

CIVIL ENGINEERING PAPER-I

Time Allowed: **Three Hours**

Maximum Marks: **300**

Question Paper Specific Instructions

Please reach each of the following instruction carefully before attempting questions:

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

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

Questions **No.1** and **5** are **compulsory** and out of the remaining, any **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 question itself.

Unless otherwise mentioned, symbols and rotations carry 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 QCA Booklet must be clearly struck off.

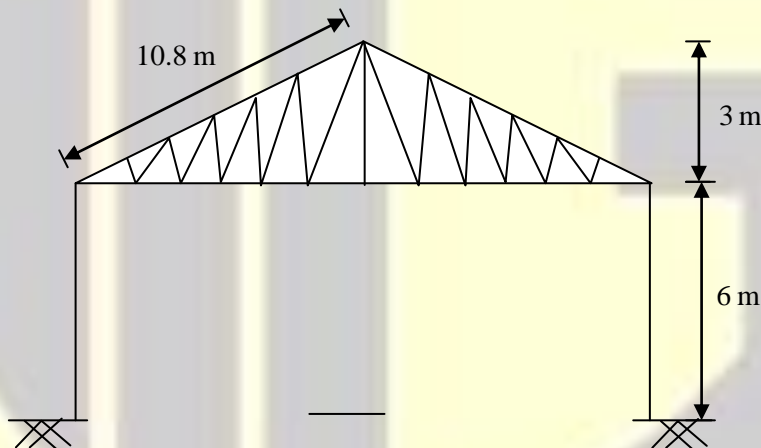
Answers must be written in **ENGLISH** only.

SECTION-A

1. (a) (i) Describe how stones are preserved.
(ii) What are the advantages and disadvantages of fibre reinforced concrete?

[6 + 6 Marks]

- (b) A factory shed of size 40 m x 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, $K_1 = 1$, $K_2 = 0.9$ (up to 10 m ht and category-II). $K_3 = 1$, $K_4 = 1$, $K_a = 0.9$, $K_c = 0.9$, $K_d = 0.9$. For wind angle 0° , take $C_{pe} = -1.2$ (windward side), $C_{pe} = -0.4$ (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 Marks]

- (c) A simply supported pre-stressed 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 pre-stressing 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 Marks]

- (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 $E = 2.10 \times 10^5 \text{ N/mm}^2$ and Poisson's ratio = 0.26.

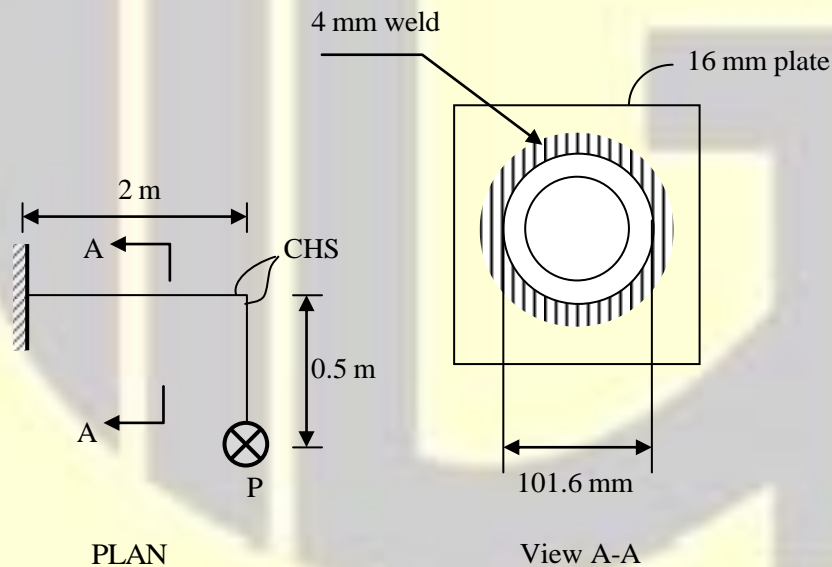
[12 Marks]

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

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

[6 + 6 Marks]

2. (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

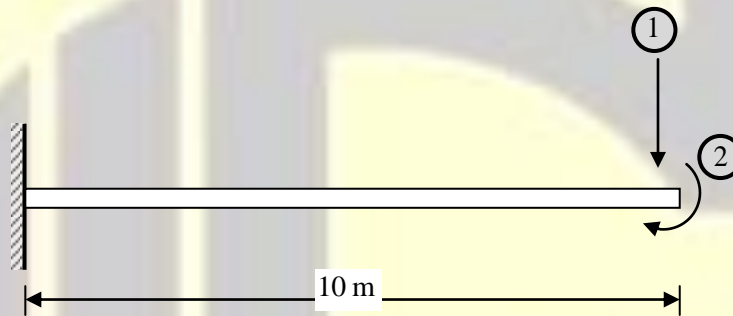


[20 Marks]

