AE4ASM003 Linear Modelling Assignment 4: 2D elements

Due 23 October 2024, 17:00 CET

AIAS level 3 (AI Assessment level; definition: see slides lecture 1)

Please upload on Brightspace under the 'assignments' tab (on top of the page). You can upload multiple times, but only the last version you upload is retained and will be checked and graded. Grading will only start after the deadline has passed.

Please note that the deadline is enforced: solutions uploaded less than 2 hours after the deadline will get a maximum of 80%; solutions handed in more than 2 hours after the deadline will not be graded. The plagiarism check is enabled in Brightspace. Please follow the submission guidelines on page 5 of this assignment.

As a guideline, the report should be 5-10 pages (including figures from Abaqus). This is just a guideline, your final report can be longer/shorter. Make sure you have answered all the questions as stated in the assignment. For part 1 (especially derivations), you can make pictures of your handwritten notes (on the condition that it is readable) rather than type it out to save some time making the report.

The aim is to provide you with feedback and a grade two weeks after the deadline, if grading takes longer this will be announced on Brightspace. Please refrain from asking questions about grading until two weeks after the assignment deadline or the new date announced on Brightspace.

Part 1: triangular element

Given is a triangular membrane element as shown in Figure 1, with an additional internal node m. Please note that the nodes i and j are on the x-axis, node k is on the y-axis. No exact dimensions are given: the x-location of node i is 2w, the x-location of node j is -4w, the y-location of node k is 3h, the coordinates for node m are (-w, h). For this triangular element, please solve the following questions:

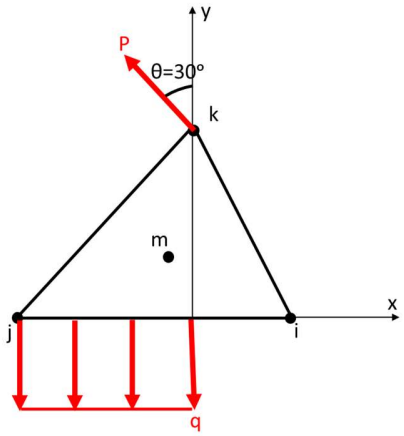

Figure 1: triangular element.

Questions:

a) Derive the shape functions for this triangular membrane element (in the local Cartesian coordinate system, not transferring back and forth to natural coordinate system) assuming the displacement to be

$$u = c_1 + c_2 x + c_3 y + c_4 xy$$

b) Derive the expression for the strain-displacement matrix B (used in the expression $\varepsilon = Bu$)

c) Explain why solving the integral $\int_V [B]^T [D][B] dV$ is not as straight-forward in this case as when using the triangular membrane elements discussed in class. How would you compute it? Please note: you only have to explain why it is harder to perform the integration and give the method to solve it. **You do NOT have to solve the integral**.

d) Calculate the force vector F (used in the expression KU=F) for the given load case: a constant load q applied along edge ij from x = -4w to x=0, and the point load P on node k. Start from the external work done.

Part 2: panel under tension

A 400 x 650 mm panel is tested by hanging many small weights from it (many more than shown schematically in figure 2). The total distributed weight equals 257.5 kg/m. The top 50 mm of the panel are clamped during the test.

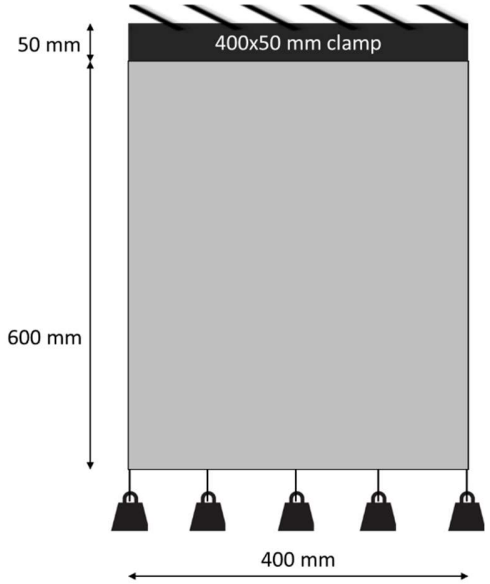

Figure 2: panel under tensile load

Questions:

a) Give an example of what this test (structure and loading) can represent in real life. Give one reason why this test is representative for that case. Also give one assumption that had to be made to make the test set-up easier (and thus why the test may not be a perfect representation of real life) and the influence on the result.

b) Discuss the approach to idealise this panel and test set-up into a finite element model and explain any assumptions you had to make. Think about the loading, boundary conditions etc.

