THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING – 3rd YEAR DEGREE

FIRST SEMESTER EXAMINATION - 2023

CE 311 – STEEL DESIGN

DATE: FRIDAY, 2nd JUNE 2023 – 08:20 A.M

VENUE: STRUCTURES LECTURE THEATRE (SLT)

TIME ALLOWED: 2 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 FIVE (5) Questions in this paper. Answer any 4 Questions.**
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 is not allowed (**Switch your Mobile Phones OFF**). Notes and textbooks are not allowed.
5. Start each question on a new page and show all your calculations in the answer book provided. No other material will be accepted.
6. **Write your NAME and Student Id NUMBER clearly on the front page. Do it now.**
7. **Marking Scheme:** All Questions carry equal marks.

QUESTION 1 [10 marks] SLO 2

a) A tension member with a full perimeter welded connection to a uniformly stiff support is subjected to a design axial tension force of 145 kN. Design a suitable tension member as per Australian Standard using rectangular hollow section (RHS) . You can use the relevant tables attached with this question paper. Assume correction factor $K_t = 1.0$ 5

b) Select a section for diagonal tension member of a truss from the following available sections:

Two standard sections are available within the company's stock: Equal angle section 125X125X 8 with gross area (Ag) = 1900 mm^2 and unequal section with Ag = 2870 mm^2 of grade 300 steel with fy = 320 MPa and fu = 440 MPa. Axial loads acting on the member are as follows:

Permanent action /dead load N_G = 100 kN

Imposed action/live load N_Q = 120 kN

K_t = Correction factor for distribution of forces = 0.75 for unequal angles and 0.85 for others. 5

QUESTION 2 [10 marks] SLO4

Design a simply supported beam of 4.0 m span subjected to uniformly distributed loads of :

G (Dead load) = 55 kN (total load)

Q (Live load) = 60 kN (short term total load).

The beam is continuously laterally restrained. The total deflection of the beam under serviceability load must not exceed L/250. Select an appropriate grade C350 RHS to support the loading system.

Given: Maximum design loads are as follows:

a) Strength Limit state : $W_L^* = 1.25G + 1.5Q$

b) Serviceability limit state: $W_S^* = G + 0.7Q$

You are permitted to use the tables attached with this question paper.

QUESTION 3 [10 marks] SLO 3 & 5

Determine the design action effects for an isolated braced beam column which is subjected to axial compression of 105 kN and 5 kNm end moments at both ends about y axis with 0 kNm at top and 45kNm at bottom of the member about x-axis (**Fig. 1**).

Use section 200X100X9 RHS of Grade C350 steel.

Effective lengths:

Flexural buckling (x-axis) = 4 m

Flexural buckling (y-axis) = 4 m

Factor for unequal moments, $C_{mx} = 0.6$ for $\beta_{mx} = 0$ and $C_{my} = 1.0$ for $\beta_{mx} = -1$

And moment amplification factor $\delta_b = C_m / [1-(N^*/N_{omb})]$

Where β_m = ratio of the smaller to the larger bending moment at the ends of the member taken as positive when the member is bent in reverse curvature.
N_{omb} = Elastic flexural buckling loads for a braced member.
Assume any other data needed for the solution.

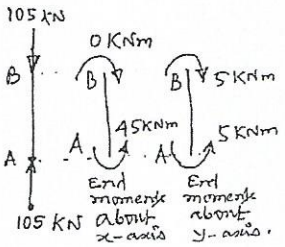

Fig. 1

QUESTION 4 [10 marks] SLO 6

Check the adequacy of 5-M20 grade 4.6 bolts to carry a maximum axial force of 540 kN in the connection shown in **Fig 2.**
Given:

i) The tie consists of 2-125X125X8 angles placed back to back with Ag = 1900 mm² and b = 7.8 mm
ii) The angles are manufactured by steels with f_y = 320 MPa and f_u = 440 MPa.
iii) The members are connected to 150X 6 mm gusset plate by 5-M 20 bolts
iv) The gusset plate is manufactured by steels with f_y = 250 MPa and f_u = 410 MPa.
v) From safe load tables, φV_{fn} = 44.6 kN/bolt (threads included in the shear plane)
vi) From safe load tables, φV_{fn} = 62.3 kN/bolt (threads excluded in the shear plane)
vii) For each angled section, (t. Sp2/4Sg) is to be added for each stagger.
Where Sp = pitch and Sg = gauge perpendicular to N*
Assume any other data needed for the solution.

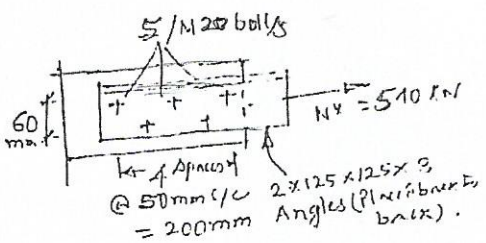

Fig. 2

OR

Fig. 3 shows an eccentric welded connection with fillet weld. Determine the greatest load P per Bracket Plate which can be applied on the connection if the shear stress in the weld is not to exceed 108 MPa?

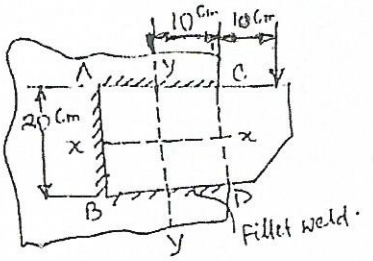

Fig. 3

QUESTION 5 **[Answer any 5 questions 2 x 5=10 marks] SLO 1 & 7**

a. Write the conditions to be satisfied for section capacity in limit state design of steel components subjected to biaxial bending as per Australian standard. 2

b. Write the expression for design shear force under serviceability limit state for bolted connections as per AS4100. 2

c. What is the relation between the effective length and effective length factor in the analysis of steel structural member subject to compression in limit state method of design? 2

d. Which parameters are included in the tables of steel hollow sections as per AS 4100? 2

e. What is meant by "Grade C350" as per Australian Standard for design of steel structures? 2

f. What is meant by "effective section modulus" in AS 4100? 2