The University of Sydney

CIVL3206 Steel Structures 1

School of Civil Engineering

Semester 2, 2008

Time Allowed: 3 hours + 20 minutes reading time

Instructions to Candidates

(a) Students should attempt all questions.

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

(c) Marks may be deducted for work that is not satisfactorily set out.

(d) Units are important and answers with incorrect units will not be awarded full marks.

(e) Programmable and non-programmable calculators may be used.

(f) Read the questions carefully before answering.

(g) Annotated copies of AS 4100 (or the student edition HB2.2) may be taken into the exam, but no other written material is permitted. Additional pages are not to be inserted into AS 4100 (or HB 2.2).

(h) Each question has an "explanation type" section. These should be answered in about ½ page of text plus diagrams. Directly quoting text from AS 4100 or the lecture notes is not considered an appropriate response.

(i) If required, any relevant values should be taken from the OneSteel product tables, which are given as a separate set of data sheets.

Q 1 Tension Members and Connections (25 marks)

a) One of the equations for tension capacity is $0.85k_tA_nf_u$. Explain the behaviour modelled by this equation by referring to each of the 4 terms in the equation.

b) An engineer is assessing the tensile strength of a bracing connection in which a 200×200×16 EA (Grade 300) is bolted to a 25 mm thick gusset plate (Grade 300 to AS/NZS 3678) by an unknown number of bolts as shown in Figure 1. The bolt pitch is 75 mm. Grade 8.8 snug tight M20 bolts are used in this connection, and the plane between the gusset plate and angle coincides with the threaded part of the bolt.

(i) **Determine section capacity in tension of the angle ϕN_t.**

(ii) **How many bolts are required for the connection to transfer the full section capacity calculated in (a) above?** (Hint: The answer will be greater than the 5 bolts actually shown)

(iii) **Suggest some possible improvements to this connection.**

The following properties of an M20 bolt may be useful.

Core area, A_c = 225 mm^2
Shank area, A_o = 314 mm^2
Tensile stress area, A_s = 245 mm^2
Diameter of the hole, d_h = 22 mm

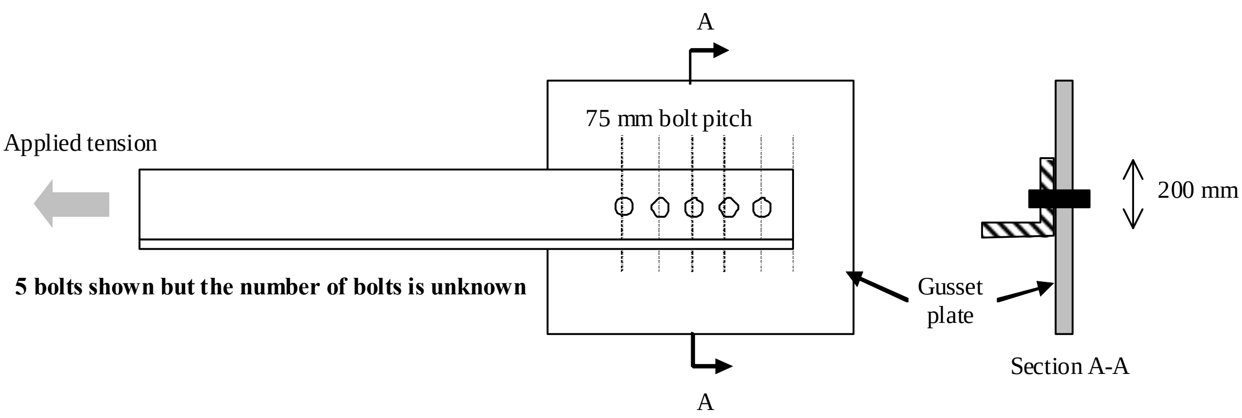


Figure 1 (All dimensions in mm)

Q2 Compression Members (25 Marks)

a) **Explain what the different terms α_b and α_c account for when determining the compression capacity of a column.**

b) Consider the frame shown in Figure 2. All columns are 200UC59.5 and all beams are 250UB37.3 in Grade 300 steel. The columns are 3.5 m apart in the north-south and 4 m apart in the east-west directions and each storey is 4 m in height. The beam column connections in the north-south direction are flexible, and the connections are rigid in the east-west direction. There is cross bracing in the north-south direction. The column base plate connections should be considered as pinned in both directions. The webs of all columns are oriented east-west and all beams are oriented such that the flanges are horizontal.

Determine the design member capacity (ϕN_c) of Column 1.

