The University of Sydney

Faculty of Engineering

Department of Civil Engineering

Senior Year Examination

CIVL 3206 Steel Structures 1

Semester 2, 1999
Time Allowed: 3 hours

All questions should be attempted.

Suitable working, diagrams and explanations are required for each question.

Programmable and non-programmable calculators may be used.

Annotated copies (but no inserts) of the following documents may be taken into the exam:
"Hot Rolled and Structural Steel Products - BHP"
"Structural Cold-Formed Hollow Sections and Profiles - BHP"
"Australian Standards for Civil Engineering Students - Part 2: Structural Engineering HB2.2"
"Australian Standard - Steel Structures - AS 4100"

The marks shown for each question on this paper correspond to the percentage of the examination paper and not the course.

Q1:	Tension Members	(15 marks)
Q2:	Compression Members	(15 marks)
Q3:	Bending	(20 marks)
Q4:	Combined Actions	(30 marks)
Q5	Connections	(20 marks)
		100 marks total

Q 1 Tension Members (15 marks) *(This question has two (2) parts: (a) & (b))*

a) A tension splice connection is located between two 310UC158 sections in Grade 300 steel. The two splice plates are bolted to the top and bottom flanges of the UC. The arrangement of **26 mm diameter bolt holes** on each flange is shown in Figure 1. It may be assumed that the splice plates and the bolts are sufficient to take the design axial tension.

What is the design section capacity in tension (φN_t) of the bolted UC section?

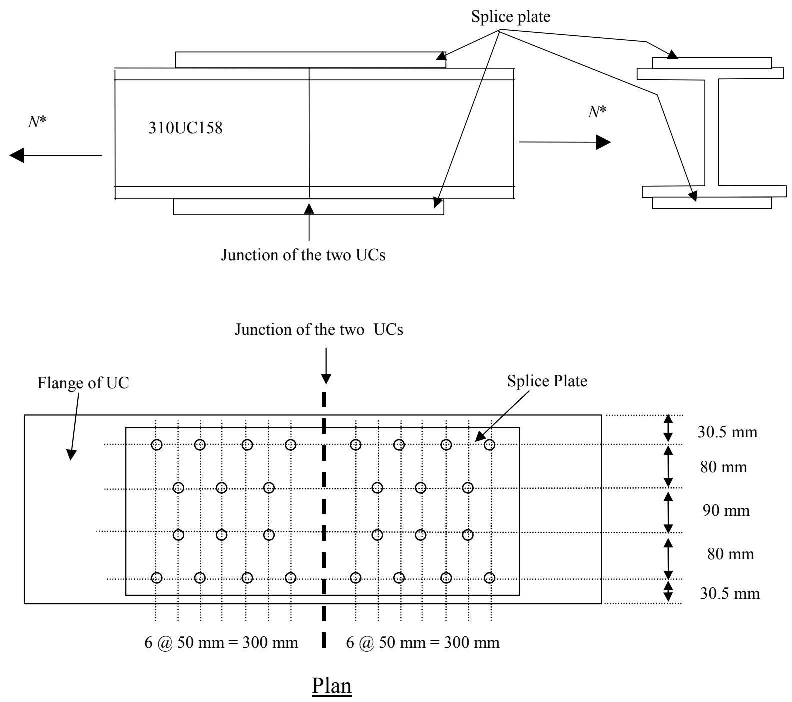

Figure 1: Bolted UC Tension Splice

b) The bolted splice plate is replaced by a welded splice plate (ie there are no bolt holes). It may be assumed that the splice plates and the welds are sufficient to take the design axial tension.

What is the design section capacity in tension (φN_t) of the welded UC section?

Q2 Compression Members (15 Marks)

A frame consisting of four 310UC96.8 Grade 300 columns is shown in Figure 2 and is supported by beams as also shown in Figure 2. The beams in the *x*-direction are 250UB25.7 in Grade 300 steel and are **not rigidly** connected to the columns. The beams in the *y*-direction are 360UB44.7 in Grade 300 steel and are **rigidly** connected to the columns. The frame is cross-braced in the *x*-direction as shown in Section A-A.

