

GENERAL CERTIFICATE OF EDUCATION BOARD

Technical and Vocational Education Examination

BUILDING CONSTRUCTION APPLIED MECHANICS 3

7216

JUNE 2022

ADVANCED LEVEL

Specialty Name and Acronym	CIVIL ENGINEERING -BUILDING CONSTRUCTION :CE-BC(F4-BA)
Subject Title	BUILDING CONSTRUCTION APPLIED MECHANICS 3
Subject Code No.	7216
Paper No.	3

Duration: 3 Hours

INSTRUCTIONS TO CANDIDATES

This Paper has **THREE** Parts. 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

GRAND STAND PROJECT

The drawings on pages 4 and 5 represent a cross section and roof Plan View of the Grand Stand of a football field. The roof covering is made of corrugated iron sheets resting on glued-laminated timber purlins. The main structure (rafter) of the roof covering is made of glued laminated timber beams placed 5.00m axis to axis. Each rafter is centrally articulated on an 80 x 80 cm reinforced concrete pillar and is equilibrated by a steel cable **AB** which is anchored in a reinforced concrete mass embedded into the bearing soil.

The concrete pillars are placed 5.00 m centre to centre.

Technical Information

- **Permanent loads:**
 - Corrugated iron sheets.....300N/m²
 - Laminated timber purlins.....300N/ml
 - Laminated beams (rafter).....1000N/ml
- Exploitation of the roof..... 400N/m²
- Security coefficients for wooden elements:
 - Permanent load.....1
 - Exploitation load.....1.2

PART ONE: STRENGTH OF MATERIALS. / 50marks

a) Study of a purlin

Assuming that each purlin is on 2 simple supports;

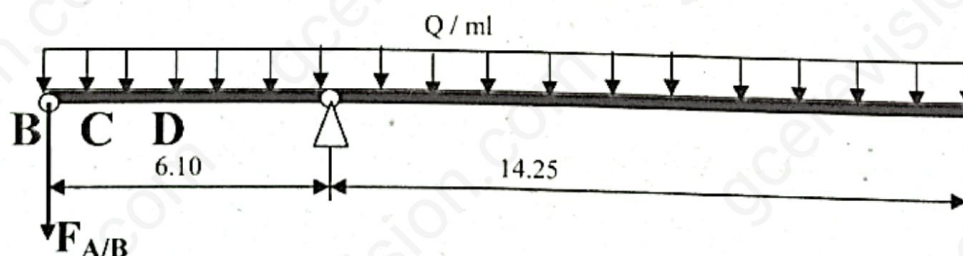
Calculate

- i. The load per linear meter **P** of an intermediate purlin. (5 marks)
- ii. The maximum bending moment (**M_{max}**) in the span of the above purlin. $P=1000\text{N/ml}$ (2.5 marks)
- iii. The height of the cross section of a purlin if the width is 4 cm and the practical resistance of laminated wood is 25N/mm^2 and **M_{max} = 3500Nm**. (5 marks)

b) Study of the equilibrium of an intermediate rafter beam

Assume that:

- Each beam is straight, horizontal, articulated on a reinforced concrete pillar with cross section of 10 x 45 cm²;
- The tie bar is articulated at its ends;
- The load transmitted to the beam by the roofing sheets and the purlins is uniformly distributed;
- Here below is the mechanical line diagram of the beam;



- i. Calculate the load **Q**, per linear meter in daN/ml if the total load transmitted by a purlin to the rafter is 540daN/ml.

(2.5 marks)

- ii. Determine the contact actions at B and C if $Q = 630 \text{ daN/ml}$. (2.5 marks)
- iii. Write the equations of bending moment $M(x)$, and shearing force $T(x)$ along the beam. (10 marks)
- iv. Sketch the bending moment and shearing force diagrams along the beam. (10 marks)
- v. Calculate the minimum diameter of the steel cable if it has a practical resistance of 120 N/mm^2 and $F_{AB} = 8537 \text{ daN}$. (5 marks)
- vi. Calculate the normal stress in the beam at the support C if the cross section of the beam is $10 \times 40 \text{ cm}^2$ and the bending moment $M_u = 79233 \text{ daN.m}$. (7.5 marks)

PART TWO: REINFORCED CONCRETE

/ 30 marks

a) Reinforcement of one of the Pillars

Consider the following hypotheses.

- Section of the pillar 80×80
- Height of the pillar: $L_0 = 7.00 \text{ m}$ It's embedded into the ground and articulated at the other end.