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

[20 Marks]

- (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) 1m 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 .
Taken $E_s = 2 \times 10^5 \text{ N/mm}^2$ and $E_b = 8 \times 10^4 \text{ N/mm}^2$.
- (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 + 10 Marks]

3. (a) (i) What is quality management system in concrete construction?
(ii) What is cement grout? How does it differ from cement mortar?

[10 + 10 Marks]

- (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 liveload 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 = 50mm.

No pedestal is to be provided. Given:

$\frac{100A_{st}}{b_d}$	≤ 0.15	0.25	0.50	0.75	1.00	1.25	1.50	1.75
$\tau_c \text{ N/mm}^2$	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 Marks]

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

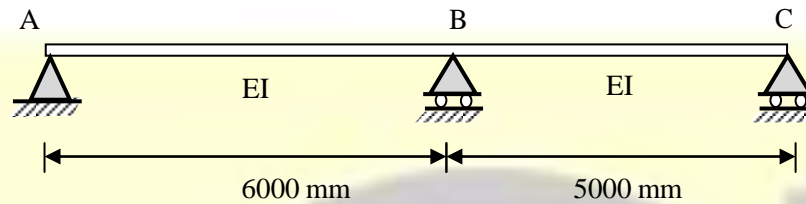
$f_{ck} = 25 \text{ N/mm}^2$

M_u/bd^2 , N/mm ²	f_y , N/mm ²					M_u/bd^2 , N/mm ²	f_y , N/mm ²				
	240	250	415	480	500		240	250	415	480	500
0.30	0.146	0.140	0.084	0.073	0.070	2.55	1.415	1.358	0.818	0.708	0.679
0.35	0.171	0.164	0.099	0.085	0.082	2.60	1.448	1.390	0.837	0.724	0.695
0.40	0.195	0.188	0.113	0.098	0.094	2.65	1.482	1.422	0.857	0.741	0.711
0.45	0.220	0.211	0.127	0.110	0.106	2.70	1.515	1.455	0.876	0.758	0.727
0.50	0.245	0.236	0.142	0.123	0.118	2.75	1.549	1.487	0.896	0.775	0.744
0.55	0.271	0.260	0.156	0.135	0.130	2.80	1.584	1.520	0.916	0.792	0.760
0.60	0.296	0.284	0.171	0.148	0.142	2.85	1.618	1.554	0.936	0.809	0.777
0.65	0.321	0.309	0.186	0.161	0.154	2.90	1.653	1.587	0.956	0.827	0.794
0.70	0.347	0.333	0.201	0.174	0.167	2.95	1.689	1.621	0.977	0.844	0.811
0.75	0.373	0.358	0.216	0.186	0.179	3.00	1.724	1.655	0.997	0.862	0.828
0.80	0.399	0.383	0.231	0.199	0.191	3.05	1.760	1.690	1.018	0.880	0.845
0.85	0.425	0.408	0.246	0.212	0.204	3.10	1.797	1.725	1.039	0.898	0.863
0.90	0.451	0.433	0.261	0.225	0.216	3.15	1.834	1.760	1.061	0.917	0.880
0.95	0.477	0.458	0.276	0.239	0.229	3.20	1.871	1.796	1.082	0.936	0.898
1.00	0.504	0.483	0.291	0.252	0.242	3.25	1.909	1.832	1.104	0.954	0.916
1.05	0.530	0.509	0.307	0.265	0.255	3.30	1.947	1.869	1.126	0.973	0.935
1.10	0.557	0.535	0.322	0.279	0.267	3.32	1.962	1.884	1.135	0.981	0.942
1.15	0.584	0.561	0.338	0.292	0.280	3.34	1.978	1.899	1.144	0.989	
1.20	0.611	0.587	0.353	0.306	0.293	3.36	1.993	1.914	1.153		
1.25	0.638	0.613	0.369	0.319	0.306	3.38	2.009	1.929	1.162		
1.30	0.666	0.639	0.385	0.333	0.320	3.40	2.025	1.944	1.171		
1.35	0.693	0.666	0.401	0.347	0.333	3.42	2.040	1.959	1.180		
1.40	0.721	0.692	0.417	0.360	0.346	3.44	2.056	1.974	1.189		
1.45	0.749	0.719	0.433	0.374	0.359	3.46	2.072	1.989			
1.50	0.777	0.746	0.449	0.388	0.373	3.48	2.088	2.005			
1.55	0.805	0.773	0.466	0.403	0.387	3.50	2.104	2.020			
1.60	0.834	0.800	0.482	0.417	0.400	3.52	2.120	2.036			
1.65	0.862	0.828	0.499	0.431	0.414	3.54	2.137	2.051			
1.70	0.891	0.856	0.515	0.446	0.428	3.56	2.153	2.067			
1.75	0.920	0.883	0.532	0.460	0.442	3.58	2.170	2.083			
1.80	0.949	0.911	0.549	0.475	0.456	3.60	2.186	2.099			
1.85	0.979	0.940	0.566	0.489	0.470	3.62	2.203	2.115			
1.90	1.009	0.968	0.583	0.504	0.484	3.64	2.219	2.131			
1.95	1.038	0.997	0.601	0.519	0.498	3.66	2.236	2.147			
2.00	1.068	1.026	0.618	0.534	0.513	3.68	2.253	2.163			
2.05	1.099	1.055	0.635	0.549	0.527	3.70	2.270	2.179			
2.10	1.129	1.084	0.653	0.565	0.542	3.72	2.287	2.196			
2.15	1.160	1.114	0.671	0.580	0.557	3.74	2.304				
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						

