

BUILDING CONSTRUCTION APPLIED MECHANICS 3
7216

GENERAL CERTIFICATE OF EDUCATION BOARD
Technical and Vocational Education Examination

JUNE 2021

ADVANCED LEVEL

Specialty Name/ Code	CIVIL ENGINEERING -BUILDING CONSTRUCTION :CE-BC (F4-BA)
Subject Title	BUILDING CONSTRUCTION APPLIED MECHANICS 3
Subject Code N ^o .	7216
Paper N ^o .	3

THREE HOURS

This Paper Consists of THREE Parts. You are required to Answer ALL.

In all cases involving calculations, you are advised to show all the steps in your working.

Graph Paper will be provided if necessary.

Do not write in pencil except for diagrams and graphs.

Non-programmable scientific Calculators and formulae booklets may be used.

Where not stated, take $g = 10 \text{ m/s}^2$.

At the end of your examination, fasten your work together with a string.

You are reminded of the necessity for good English and orderly presentation in your answers.

Turn over

CONSTRUCTION OF A SHADE

Study of a shade for reserve players and coaches in a football stadium.

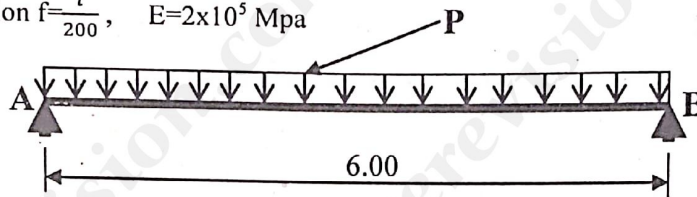
The drawings on page 4 represent a shelter in a stadium. This shelter is made up of two reinforced concrete portal frames, three IPE purlins, and a reinforced concrete bench.

PART ONE: STRENGTH OF MATERIALS /52.5 marks

I - Study of an Intermediate IPE Purlin (see mechanical sketch below)

Related Technical information:

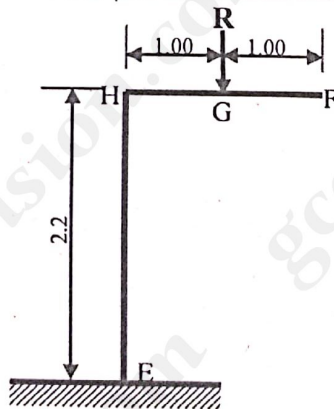
- Weight of Aluminum roofing sheets plus the IPE Profile = 250 daN/m²
- Exploitation load = 400 daN/m²
- Deflection at mid span = $\frac{5pl^4}{384EI}$
- Limited deflection $f = \frac{l}{200}$, $E = 2 \times 10^5$ Mpa



MECHANICAL SKETCH OF A PURLIN

- a) Determine the dead load per meter length along the purlin. (2.5 marks)
- b) Determine the live load per meter length on the purlin. (2.5 marks)
- c) Deduce the total load (P_{ser}) at SLS with $P_{ser} = g + q$. (1.25 marks)
- d) Write the equations of T and M along the purlin and sketch their diagrams at the ULS considering $P_u = 850$ daN/ml (7.5 marks)
- e) Taking $P_{ser} = 600$ daN/m, Chose the required profile and give its characteristics. (5 marks)
- f) Supposing that the purlin is IPE180, calculate the maximum tensile and compress stress in the beam. (5 marks)
- g) Draw the corresponding diagram. (5 marks)

II - Study of the Portal Frame in R.C. (see mechanical sketch below)



Let the diagram above represents the mechanical sketch of the portal frame. Take $R = 3600$ daN, and the inclination angle at $h = 0$.

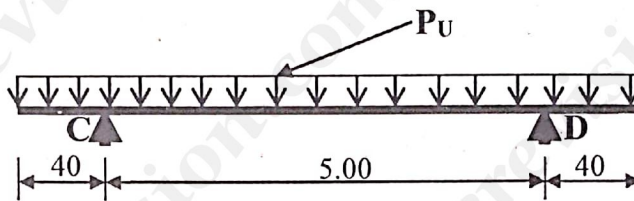
- a) Determine the reaction at Point E. (5 marks)
- b) Give the expressions of the shearing force, normal effort, and bending moment across the Portal frame. (11.25 marks)
- c) Draw their respective diagrams. (7.5 marks)

PART TWO: REINFORCED CONCRETE /37.5 marks

Study of the Slab of the Seat (see mechanical sketch)

