230 N/mm^2

(c) 140 N/mm^2 (d) None of the above

2.11. A prestressed concrete rectangular beam of size 300 mm × 900 mm is prestressed with an intial prestressing force of 700 kN at an eccentricity of 350 mm at midspan. Stress at top of the due to prestress alone, in N/mm^2 is

(a) – 3.46 (tension) (b) 2.59 (compression)

(c) zero (d) 8.64 (compression)

2.12. Maximum size of a fillet weld for a plate of square edge is

(a) 1.5 mm less than the thickness of the plate

(b) one half of the thickness of the plate

(c) thickness of the plate itself

(d) 1.5 mm more than the thickness of the plate

2.13. Factor of safety adopted by IS : 800 – 1984 while arriving at the permissible stress in axial compression is

(*a*) 2.00 (*b*) 1.00

(*c*) 1.67 (*d*) 1.50

2.14. Effective length of a rafter member between two nodes at a distance L, perpendicular to the plane of the truss is

(*a*) 2.00 L (*b*) 0.85

(*c*) 1.50 (*d*) 1.00 L

2.15. Allowable average shear stress in an unstiffened web for beams made of steel of grade 250 N/mm^2 is

(*a*) 250 N/mm^2 (*b*) 165 N/mm^2

(*c*) 150 N/mm^2 (*d*) 100 N/mm^2

3. For each subquestion given below, four answers viz : A, B, C and D are provided, out of which only one is correct.

(15 × 1 = 15)

3.1. If the porosity of a soil sample is 20%, the void ratio is

(*a*) 0.20 (*b*) 0.80

(*c*) 1.00 (*d*) 0.25

3.2. The shape of clay particle is usually

(*a*) angular (*b*) flaky

(*c*) tubular (*d*) rounded

3.3. Consistency Index for a clayer soil is [LL = Liquid Limit, PL = Plastic Limit, PI = Plasticity Index, W = natural moisture content]

(*a*) $\dfrac{LL - w}{PI}$ (*b*) $\dfrac{w - PL}{PI}$

(*c*) LL – PL (*d*) 0.5 w

3.4. According to Darcy's law for flow through porous media, the velocity is proportional to

(*a*) effective stress (*b*) hydraulic gradient

(*c*) cohesion (*d*) stability number

3.5. A soil mass has coefficients of horizontal and vertical permeability as 9×10^{-7}cm/s and 4×10^{-7}cm/s, respectively. The transformed coefficient of permeability of an equivalent isotropic soil mass is

(*a*) 9×10^{-7}cm/s (*b*) 4×10^{-7}cm/s

(*c*) 13×10^{-7}cm/s (*d*) 6×10^{-7}cm/s

3.6. In a compaction test, as the compaction effort is increased, the optimum moisture content

(*a*) decreases

(*b*) remains same

(*c*) increases

(*d*) increases first there after decreases

3.7. The vertical stress at depth. z directly below the point load p is (k is a constant)

(*a*) $k\dfrac{p}{z}$ (*b*) $k\dfrac{p}{z^3}$

(*c*) $k\dfrac{p}{z^2}$ (*d*) $k\dfrac{p}{\sqrt{z}}$

3.8. The slope of the e - log p curve for a soil mass gives

(*a*) coefficient of permeability, k

(*b*) coefficient of consolidation C_v

(*c*) compression index, C_c

(*d*) coefficient of volume compressibility, m_v

3.9. Sand and drains are used to

(*a*) reduce the settlement

(*b*) accelerate the consolidation

(*c*) increase the permeability

(*d*) transfer the load

3.10. Coulomb's theory of earth pressure is based on

(*a*) the theory of elasticity

(*b*) the therory of plasticity

(*c*) empirical rules

(*d*) wedge theory

3.11. The depth of tension crack in a soft clay ($\phi_u = 0$) is

(*a*) $\dfrac{4C_u}{\gamma}$ (*b*) $\dfrac{2C_u}{\gamma}$

(*c*) $\dfrac{C_u}{\gamma}$ (*d*) $\dfrac{C_u}{2\gamma}$

3.12. Vane tester is normally used for determining in situ shear strength of

(*a*) soflt clays (*b*) sand

(*c*) stiff clays (*d*) gravel

3.13. The unit for coefficient of subgrade modulus is

(*a*) kN/m^3 (*b*) ku/m^2

(*c*) ku/m (*d*) ku/m

3.14. The ratio of unconfined compressive strength of an undisturbed sample of soil to that of a remoulded sample, at the same water content, is known as

