Question Paper 2016

Civil Engineering

(Paper II)

1. (*a*) A town on the bank of river Ganga discharges 18000 m^3/day of treated wastewater into the river. The treated wastewater has a BOD_5 of 20 mg/L, and a BOD decay constant of 0.12 day^{-1} at 20°C. The river has a flow rate of 0.43 m^3/sec and an ultimate BOD of 5.0 mg/L. The DO of the river is 6.0 mg/L and the DO of the wastewater is 0.4 mg/L. Compute the DO and initial ultimate BOD in the river, immediately after mixing. (15)

(*b*) A sample of normally consolidated clay was subjected to a consolidated undrained triaxial compression test that was carried out until the specimen failed at a deviator stress of 50 kN/m^2. The pore water pressure at failure was recorded to be 20 kN/m^2 and confining pressure of 50 kN/m^2 was used in the test. Determine the consolidated undrained friction angle. (15)

(*c*) Using Lacey's theory, design an irrigation channel carrying 30 m^3/sec. Take silt factor as 1.0. (15)

(*d*) Discuss the various causes of disintegration and the major faults occurring in WBM and surface treated (asphalt roads) in India. (15)

2. (*a*) Differentiate between the following with reference to bituminous construction: (15)

(*i*) Prime coat and Tack coat

(*ii*) Bituminous concrete and Bituminous macadam.

(*b*) A road is to be constructed with a uniform rising gradient of 1 in 100. Determine the staff readings required for setting the tops of the two pegs on the given gradient at 30 meters interval from the last position of the instrument. The RL of the first peg is 384.500 m. A fly levelling was carried out from a BM of RL 387.000 m. The following observations (in m) were recorded: (15)

Backsight :	1.625	2.345	2.045	2.955
Foresight :	1.315	3.560	2.355	

(*c*) What are the errors induced in theodolite survey? (15)

(*d*) A solid shaft transmits 250 kW at 100 r.p.m. If the shear stress is not to exceed 75 N/mm^2, what should be the diameter of the shaft ?

If this shaft is to be replaced by a hollow shaft whose internal diameter shall be 0.6 times the outer diameter, determine the size and percentage saving in weight maximum stresses being the same. (15)

3. (*a*) Design a circular column with helical reinforcement subjected to a working load of 1500 kN. Diameter of the column is 450 mm. The column has unsupported length of 3.5 m and is effectively held is position at both ends but not restrained against rotation. Use limit state design method. Use M-25 concrete and HYSD Fe-415 steel. (25)

(*b*) Design a constant thickness footing for a reinforced concrete column of 300 mm × 300 mm. The column is carrying an axial working load of 600 kN. The bearing capacity of soil is 200 kN/m^2. Use M-25 concrete and HYSD Fe-415 bars. Use limit state design method. (15)

100 (A_{st}/bd)	0.15	0.25	0.50	0.75	1.0
τ_c (N/mm^2)	0.19	0.36	0.49	0.57	0.64

(*c*) State and discuss different factors influencing compaction of soil in the field. (20)

4. (*a*) Classify the solid wastes, giving suitable example for each of them. Also explain the different methods of disposal of solid wastes. (15)

(*b*) Estimate for 1 : 20 model of a spillway (*i*) prototype velocity corresponding to a model velocity of 2 m/sec, (*ii*) prototype discharge per unit width corresponding to a model discharge per unit width of 0.3 m^3/sec/m, (*iii*) pressure head in the prototype corresponding to a model head of 5 cm of mercury at a point, and (*iv*) the energy dissipated per second in the model corresponding to a prototype value of 1.5 kW. (15)

(*c*) A centrifugal pump having an impeller of 35 cm outside diameter rotates at 1050 r.p.m. The vanes are radial at exit and are 7.0 cm wide. The velocity of radial flow through the impeller is 3 m/sec. The velocity in the suction and delivery pipes are 2.5 m/sec and 1.5 m/sec respectively. Neglecting frictional losses, determine the height through which the pump lifts and the horse-power of the pump. (15)

(*d*) Name the four important constituents of cement and also state the role of each in achieving its properties. (15)

5. (*a*) A retaining wall with a smooth vertical back is 9 m high and retains a two-layer sand backfill with the following properties:

0 – 3 m depth : $c' = 0.0$, $\varphi = 30°$, $\gamma = 18$ kN/m^3

3 – 9 m depth : $c' = 0.0$ $\varphi = 35°$, $\gamma = 20$ kN/m^3.

