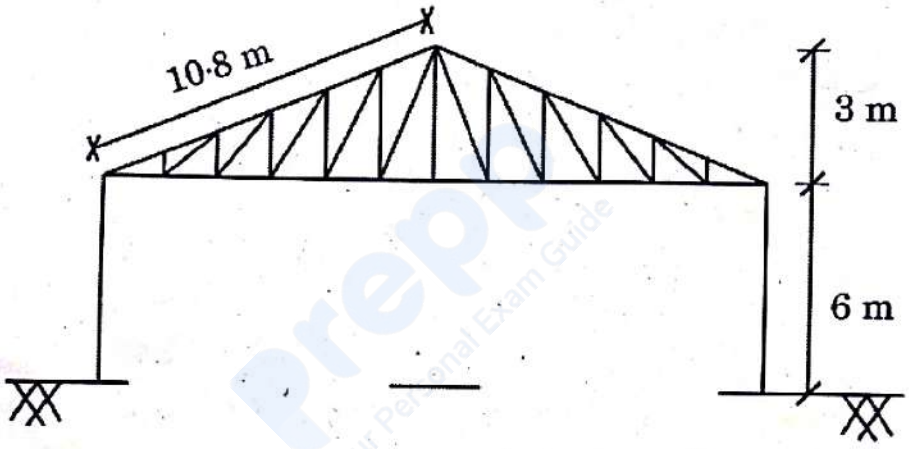
SECTION A

Q1. (a) (i) Describe how stones are preserved. 6

(ii) What are the advantages and disadvantages of fibre reinforced concrete ? 6

(b) A factory shed of size 40 m × 18 m is to be constructed at New Delhi with roof trusses. Calculate the nodal wind force on a roof truss of span 18 m and central rise of 3 m. The spacing of roof truss is 4 m, basic wind speed = 50 m/s, $K_1 = 1$, $K_2 = 0{\cdot}9$ (up to 10 m ht and category-II), $K_3 = 1$, $K_4 = 1$, $K_a = 0{\cdot}9$, $K_c = 0{\cdot}9$, $K_d = 0{\cdot}9$. For wind angle 0°, take Cpe = – 1·2 (windward side), Cpe = – 0·4 (leeward side). Assume wall opening is less than 5%. Purlins are located at the node points. Show the forces in a sketch of truss for wind angle 0° only. 12



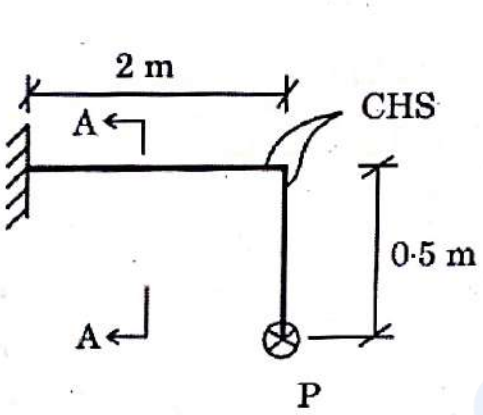
(c) A simply supported prestressed concrete beam of span 12 m and size 300 × 700 mm carries uniformly distributed load of 20 kN/m. Suggest a suitable cable profile and the prestressing force so that no tension is developed in the beam. Assume density of concrete to be 24 kN/m^3. Maximum eccentricity for the cable to be provided is 200 mm. 12

(d) A metallic rod 6·25 m long and 35 mm in diameter is subjected to an axial tensile load of 65 kN. Determine the change in dimension and volume of the rod. Assume modulus of elasticity of metal as $E = 2{\cdot}10 \times 10^5$ N/mm^2 and Poisson's ratio = 0·26. 12

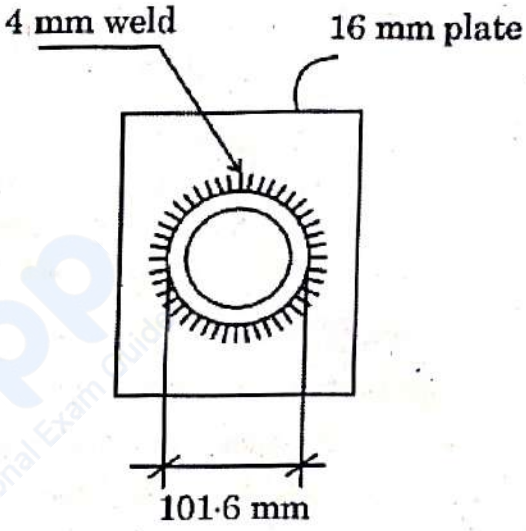
(e) (i) Explain the split tensile test of concrete. How is it related to compressive strength and flexure strength of concrete ? 6

(ii) What are the effects of air-entraining admixtures on the properties of concrete ? 6

Q2. (a) A circular hollow section of outside diameter 101·6 mm and thickness 4·05 mm is connected to a plate of thickness 16 mm as shown in the figure, by welding of weld size 4 mm. Determine the maximum load 'P' that can be applied for the weld. The hollow section is safe. Assume shop weld to be made. Apply limit state method. Assume E 250 grade of steel. Given $f_e = \sqrt{f_a + 3q^2}$. Assume partial load factor as 1·5. 20



PLAN

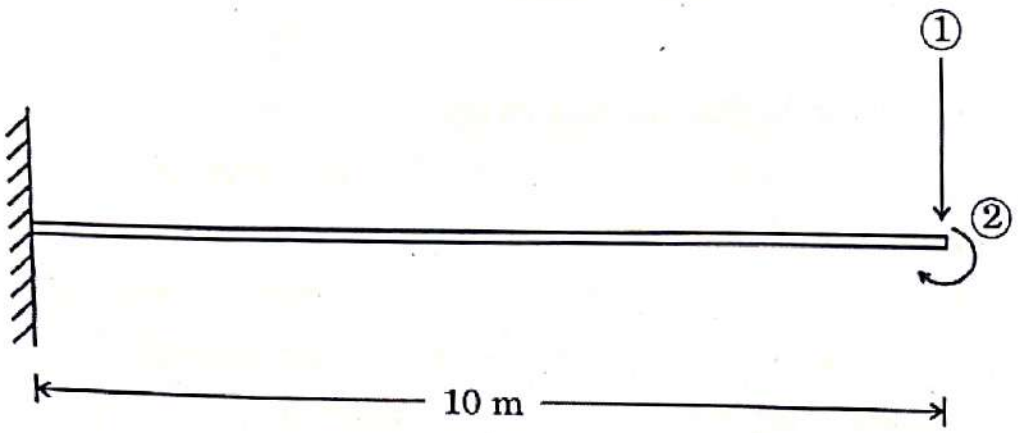


View A - A

(b) Discuss the mechanisms that are used to enhance the performance characteristics of the concrete. 20