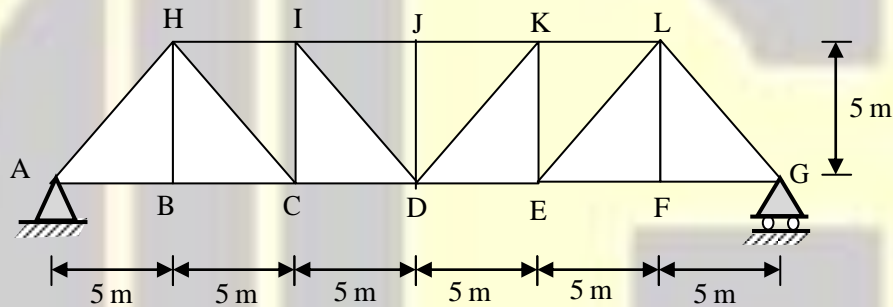
NOTE — Blanks indicate inadmissible reinforcement percentage (see Table E).

f_y
240
250
415
480
500
 f_{ck}
25

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

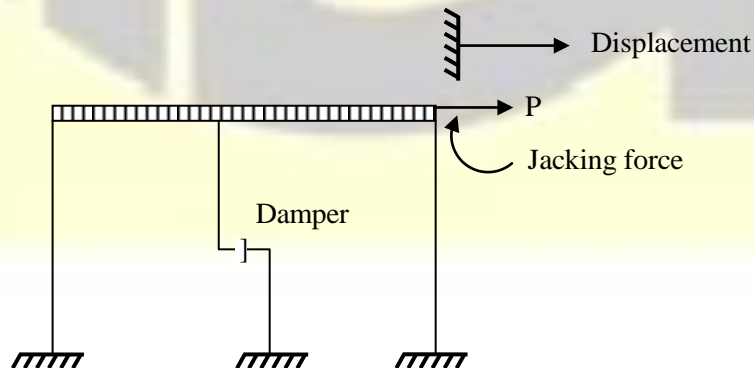


- (ii) Draw the influence line diagram for member ID of the truss shown in the figure. Assume that the load moves along the bottom chord.

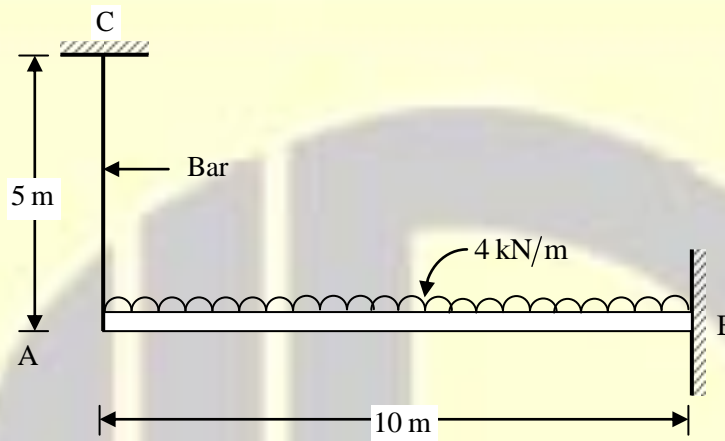


[10 + 10 Marks]

4. (a) (i) A single storey building is idealized 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 10kN. 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.