If the height of the columns is 3 metres, and the columns are located on a (pinned) base plate attached to a concrete floor, **compute the axial capacity (φN_c) of the columns in the bottom storey of the building**. It can be assumed that the floor height for the first floor is also 3 metres.

If required, the values of Z_{ex} and k_f may be taken from the BHP product literature.

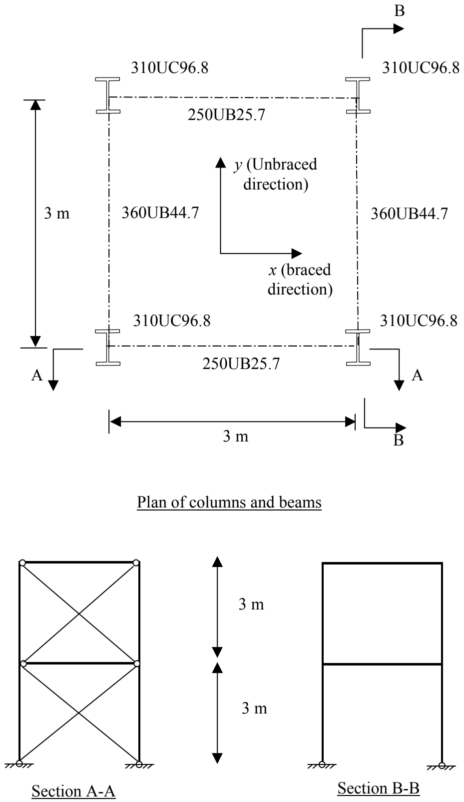

Figure 2: Plan and Elevation of Frame System

Q 3 Bending (20 Marks) *(This question has two (2) parts: (a) & (b))*

a) The cross section of a beam supporting a concrete slab is shown in Figure 3(a). The top flange of the beam is attached to the concrete slab by shear connectors. The bending moment diagram for the beam is shown in Figure 3(b). The bending moment is drawn on the compression flange of the section.

Could the beam be considered to have full lateral restraint? Briefly explain your answer, making particular reference to the bending moment diagram, and the regions of positive and negative bending moment. There is no need to perform any calculations in answering this question.

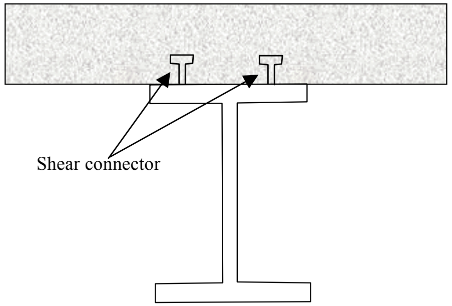

Figure 3(a): Cross-section of Steel Beam with Top Flange Connected to Concrete Slab

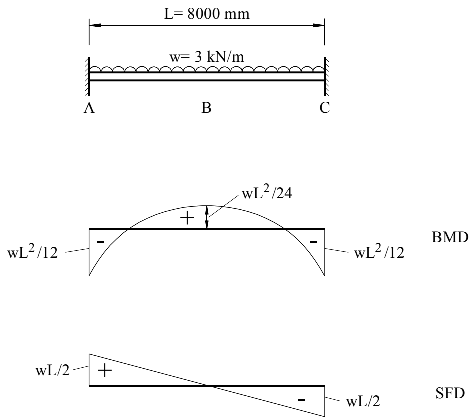

Figure 3(b): Loading, Bending Moment and Shear Force Distribution for the Beam

b) A 10 m long simply supported beam is constructed from an 800WB122 section in Grade 300 steel, and is subjected to a design point load of P^* = 1100 kN, as illustrated in Figure 3(c). The beam can be considered to have full lateral restraint to the critical flange along its entire length.

i) Draw the bending moment and shear force diagrams for the entire beam.
ii) Identify the cross-section of the beam which is most critical with regards to interaction of bending moment and shear force.
iii) Determine whether the critical cross-section satisfies Clause 5.12.3 of AS 4100, with regards to interaction of shear force and bending moment. Clearly identify the values of all appropriate design capacities calculated (eg ϕV_{vm}).