Effective length: $L_f = 0.7l_0$

- Total load carried by the pillar: $N_u = 1,35G + 1,5Q = 21420 \text{ daN}$
- For the concrete: $f_{c28} = 25 \text{ MPa}$, $\eta_b = 1,5$
- For the steel: FeE400, take $\eta_s = 1,115$
- $N_u \leq \alpha \left[\frac{B_r f_{c28}}{0.9 \gamma_b} + A_{sc} \frac{f_e}{\gamma_s} \right]$ with $\alpha = \frac{0.85}{1 + 0.2 \left(\frac{l^2}{35} \right)}$ for $\eta < 50$ and $\alpha = 0.62 \left(\frac{50}{l} \right)^2$ for $\eta \geq 50$

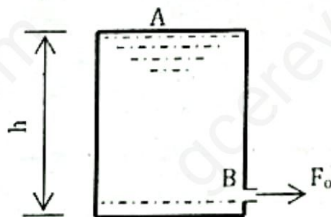
- i. Calculate the reinforcement of this pillar. (20 marks)
- ii. Sketch its cross section, showing the reinforcement. (10 marks)

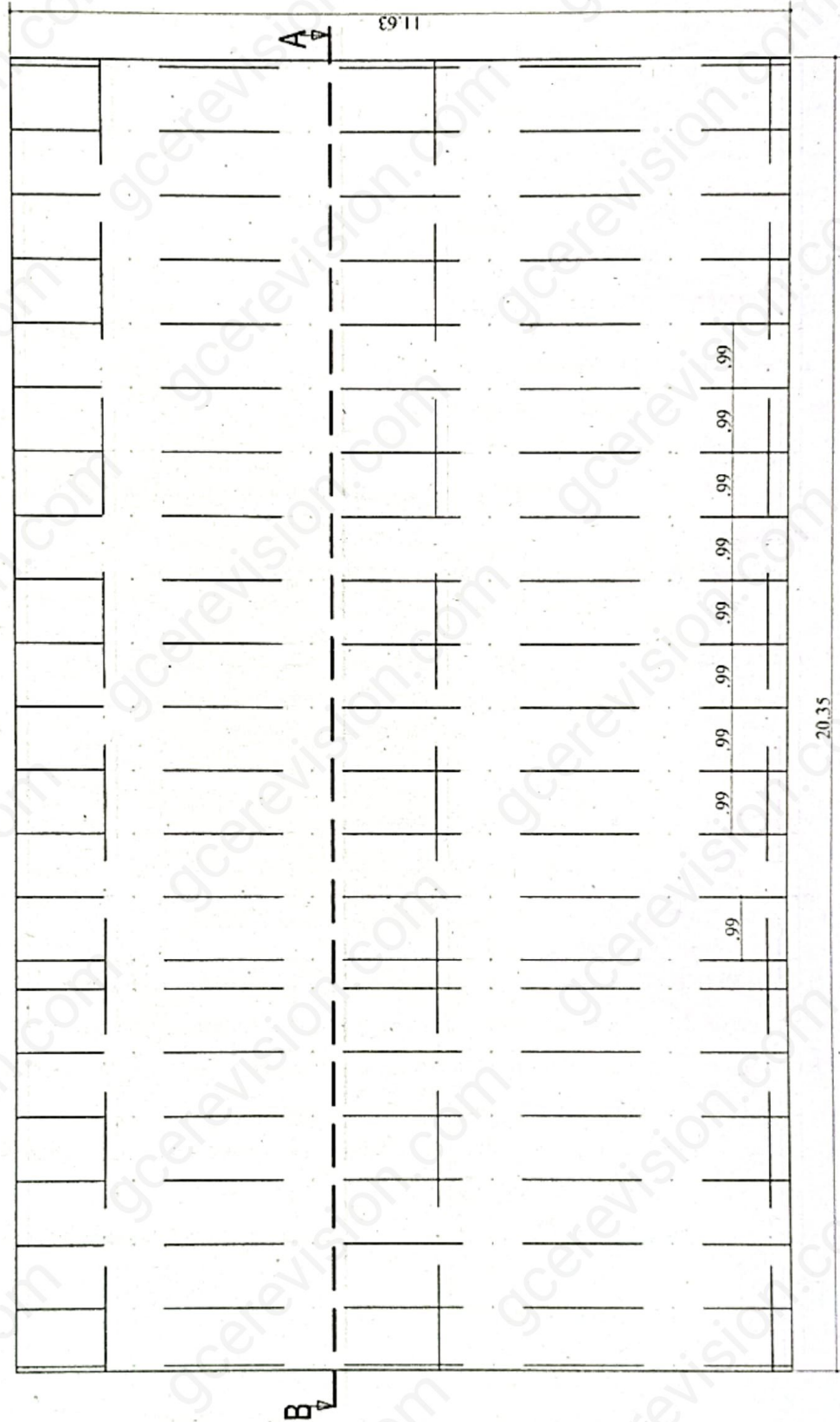
PART THREE: HYDRAULICS

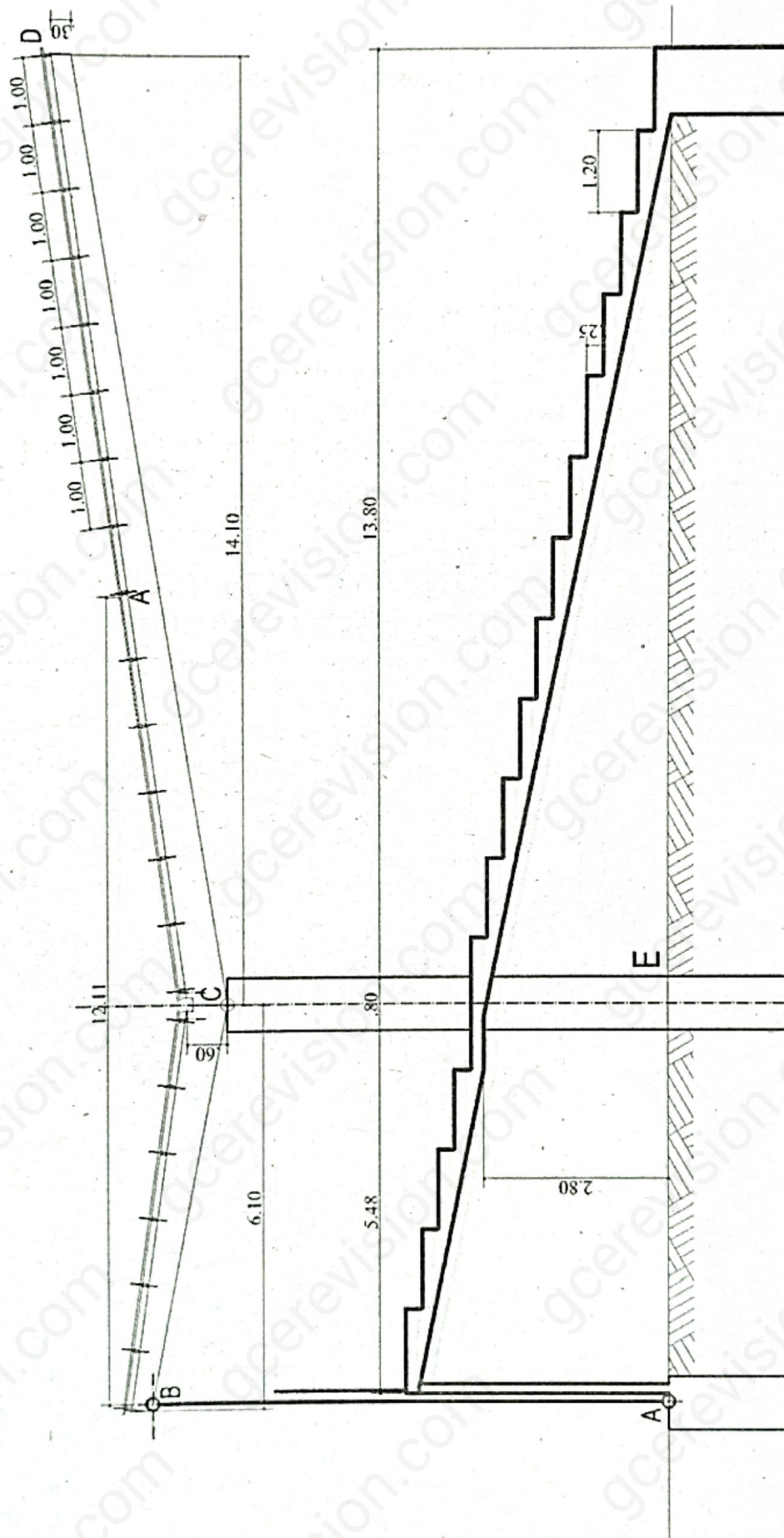
/ 15 marks

The figure below represents a water tank containing water which flows through a narrow circular aperture.

- a) Considering the line of the water current leaving from the point A to the point B, write the BERNOUILLI'S equation between these two points. (2.5 marks)