(c) (i) Two rectangular plates, one of steel and another of brass, each 50 mm wide and 8 mm deep are placed together to form a beam 50 mm wide and 16 mm deep, on two supports (simply supported) 1 m apart, the brass plate being on the top. Determine the maximum load which can be applied at the centre of the beam, if the plates are separate and can bend independently. Maximum allowable stress in steel = 120 N/mm^2 and in brass = 80 N/mm^2. Take $E_s = 2 \times 10^5$ N/mm^2 and $E_b = 8 \times 10^4$ N/mm^2. 10

(ii) For the cantilever beam shown in the figure with the co-ordinates, obtain the stiffness matrix. Take EI to be constant. Hence, find the flexibility matrix using their relationship. *10*



Q3. (a) (i) What is quality management system in concrete construction ? *10*

(ii) What is cement grout ? How does it differ from cement mortar ? *10*

(b) Design a reinforced concrete isolated square footing for a column of size 500 mm × 500 mm subjected to an axial load of 1500 kN under dead and live load condition. The safe bearing capacity of the soil is 120 kN/m^2. Apply limit state method of design and use M25 and Fe500. Assume uniform thickness of footing as 600 mm. Nominal cover = 50 mm. No pedestal is to be provided. Given :

$\frac{100\ A_{st}}{b_d}$	≤ 0·15	0·25	0·50	0·75	1·00	1·25	1·50	1·75
τ_c N/mm^2	0·29	0·36	0·49	0·57	0·64	0·70	0·74	0·78

Use table 3 of SP – 16.

Show reinforcement details. The column is reinforced with 8 nos. of 20 ϕ bars.

20

f_y
240
250
415
480
500

f_{ck}
25

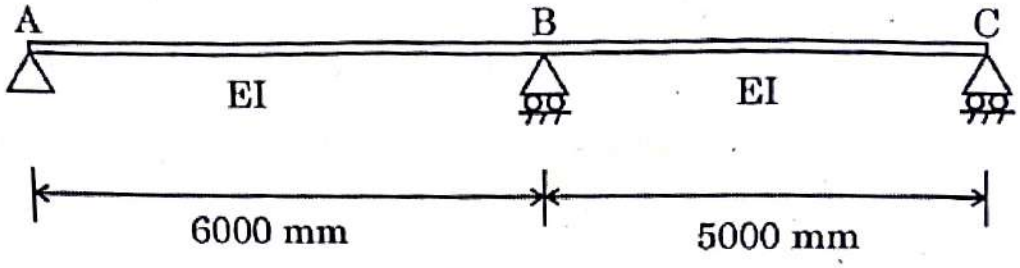
TABLE 3 FLEXURE — REINFORCEMENT PERCENTAGE, p_t FOR SINGLY REINFORCED SECTIONS

f_{ck} = 25 N/mm²

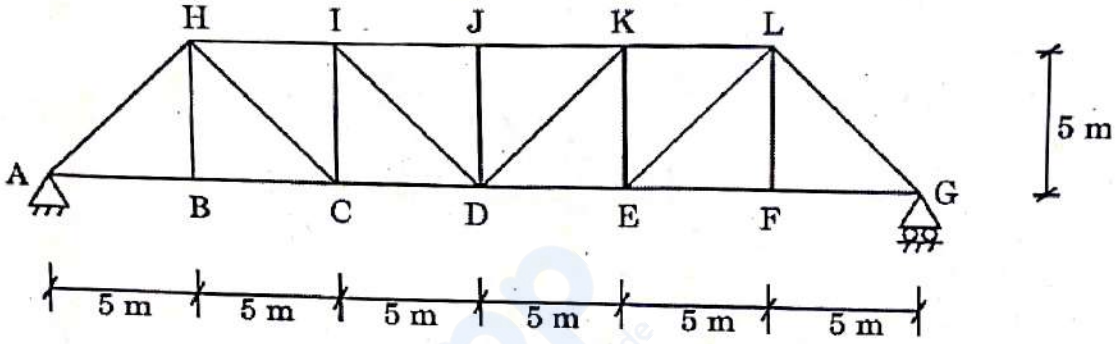
M_u/bd^2, N/mm²	f_y, N/mm²				
	240	250	415	480	500
0·30	0·146	0·140	0·084	0·073	0·070
0·35	0·171	0·164	0·099	0·085	0·082
0·40	0·195	0·188	0·113	0·098	0·094
0·45	0·220	0·211	0·127	0·110	0·106
0·50	0·245	0·236	0·142	0·123	0·118
0·55	0·271	0·260	0·156	0·135	0·130
0·60	0·296	0·284	0·171	0·148	0·142
0·65	0·321	0·309	0·186	0·161	0·154
0·70	0·347	0·333	0·201	0·174	0·167
0·75	0·373	0·358	0·216	0·186	0·179
0·80	0·399	0·383	0·231	0·199	0·191
0·85	0·425	0·408	0·246	0·212	0·204
0·90	0·451	0·433	0·261	0·225	0·216
0·95	0·477	0·458	0·276	0·239	0·229
1·00	0·504	0·483	0·291	0·252	0·242
1·05	0·530	0·509	0·307	0·265	0·255
1·10	0·557	0·535	0·322	0·279	0·267
1·15	0·584	0·561	0·338	0·292	0·280
1·20	0·611	0·587	0·353	0·306	0·293
1·25	0·638	0·613	0·369	0·319	0·306
1·30	0·666	0·639	0·385	0·333	0·320
1·35	0·693	0·666	0·401	0·347	0·333
1·40	0·721	0·692	0·417	0·360	0·346
1·45	0·749	0·719	0·433	0·374	0·359
1·50	0·777	0·746	0·449	0·388	0·373
1·55	0·805	0·773	0·466	0·403	0·387
1·60	0·834	0·800	0·482	0·417	0·400
1·65	0·862	0·828	0·499	0·431	0·414
1·70	0·891	0·856	0·515	0·446	0·428
1·75	0·920	0·883	0·532	0·460	0·442
1·80	0·949	0·911	0·549	0·475	0·456
1·85	0·979	0·940	0·566	0·489	0·470
1·90	1·009	0·968	0·583	0·504	0·484
1·95	1·038	0·997	0·601	0·519	0·498
2·00	1·068	1·026	0·618	0·534	0·513
2·05	1·099	1·055	0·635	0·549	0·527
2·10	1·129	1·084	0·653	0·565	0·542
2·15	1·160	1·114	0·671	0·580	0·557
2·20	1·191	1·143	0·689	0·596	0·572
2·25	1·222	1·173	0·707	0·611	0·587
2·30	1·254	1·204	0·725	0·627	0·602
2·35	1·285	1·234	0·743	0·643	0.617
2·40	1·317	1·265	0·762	0·659	0·632
2·45	1·350	1·296	0·781	0·675	0·648
2·50	1·382	1·327	0·799	0·691	0·663
2·55	1·415	1·358	0·818	0·708	0·679
2·60	1·448	1·390	0·837	0·724	0·695
2·65	1·482	1·422	0·857	0·741	0·711
2·70	1·515	1·455	0·876	0·758	0·727
2·75	1·549	1·487	0·896	0·775	0·744
2·80	1·584	1·520	0·916	0·792	0·760
2·85	1·618	1·554	0·936	0·809	0·777
2·90	1·653	1·587	0·956	0·827	0·794
2·95	1·689	1·621	0·977	0·844	0·811
3·00	1·724	1·655	0·997	0·862	0·828
3·05	1·760	1·690	1·018	0·880	0·845
3·10	1·797	1·725	1·039	0·898	0·863
3·15	1·834	1·760	1·061	0·917	0·880
3·20	1·871	1·796	1·082	0·936	0·898
3·25	1·909	1·832	1·104	0·954	0·916
3·30	1·947	1·869	1·126	0·973	0·935
3·32	1·962	1·884	1·135	0·981	0·942
3·34	1·978	1·899	1·144	0·989	
3·36	1·993	1·914	1·153		
3·38	2·009	1·929	1·162		
3·40	2·025	1·944	1·171		
3·42	2·040	1·959	1·180		
3·44	2·056	1·974	1·189		
3·46	2·072	1·989			
3·48	2·088	2·005			
3·50	2·104	2·020			
3·52	2·120	2·036			
3·54	2·137	2·051			
3·56	2·153	2·067			
3·58	2·170	2·083			
3·60	2·186	2·099			
3·62	2·203	2·115			
3·64	2·219	2·131			
3·66	2·236	2·147			
3·68	2·253	2·163			
3·70	2·270	2·179			
3·72	2·287	2·196			
3·74	2·304				