If required, the values of Z_{ex} and k_f may be taken from the BHP product literature.

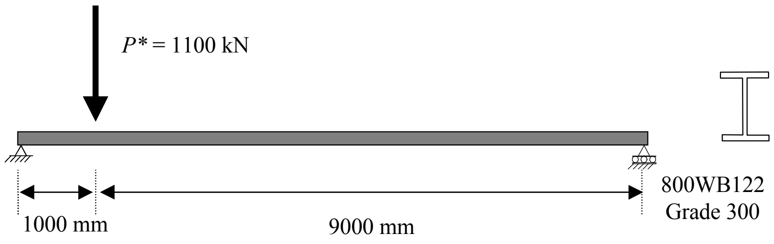

Figure 3(c): Simply Supported Beam Under Point Load

Q4 Combined actions (30 Marks)

The rigid jointed pitched roof portal frame shown in Figure 4 is subjected to a distributed load along the rafters of w = 10 kN/m as shown. The rafters have full restraint against lateral buckling at the ends and mid-point as shown by the crosses in Figure 4(a). The distributed load can be assumed to act on the top flange.

The rafters of the frame are constructed from 610UB125 sections in Grade 300 steel, and the columns are 200UC52.2 sections in Grade 300 steel.

The second order bending moment distribution (M^*) in the rafter is shown in Figure 4(b) and the second order axial force distribution (N^*) in the rafter is shown in Figure 4(c). The bending moment is drawn on the compression flange of the section.

Check the section capacity of the rafter for in-plane bending according to Clause 8.3.2 of AS 4100 and the out-of-plane member capacity according to Clause 8.4.4.1.

The in-plane member capacity according to Clause 8.4.2.2 does not need to be checked.

If required, the values of Z_{ex} and k_f may be taken from the BHP product literature.