(*a*) activity (*b*) damping

(*c*) plasticity (*d*) sensitivity

3.15. Well foundation are commonly used as foundation for the following structures :

(*a*) Water tanks

(*b*) Bridges

(*c*) Buildings

(*d*) Reciprocating machines

4. For each subquestion given below, four answers viz : A, B, C and D are provided, out of which only is correct.

(15 × 1 = 15)

4.1. The unit of dynamic viscosity of a fluid is

(*a*) m^2/s (*b*) Ns/m^2

(*c*) $Pa\ s/m^2$ (*d*) $kg\ s^2/m^2$

4.2. The centre of pressure of a liquid on a plane surface immersed vertically in a static body of liquid, always lies below the centroid of the surface area, because

(*a*) in liquids the pressure acting is same in all directions

(*b*) there is no shear stress in liquids at rest

(*c*) the liquid pressure is constant over depth

(*d*) the liquid pressure increasses linearly with depth

4.3. One of the following statements is true with regards to bodies that float or are submerged in liquids:

(*a*) For a body wholly submerged in a liquid the stability is ensured if the centre of buoyancy is below the centre of gravity of the body

(*b*) For a body floating in a liquid the stability is ensured if the centre of buoyancy is below the centre of gravity of the body

(*c*) For a body floating in a liquid the stability is ensured if the centre of buoyany and the centre of gravity, regardless of the relative positions of the centre of buoancy and gravity

(*d*) For a body floating in a liquid the stability is ensured if the centre of buoyancy is below the centre of gravity and the metacentre is above both the centres of gravity and buoyancy.

4.4. The kinetic energy correction factor for a fully developed laminar flow through a circular pipe is

(*a*) 1.00 (*b*) 1.33

(*c*) 2.00 (*d*) 1.50

4.5. Two flow patterns are represented by their stream functions ψ_1 and ψ_2 as given below :

$$\psi_1 = x^2 + y^2, \quad \psi_2 = 2xy$$

If these two parterns are superposed on one another, the resulting streamline pattern can be represented by one of the following:

(*a*) A family of parallel straight lines

(*b*) A family of circles

(*c*) A family of parabolas

(*d*) A family of hyperbolas

4.6. While deriving an expression for loss of head due to a sudden expansion in a pipe, in addition to the continuity and impulse - momentum equations, one of the following assumptions is made :

(*a*) Head loss due to friction is equal to the head loss in eddying motion

(*b*) The mean pressure in eddying fluid is equal to the downstream pressure

(*c*) The mean pressure in eddying fluids is equal to the upstream pressure

(*d*) Head lost in eddies is neglected

4.7. If a single pipe of length L and diameter D is to be replaced by three pipes of same material, same length and equal diameter d (d< D), to convey the same total discharge under the same head loss, then d and D are related by

(*a*) $d = \frac{D}{3^{2/5}}$ (*b*) $d = \frac{D}{2^{5/3}}$

(*c*) $d = \frac{D}{3^{2/3}}$ (*d*) $d = \frac{D}{2^{3/2}}$

4.8. The downstream end of long prismatic channel of mild slope ends in a pool created by a dam. The resulting non-uniform water surface profile can be described as one of the following.

(*a*) M_3 profile ending in a hydraulic pump

(*b*) M_1 profile that les above normal depth line

(*c*) M_2 profile that lies between critical and normal depth lines.

(*d*) M_3 profile that lies between critical and normal depth lines.

4.9. A hydraulic turbine develops a power on 10^4 metric horse power while running at a speed of 100 revolutions per minute, under a head of 40 m. Its specific speed is nearst to one of the following:

(*a*) 100 (*b*) 628

(*c*) 523 (*d*) 314

4.10. A hyetograph is a graph representing
(*a*) rainfall volume with time
(*b*) rainfall intensity with time
(*c*) rainfall intensity with duration
(*d*) rainfall intensity over an area

4.11. Mukingham method for routing of flood
(*a*) is used for routing floods through reservoirs
(*b*) is a method of routing that uses continuity and momentun equations
(*c*) is a hydrologic method of routing floods through streams
(*d*) is one is which only energy equation is used

4.12. Both Reynolds and Froude numbers assume significance in one of following examples :
(*a*) Motion of submarine at large depths
(*b*) Motion of ship in deep seas
(*c*) Cruising of a misssile in air
(*d*) Flow over spillways