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

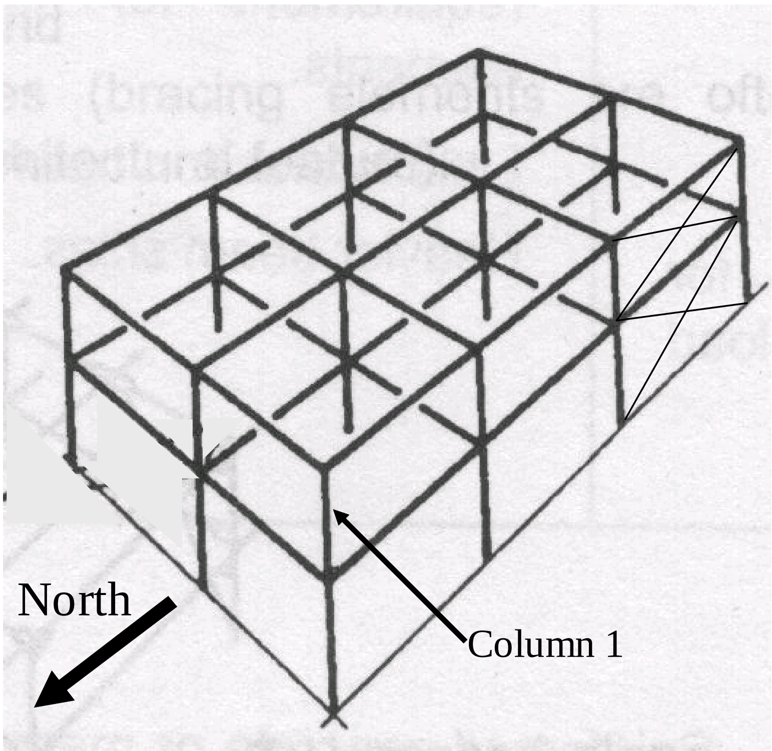


Figure 2

Q 3 Bending (25 Marks)

a) For a typical low rise portal frame structure (such as the one considered in the design assignment), UB sections are more commonly used for the columns compared to UC sections. **Explain why the typical shape of a UB compared to a UC makes it more suitable for use as a column in such a structure.** Use of diagrams and reference to different types of buckling would assist the answer. Calculations are not necessary, but identification of loads, key equations or parameters may be useful.

b) A beam ABC is built in at both ends and subjected to a distributed load w = 4.0 kN/m applied downwards to the top flange. The Bending Moment Diagram (BMD) and Shear Force Diagram (SFD) are as shown in Figure 3. The beam is being bent about the *x*-axis.

i) Assuming the beam is fully restrained along its entire length, determine a suitable size Grade 300 UB based on bending section capacity (ϕM_{sx}) alone.

ii) For the beam determined in (i), is the combined bending and shear capacity adequate at the ends (give values)?

iii) For the beam determined in (i), what is the maximum value of *w* based on lateral buckling considerations (ϕM_{bx}) assuming there are no restraints within the span, and full restraint is provided at the supports only.