- (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 $I = 0.05 \text{ m}^4$ and for the bar take $L = 5 \text{ m}$ and area of cross-section $A = 1500 \text{ mm}^2$. (Refer the following figure for loading)



[12 + 8 Marks]

- (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?

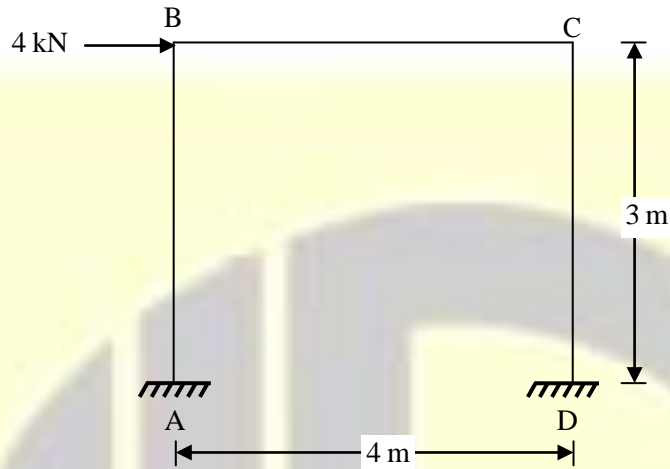
Overhead costs are ₹2,000 per day

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 leveling.

[10 + 10 Marks]

- (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 Marks]

SECTION-B

5. (a) (i) What is the difference between soft wood and hard wood?
(ii) What are the different phases of a project?

[6 + 6 Marks]

- (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 Marks]

- (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 Marks]

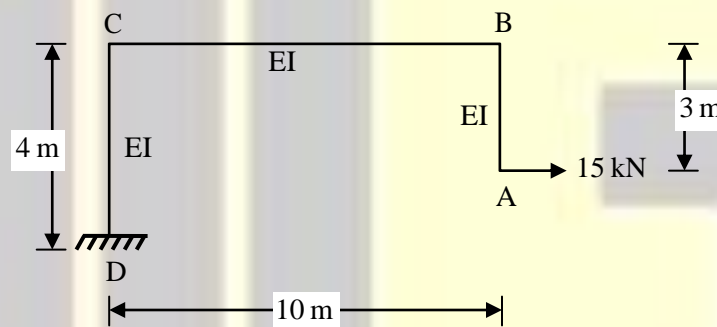
- (d) Find the development length for a reinforcement bar of diameter 20 mm under tension and compression embedded in concrete of M30 grade. The design bond stress τ_{bd} in limit state method for plain bar in tension is 1.5 MPa for M30. The grade of reinforcement bars is Fe500. Also find the corresponding anchorage lengths of the bar for 90° bend.

[12 Marks]

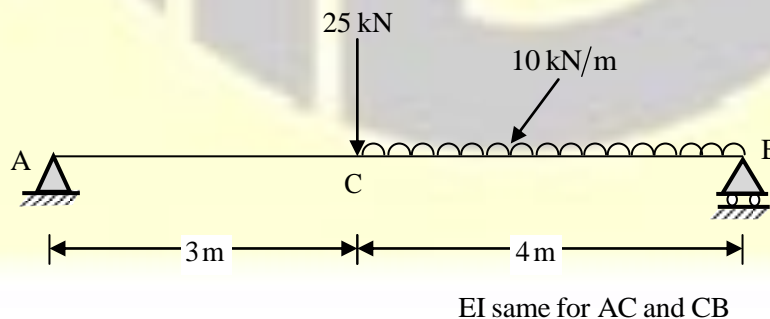
- (e) The maximum allowable shear stress in a hollow shaft of external diameter equal to twice the internal diameter is 120 N/mm^2 . Determine the diameter of the shaft if it is subjected to a torque of 12 kNm and a bending moment of 5 kNm.

[12 Marks]

6. (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.