4.13. For a 'best' symmetrical trapezoidal section of an open channel with a given area of section and side slopes, one of the following statements holds true:
(*a*) Half the top width is equal to one of the side slope
(*b*) Half the top width plus the bottom width is equal to both the side slopes put together
(*c*) Water depth is equal to half bottom width
(*d*) Hydraulic mean depth is equal to half the top width

4.14. Storage coefficient of a compressible confined aquifer is a function of
(*a*) specific weight of water, thickness of the aquifer, compressibility of the aquifer and that of water.
(*b*) permeability, thickness and compressibility of aquifer and compressibility of water
(*c*) transmissibility of the auifer and compressibility of water
(*d*) transmissibility of aquifer and specific yield of aquifer

4.15. Lysimeter and Tensiometer are used to measure respectively, one of the following groups of quantities :
(*a*) Capillary potential and permeability
(*b*) Evapotranspiration and capillary potential
(*c*) Velocity in channels and vapour pressure
(*d*) Velocity in pipes and pressure head

5. For each subquestion given below, four answers viz : A, B, C and D are provided, out of which only one is correct, (10 × 1 = 10)

5.1. Flocculation is a process
(*a*) that removes algae from stabilization pond effluent
(*b*) that promotes the aggregation of small particles into larger particles to enchance their removal by gravity

5.2. Pathogens are usually removed by
(*a*) chemical precipitation
(*b*) sedimentation
(*c*) activated sludge process
(*d*) chlorination

5.3. The 'sag' in the dissolved oxygen curve results because
(*a*) it is a function of the rate of addition of oxygen to the stream
(*b*) it is a function of the rate of depletion of oxygen from the stream
(*c*) it is a function of both addition and depletion of oxygen from the stream
(*d*) the rate of addition is linear but the rate of depletion is non-linear.

5.4. Design parameters for rapid mixing units are
(*a*) velocity gradient and the volume of mixing basin
(*b*) viscosity and velocity gradient
(*c*) viscosity, velocity gradient and the volume of the mixing basin
(*d*) detention time and viscosity of water.

5.5. The absorbent most commonly used in water and waste treatment is
(*a*) Sand of grain size from 0.1 to 2 mm
(*b*) Activated carbon granules of size 0.1 to 2 mm
(*c*) Ordinary wood shavings of fine size
(*d*) Coal-tar.

5.6. Among the following disinfectants of waste water, the one that is most commonly used is
(*a*) Chlorine dioxide (*b*) Chlorine
(*c*) Ozone (*d*) UV-radiation.

SECTION B (50 Marks)

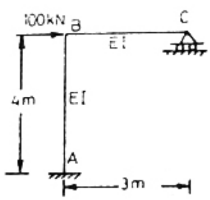
Answer any TEN question from this Section. All question carry equal marks.

(5 × 10 = 50)

12. Find the co-ordinates of the centroid of a plane lamina of the quadrant of an ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ if the density at any point (x, y) is given Kxy, where k is a constant, using double intergration. (5)

13. Find the limiting value of the ratio of the square of the sum of n natural numbers to n times the sum of squares of the n natural number as, n approaches infinity. (5)

14. Analyse the frame shown in figure by the method of moment distribution. Draw the bending moment diagram on the tension side of the members. (5)



15. A two-hinged parabolic arch of span 100 m and rise 20 m carries a central concentrated load of 100 kN. The moment of inertia of any section is I_c sec θ, where θ is the slope at the section and I_c is the moment of inertia at the crown. Compute the reactions at support by the strain energy method and draw the bending moment diagram. Neglect the effect of ribshortening.

16. A hall is covered by a beam and slab system with beams placed at 3.0 m centres. The effective span of the beam is 8.35 m. The thickness of the slab is 120 mm. The size of the beam below the slab is 230 mm width and 380 mm depth. The beam is reinforced with two numbers of 32 mm diameter steel rods of grade 415 N/mm². Compute the maximum total load/m run, the beam can carry, including its own weight at service stage. Grade of concrete is M 25. (5)

17. (a) A simply supported beam of a beam and slab system, rests on a support of width 450 mm. The clear span of the beam is 10.0 m. The thickness of the slab is 120 mm. The depth of the beam below the slab is 480 mm and the width of the beam is 250 mm. The beam is reinforced with one row of 32 mm diameter steel rods. The total load including the super imposed dead load, live load and its own weight is 25.0 kN/m at service stage. Compute the maximum nominal design shear stress in the concrete. (3)

(b) Design a square R. C column to resist an axial load of 400 kN due to dead load and 240 kN due to live load at service stage. Design the section as a short axially loaded column. Use M 25 concrete and steel of grade 415 N/mm². Give a neat sketch of the cross section. (2)

18. A compound steel column consisting of 2 ISHB 400 placed at 320 mm centres, carries a total axial load of 2500 kN. Minimum slenderness ratio of the compound column is 30. Width of the flange of one ISHB section is 250 mm and its minimum radius of gyration is 51.6 mm. Design a suitable single flat lacing. 20 mm diameter single rivet is used to connect the lacings to the column. Rivet capacity need not be calculated. The following table may be used.