Complementary information

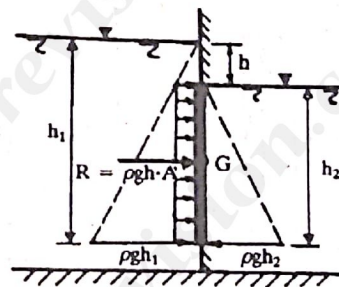
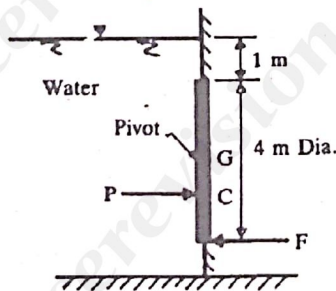
- It is considered as a beam of section 40 by 10cm
- It supports the following:-
 - Self-weight.
 - Weight of persons on it = 150 daN/M²
- $f_{bu} = \frac{0.85 f_{c28}}{\gamma_b}$,
- Transversal bar = $\frac{\emptyset}{3}$
- Density of concrete = 2500 daN / m³, $F_{c28} = 25 \text{ mpa}$, $F_e = 400 \text{ mpa}$

**MECHANICAL SKETCH OF THE SLAB**

- a) Calculate the permanent load (g) and the live load (q) per meter. **(8 marks)**
- b) Calculate the total load per meter at both SLS and ULS. **(7 marks)**
- c) Supposing that $M_u = 7000 \text{ Nm}$ and $M_{ser} = 5000 \text{ Nm}$, Calculate and choose the steel bars needed for the slab. **(15 marks)**
- d) Deduce the transversal steel bars. **(2.5 marks)**
- e) Draw a section of the slab showing the reinforcement bars. **(5 marks)**

PART THREE: FLUID MECHANICS /10marks

- a) A circular butterfly gate pivoted about a horizontal axis passing through its centroid is subjected to hydrostatic thrust on one side and counterbalance by a force F, applied at the bottom as shown in the figure below. If the diameter of the gate is 4m and the water depth is 1m above the gate, determine the force F, required to keep the gate in position. The density of water is 1000 kg/m³. **(5 marks)**



- b) If the gate is to retain water to its top level on the other side, determine the net hydrostatic thrust on the gate and suggest the new condition for the gate to be in equilibrium. **(5 marks)**

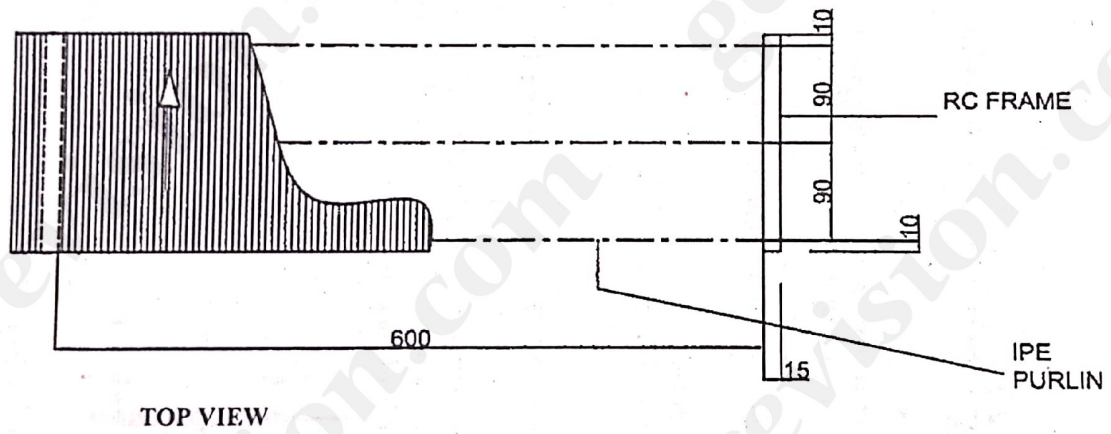
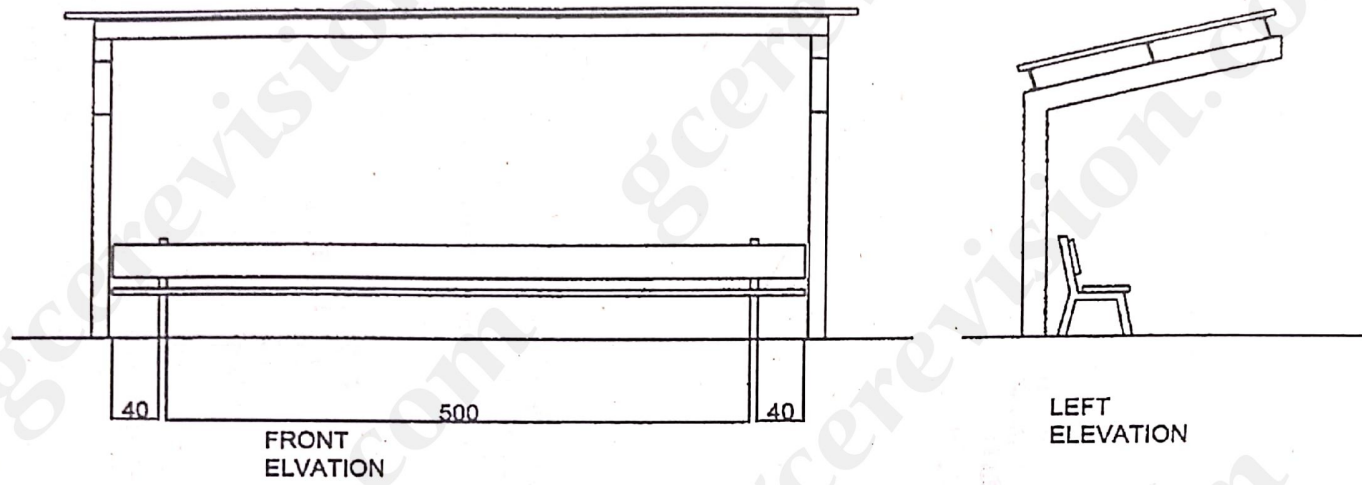
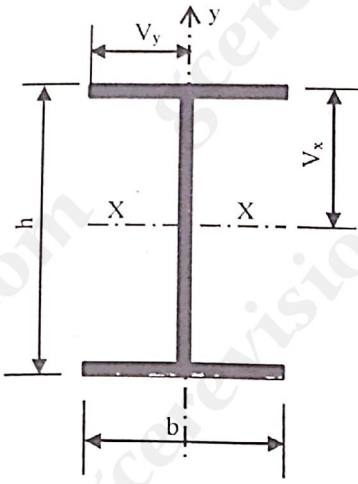