- b) Considering that, the water is at rest at the top of the reservoir, calculate the discharge speed V_B knowing that, the height $h = 5 \text{ m}$ and the force of gravity, $g = 10 \text{ m/s}^2$. (7.5 marks)
- c) Calculate, the discharge Q which flows through the aperture knowing that, the diameter of the aperture is $\varnothing = 20 \text{ mm}$. (5 marks)







SECTION A - A

Ø of rods in mm	CROSS SECTIONAL AREA OF ROD IN cm ²									
	1 bar	2 bars	3 bars	4 bars	5 bars	6 bars	7 bars	8 bars	9 bars	10 bars
5	0.196	0.39	0.58	0.78	0.98	1.17	1.37	1.57	1.76	1.96
6	0.28	0.56	0.84	1.13	1.41	1.69	1.97	2.26	2.54	2.82
8	0.50	1.00	1.50	2.01	2.51	3.01	3.51	4.02	4.52	5.02
10	0.78	1.57	2.5	3.14	3.92	4.71	5.49	6.28	7.06	7.85
12	1.13	2.26	3.39	4.52	5.65	6.78	7.91	9.04	10.17	11.31
14	1.53	3.07	4.61	6.15	7.69	9.23	10.77	12.31	13.85	15.
16	2.01	4.02	6.03	8.04	10.1	12.1	14.1	16.1	18.1	20.1
20	3.14	6.28	9.42	12.6	15.7	18.8	22	25.1	28.3	31.4
25	4.91	9.82	14.7	19.6	24.6	29.5	34.4	39.3	44.2	49.1
32	8.01	16.1	24.1	32.2	40.2	48.2	56.3	64.3	72.4	80.4
40	12.6	25.2	37.8	50.4	63	75.6	88.2	101	113	126