Non linearity

Computational Mechanics Tools

12th November 2019

Homework 3

Head professor: Natividad Pastor

Author: Antoine CHAN-LOCK

Abstract

In this homework we will perform an analysis of a non-linear material response using Abaqus.

Contents

1 Tutorial 1

We follow the given tutorial and plot the following interesting results

1.1 Von Mises stresses

Here we plot the Von Mises stresses.

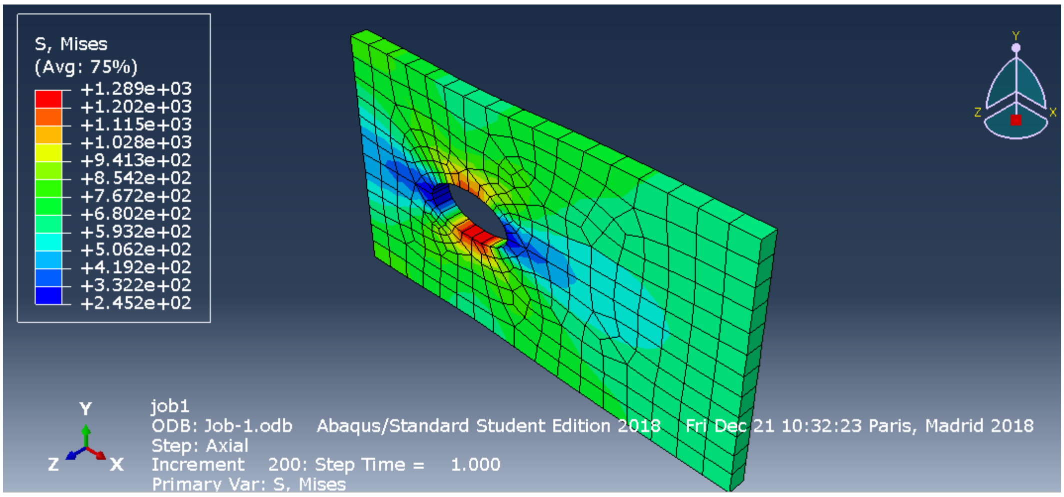


Figure 1: Von Mises stresses

We can see that the visual render and the magnitude of the values is coherent. The $460MPa$ limit is overpassed as we see that the maximal value is $1289MPa$.

1.2 Force-Displacement curve

Here from the History output of displacements $U(t)$ and force $F(t)$, we use the function `combine(•,•)` to plot the data. We have the following result

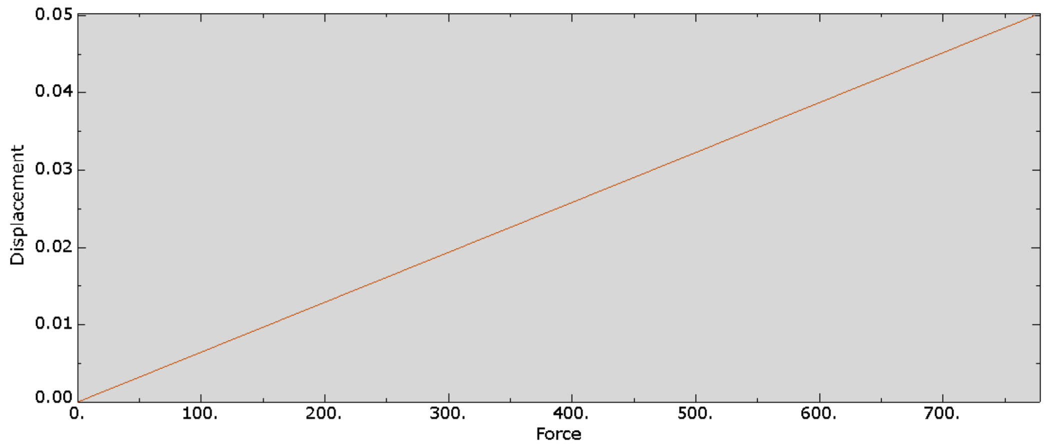


Figure 2: Force-Displacement curve

This result is totally coherent as we are in a linear elasticity case, the the relation in linear.

1.3 Plastic properties

We modify the material properties setting plastic behavior.

