Assignment 1

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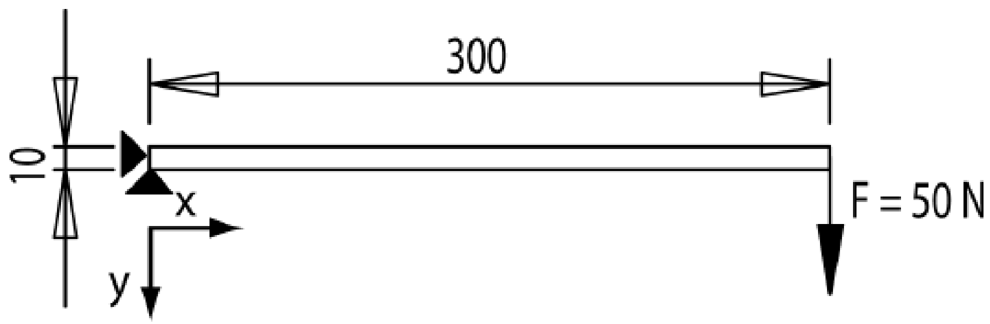
Introduction

Problem

Bending of a Cantilever beam



Parameters:

Length	300 mm
Wide	5 mm
Deep	10 mm
Load	50 N
Young's Modulus	90 GPa
Poisson's ratio	0.3

Beam Theory:

$$y(x) = \frac{Fx^2}{6EI}(3l - x)$$

$$I = \frac{wd^3}{12}$$

Task:

- Calculate analytical result (displacement)
- Simulate the bending in Abaqus
- Compare the analytical results with the FE calculations & discuss the results

Topics to Discuss:

- Numerical results change with analytical ones
- Changing number of elements
- How does influence the changing of element type?
- How does influence the changing of integration methods?
- Brief explanation why results change with respect to different mesh and element configurations