Note — Blanks indicate inadmissible reinforcement percentage (*see* Table E).

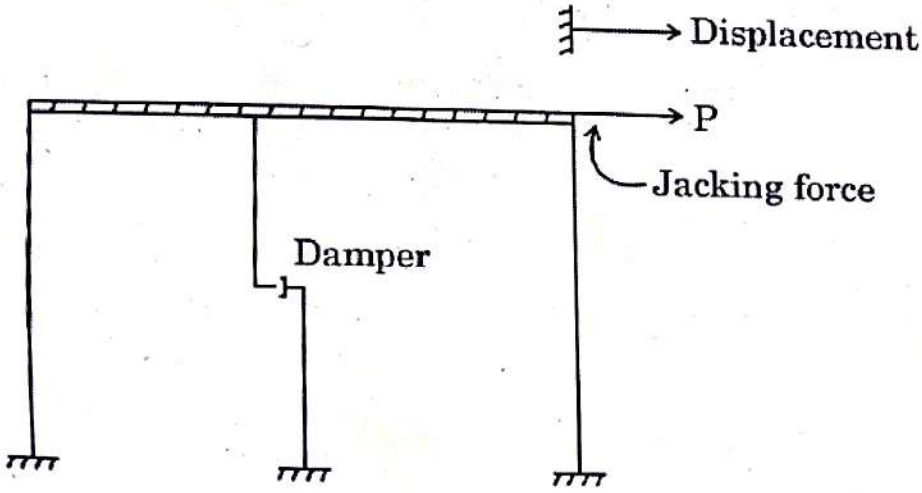
(c) (i) Draw the influence line diagram for reaction R_A for the continuous beam shown in the figure at 1 m interval. Assume flexural rigidity is constant throughout. Use Muller-Breslau Principle. *10*



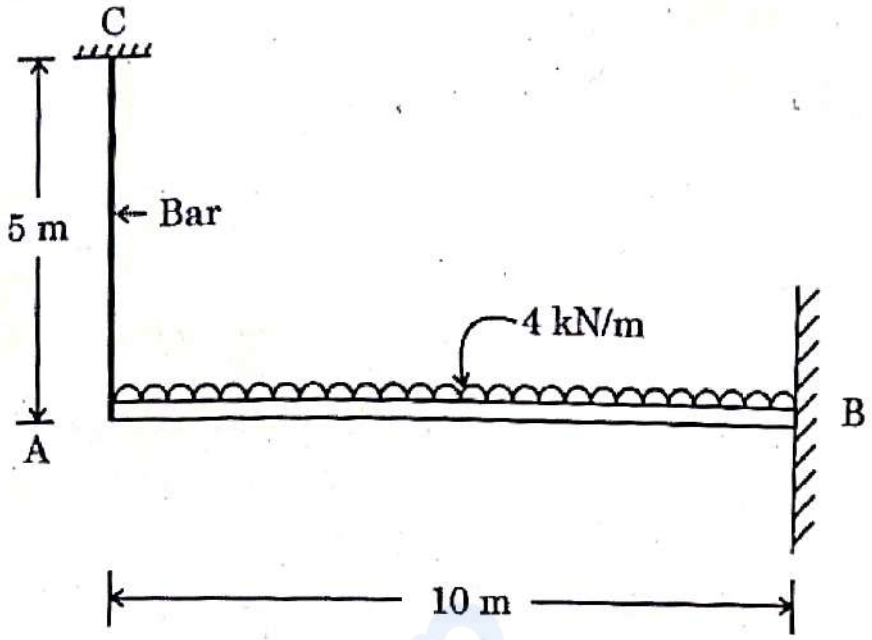
(ii) Draw the influence line diagram for member ID of the truss shown in the figure. Assume that the load moves along the bottom chord. *10*



Q4. (a) (i) A single storey building is idealised as a rigid bar supported by weightless columns as shown in the figure. For dynamic response, using jack, a displacement of 5 mm of the girder was observed for a force of 10 kN. After instantaneous release of this initial displacement, the maximum displacement on the return swing was only 4 mm and the period of displacement cycle was 1·5 sec. Find approximately, the effective weight of the girder, damping factor and damping coefficient. *12*



(ii) A cantilever beam AB is fixed at B and is supported at A by the bar AC which serves as a yielding prop. Determine the tensile force in the bar if it is extensible, and if it is inextensible. EI is same for the beam and the bar. For the beam, take moment of inertia $I = 0{\cdot}05\ m^4$ and for the bar take $L = 5$ m and area of cross-section $A = 1500\ mm^2$. (Refer the following figure for loading) 8



(b) (i) A small maintenance project consisting of jobs given in the following table, with normal time and crash time are given in days.

(I) What is the normal length and its cost ?