Show the active earth pressure distribution and determine the total active thrust on the wall. Assume that the water table is well below the base of the wall. (20)

(*b*) A layer of sand 6.0 m thick lies above a layer of clay soil. The water table is at a depth of 2.0 m below the ground surface. The void ratio of the sand layer is 0.6 and the degree of saturation of the sand layer above the water table is 40%. The void ratio of the clay layer is 0.7. Determine the total stress, neutral stress and effective stress at a point 10 m below the ground surface. Assume specific gravity of the sand and clay soil respectively as 2.65 and 2.7. (20)

(*c*) What is grit? Why should grit be removed from wastewater? What is the basic principle behind the design of grit chambers? What is the reason to have constant velocity of flow in a grit chamber (conventional horizontal flow) and how is it achieved? (20)

6. (*a*) Design riveted splices for a tie of a steel bridge, 20 cm wide, 20 mm thick, carrying an axial tensile force of 50,000 kg. Use 12 mm thick cover plates and 22 mm diameter rivets.

Permissible stresses :

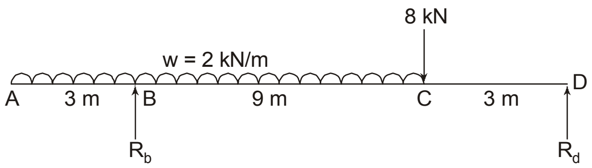
Tension in plates = 1500 kg/cm^2

Shear in rivets = 1000 kg/cm^2

Bearing in rivets = 3000 kg/cm^2

Give a neat sketch of the arrangement. (25)

(*b*) Draw BMD and SFD for the beam shown below: (25)



6. (*c*) Enumerate the situation in which doubly reinforced concrete beams become necessary. What is the role of compression steel? (10)

Essential Table of IS 456 : 2000 Code of Practice IS 456 : 2000

25. 2. 1.1 Design bond stress in limit state method for plain bars in tension shall be as below

Grade of concrete	M 20	M 25	M 30	M 35	M 40 and above
Design bond stress, τ_{bd}, *N/mm²*	1.2	1.4	1.5	1.7	1.9

Table 16. Nominal Cover to Meet Durability Requirements (*Clause 26.4.2*)

Exposure	*Nominal Concrete Cover in mm Not Less Than*
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

Notes :

1. For main reinforement up to 12 mm diameter bar for mild exposure, the nominal cover may be reduced by 5 mm.
2. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by $^{+10}_{0}$ mm.
3. For exposure condition 'severe' and 'very severe', reduction of 5 mm may be made, where concrete grade is *M* 35 and above

Table 19 : Design Shear Strength of Concrete, τ_c, N/mm²

(Clauses 40.2.1, 40.2.2, 40.4, 40.5.3, 41.3.2, 41.3.3 and 41.4.3)

$100\frac{A_s}{bd}$	Concrete Grade					
	M 15	**M 20**	**M 25**	**M 30**	**M 35**	**M 40 and above**
(1)	(2)	(3)	(4)	(5)	(6)	(7)
≤ 0.15	0.28	0.28	0.29	0.29	0.29	0.30
0.25	0.35	0.36	0.36	0.37	0.37	0.38
0.50	0.46	0.48	0.49	0.50	0.50	0.51
0.75	0.54	0.56	0.57	0.59	0.59	0.60
1.00	0.60	0.62	0.64	0.66	0.67	0.68
1.25	0.64	0.67	0.70	0.71	0.73	0.74
1.50	0.680.71	0.72	0.74	0.76	0.78	0.79
1.75	0.71	0.75	0.78	0.80	0.82	0.84
2.00	0.71	0.79	0.82	0.84	0.86	0.88
2.25	0.71	0.81	0.85	0.88	0.90	0.92
2.50	0.71	0.82	0.88	0.91	0.93	0.95
2.75	0.71	0.82	0.90	0.94	0.96	0.98
3.00 and above	0.71	0.82	0.92	0.96	0.99	1.01

Note : The term A_s is the area of longitudinal tension reinforcement which continues at least one effective depth beyond the section being considered except at support where the full area of tension reinforcement may be used provided the detailing conforms to 26.2.2 and 26.2.3.