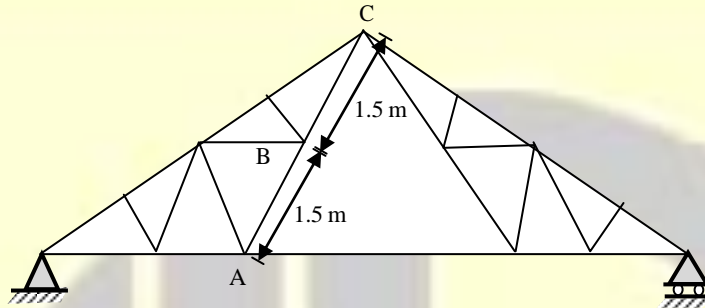
- (ii) Use Castigliano's theorem and determine vertical displacement of point C of the beam shown in the figure. Assume $E = 210 \text{ GPa}$ and $I = 150 \times 10^6 \text{ mm}^4$.



[10 + 10 Marks]

- (b) The member A-B-C in a truss consists of two angles $\angle 75 \times 75 \times 8$ 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 $\angle 75 \times 75 \times 8$ are :

$$A = 1140 \text{ mm}^2, C_y = C_z = 21.4 \text{ mm}, I_{yy} = I_{zz} = 59 \times 10^4 \text{ mm}^4.$$



$\frac{KL}{r}$	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

[20 Marks]

(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:

- Straight line method
- Sinking fund method

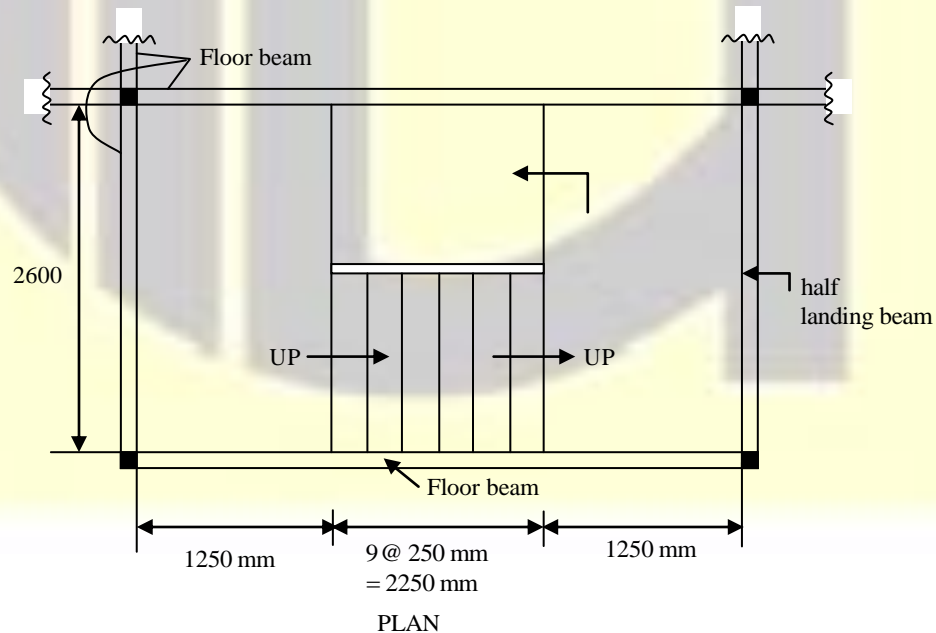
[20 Marks]

7. (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/mm^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 Marks]

(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 $250 \text{ mm} \times 400 \text{ mm}$. 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 Marks]