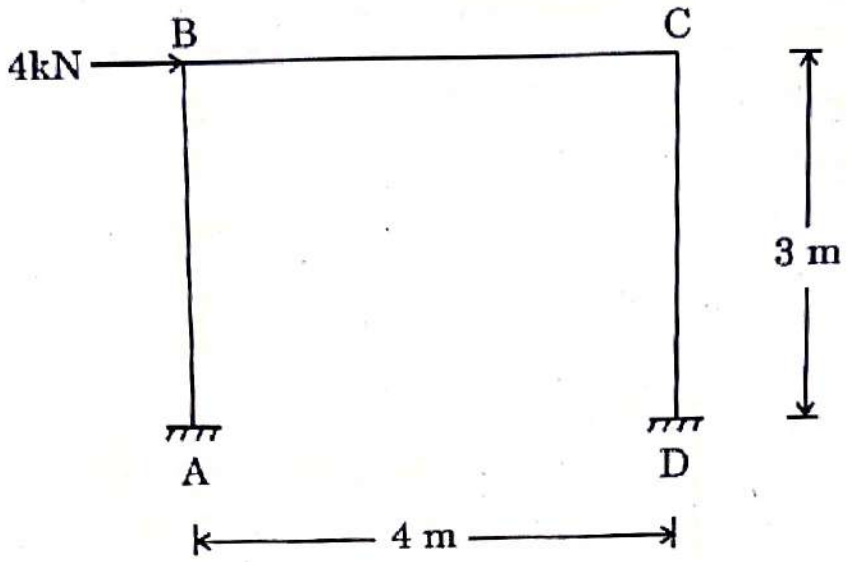
(II) If the project duration is to be crashed by 2 days, what is the total project cost ? 10

Overhead costs are ₹ 2,000 per day.

Activity	Duration (days)		Cost (₹)	
	Normal	Crash	Normal	Crash
1 – 2	4	2	4,000	12,000
2 – 3	5	2	3,000	6,000
2 – 4	7	5	4,000	6,000
3 – 4	4	2	8,000	12,000

(ii) Write a note on resources smoothing and resources levelling. 10

(c) Analyse the portal frame shown in the figure by using slope-deflection method. Take EI as constant and draw the bending moment diagram. Supports A and D are fixed. 20



Q5. (a) (i) What is the difference between soft wood and hard wood ? 6

(ii) What are the different phases of a project ? 6

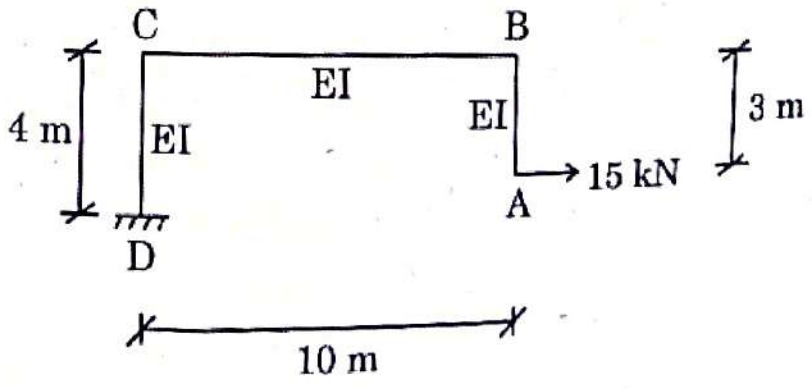
(b) A suspension bridge of 116 m span has three-hinged stiffening girder, and is subjected to two concentrated loads of 250 kN and 340 kN at a distance of 30 m and 58 m respectively from the left support. Determine the shear force and bending moment for the girder at a distance of 35 m from the left end. The supporting cable has a central dip of 12 m. Also determine maximum tension and its slope in the cable. 12

(c) What are the four classes of steel sections as per IS : 800 – 2007 ? Explain with a moment-rotation diagram and a stress diagram. 12

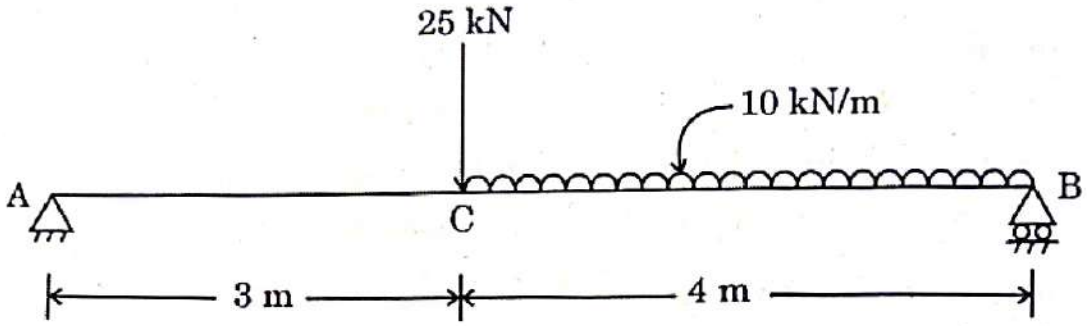
(d) Find the development length for a reinforcement bar of diameter 20 mm under tension and compression embedded in concrete of M30 grade. The design bond stress τ_{bd} in limit state method for plain bar in tension is 1·5 MPa for M30. The grade of reinforcement bars is Fe500. Also find the corresponding anchorage lengths of the bar for 90° bend. 12

(e) The maximum allowable shear stress in a hollow shaft of external diameter equal to twice the internal diameter is 120 N/mm^2. Determine the diameter of the shaft if it is subjected to a torque of 12 kNm and a bending moment of 5 kNm. 12

Q6. (a) (i) Using the unit load method, determine the horizontal deflection of the free end (Point A) of the frame shown in the figure below. Support D is fixed, C and B are rigid joints. Assume flexural rigidity EI as constant. 10



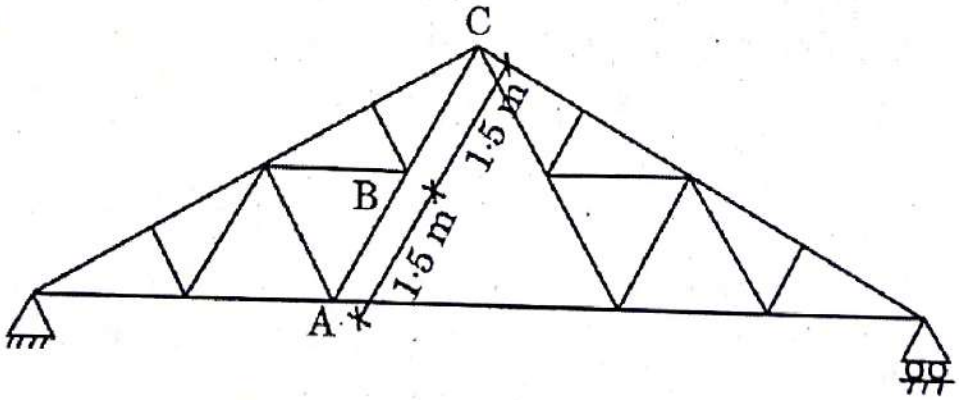
(ii) Use Castigliano's theorem and determine vertical displacement of point C of the beam shown in the figure. Assume E = 210 GPa and $I = 150 \times 10^6$ mm^4. 10



