The University of Sydney

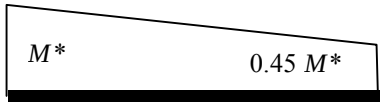
School of Civil Engineering

Steel Structures 1

Tutorial Set 4 – Combined Actions

1)

Consider a 200UC52.2 member constructed from Grade 300 steel. The member forms part of a braced frame and is subject to a concentric axial compression force of N^* = 700 kN and a distribution of bending moment as shown. The bending moment diagram was obtained from a first-order elastic analysis. The member is 5000 mm long. Determine the maximum values of M^* for the following case.



Bending Moment Distribution

Compression N^* = 700 kN

Bending about the x axis - *First - Order* Moment Distribution

The applied moment is about the major axis (x axis) with the bending moment distribution shown, and the effective length factor for x - axis column buckling is k_{ex} = 0.85. The effective length factor for y - axis column buckling is k_{ey} = 1.0. The effective length for buckling as a beam is $L_{e,beam}$ = 5000 mm.

Please clearly indicate the values of all appropriate capacities used in any intermediate calculations such as δ_{bx}, δ_{by}, φN_s, φN_{cx}, φN_{cy}, φM_{sy}, φM_{sx}, φM_{bx}, φM_{rx}, φM_{ix}, φM_{ox}, etc. If required, the values of Z_{ex}, Z_{ey}, and k_f may be taken from the OneSteel product literature.

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2) Consider Example 8.2 in the lecture notes – moment amplification in sway frames. This example calculated second order moments by hand methods. Model the frame in PFRSA or Microstran and perform a second order elastic analysis and compare the PRFSA/Microstran answers to the "hand" methods in the lecture notes. Perform an elastic buckling analysis using PRFSA/Microstran and determine the moment amplification factor using Cl 4.4.2.3(b).

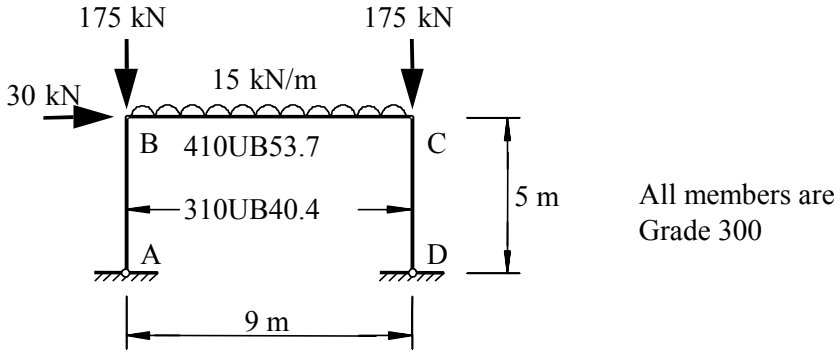
3) Spreadsheet question: Combine the spreadsheets developed in Tutorials 2 and 3 on bending and compression, to form a new spreadsheet that can calculate the relevant capacities for members under combined actions.

Have you checked your USyd email account recently? Many regular email updates on Steel Structures 1 are sent to your university email address, and you may be putting yourself at a disadvantage by not reading those messages. I would recommend that students check their USyd email account at least twice a week.

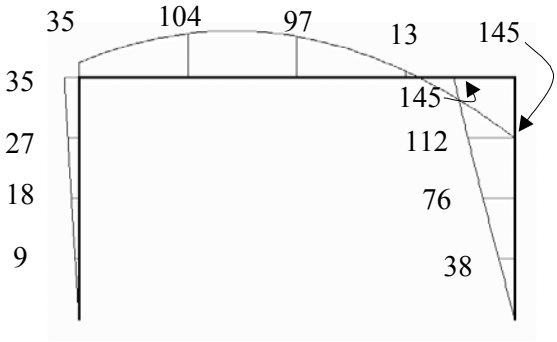
4) A rectangular portal frame ABCD subjected to a design load combination is shown in Figure 4(a). All members are bent about their major (x) axis in the plane of the frame. The connections between the beam and the column at B and C are rigid connections. The supports at A and D are pinned. The bending moment and axial force diagrams obtained by conducting a **second-order elastic** analysis of the frame are shown in the figures below. The columns are 310UB40.4 Grade 300 sections and are 5.0 m high, and the beam is a 410UB53.7 Grade 300 section and is 9.0 m in length. The frame is subjected to a uniformly distributed load, and three point loads. Each rafter of the frame is braced so that the effective lengths for out-of-plane buckling are $L_{ey} = L_{e,\,beam} = L$, while there are restraints at the bottom, midheight, and top of each columns so that the effective lengths for out-of-plane buckling are $L_{ey} = L_{e,\,beam} = 0.5L$. The values of bending moment are given at the quarter points of each member. The magnitude of the axial compression in the beam can be considered negligible.

i) Are the columns AB and CD braced or sway columns (in-plane)?
ii) Determine the effective length of the column CD for in-plane buckling. By symmetry the effective length of AB is the same as the effective length of CD.
iii) What are the design actions, M_x* and N*, that apply to the design of column CD?
iv) Determine the section capacity (ϕM_{rx}) of the column CD for in-plane bending according to Clause 8.3.2 of AS 4100.
v) Determine the in-plane member capacity (ϕM_{ix}) of the column CD according to Clause 8.4.2.2 of AS 4100.
vi) Determine the out-of-plane member capacity (ϕM_{ox}) of the column CD according to Clause 8.4.4.1 of AS 4100.
vii) Hence establish whether column CD is adequate according to the design rules of AS 4100.

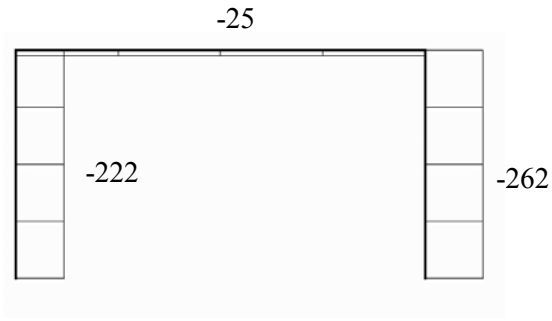
Clearly indicate the values and units of all appropriate capacities used in any intermediate calculations. The values of Z_{ex} and k_f may be taken from the OneSteel product literature if necessary.



(a) Frame and loading



(b) Bending moment diagram (kNm)



(c) Axial force diagram (kN)
(-ve = compression)

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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