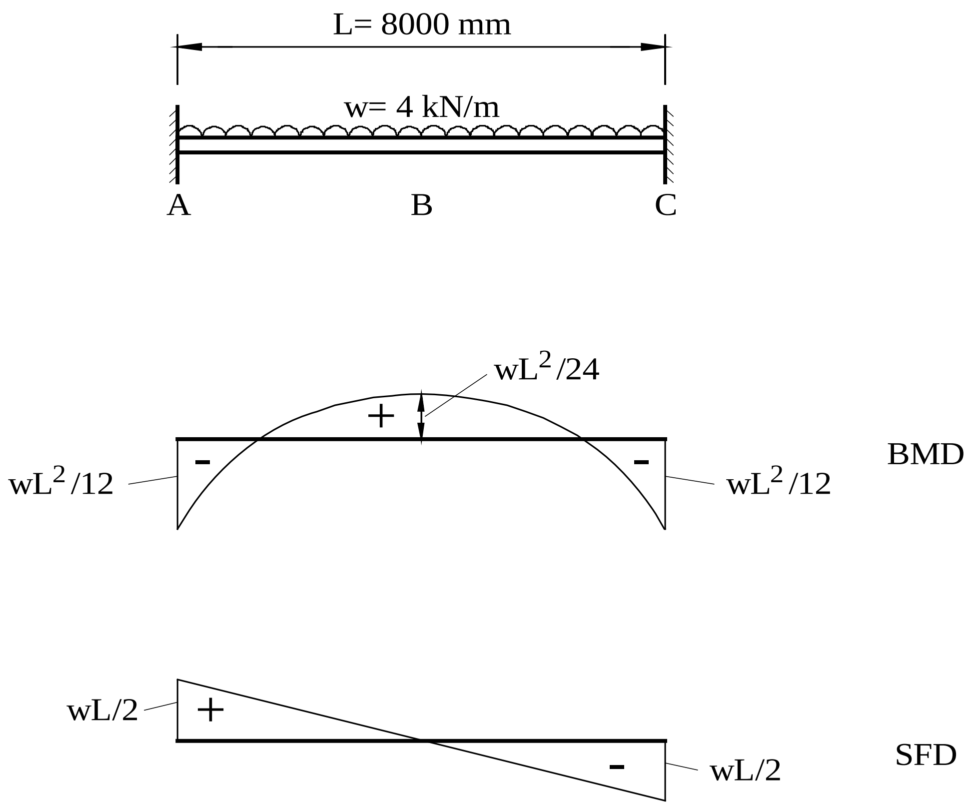


Figure 3

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

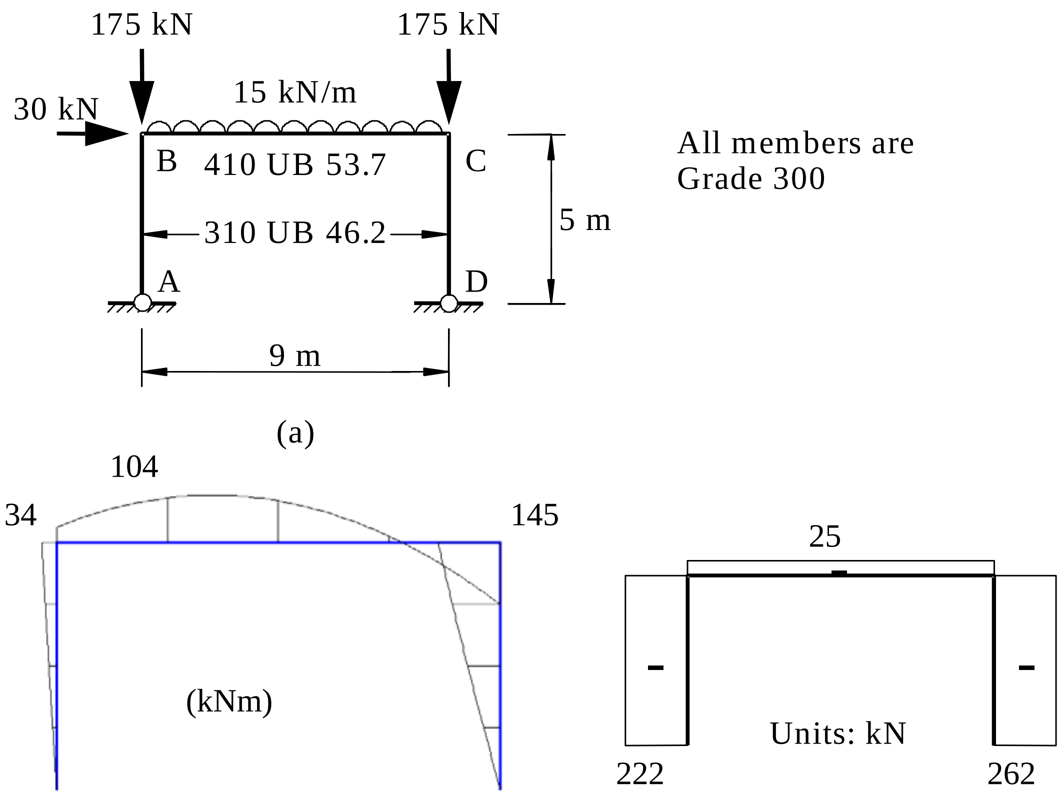
Q4 Combined actions (25 Marks)

a) Explain the difference between 1st order and 2nd order bending moments by considering the behaviour of the frame in Figure 4 below. For a typical frame such as this one, are second order effects likely to be more significant for a gravity only load case (eg 1.2*G* + 1.5*Q*) or a case involving wind load? Explain your answer.

b) A rectangular portal frame ABCD subjected to a design load combination is shown in Figure 4(a). All members are oriented such that the planes of the webs of the section are in the plane of the frame shown. The beam column connections are rigid, while the column base plate connections are pinned. The bending moment and axial force diagrams obtained by conducting a *second order elastic analysis* of the frame are shown in Figures 4(b) and 4(c), respectively. An engineer has already assessed the effective lengths of the columns for different types of buckling:

- In plane (flexural) compression buckling: 9.0 m
- Out of plane (flexural) compression buckling: 5.0 m
- Beam (flexural torsional) buckling: 2.5 m (there are 2 equally spaced segments along CD).
- There is no need for you to work out effective lengths.

Determine the combined action member strengths (ϕM_{rx}, ϕM_{ix}, ϕM_{ox}) of both members AB & CD and hence establish if the members are satisfactory.



(b) Bending moment diagram (c) Axial force diagram

Figure 4