EI same for AC and CB

(b) The member A–B–C in a truss consists of two angles ∠75 × 75 × 8 back to back on both sides of the gusset of thickness 10 mm. The length of members AB and BC is 1·5 m each. Find the maximum (factored) compressive load carrying capacity of the member A–B–C. Assume E250 grade of steel and all joints are welded. Properties of ∠75 × 75 × 8 are :

$A = 1140$ mm^2, $C_y = C_z = 21{\cdot}4$ mm, $I_{yy} = I_{zz} = 59 \times 10^4$ mm^4. 20



$\frac{KL}{r}$	f_{cd} (MPa)
20	224
30	211
40	198
50	183
60	168
70	152
80	136
90	121
100	107
110	94·6
120	83·7
130	74·3
140	66·2
150	59·2
160	53·3
170	48·1
180	43·6

(c) The cost of a machine required at the construction site is ₹ 1,20,000 and its salvage value is ₹ 20,000. The expected life of the machine is 5 years only. It is also expected to work 2000 hours in a year. Compute the yearly depreciation for the machine by using the following methods : *20*

- Straight line method
- Sinking fund method

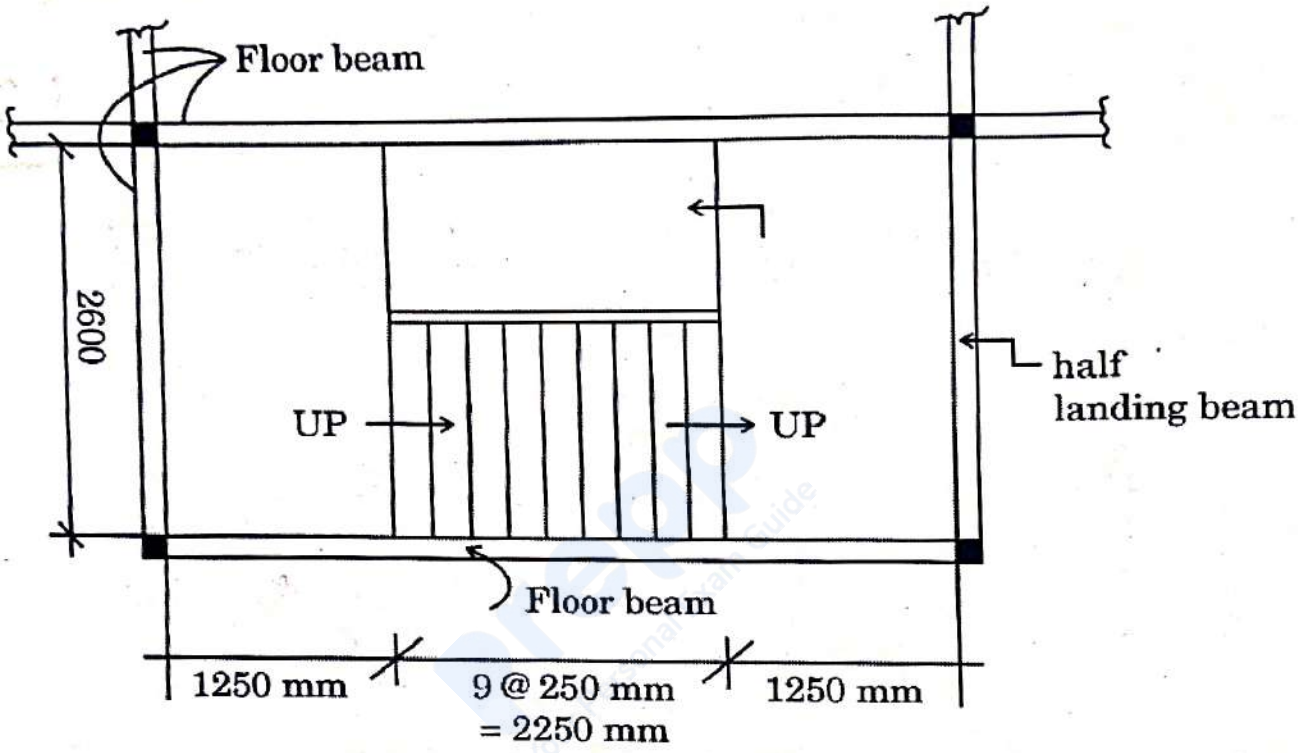
Q7. (a) A cylindrical shell of mild steel sheet and 1250 mm diameter is to be subjected to an internal pressure of 1·55 MN/mm^2. If the mild steel yields at 225 MN/m^2, determine the thickness of the mild steel sheet on the basis of the following theories of failure. Assume a F.O.S. = 3.

(i) Maximum principal stress theory

(ii) Maximum shear stress theory

(iii) Maximum shear strain energy theory *6+7+7=20*

(b) A dog-legged stair is to be constructed in a building resting on beams and columns as shown in the figure. The floor to floor height of the building is 3 m. The cross-sectional dimensions of beams including half landing beams are 250 mm × 400 mm. Intensity of live load is 3 kN/m^2. Design and detail the reinforcement (with sketches) of a typical flight of the stair, applying 'limit state method' of design. Use M25 and Fe500. Deflection check is not needed. Assume the depth of waist slab as 150 mm. 20