c) As a first step, model the panel as a flat panel. Use Linear quadrilateral elements (S4R) with a uniform mesh size of approximately 20x20 mm. Discuss the results you obtain, and the effect of the choices made during idealisation (i.e., are there any results that are a consequence of how you applied the boundary conditions/load, why do you (not) trust the outcome of the model, anything you wanted to do in Abaqus but were not able to do?).

d) To reduce the displacement, two options are considered.
   - option I: doubling the thickness of the middle 150x600 mm part (darker part in figure 3)
   - option II: adding 2 stiffeners as shown in figure 3. The stiffeners have an L-shaped profile with dimensions indicated in Figure 3, the thickness is constant. The centre lines of the stiffeners (i.e., where to model them in Abaqus) are drawn (they can have the same orientation, no need to rotate the stiffeners). Model the stiffeners as 1D beam elements.

   Model both options and discuss their advantages and disadvantages, mention possible assumptions you had to make during modelling and which option you prefer (explaining why).

e) What would need to be changed to the model if the bottom was first clamped, and then loaded with the same weight? No need to implement this in Abaqus, just explain what you would change in Abaqus (if anything, and say how you would do so in Abaqus)

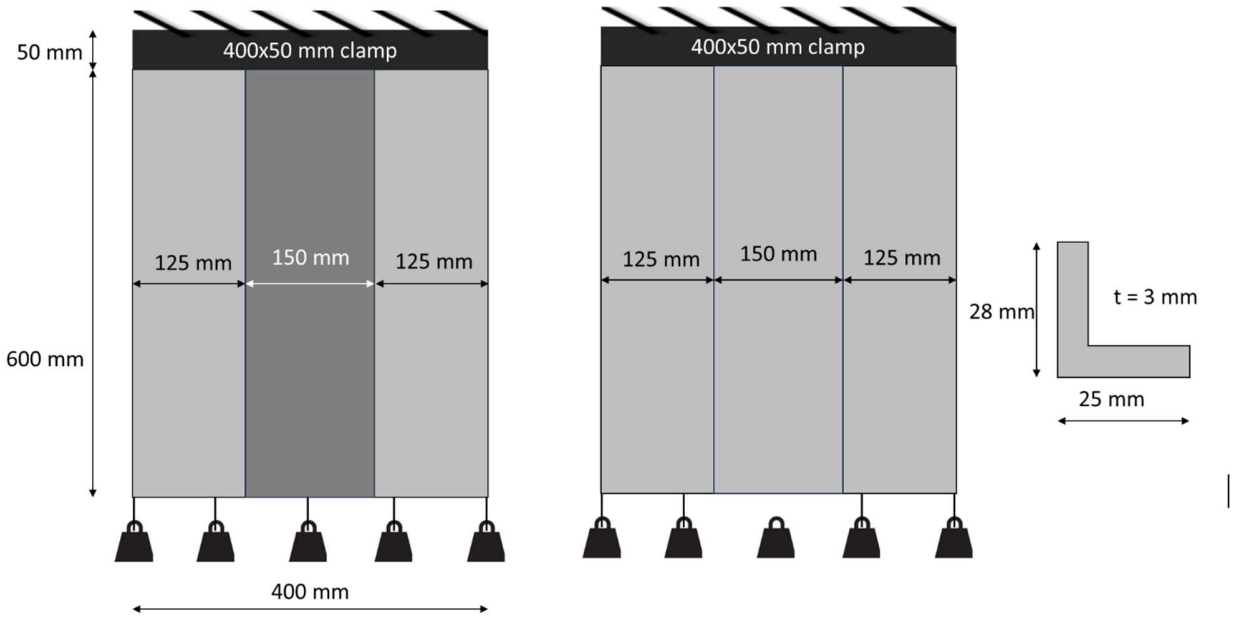

Figure 3: two options to change the panel: a thicker region (indicated by the darker colour) or adding L-stiffeners (lines indicate the location where stiffeners should be placed in Abaqus, 25 mm bottom edge is in contact with plate)

Submission and naming:

- submit your report in pdf format and the Abaqus model (containing the stiffened panel) using the following naming convention:
    - LMex4_StudentNumber.pdf
    - Your Abaqus model of the panel (including the original option, and both options of part 2d, preferably all in one cae file containing 3 models): LMex4_StudentNumber.cae
    - change StudentNumber by your student number in the naming convention
- Upload each individual file, no external links to the files, no zip folders.
- Make sure you upload all files and click 'submit' (only last submission is visible for grading, so if you hit submit for each file only 1 file will be visible for grading; if you want to make a change to a file, you have to upload all files again).
- Your submission should look like this right before submitting (check all files have been uploaded and are visible). Do not forget to click 'submit':