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

$f_{ck} = 25 \text{ N/mm}^2$

M_u/bd^2 , N/mm ²	f_y , N/mm ²					M_u/bd^2 , N/mm ²	f_y , N/mm ²				
	240	250	415	480	500		240	250	415	480	500
0.30	0.146	0.140	0.084	0.073	0.070	2.55	1.415	1.358	0.818	0.708	0.679
0.35	0.171	0.164	0.099	0.085	0.082	2.60	1.448	1.390	0.837	0.724	0.695
0.40	0.195	0.188	0.113	0.098	0.094	2.65	1.482	1.422	0.857	0.741	0.711
0.45	0.220	0.211	0.127	0.110	0.106	2.70	1.515	1.455	0.876	0.758	0.727
0.50	0.245	0.236	0.142	0.123	0.118	2.75	1.549	1.487	0.896	0.775	0.744
0.55	0.271	0.260	0.156	0.135	0.130	2.80	1.584	1.520	0.916	0.792	0.760
0.60	0.296	0.284	0.171	0.148	0.142	2.85	1.618	1.554	0.936	0.809	0.777
0.65	0.321	0.309	0.186	0.161	0.154	2.90	1.653	1.587	0.956	0.827	0.794
0.70	0.347	0.333	0.201	0.174	0.167	2.95	1.689	1.621	0.977	0.844	0.811
0.75	0.373	0.358	0.216	0.186	0.179	3.00	1.724	1.655	0.997	0.862	0.828
0.80	0.399	0.383	0.231	0.199	0.191	3.05	1.760	1.690	1.018	0.880	0.845
0.85	0.425	0.408	0.246	0.212	0.204	3.10	1.797	1.725	1.039	0.898	0.863
0.90	0.451	0.433	0.261	0.225	0.216	3.15	1.834	1.760	1.061	0.917	0.880
0.95	0.477	0.458	0.276	0.239	0.229	3.20	1.871	1.796	1.082	0.936	0.898
1.00	0.504	0.483	0.291	0.252	0.242	3.25	1.909	1.832	1.104	0.954	0.916
1.05	0.530	0.509	0.307	0.265	0.255	3.30	1.947	1.869	1.126	0.973	0.935
1.10	0.557	0.535	0.322	0.279	0.267	3.32	1.962	1.884	1.135	0.981	0.942
1.15	0.584	0.561	0.338	0.292	0.280	3.34	1.978	1.899	1.144	0.989	
1.20	0.611	0.587	0.353	0.306	0.293	3.36	1.993	1.914	1.153		
1.25	0.638	0.613	0.369	0.319	0.306	3.38	2.009	1.929	1.162		
1.30	0.666	0.639	0.385	0.333	0.320	3.40	2.025	1.944	1.171		
1.35	0.693	0.666	0.401	0.347	0.333	3.42	2.040	1.959	1.180		
1.40	0.721	0.692	0.417	0.360	0.346	3.44	2.056	1.974	1.189		
1.45	0.749	0.719	0.433	0.374	0.359	3.46	2.072	1.989			
1.50	0.777	0.746	0.449	0.388	0.373	3.48	2.088	2.005			
1.55	0.805	0.773	0.466	0.403	0.387	3.50	2.104	2.020			
1.60	0.834	0.800	0.482	0.417	0.400	3.52	2.120	2.036			
1.65	0.862	0.828	0.499	0.431	0.414	3.54	2.137	2.051			
1.70	0.891	0.856	0.515	0.446	0.428	3.56	2.153	2.067			
1.75	0.920	0.883	0.532	0.460	0.442	3.58	2.170	2.083			
1.80	0.949	0.911	0.549	0.475	0.456	3.60	2.186	2.099			
1.85	0.979	0.940	0.566	0.489	0.470	3.62	2.203	2.115			
1.90	1.009	0.968	0.583	0.504	0.484	3.64	2.219	2.131			
1.95	1.038	0.997	0.601	0.519	0.498	3.66	2.236	2.147			
2.00	1.068	1.026	0.618	0.534	0.513	3.68	2.253	2.163			
2.05	1.099	1.055	0.635	0.549	0.527	3.70	2.270	2.179			
2.10	1.129	1.084	0.653	0.565	0.542	3.72	2.287	2.196			
2.15	1.160	1.114	0.671	0.580	0.557	3.74	2.304				
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						

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

f_y
240
250
415
480
500
 f_{ck}
25

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

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

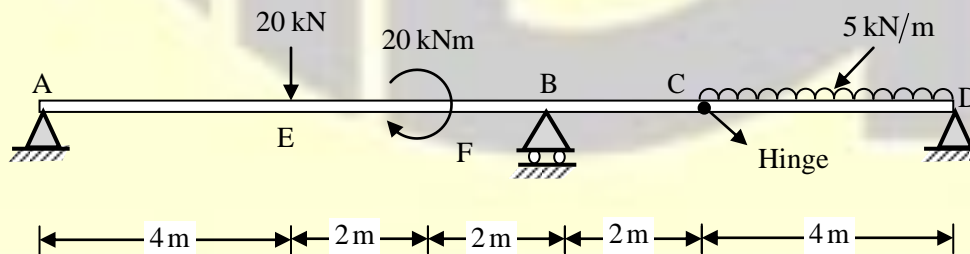
If the desired placement temperature is 11°C and concrete gains 4°C after cooling has occurred, find the quantity of ice to be added for the given set of materials.

(ii) What are the causes of accidents in the construction industry?

How can they be reduced?

[10 + 10 Marks]

8. (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 Marks]

- (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 30m (simply supported) and the total load (udl) including its self weight is 160 kN/m. Assume E250 grade of steel.

Assume field weld.

- (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.

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

[10 + 10 Marks]

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

- (ii) Explain the following terms:

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

[10 + 10 Marks]