PLAN

f_y
240
250
415
480
500

f_{ck}
25

TABLE 3 FLEXURE — REINFORCEMENT PERCENTAGE, p_t FOR SINGLY REINFORCED SECTIONS

f_{ck} = 25 N/mm²

M_u/bd^2, N/mm²	f_y, N/mm²				
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0·35	0·171	0·164	0·099	0·085	0·082
0·40	0·195	0·188	0·113	0·098	0·094
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0·60	0·296	0·284	0·171	0·148	0·142
0·65	0·321	0·309	0·186	0·161	0·154
0·70	0·347	0·333	0·201	0·174	0·167
0·75	0·373	0·358	0·216	0·186	0·179
0·80	0·399	0·383	0·231	0·199	0·191
0·85	0·425	0·408	0·246	0·212	0·204
0·90	0·451	0·433	0·261	0·225	0·216
0·95	0·477	0·458	0·276	0·239	0·229
1·00	0·504	0·483	0·291	0·252	0·242
1·05	0·530	0·509	0·307	0·265	0·255
1·10	0·557	0·535	0·322	0·279	0·267
1·15	0·584	0·561	0·338	0·292	0·280
1·20	0·611	0·587	0·353	0·306	0·293
1·25	0·638	0·613	0·369	0·319	0·306
1·30	0·666	0·639	0·385	0·333	0·320
1·35	0·693	0·666	0·401	0·347	0·333
1·40	0·721	0·692	0·417	0·360	0·346
1·45	0·749	0·719	0·433	0·374	0·359
1·50	0·777	0·746	0·449	0·388	0·373
1·55	0·805	0·773	0·466	0·403	0·387
1·60	0·834	0·800	0·482	0·417	0·400
1·65	0·862	0·828	0·499	0·431	0·414
1·70	0·891	0·856	0·515	0·446	0·428
1·75	0·920	0·883	0·532	0·460	0·442
1·80	0·949	0·911	0·549	0·475	0·456
1·85	0·979	0·940	0·566	0·489	0·470
1·90	1·009	0·968	0·583	0·504	0·484
1·95	1·038	0·997	0·601	0·519	0·498
2·00	1·068	1·026	0·618	0·534	0·513
2·05	1·099	1·055	0·635	0·549	0·527
2·10	1·129	1·084	0·653	0·565	0·542
2·15	1·160	1·114	0·671	0·580	0·557
2·20	1·191	1·143	0·689	0·596	0·572
2·25	1·222	1·173	0·707	0·611	0·587
2·30	1·254	1·204	0·725	0·627	0·602
2·35	1·285	1·234	0·743	0·643	0·617
2·40	1·317	1·265	0·762	0·659	0·632
2·45	1·350	1·296	0·781	0·675	0·648
2·50	1·382	1·327	0·799	0·691	0·663
2·55	1·415	1·358	0·818	0·708	0·679
2·60	1·448	1·390	0·837	0·724	0·695
2·65	1·482	1·422	0·857	0·741	0·711
2·70	1·515	1·455	0·876	0·758	0·727
2·75	1·549	1·487	0·896	0·775	0·744
2·80	1·584	1·520	0·916	0·792	0·760
2·85	1·618	1·554	0·936	0·809	0·777
2·90	1·653	1·587	0·956	0·827	0·794
2·95	1·689	1·621	0·977	0·844	0·811
3·00	1·724	1·655	0·997	0·862	0·828
3·05	1·760	1·690	1·018	0·880	0·845
3·10	1·797	1·725	1·039	0·898	0·863
3·15	1·834	1·760	1·061	0·917	0·880
3·20	1·871	1·796	1·082	0·936	0·898
3·25	1·909	1·832	1·104	0·954	0·916
3·30	1·947	1·869	1·126	0·973	0·935
3·32	1·962	1·884	1·135	0·981	0·942
3·34	1·978	1·899	1·144	0·989	
3·36	1·993	1·914	1·153		
3·38	2·009	1·929	1·162		
3·40	2·025	1·944	1·171		
3·42	2·040	1·959	1·180		
3·44	2·056	1·974	1·189		
3·46	2·072	1·989			
3·48	2·088	2·005			
3·50	2·104	2·020			
3·52	2·120	2·036			
3·54	2·137	2·051			
3·56	2·153	2·067			
3·58	2·170	2·083			
3·60	2·186	2·099			
3·62	2·203	2·115			
3·64	2·219	2·131			
3·66	2·236	2·147			
3·68	2·253	2·163			
3·70	2·270	2·179			
3·72	2·287	2·196			
3·74	2·304				

NOTE — Blanks indicate inadmissible reinforcement percentage (*see* Table E).

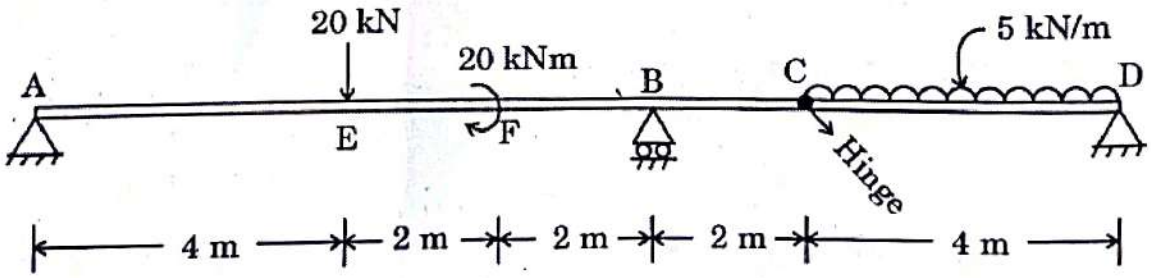
(c) (i) A batch of concrete consists of the following ingredients : 10

Ingredients	Batch Mass (kg)	Specific heat cal/gm/°C	Initial Temperature (°C)
Cement	86	0·27	44
Sand	320	0·25	26·0
Coarse Aggregate	1498	0·23	4·2
Water	35	1·00	1·8
Free Moisture in Sand (3%)	9·0	1·00	26·0
Free Moisture in Coarse Aggregate (1%)	14·5	1·00	4·2
Ice	X	0·50	– 4·0

If the desired placement temperature is 11°C and concrete gains 4°C after cooling has occurred, find the quantity of ice to be added for the given set of materials.

(ii) What are the causes of accidents in the construction industry ? How can they be reduced ? 10

Q8. (a) Draw the shear force and bending moment diagrams for the beam loaded, as shown in the figure below. There is an internal hinge at C. Determine the values of maximum bending moment and maximum shearing force. 20



(b) (i) A welded plate girder is made of a web 2000 mm deep and 20 mm thick and flange 500 mm wide and 40 mm thick. Design a suitable welded connection between the flange and web. The span of the girder is 30 m (simply supported) and the total load (udl) including its self weight is 160 kN/m. Assume E250 grade of steel. Assume field weld. *10*

(ii) Find the moment of resistance of reinforced concrete beam of size 250 mm × 500 mm. The beam is reinforced with 3 Nos. 20 ϕ bar at bottom and 2 Nos. 12 ϕ bar at top. The beam is simply supported and under vertical load. Assume effective cover to bar at the top and the bottom is 50 mm. Use M25 and Fe415. Apply limit state method. Assume the stress strain values of a steel bar from the table. *10*

Strain	Stress (MPa)
0·00174	347·8
0·00195	369·6
0·00226	391·3
0·00277	413·0
0·00312	423·9
0·00417	434·8

(c) (i) What is a sheep's foot roller ? How does it compact the earth ? *10*

(ii) Explain the following terms : *10*

- Total float
- Free float
- Independent float
- Interfering float

CIVIL ENGINEERING

PAPER—II

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions

There are **EIGHT** questions divided in **TWO** Sections.

Candidate has to attempt **FIVE** questions in all.

Question Nos. **1** and **5** are compulsory and out of the remaining, **THREE** are to be attempted choosing at least **ONE** question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Diagrams/Figures, wherever required, shall be drawn in the space provided for answering the questions itself.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.

Any page or portion of the page left blank in the Question-cum-Answer (QCA) Booklet must be clearly struck off.