- **Case A:** Isotropic, make it perfectly plastic for $f_y = 460N/mm2$
- **Case B:** Isotropic, with $f_y = 460$, plastic strain=0; $f_{y2} = 520$, plastic strain $5.e-3$
- **Case C:** Isotropic, with $f_y = 460$, plastic strain= 0; $f_{y2} = 520$, plastic strain $= 2.e-3$

The plastic response is the following

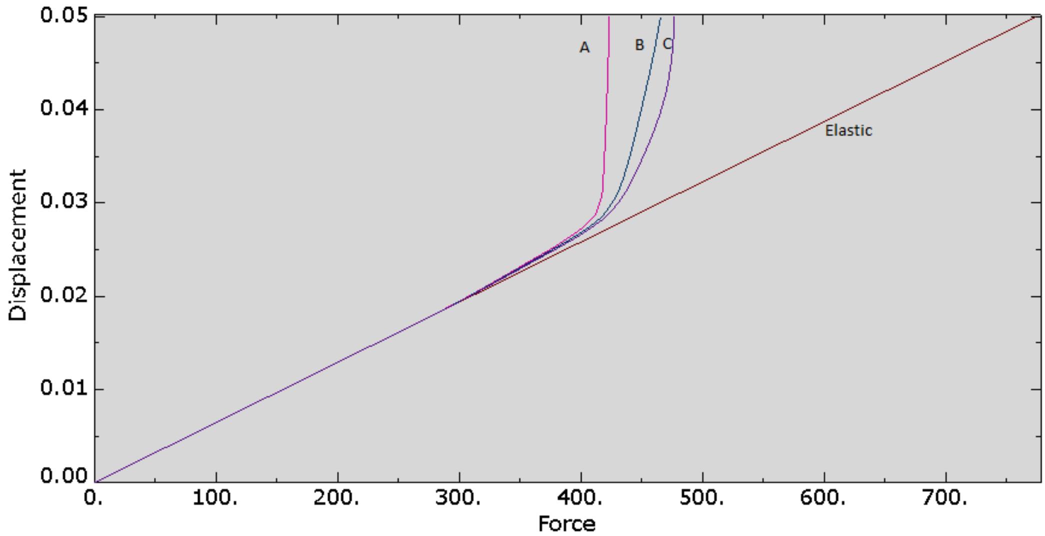
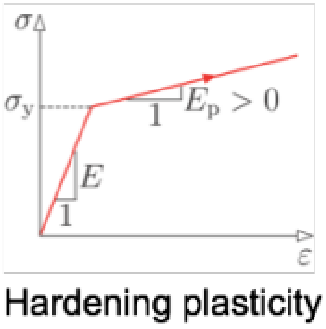
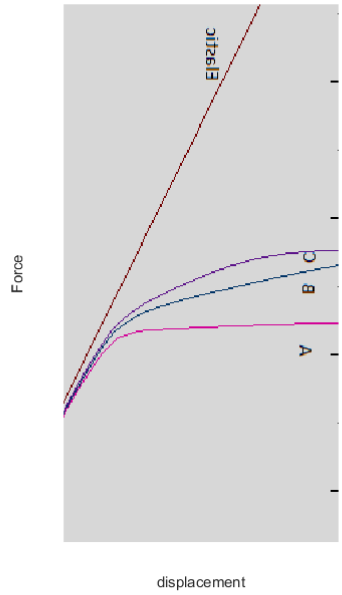


Figure 3: Force-displacement cases comparison

The material non linearity appears clearly with the plastic model. We can see that A is a perfect plasticity as the plastic curve looks straight along the displacement axis. The cases B and C shows hardening plasticity as their slope is positive.





The plastic stain represent the irreversible displacement. We can see that it got an influence on the curvature of the plastic slope.

We can also see that $f_y = 460$ correspond to the transition form elastic to plastic on the curve.

2 Tutorial 2

Here the non linear geometry property is set in the model (to activate large displacement formulation)[1], we add a contact with the plane and a pin, and evaluate the following response with different material properties

We set a 10 amplification factor in `Options -> Common -> Basic -> Deformation scale factor -> Uniform -> Value = 10`.

We set the maximum values color in `Options -> Contour -> Color & Style -> Spectrum` and the scale in `Options -> Contour -> Limits -> Min/Max`

2.1 Von Mises stresses

Here we plot the Von Mises stresses.

[1] Nonlinearities comes from large-displacement effects, material nonlinearity, and boundary nonlinearities like contact and friction and must be accounted for.