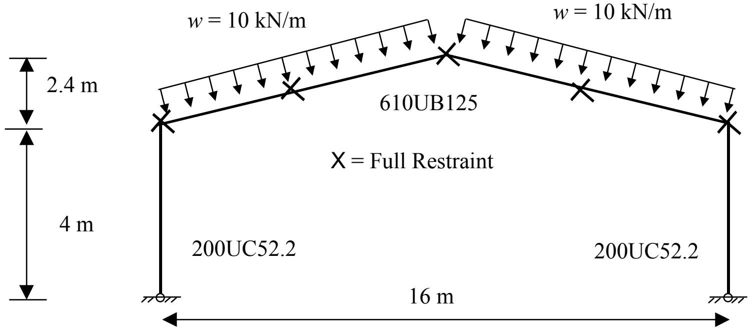

Figure 4(a): Frame Dimensions, Restraints and Loads

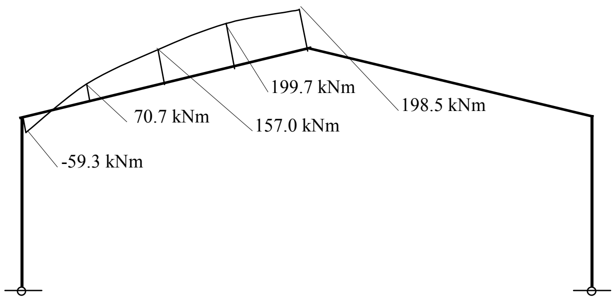

Figure 4(b): BMD for Rafter

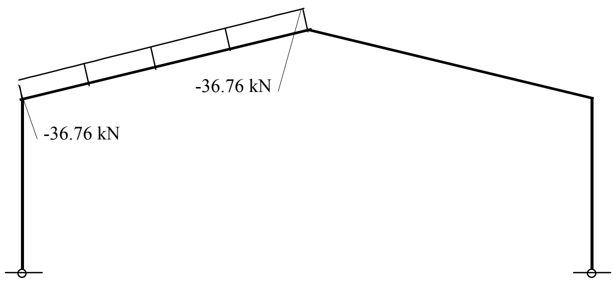

Figure 4(c): Axial Force in Rafter

Q5 Connections (30 Marks) *(This question has three (3) parts: (a), (b) & (c))*

a) **Give two methods of guaranteeing the specified pre-tension in a fully-tensioned high-strength bolt.**

b) The following properties are for an M20 bolt:
Core area, A_c = 225 mm^2.
Shank area, A_o = 314 mm^2.
Tensile stress area, A_s = 245 mm^2.
Grade 4.6 bolt, minimum tensile strength, f_{uf} = 400 MPa.

i) **What is the design shear capacity (φV_f)** of a Grade 4.6 M20 bolt assuming that there is one shear plane through the threaded portion of the bolt? It may be assumed that the reduction factor, k_r = 1.0.

ii) **What is the design tension capacity (φN_{tf})** of a Grade 4.6 M20 bolt?

c) Two 150UC30.0 sections, Grade 300 to AS 3679, are connected with splice plates connected to the top and bottom flanges of each section, as shown in Figure 5. Each splice plate is Grade 300 to AS 3678, and is 120 mm wide and 16 mm thick. The splice plates are welded to the flanges of the UC section. The fillet welds are SP Grade, made from E48XX electrode, and equal leg lengths of 6 mm. Each weld is 250 mm long, and eight (8) individual fillet welds are used to construct the splice connection.

It is not necessary to calculate the section capacity in tension (φN_t) of either the UC or the splice plates. For the UC section φN_t = 1110 kN, and for each of the splice plates φN_t = 518 kN.

i) What is the design shear capacity per unit length (φv_w) of the weld?

ii) What failure modes need to be considered when calculating the design capacity of this connection?

iii) What is the maximum design tension (N*) to which the connection can be designed? What is the critical failure mode?

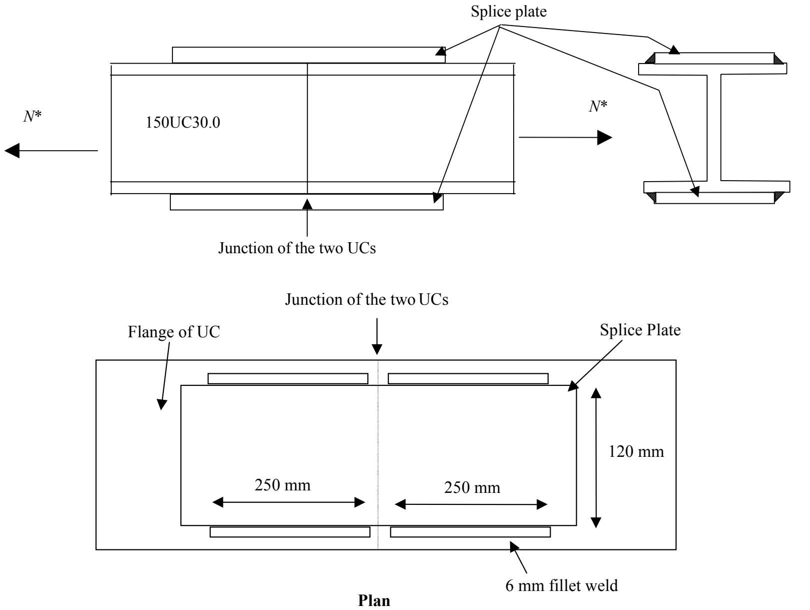

Figure 5: Welded UC Tension Splice

This is the end of the examination paper.