Answers must be written in **ENGLISH** only.

SECTION—A

1. *(a)* A rectangular plate of 0·50 m × 0·50 m dimensions and weighing 500 N slides down an inclined plane making 30° angle with the horizontal. The velocity of the plate is 1·75 m/s. If the 2 mm gap between the plate and the inclined surface is filled with lubricating oil, find the viscosity of oil and express it in units of poise as well as N-s/m^2. Assume the plate as frictionless. 12

(b) The following is the set of observed data for successive 15 minutes period of 105 minutes storm in a catchment :

Duration (min)	15	30	45	60	75	90	105
Rainfall (cm/hr)	2·0	2·0	8·0	7·0	1·25	1·25	4·5

If the value of ϕ-index is 3·0 cm/hr, estimate the net runoff, the total rainfall and the value of W-index. 12

(c) A hydraulic turbine has an output of 6600 kW when it works under a head of 25 m and runs at 100 r.p.m. What is the type of the turbine? What would be its speed and what power will it develop when working under a head of 16 m? 12

(d) A large stream flowing through an industrialised area is the only source of raw water for the community water supply. The stream water is consistently turbid, has hardness in excess of 300 mg/L as $CaCO_3$ and has refractory organics that are known precursor of trihalomethanes. Draw a schematic diagram of a treatment plant that could render this water potable. Identify all the units. State their purpose, show points of chemical addition and identify all the chemicals. 12

(e) For BOD analysis, 30 mL of treated wastewater sample with DO of zero was mixed with 270 mL of dilution water with DO of 10 mg/L. The 5th and 6th days being holidays, the lab was closed. The final DO was measured as 4 mg/L on the 7th day. It was also found that the incubator was set at 30 °C. Assuming the BOD reaction rate constant as 0·23 day^{-1} at 20 °C and the temperature coefficient as 1·047, determine the 5-day, 20 °C BOD of the sample. 12

2. *(a)* Treated wastewater having a peak flow rate of 12000 m^3/day, BOD_5 of 30 mg/L, DO concentration of 1 mg/L and temperature of 27 °C is discharged in a stream. Before getting mixed with the wastewater, the stream has a minimum flow rate of 0·4 m^3/s, BOD_5 of 4 mg/L, DO concentration of 7 mg/L and temperature of 25 °C. After instantaneous and complete mixing, the velocity of the mixed flow is 0·2 m/s. For the mixed flow, the BOD reaction rate constant is 0·2 day^{-1} and the reaeration constant is 0·4 day^{-1} at 20 °C. Estimate the initial oxygen deficit and DO after two days of flow. Take temperature coefficient for BOD reaction rate constant as 1·047 and for stream reaeration rate constant as 1·016. Take equilibrium concentration of DO for water after mixing as 8·3 mg/L. 20

(b) (i) For a hydraulic jump in a rectangular channel, the velocity and depth after the jump are known to be 0·80 m/s and 1·75 m respectively. Calculate the depth before jump, the energy loss and the power dissipated per metre width. 15

(ii) What do you mean by diversion headworks? Distinguish clearly between a weir and a barrage. 5

(c) (i) A water treatment plant in a city of 100000 population supplies water at the rate of 150 lpcd. Two equal capacity circular settling tanks are to be provided to settle flocculent suspension through Type–II settling. Design the tanks. Take SOR as 20 m^3/m^2-d and water depth of 3·5 m. Leave sludge zone of 0·5 m and keep inlet and outlet zones equal to the side water depth. Calculate the weir loading. Draw the sketch of the tank showing all the zones and dimensions. 12

(ii) In an ideal granular media filter, the entire depth of the filter media should contribute to the retention and removal of solids, ensuring longer filter runs, less head loss and greater filtration rates. Why will the single media filters fail to achieve this? How can the mixed media filter approach an ideal filter in performance? 8

3. (a) (i) Design a tube well for the following data :

Yield required = 0·10 m^3/s
Radius of circle of influence = 200 m
Coefficient of permeability = 60 m/day
Drawdown = 6 m
Thickness of confined aquifer = 30 m 15

(ii) Describe briefly the various methods adopted as anti-waterlogging measures. 5

(b) (i) Design an irrigation channel in alluvial soil according to Lacey's silt theory for the following data :

Full supply discharge = 10 m^3/s
Lacey's silt factor = 0·9
Side slopes of channel = $\frac{1}{2}$ (H) : 1 (V) 15

(ii) What is gravity dam? Enumerate the various forces acting on gravity dam. 5

(c) (i) A settling column analysis is run to determine the settling characteristics of sludge from an activated sludge reactor with the following results :

Concentration of MLSS (mg/L) :	1000	2000	3000	4000	5000	6000
Settling velocity (m/hr) :	2·8	1·4	0·4	0·2	0·1	0·06

The flow to the secondary clarifier is 4200 m^3/day with MLSS concentration of 2000 mg/L. Determine the required diameter of the clarifier for a preselected solid flux rate of 2·5 kg/m^2-hr. Check the area requirement for the clarification function also. 12

(iii) Why do the conventional channel type horizontal flow grit chambers require the velocity control devices? What are the common velocity control devices that are used? What advantages the aerated grit chamber has over the conventional grit chamber? 8

4. (a) (i) A kite weighing 12·26 N has an effective area of 0·9 m^2. The tension in the kite string is 32·37 N when the string makes an angle of 45° with the horizontal. For a wind of 32 km/hr, what are the coefficients of lift and drag if the kite assumes an angle of 8° with the horizontal? Take specific weight of air as 11·801 N/m^3. 10

(ii) A 1·25 m diameter pipe has to be provided to convey oil of specific gravity 0·85 and kinematic viscosity of 2·75 centistokes at a velocity of 1·25 m/s. In order to model the flow, if a 120 mm diameter pipe is used to convey water of kinematic viscosity 1·0 centistokes, what should be the velocity and the discharge in the model? 10

(b) A city of 1 million population generates 0·45 kg per capita per day of MSW. Collection trucks of capacity 4·5 metric tonnes averaging two trips per day at 75% capacity operate all the days in a week to transfer the waste to centralised processing and landfill site. How many trucks per day will be required to transfer the waste? If about 45% waste is recycled, what is the mass of MSW entering the landfill? If the density of the waste is 280 kg/m^3, what is the volume of MSW? Determine the area required for the landfill with the projected life of 30 years, if the density of the compacted waste is 450 kg/m^3 and the maximum height of the landfill is limited to 15 m. Neglect the volume of cover. 20

(c) (i) Explain the following characteristic terms for biological organisms based on their carbon and energy sources :

(I) Phototrophs

(II) Chemotrophs

(III) Autotrophs

(IV) Heterotrophs

Arrange the following organisms according to their trophic levels giving your reasoning :

