

Modeling of Physical Systems

Simulation of stress and strain distribution using finite element
method

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1 Aim of laboratory

The aim of this laboratory was to calculate, visualize and analyze stress and strain distribution for 2d models. What is more, this laboratory had to teach us how to use PDETool.

2 Exercises

During this laboratories we used pdetool, installed in Matlab. It is a program which allow us to draw the model, set parameters and finally make a desired calculation. It also visualize result.

2.1 Parameters

The image shows two MATLAB dialog boxes. The top one is 'PDE Specification' and the bottom one is 'Plot Selection'.

PDE Specification

Equation: Structural mechanics, plane strain

Type of PDE:	Coefficient	Value	Description
<input checked="" type="radio"/> Elliptic	E	1.8E11	Young's modulus
<input type="radio"/> Parabolic	nu	0.305	Poisson ratio
<input type="radio"/> Hyperbolic	Kx	0.0	Volume force, x-direction
<input type="radio"/> Eigenmodes	Ky	0.0	Volume force, y-direction
	rho	7480	Density

Buttons: OK, Cancel

Plot Selection

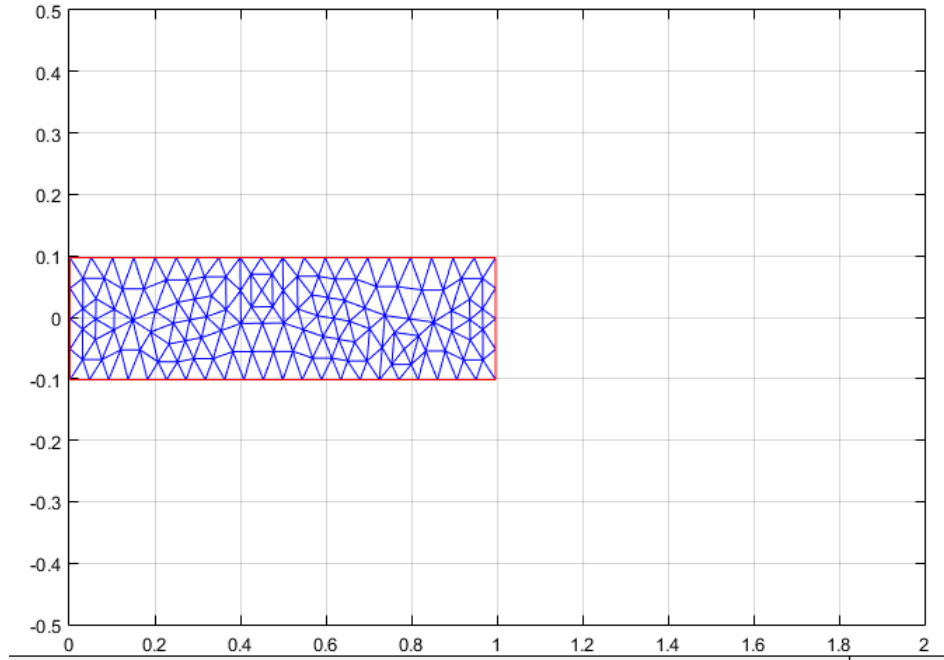
Plot type:	Property:	User entry:	Plot style:
<input checked="" type="checkbox"/> Color	y displacement (v)		interpolated shad.
<input type="checkbox"/> Contour	(u,v)		proportional
<input checked="" type="checkbox"/> Deformed mesh	(u,v)		
<input type="checkbox"/> Height (3-D plot)	x displacement (u)		continuous
<input type="checkbox"/> Animation	Options...		

Buttons: Plot, Close, Cancel

Additional options at the bottom of Plot Selection:

- ☐ Plot in x-y grid
- Contour plot levels: 20
- ☒ Plot solution automatically
- ☐ Show mesh
- Colormap: cool

