THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING - 4TH YEAR DEGREE

SECOND SEMESTER EXAMINATIONS - 2023

CE 423 – BRIDGE ENGINEERING

DATE: WEDNESDAY, 25TH OCTOBER 2023 – 08:20 A.M

VENUE: STRUCTURES LECTURE THEATRE (SLT)

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES

1. You have 10 minutes to read the paper before the examination starts. You must **not** begin writing during this time.
2. **There are Two Parts to this Exam. Part A –Short/Long Answer Questions, and Part B – Analysis and Design of Steel Girder Bridge. Answer ALL questions to get full 100 Marks.**
3. Use only ink. Do not use pencils for writing except for drawings and sketches.
4. Only Calculator is allowed in the examination room. **MOBILE PHONE,** Notes and textbooks are **NOT ALLOWED** except the PNG and Australian Bridge Design Standards/Specifications.
5. All answers must be written in the ANSWER SHEET provided. Start each question on a new page and show all your calculations in the answer sheet. No other material will be accepted.
6. **Write your NAME and Student NUMBER clearly on the front page. Do it now.**
7. **Marking Scheme:** As shown in each Questions.

PART A – SHORT/LONG ANSWER QUESTIONS

1. Explain how the construction method affects the total cost of a bridge. **(5 Marks)**
2. Discuss the role of technology in modern bridge construction. Provide examples of innovative technologies that have improved the construction process and the durability of bridges. **(10 Marks)**
3. Compare the advantages & disadvantages of various types of joints used in construction of bridge. **(15 Marks)**

PART B – ANALYSIS AND DESIGN OR STEEL GIRDER BRIDGE

1. A steel girder bridge **(Refer Figures 1 and 2)** on a National Road in PNG has the following data;

Concrete: fc = 40 MPa	Carriage way width = 7.6 m
F_{sy} = 500 MPa	Carriage way = 2 Lane
Concrete Depth = 200 mm,	Pedestrian Footpath = 1.1 m wide on both sides
Concrete Cover = 30 mm	
Top wearing surface = 10 mm	2 x T44 Vehicle Load
Concrete Density = 25 kN/m^3	Assume SDL = 2 kPa
Cross beams at 4000 mm interval	Construction Load = 4kPa, Pedestrian Load = 5kPa

Analyze the bridge with the given loads and draw the SF and BM for the Dead Loads (including SDL). **(15 marks)**

2. Draw the SF and BM for the Pedestrian Load. **(5 marks)**

3. Draw the influence diagram for the maximum effect under the following vehicle loads
   a. T44 wheel loads placed 1.8 m apart. **(10 marks)**
   b. T33 wheel loads placed 1.8 m apart. **(10 marks)**