(A) Chemoheterotrophs

(B) Photoheterotrophs

(C) Photoautotrophs

(D) Chemoautotrophs 10

(ii) The ambient air concentration of carbon monoxide was reported as 4 mg/m^3 at the temperature of 25 °C and pressure of 103·193 kPa. What will be the concentration in ppm at STP? 10

SECTION—B

5. *(a)* A field vane shear test was carried out on a deep-seated soft clay layer. The vane was 11·25 cm high and 7·5 cm across the blades. The equivalent torque recorded at the torque head at failure was 800 kg-cm. The vane was then rotated very rapidly in order to completely remould the soil. It was found that the remoulded soil can be sheared by applying a torque of 400 kg-cm. Compute the shear strength of the soil in the undisturbed and remoulded states and its sensitivity. 12

(b) A 2·5 m wide strip footing is founded at a depth of 2·0 m below the ground level in a homogeneous pure clay bed. The unit cohesion of clay is 35 kPa. Due to seasonal fluctuations of water table from peak summer (fully dry soil) to peak monsoon (fully saturated soil), compute the change in the net ultimate bearing capacity as per Terzaghi's theory. 12

(c) Design the thickness of a flexible pavement for the design life of 15 years having two-lane single carriageway 7·0 m wide and present traffic of 800 commercial vehicles per day (CVPD). Out of total 800 CVPD, 300 have vehicle damage factor (VDF) of 2·5 and 500 have VDF of 3·0. The planning and construction period is 2 years and annual vehicle growth rate is 7·5%. Design the flexible pavement from the data given below if the effective CBR of the subgrade is 9%. Assume any missing data suitably :

Design traffic	*Wearing course* (mm)	*Binder course* (mm)	*Base* (mm)	*Sub-base* (mm)
5 msa	25 SDBC	50 DBM	250	150
10 msa	40 BC	50 DBM	250	200
20 msa	40 BC	80 DBM	250	200
30 msa	40 BC	95 DBM	250	200

12

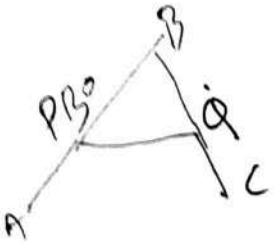
(d) Calculate the speed restriction for a 2° curve on a broad-gauge section with maximum permissible speed of 100 km/hr. Due to space restrictions, the length of transition curve is limited to 50 m and superelevation provided is 60 mm. 12

(e) The following staff readings were taken with a level :

1·255, 1·950, 2·450, 3·100, 3·900, 1·215, 1·795, 2·800, 3·500, 0·560, 1·210, 1·900, 2·955

The level was shifted after the 5th and 9th reading, and the 7th reading was taken to a benchmark of RL 120·00 m. Arrange the data in tabular form and find the reduced level of all the points by rise and fall method. Also apply the usual checks for calculations. 12

6. *(a)* *(i)* Two straights AB and BC are to be connected by a 2° simple circular curve. Two points P and Q are selected on AB and BC respectively and the following observations are done in the field :



$\angle APQ = 130°$ Length $PQ = 120$ m

$\angle CPQ = 120°$ Chainage of point $P = 1700$ m

Calculate the chainages of intersection and all other important points in the curve. Assume the standard chord length of 20 m. 10

(ii) Explain the various sources of errors and their corrections in positioning with Global Positioning System (GPS). 10

(b) *(i)* A greenfield airport is proposed at an elevation of 250 m above mean sea level (m.s.l.). The monthly average of the maximum daily temperature at the proposed site is 45 °C during the hottest month of the year. During the same month, the average daily temperature is 35 °C. The maximum difference in elevation is 6·0 m along the proposed runway of basic length 2000 m. Calculate the actual length of runway to be provided. 15

(ii) What are the various considerations in the selection of the site for a harbour? 5

(c) A concrete driven pile of 20 m length and 1 m × 1 m in cross-section is fully embedded in sand having unit weight, $\gamma = 18$ kN/m^3 and $\phi' = 30°$. Estimate the ultimate load Q_u which the pile can take and mention the contributions from point load (tip load Q_p using Meyerhof's method) and frictional resistance Q_s. Consider $N_q^* = 55$ (for $\phi' = 30°$), $\delta' = 0{\cdot}8\phi'$, $K = 1{\cdot}8\,(1 - \sin\phi')$, $L_{cr} = 15D$. 20

7. *(a)* An infinite soil slope is having a slope angle as 25°. The soil properties are $c' = 26$ kN/m^2, $\phi' = 20°$, $e = 0{\cdot}71$ and $G = 2{\cdot}65$. Given $\gamma_w = 10$ kN/m^3. Find out the critical height of the slope considering stability number which represents cohesion and $F_\phi = 1{\cdot}0$, for cases (i) soil slope is dry and (ii) soil slope is submerged. 20

(b) A smooth rigid vertical retaining wall of height 7·0 m supports two layers of horizontal backfill. Top layer 1 is of 2·0 m depth having $\phi = 20°$, $c = 15$ kN/m^2 and $\gamma = 15$ kN/m^3. Bottom layer 2 is pure sand with $\phi = 30°$ and $\gamma = 17$ kN/m^3. Mention the practical depth of tensile crack. Also draw active earth pressure diagram and compute the total active thrust on the wall. Assume that the entire soil layers are dry. 20

(c) *(i)* What is meant by wear of rails? How is it measured? Explain the methods adopted to reduce wear of rails. 10

(ii) What is 'mucking' in the construction of tunnels? Explain the various techniques for haulage of muck from the tunnel. 10

8. *(a)* Estimate the traffic density and theoretical capacity of six-lane expressway at a stream speed of 80 km/hr. The average reaction time is 0·75 s and the average length of vehicle is 5 m. 10

(b) List all the major methods of ground modifications (ground improvement) in *(i)* cohesive soil and *(ii)* cohesionless soil. 10

(c) A building is proposed to be constructed on a thick silty clay deposit. The maximum vertical load on a column is 5000 kN. Using Boussinesq's stress distribution, calculate the minimum depth of soil exploration required for the foundation design. Note that as per De Beer's recommendation, the vertical additional stress should be less than or equal to 10% of the effective vertical stress. Take unit weight, γ, of soil as 18 kN/m^3 and γ_w = 10 kN/m^3. 20

(d) *(i)* A survey line *OPQR* running in the east direction has a lake between points *P* and *Q*; *P* and *Q* are intervisible but it is not possible to measure its length in the field. A traverse *PABCQ* was run around the lake and the following measurements were done in the field :

Line	*Length* (m)	*Bearing*
PA	160	N 15° E
AB	300	N 45° E
BC	200	N 60° E
CQ	—	S 30° E

Calculate the lengths of the lines *CQ* and *QP*. 10

(ii) Enlist the various geological challenges need to be considered for construction of tunnels in the Himalayan region. 10

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