Slenderness ratio	Premissible compressive Stress N/mm²
100	80
110	71
120	64
130	57
140	51
150	45

19. A settlement analysis carried out for a proposed structure indicates that 9 cm of settlement will occur in 5 years and the final settlement will occur in 5 years and the final settlement will be 45 cm bases on double drainage condition. A detailed site investigation indicates that only single drainage exists. Estimate the settlement at the end of 5 years for the changes condition. Use $T = \frac{\pi}{4} U^2$. (5)

20. Two identical soil specimen were tested in a triaxial apparatus. First specimen failed at a deviator stress of 770 kN/m^2 when the cell pressure was 200 kN/m^2. Second specimen failed at a deviator stress of 1370 kN/m^2 under a cell pressure of 400 kN/m^2. Determine the value of 'C' and 'ϕ' analytically. If the same soil is tested in a direct shear apparatus with a normal stress of 600 kN/m^2, estimate the shear stress at failure. (5)

21. Using Terzaghi throry, determine the ultimate bearing capacity of a strip footing 1.5 m wide resting on a saturated clay ($C_u = 30$ kN/m^2, $\phi_u = 0$ and $\gamma_{sat} = 20$ kN/m^3), at a depth of 2 m below ground level. The water table is also at a depth of 2 m from the ground level. If the water table rises by 1m, calculate the percentage reduction in the ultimate bearing capacity.

22. An anchored sheet pile wall is to retain soil to a height of 5.5 m. The soil including that into which the pile is driven, is cohesionless with $\phi = 30°$ and $\gamma_b = 20.8$ kN/m^3. The surface of the retained soil is horizontal and level with the top of the wall. Tie rodes are fixed at 1.83 m below the top of the wall. Determine the minimum penetration depth of the pile to achieve free earth support conditions. (5)

23. A hydraulic jump occurs in a wide, rectangular channel with initial and sequent depths of 0.5 m and 2.0 m respectively. Calculate

(a) the discharge in m^3/s per metre width

(b) the possible critical depth for this discharge

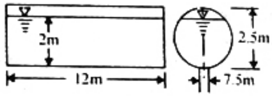
(c) the energy loss in the jump, (in metres head) and

(d) sketch the critical depth line on the jump profile (5)

24. Measured infiltration rates, *f*, in cm/hour, for every hour from t = 0, when the rainfall just commenced to t = 8 hours, are given in the table below. The rainfall lasts over 8 hours. Calculate the total infiltration quantity during 8 hours using HORTON constant of $k = 4$ (day^{-1}). (5)

Time (hours)	*f*(cm. hour)
0	2.00
1	1.10
2	0.75
3	0.65
4	0.55
5	0.50
6	0.50
7	0.50

25. A cylindrical tank 2.5 m diameter and 12 m long is installed with its axis horizontal. It holds water up to a depth of 2 m. There is a circular opening of 7.5 cm in diameter at the bottom, which is kept plugged. If the plug is removed to drain the water completely, estimate how long does it take to completely drain the water. C_d for the opening is 0.6.



26. In a farmland irrigated by a system of pumps from wells, the area irrigated is 50 hectares. Water pumped from wells is conveyed through a canal to the farms. Efficiency of water conveyance is 85% and pumps work at 12 hours/day. Available moisture holding capacity of the soil is 20 cm per metre depth and the average root zone depth is 1m. Water application efficiency is 80%. Irrigation is started when moisture extraction level of 50% of available moisture is reached. Peak rate of moisture use by plants is 5 mm. Calculate the irrigation period in days and total pumping capacity required in litres/minute. (5)

27. A municipal waste water treatment plant is to work with average and peak loading rates of 4,000 and 8,000 m^3/day respectively. Design a primary clarifier to remove 65% suspended matter at average flow. An average overflow rate of $35m^3/m^2$ day is expected to correspond to 65% suspended matter removal efficiency. Obtain the diameter, side wall depth, detention time and calculate the overflow rate at peak condition.