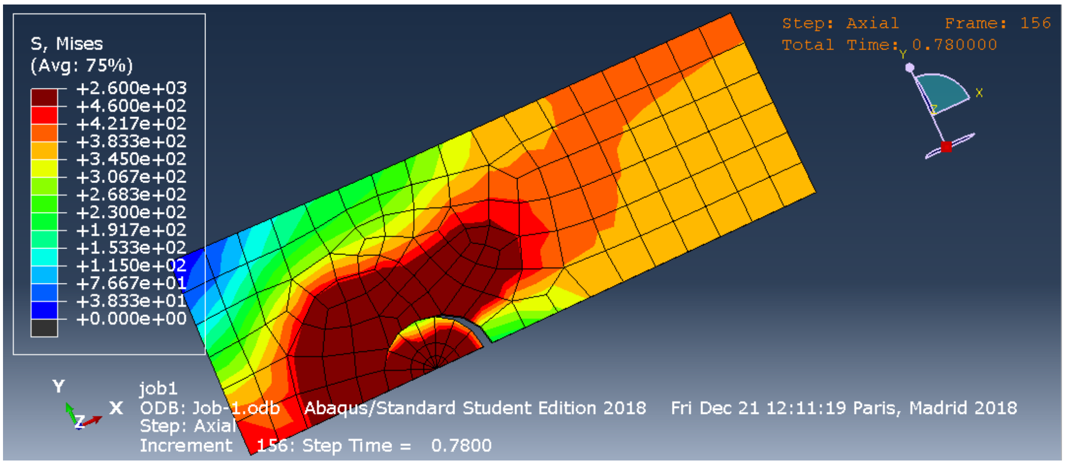


Figure 4: Von Mises stresses

We can see that the visual render and the magnitude of the values is coherent.

2.2 Force-Displacement curve

Like previously, we plot the elastic response

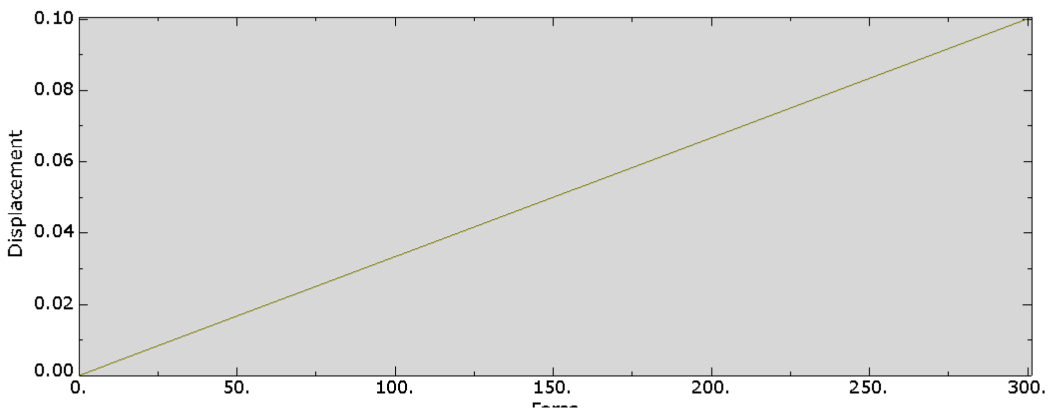


Figure 5: Force-Displacement curve

As previously, the data is coherent as we are in an linear elasticity case.

2.3 Plastic properties

In this case we set the following properties for the plate

- Isotropic, with $f_y = 460$, plastic strain=0; $f_{y2} = 520$, plastic strain $5.e - 3$

And we set 2 cases for the pin material

- **Case 1:** Plastic, Isotropic, $f_y = 900$, $eps_p = 0.$; $f_y = 1000$, $eps_p = 2.e3$

- **Case 2:** Plastic, Isotropic, $f_y = 320$, $eps_p = 0.$; $f_y = 400$, $eps_p = 5.e - 3$

The response is the following

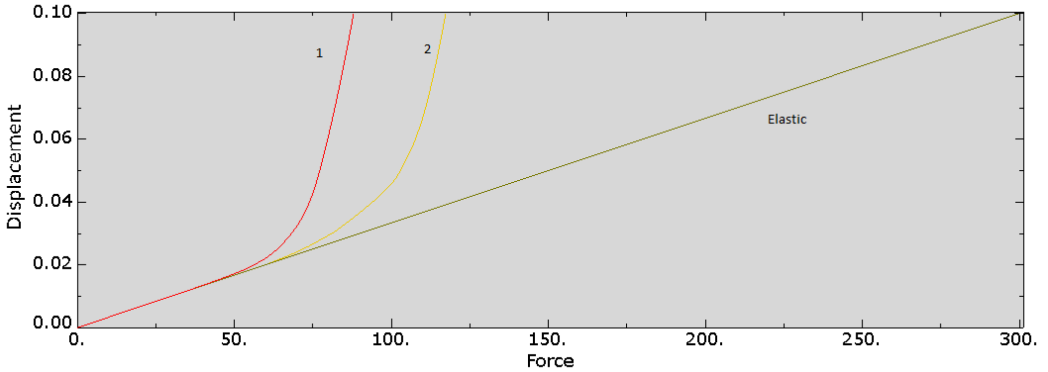


Figure 6: Force-Displacement curve

We can see that the transition from elastic behavior to plastic is located between 50-100 while the f_y parameters are much more higher. This is due to the non linearity in the geometry.