NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY NTNU
FACULTY OF ENGINEERING
DEPARTMENT OF STRUCTURAL ENGINEERING

TKT4142 Finite Element Methods in Structural Engineering

CASE STUDY 6

Case Study 6 will use a thin-walled canal cross-section to address the modelling of shell problems (i.e., h/L < 1/10). The purpose is to provide knowledge and experience in how to use shell elements to model thin-walled beam sections. We will also compare the solution obtained with various types of shell elements to that using beam elements and/or beam theory. A workshop on how to model the different aspects addressed in this case study is uploaded to Blackboard (see "*Workshop6.pdf*" in the folder "Case studies").

Learning outcome:

- Modelling of shell problems
- Convergence studies
- Knowledge and experience in modelling thin-walled beam sections with various shell and beam element types

Problem description

Figure 1 shows a cantilevered beam with a thin-walled canal cross-section. The beam is fixed on one end and a line load is applied to the top flange on the other end. The beam should be modelled and analysed with ABAQUS. The material properties correspond to structural steel.

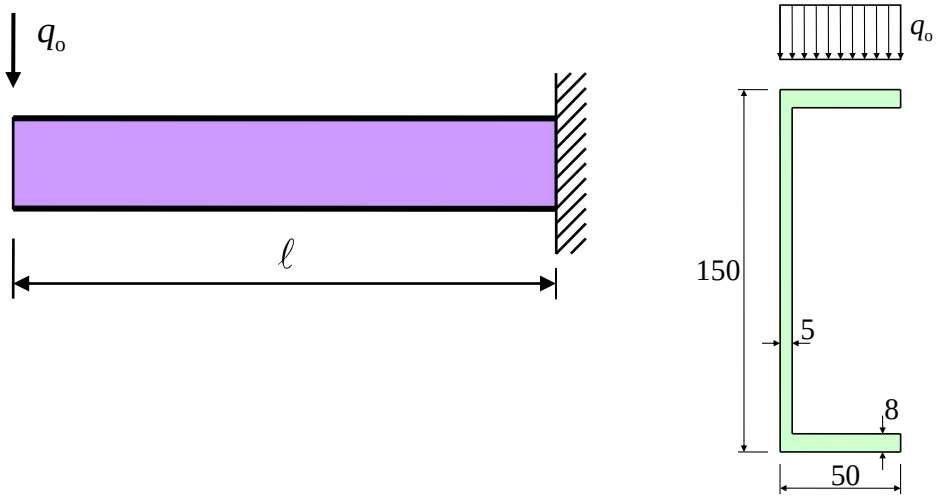

Figure 1 – Cantilever beam fixed in one end and loaded with a line load to the top flange in the other end. All measures are in millimetres.

Load: $q_0 = -200$ N/mm (downwards)
Material data: $E = 210\,000$ N/mm^2, $\nu = 0.30$, $l = 900$ mm, $\sigma_y = 355$ N/mm^2

a) Perform a convergence study and compare the largest bending stresses and displacements based on finite element analysis of both linear and quadratic, triangular and square shell elements. Explain how the convergence study has been conducted.

b) Determine the cross-section properties for the thin-walled section and perform a finite element analysis with one-dimensional beam elements. Compare with the results obtained in a). What is the cause of the large difference in both stresses and displacements between the two solution methods?

c) Perform hand calculations based on elementary beam theory where only bending deformations are considered.

d) Compare the results obtained in a), b) and c), and explain the observed differences.

e) Suggest measures to perform finite element analyses with shell elements such that they can be comparable to the results with beam elements.

f) What will be the consequences of allowing for non-linear geometry in the finite element solution? Hint: You can allow for non-linear geometry by opening the **Step Manager**, then **Edit step** and change **Nlgeom** from **Off** to **On**.