28. Secondary effluent from a municipal waste plant is discharged into a stream at the rate of 12,000 m^3/day at 20°C with a BOD_5 of 50 mg/litre, a dissolved oxygen concentreation of 2 mg/litre. The stream flow is estimated to be 40,000 m^3/day, and the water quality, parameters in the stream upstream of the effluent outfall are :

BOD_5 of 3mg/litre, dissolved oxgyen 7 mg/litre at 20° C.

Assume a decay constant for the mixture to be K = 0.23 (to the base 'e' in the decay curve). Estimate.

(a) BOD of the mixture

(b) Ultimate BOD

(c) DO of the mixture

29. In order to test a filtration process, clear water is made to pass through a bed of uniform sand at a filtering velocity of 3.0 m/hour. Sand bed has the following properties:

Depth of bed	:	0.6 m
Sand grain size	:	0.5 mm
Sand grain size	:	2.65
Sand grain shape factor used to calculate filtration Reynolds number	:	$\phi = 0.80$
Porosity of sand bed	:	$e = 0.40$
Kinematic viscosity of water	:	$v = 1.0 \times 10^{-6} m^2/s$.

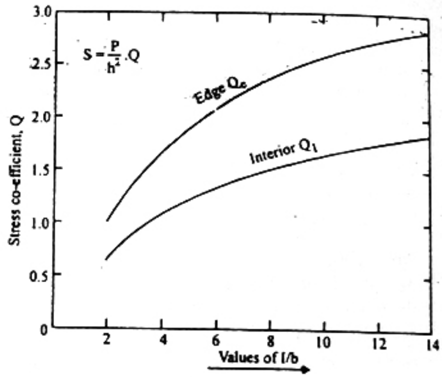
Calculate the lossof head in filtration (5)

30. Determine the extra width of pavement and the length of transition curve needed on a horizontal alignment of radius 225 m for a two-lane road, with a design speed of 80 kmph. Assume the wheel base of design vehicle as 6 m. (5)

31. Estimate the wheel load stress at interior and edge of cement concrete pavement of 231 cm thickness, using stress coefficient.

Modulus of elasticity of concrete	:	2×10^7 kN/m^2
Poission's ratio of concrete	:	0.15
Modulus of subgrade	:	3.6×10^4 kN/m^3
Wheel load	:	40.8 kN
Tyre pressure	:	600 kN/m^2

(5)



ANSWERS

1.1. (*a*)	1.2. (*c*)	1.3. (*d*)	1.4. (*a*)	1.5. (*a*)	1.6. (*a*)	1.7. (*b*)	1.8. (*d*)	1.9. (*a*)	1.10. (*c*)
2.1. (*b*)	2.2. (*a*)	2.3. (*b*)	2.4. (*b*)	2.5. (*a*)	2.6. (*c*)	2.7. (*b*)	2.8. (*b*)	2.9. (*d*)	2.10. (*b*)
2.11. (*a*)	2.12. (*a*)	2.13. (*c*)	2.14. (*b*)	2.15. (*d*)					
3.1. (*d*)	3.2. (*b*)	3.3. (*a*)	3.4. (*b*)	3.5. (*d*)	3.6. (*a*)	3.7. (*c*)	3.8. (*b*)	3.9. (*a*)	3.10. (*d*)
3.11. (*b*)	3.12. (*a*)	3.13. (*a*)	3.14. (*d*)	3.15. (*b*)					
4.1. (*b*)	4.2. (*d*)	4.3. (*d*)	4.4. (*c*)	4.5. (*b*)	4.6. (*c*)	4.7. (*a*)	4.8. (*d*)	4.9. (*a*)	4.10. (*b*)
4.11. (*b*)	4.12. (*d*)	4.13. (*a*)	4.14. (*d*)	4.15. (*b*)					
5.1. (*b*)	5.2. (*d*)	5.3. (*c*)	5.4. (*c*)	5.5. (*b*)	5.6. (*b*)	5.7. (*a*)	5.8. (*c*)	5.9. (*d*)	5.10. (*a*)
6.1. (*a*)	6.2. (*b*)	6.3. (*a*)	6.4. (*b*)	6.5. (*c*)	6.6. (*a*)	6.7. (*d*)	6.8. (*a*)	6.9. (*a*)	6.10. (*b*)