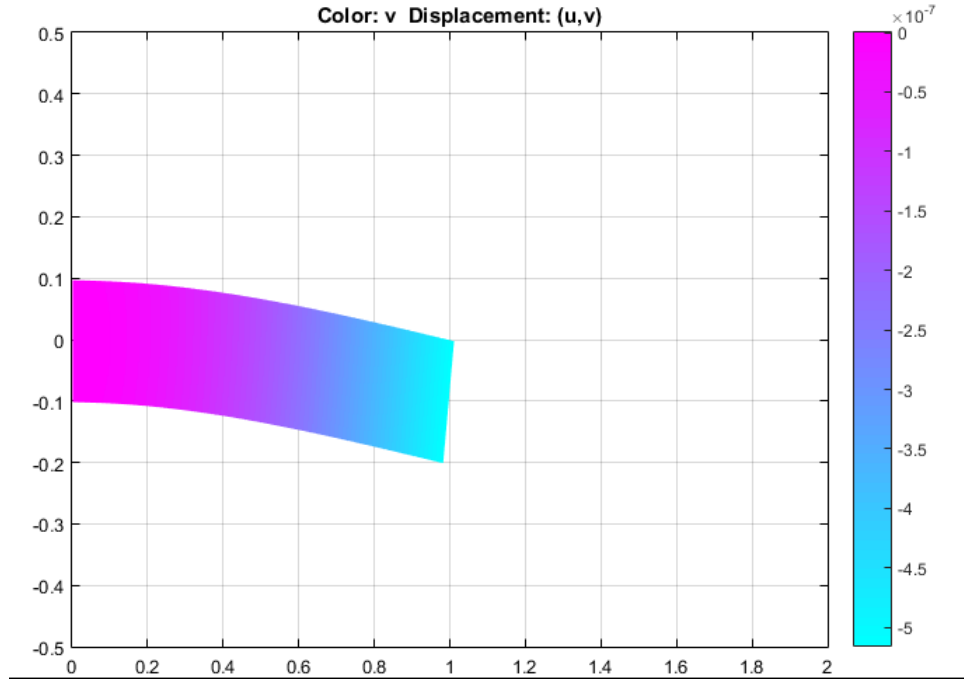
2.2 Mesh from laboratories



Boundary conditions with applied forces:

Side	Condition type	surface tractions	weights
left	Dirchlet	NA	$h_{11}, h_{22} = 1, h_{12}, h_{21} = 0$
top	Dirchlet	NA	$h_{11}, h_{12}, h_{21}, h_{22} = 0$
right	Neumann	$g_1 = 0, g_2 = -1000$	NA
bottom	Dirchlet	NA	$h_{11}, h_{12}, h_{21}, h_{22} = 0$

Table 1: Boundary conditions settings



2.3 Theoretical value

The value of deformation on the end of beam can be calculated using equation below

$$h = \frac{F \cdot L^3}{3E \cdot J} \quad (1)$$

For the rectangular cross section elastic modulus can be calculated from the equation:

$$J = \frac{g \cdot d^3}{12} \quad (2)$$

Where:

- $F = 1000N$ - loading force
- $L = 1m$ - beam length
- $E = 1.8 * 10^{11}Pa$ - Young's modulus
- $g = 1m$ - beam thickness
- $d = 0.2m$ - beam width

The theoretical result is :