Table 20 : Maximum Shear Stress, $\tau_{c\ max}$, N/mm²

(Clauses 40.2.3, 40.2.3.1, 40.5.1 and 41.3.1)

Concrete Grade	M 20	M 25	M 30	M 35	M 40 and above
$\tau_{c\ max}$, N/mm²	2.8	3.1	3.5	3.7	4.0

Table 21 : Permissible Stresses in Concrete

(Clauses B.1.3, B.2.1, B.2.1.2, B. 2. 3 and B-4.2)

All values in N/mm²

Grade of Concrete	Permissible Stress in Compression		Permissible Stress in Bond (Average) for plain Bars in Tension
	Bending	Direct	
(1)	(2)	(3)	(4)
	σ_{cbc}	σ_{cc}	τ_{bd}
M 10	3.0	2.5	–
M 15	5.0	4.0	0.6
M 20	7.0	5.0	0.8
M 25	8.5	6.0	0.9
M 30	10.0	8.0	1.0
M 35	11.5	9.0	1.1
M 40	13.0	10.0	1.2
M 45	14.5	11.0	1.3
M 50	16.0	12.0	1.4

Notes:

1. The values of permissible shear stress in concrete are given in Table 23.
2. The bond stress given in column 4 shall be increased by 25 percent for bars in compression.

Table 23 : Permissible Shear Stress in Concrete

(Clauses B.2.1, B.2.3, B-4.2, B-5.2.1, B.5.2.2, B.5.3, B-5.4, B-5.5.1, B-5.5.3, B-6.3.2, B-6.3.3 and B.6.4.3 and Table 21)

$100\frac{A_s}{bd}$	Permissible Shear Stress in Concrete, τ_c, N/mm^2 Grade of Concrete					
	M 15	M 20	M 25	M 30	M 35	M 40 and above
(1)	(2)	(3)	(4)	(5)	(6)	(7)
≤ 0.15	0.18	0.18	0.19	0.20	0.20	0.20
0.25	0.22	0.22	0.23	0.23	0.23	0.23
0.50	0.29	0.30	0.31	0.31	0.31	0.32
0.75	0.34	0.35	0.36	0.37	0.37	0.38
1.00	0.37	0.39	0.40	0.41	0.42	0.42
1.25	0.40	0.42	0.44	0.45	0.45	0.46
1.50	0.42	0.45	0.46	0.48	0.49	0.49
1.75	0.44	0.47	0.49	0.50	0.52	0.52
2.00	0.44	0.49	0.51	0.53	0.54	0.55
2.25	0.44	0.51	0.53	0.55	0.56	0.57
2.50	0.44	0.51	0.55	0.57	0.58	0.60
2.75	0.44	0.51	0.56	0.58	0.60	0.62
3.00 and above	0.44	0.51	0.57	0.60	0.62	0.63

Note: A_S is the area of longitudinal tension reinforcement which continues at least one effective depth beyond the section being considered excepts at support where the full area of tension reinforcement may be used provided the detailing conforms to 26.2.2 and 26.2.3.

Table 24: Maximum Shear Stress, $\tau_{c\,max}$, N/mm^2

(Clauses B.5.2.3, B.5.2. 3.1, B.5.5.1 and B.6.3.1)

Concrete Grade	M 15	M 20	M 25	M 30	M 35	M 40 and above
$\tau_{c\,max}$, N/mm^2	1.6	1.8	1.9	2.2	2.3	2.5