4. Design the Steel Girders for W70 Wheel Loads according to AS5100. **(25 marks)**

5. Draw a neat cross-section of the steel girder design in Question 4 above. **(5 marks)**

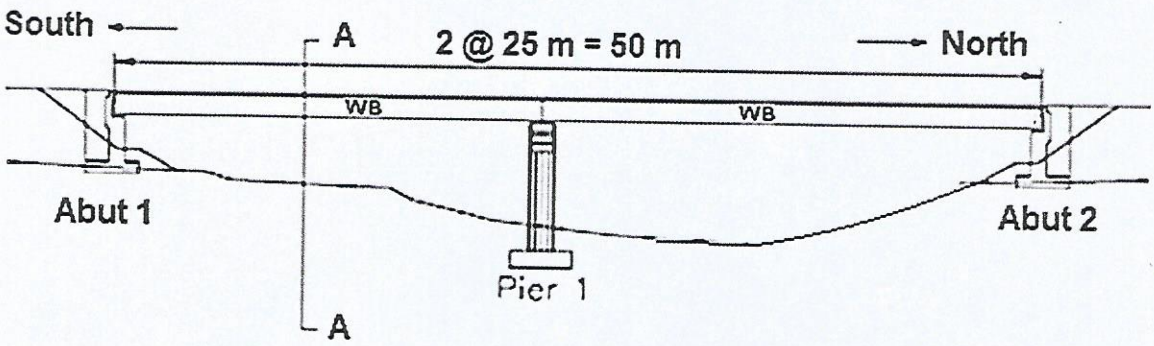

Figure 1: Elevation of Steel Girder Bridge

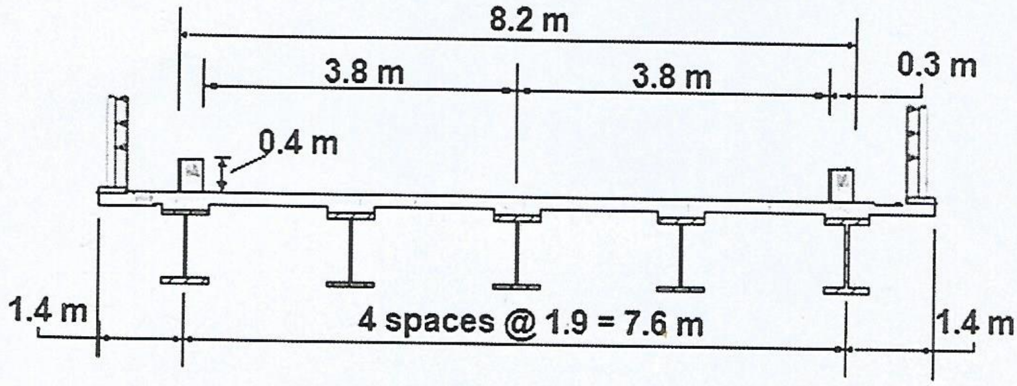

Figure 2: Cross-section of the bridge showing deck layout

<u>END OF EXAMINATION!!!! ALL THE BEST!!!!!!</u>

$$M_{max} = 96\left[L * 1.125 - 5.525 + \frac{0.7}{L}\right]$$ ....Equation 1

$$R_{max} = 96\left(4.5 - \frac{15.35}{L}\right)$$ ....Equation 2

RC Deck Design

1. $\gamma k_u\, d \leq 0.4\gamma d$
2. $a \leq 0.2\gamma d \cong 0.1d$
3. $A_{st\ (required)} = M_{u\ (required)} / (l \times f_{sy})$
4. Ast (min) = (1.4/fsy) x bd
5. $T = f_{sy} \times A_{st}$
6. A= T/0.85f'c = fsy x Ast
7. $\gamma k_u\, d = \gamma d_n = A/b$
8. $a = \gamma d_n/2$
9. I = d-a
10. $M_u = T \times I$
11. $\gamma = 0.85$
12. $k_u = \gamma\, k_u\, d / \gamma\, d$

Check Deck for Shear

1. $V_{uc} = \beta_1\, \beta_2\, \beta_3\, b_v\, d_0\, (A_{st} \times f')/(b_v\, d_0))^{1/3} \times 10^{-3}$
   a. $\beta_1 \stackrel{c}{=} 1.1(1.6 - d_0 / 1000)$
   b. $\beta_2 = 1.0$
   c. $\beta_3 = 1.0$
2. $\varphi V_{u\ (min)} = \varphi\ (V_{uc} + V_{us\ (min)})$
3. $\varphi V_{u\ (min)} = \varphi \times 0.17 \times 3\sqrt{f'_c}\ bd_0$

Check for Punching Shear

1. $\varphi V_{uo} = \varphi \times (\mu \times d_0 \times f_{cv})$
2. $\mu = (600 + 142) \times 2 + (100 + 142) \times 2 = 1{,}968$ mm
3. $B_h = 600/ 100 = 6.0$
4. $f_{cv} = 0.17(1+2/\ \beta_h)\ \sqrt{f'_c}$

BEAM DESIGN

Formulas

- $M* \leq \emptyset M_s = \emptyset f_y Z_e$
- $M* \leq \emptyset M_b = \emptyset a_m a_s M_s \leq \emptyset M_s$
- $\emptyset = 0.9$ *(Table 3.4 AS4100 – 2004) and take* $a_m = 1.0$ *at midspan*
- $M_{sx} = fy\ x\ Zex$
- $Mb_x = a_s$ x a_m x M_{sx}
- HOW TO FIND EFFECTIVE LENGTH(Le) FORMULA?

Construction Stage

1. $\lambda e = \left(\frac{d_1}{t_w}\right)\sqrt{\frac{f_y}{250}}$

2. $V_v = V_U = V_W = 0.6A_wf_y$

Check Web Bearing

a. $b_{bf} = b_s + 2.5\ (t_p + t_f)$

b. $\phi R_{by} = 0.9$ x $(1.25 b_{bf} t_{wf} f_{yw})$

Check for Web Buckling

1. $b_b = b_bf + 0.5$ x d_2
2. $\lambda n = 2.5$ x $\frac{d_1}{t_w}$
3. $\alpha_c = 0.3$
4. $\phi R_{bb} = 0.9$ (α_c x kf x Awb x f_{yw})
5. kf = 1.0 since local buckling is not a design consideration
6. $A_{wb} = b_b$ x t_w = 840 x 16 = 13440mm^2