h =

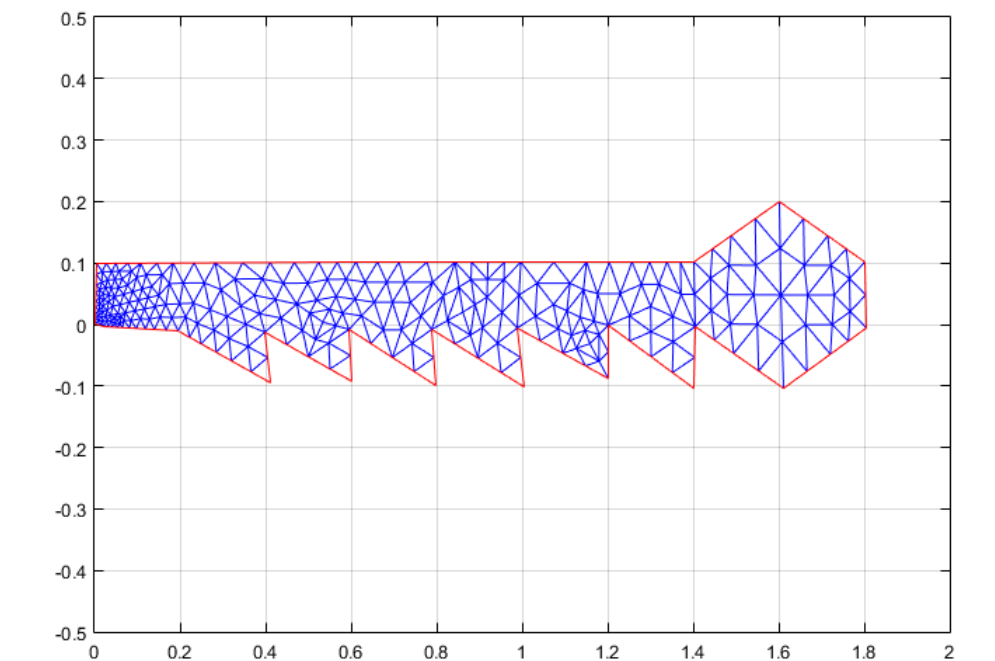
-2.7778e-06

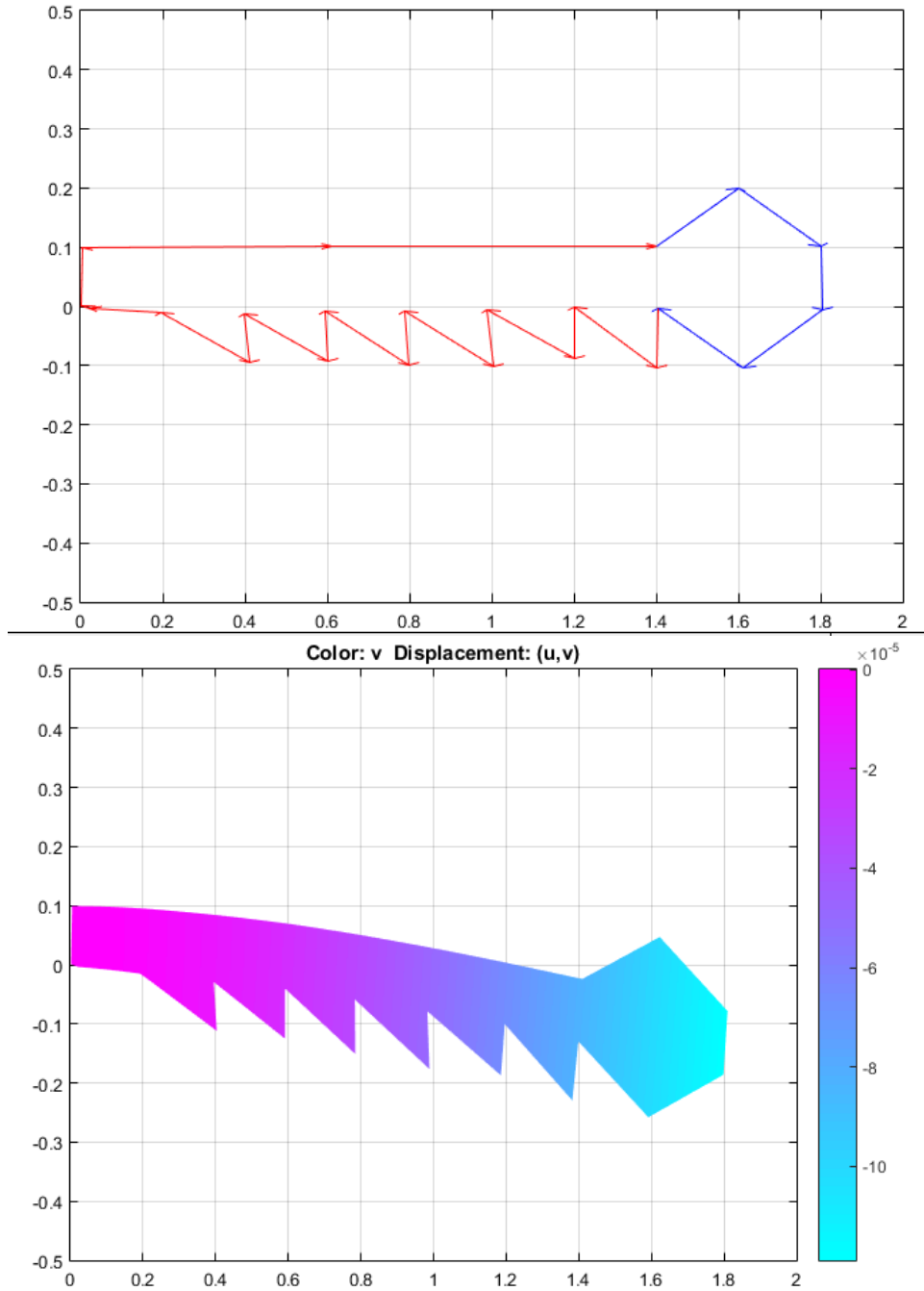
Comparison between theoretical value and calculated by tool is presented in the tabular below.

Method	result
Exported value from PDE tool	$-5.7840 \cdot 10^{-4}$
Theoretical value	$-2.7778 \cdot 10^{-6}$

In my opinion the difference in this example is caused by not perfectly drawn beam in a tool. PDETool computes values more precisely because it can adjust applying math directly to the mesh.

2.4 More complicated mesh





3 Conclusions

This report covered stress and strain distribution. All needed calculations and visualisation were made in PDEtool which is quite intuitive. It allows to create complicated models and simulates different kinds of forces which affects on mesh. What is more, theoretical calculations were made for trivial model. It proves that despite the fact that results were not the same this tool is usable. The most important difference between simulation and theoretical calculations is visualisation as time needed for compute results. This two factors indicates that it is better to use tools for simulation with complex models.