Results

Sketches

Deformation

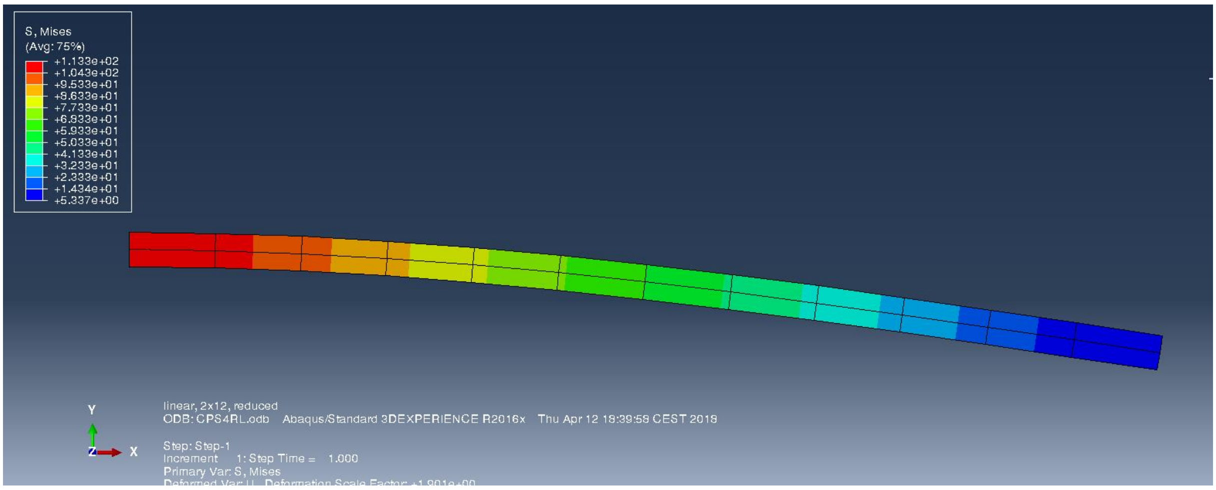


Figure 1: Deformation using CPS4R. Linear, 2x12 meshes, reduced integration

Displacement

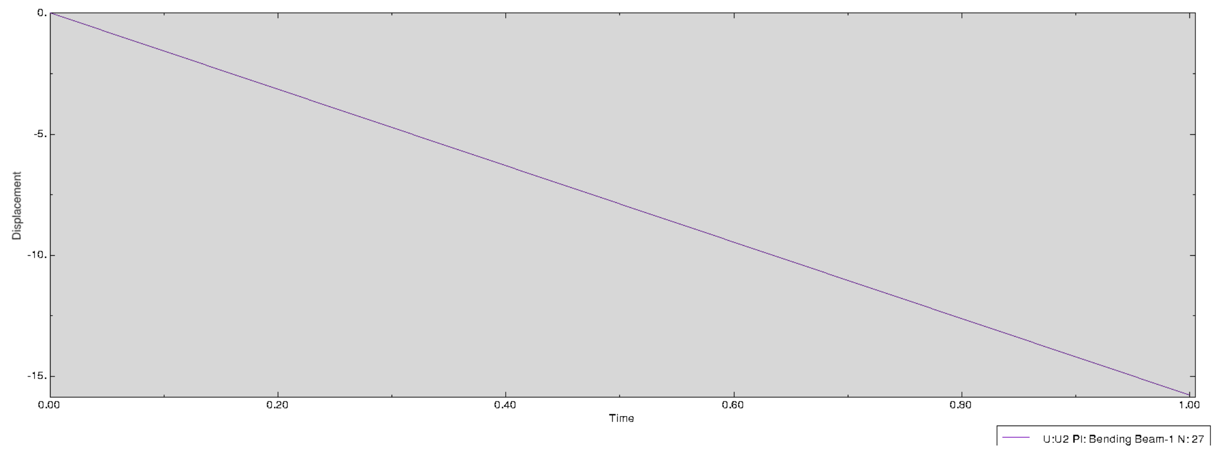


Figure 2: Displacement using CPS4R. Linear, 2x12 meshes, reduced integration

	2x12 ELEMENTS			**4x24 ELEMENTS**	
Element Type	**Max. Displacement [mm]**	**Relative Error (%)**	**Element Type**	**Max. Displacement [mm]**	**Relative Error (%)**
CPS4	3.49839	70.8	*CPS4*	7.45972	37.8
CPS4R	15.7851	31.5	*CPS4R*	12.7699	6.42
CPS8	11.9617	0.32	*CPS8*	11.9939	0.05
CPS8R	11.9859	0.12	*CPS8R*	12.0037	0.03

Analytical result

$$y = \frac{-50N*(300mm)^2*(3*300mm-300mm)}{6*90*10^3\text{MPa}*\frac{5mm*(10mm)^3}{12}} = -12\text{mm}$$

Discussion

Numerical results change with analytical ones:

The numerical value changes with respect to the analytic one, based on the meshes elements, the integration method and the element type. The results of 4 x 24 meshes presents a smaller relative error if compared with the same element type of a 2x12 meshes. However, the quadratic elements play a major role in getting an accurate value, being more relevant than other parameters.

The best (closest) numerical solution is the 4 x 24 meshes with CPS8R element type. The worst (farthest) one is the 2 x 12 meshes with CPS4 element type.

Changing number of elements:

Despite the number of element has a huge impact when an element type of CPS4 is used, it slightly influences when using a quadratic element. If more elements are used, better will be the analytical result.

How does influence the changing of element type?

The element type strongly influences in the results, playing the major role in the accurate numerical results. The linear elements are susceptible to shear locking and/or hour glassing, which increases the relative error.

How does influence the changing of integration methods?

It depends on the element type. When linear elements are used, the integration method has a relevant role in the results. In those cases, the reduced integration works better than fully integration by tolerating shape distortions. When quadratics elements are used, the integration method has a minor role.

Brief explanation why results change with respect to different mesh and element configurations

The applied force generates a moment in the beam. When using a linear element this moment is transformed in shear (shear locking). The impact of a shear locking can be reduced by increasing the number of nodes and by using a reduced integration. However, reduced integration has a problem of hour glassing due to an excessively flexibility. Those problems are avoided when a quadratic element is used, presenting a result closer of the analytical solution.

Shear locking in full integrated model and hour glassing in reduced integrated model. We must take care about hour glassing (CPS4R), if the force is to high, there will be more bending than expected. Here in this case the bending displacement is ~16mm, so a deviation of 4mm.