



Steel Structures 1

Tutorial Set 2 - Compression

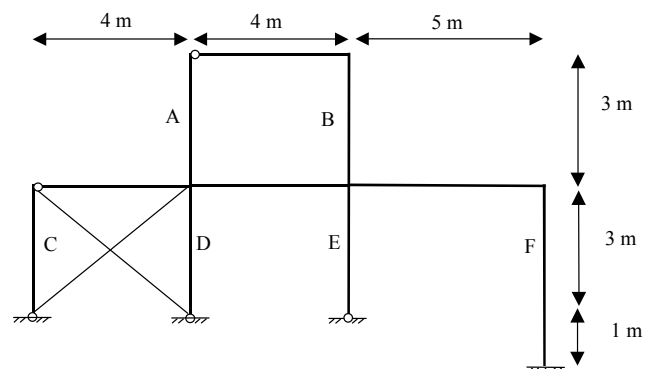
1) From first principles (ie considering the element slendernesses), **calculate the form factor k_f and the design section capacity in compression ϕN_s** of a $150 \times 100 \times 10$ UA in Grade 300 steel. Dimensions can be taken from the OneSteel tables. Compare the answer with the value of k_f listed in the table and account for any difference between the values.

2) A Grade C350 $75 \times 75 \times 2.0$ SHS is being used in a welded truss and is subjected to a design axial compression of $N^* = 150$ kN. The member is 2000 mm long. Clause 4.6.3.5 may be used to determine the effective lengths for x and y axis buckling. **Determine the design section and member capacity in compression (ϕN_s & ϕN_c) of the SHS and hence establish whether the member is adequate.** The value of k_f given in the OneSteel tables may be used, but it is good practice to derive it without reference to the tables. Compare the answer with the value of design *tension* capacity (ϕN_t) of the same section calculated in Tutorial Set 1.

3) **Spreadsheet question.** Calculation of the member capacity in compression can be time consuming. Create a spreadsheet that will calculate the ϕN_s , ϕN_{cx} & ϕN_{cy} for any given values of effective length about the x and y axes. What input data is required? Feel free to use whatever information is available in the OneSteel property tables. This is available in a spreadsheet form at <http://www.civil.usyd.edu.au/courses/civl3206>. This may be of assistance in the subsequent design exercise on compression.

4) The east-west elevation of a steel framed building is shown in Figure 1. Columns A and B are 250UC96.8 sections, and columns C, D, E & F are 310UC118 sections. All beams are 250UB37.3. All steel is Grade 300.

- Note carefully the different types of beam to column connections, and the different column base connections (pinned or fixed).
- All members are oriented so that the webs of the beams and columns are in the plane of the frame.
- The frame is braced out-of-plane in such a way that effective length factor for out-of-plane buckling for each column is $k_e = 1.0$, implying bracing at beam levels only.
- If required, the any relevant values should be taken from the OneSteel product tables.



- Use Clause 1.3 of AS 4100 to define a sway and braced member. Hence, for each column, A - F, state whether the column is a sway or a braced column, for buckling in the plane of the frame.
- Identify if in-plane buckling refers to x or y axis buckling. Identify if out-of-plane buckling refers to x or y axis buckling. A sketch would help illustrate the answer.
- Determine the effective length for in-plane and out-of-plane buckling for column A. Determine the design member capacity (ϕN_c) of column A. Is column adequate for design axial compressions of $N^*_{Col A} = 800$ kN?
- Determine the effective length for in-plane and out-of-plane buckling for column E. Determine the design member capacity (ϕN_c) of column E. Is column adequate for design axial compressions of $N^*_{Col E} = 1000$ kN?

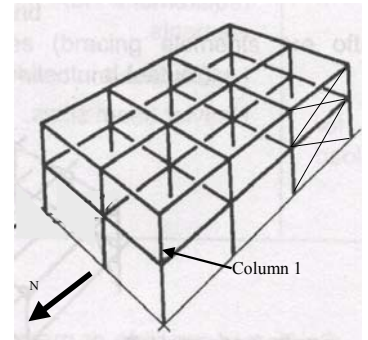
- v. Determine the effective length for in-plane and out-of-plane buckling for column F. Determine the design member capacity (ϕN_c) of column F. Is column adequate for design axial compressions of $N^*_{Col F} = 1100$ kN?

(Questions 4 & 5 are quite similar, but students should realise it is important to get practice on evaluating compression capacity in frames. If pushed for time it is recommended that students give Q5 priority over Q4 but Q4 should definitely be attempted at some stage)

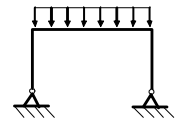
5) Consider the frame shown. All columns are 200UC52.2 and all beams are 250UB25.7 in Grade 300 steel. The columns are 4 m apart in the north-south and 3 m apart east-west directions and each storey is 3.3 m in height. The beam column connections in the north-south direction are flexible, and the connections 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 fixed in both direction. 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 (the top storey in the north west corner). Is the column adequate for design axial compressions of $N^*_{Col 1} = 900$ kN?

If required, the any relevant values should be taken from the OneSteel product tables.



- 6) Consider the frame shown. Assume that the column height is half the frame span.
- Consider different combinations of beam size and column size (move from big beam/small column, to same beam/column, to small beam/big column – with several intermediate steps)
 - Consider the bending moment diagram, and specifically the ratio of the beam midspan moment to the maximum column moment. How does this change with the ratio of the flexural stiffnesses $(EI/L)_{column}$ to $(EI/L)_{beam}$. What can you conclude from these results?
 - Do the actual dimensions and the value of the UDL have any influence on these results? Why or why not?



It is anticipated that students should be able to complete most of these tutorial questions during the allocated tutorial time.

In the exam only annotated versions of the Standard AS 4100 and the BHP/OneSteel section properties are permitted. Hence it is good practice to attempt these questions using just the standard AS 4100 and not referencing the lecture notes.

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