FIG 1

Figure	profiles	Dimensions in mm			Mass kg/m	Section Cm ²	Mechanical characteristics			
		h	b	a			I _{xx} Cm ⁴	I _{xx} /V _x Cm ³	I _{yy} Cm ⁴	I _{yy} /V _y Cm ³
	100	96	100	5	16.7	21.2	349	73	134	27
	120	114	120	5	19.9	25.3	606	106	231	38
	140	133	140	5.5	24.7	31.4	1033	155	389	56
	160	152	160	6	30.4	38.8	1673	220	616	77
	180	171	180	6	35.5	45.3	2510	294	925	103
	200	190	200	6.5	42.3	53.8	3692	389	1336	134
	220	210	220	7	50.5	64.3	5410	515	1955	178
	240	230	240	7.5	60.3	76.8	7763	675	2769	231
	260	250	260	7.5	68.2	86.8	10460	836	3668	282
	280	270	280	8	76.4	97.3	13670	1010	4763	340
	300	290	300	8.5	88.3	112.5	18260	1260	6310	421
	320	310	300	9	97.6	124.4	22930	1480	6985	466
	340	330	300	9.5	105	133.5	27700	1680	7436	496

Ø mm	Weight kg/m	Perimeter cm	SECTIONS OF BARS IN cm ²									
			1	2	3	4	5	6	7	8	9	10
5	0.154	1.571	0.196	0.393	0.589	0.785	0.982	1.178	1.374	1.571	1.767	1.96
6	0.222	1.885	0.282	0.565	0.848	1.130	1.414	1.696	1.979	2.261	2.544	2.82
8	0.394	2.513	0.502	1.000	1.507	2.01	2.51	3.01	3.51	4.02	4.52	5.02
10	0.616	3.142	0.785	1.57	2.35	3.14	3.92	4.71	5.49	6.28	7.07	7.85
12	0.887	3.770	1.130	2.26	3.39	4.52	5.65	6.78	7.92	9.04	10.18	11.31
16	1.578	5.027	2.01	4.02	6.03	8.04	10.05	12.10	14.07	16.13	18.15	20.17
20	2.466	6.283	3.14	6.28	9.42	12.57	15.71	18.85	21.93	25.13	28.27	31.42
25	3.853	6.283	4.91	9.82	14.73	19.63	24.54	29.45	34.36	39.27	44.18	49.09
32	6.313	10.053	8.04	16.08	24.13	32.17	40.21	48.25	56.30	64.34	72.38	80.42
40	9.864	12.566	12.565	25.13	37.70	50.27	62.83	75.40	87.96	100.53	113.10	125.66