Computational Mechanics Tools

Assignment 3
Abaqus: Nonlinearity

Submitted by
Karthik Neerala Suresh
MSc Computational Mechanics
Universitat Politécnica de Catalunya,
BarcelonaTECH

Submitted to
Dr. Amir Abdollahi
Assistant Professor
Universitat Politécnica de Catalunya,
BarcelonaTECH

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1 Nonlinearity

1.1 Question 1 : Problem statement

A tutorial has been provided to calculate stresses on a steel plate with a hole, which is submitted to axial tensile force. Following this tutorial, one is required to plot the distribution of von Mises stresses in the plate, plot the Force-displacement curve at the point-set and add the plastic properties and compare the results. Finally the differences in the Force-displacement curve for the three different cases have to be discussed.

1.2 Solution

The plot of the distribution of von Mises stresses in the plate is shown in Figure 1.1

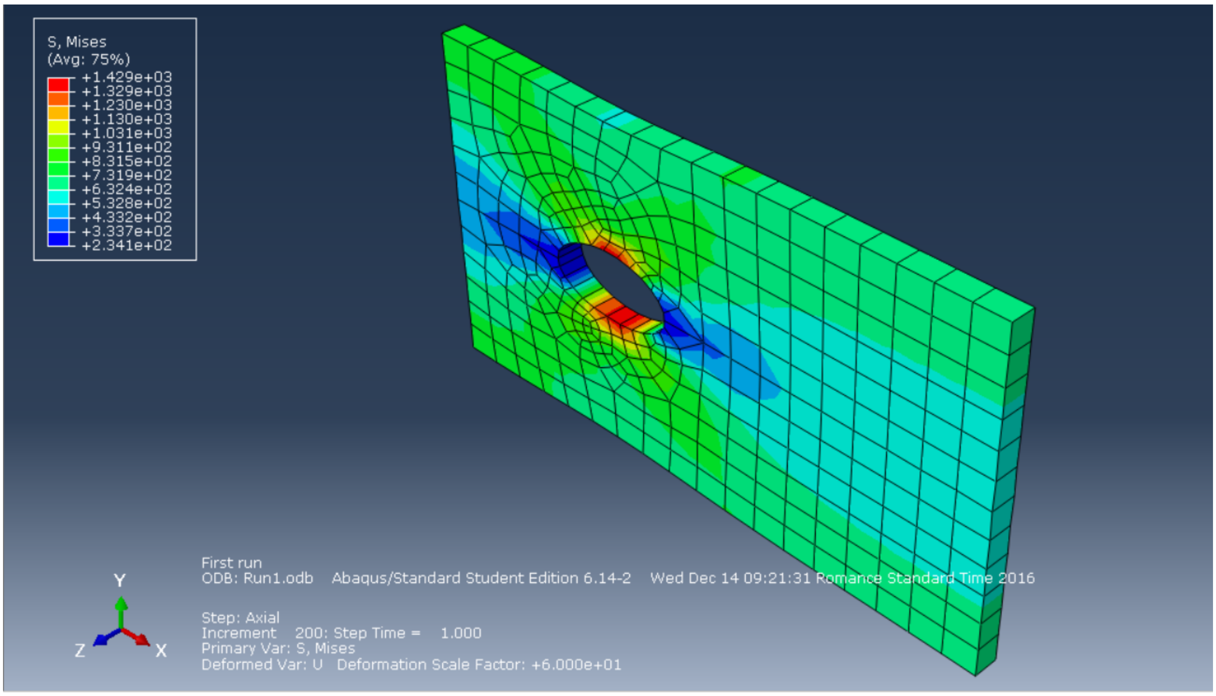
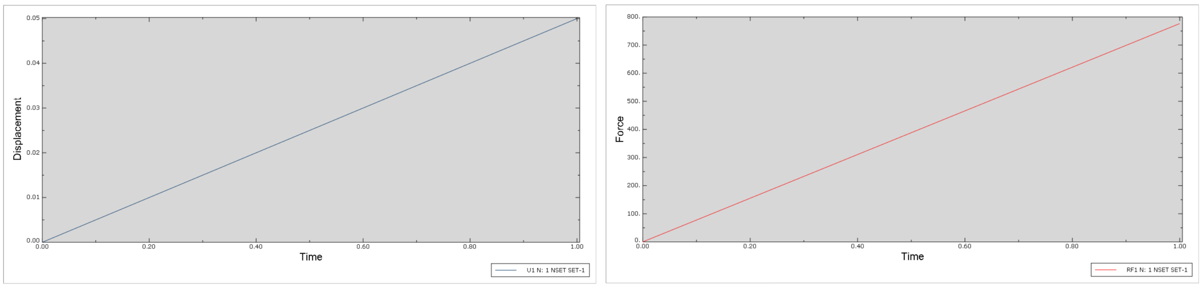


Figure 1.1: Plot of von Mises stresses in the plate with hole subjected to axial loading

From Figure 1.1 it can be seen that the stresses pass the yield limit of 460 MPa.



(a) Displacement-time (b) Force-time

Figure 1.2: Plots for the plate with hole subjected to axial loading

Figure 1.2a shows that displacement is proportional to time and hence it is sufficient to show force-time plot to understand the nature of the force-displacement plots. Figure 1.2b shows that the force-time relationship is a straight line.

Three different cases of plasticity are considered. In the first case, the material is considered as perfectly plastic with yield stress equal to 460 MPa. In the second and the third cases hardening is considered. This is achieved in Abaqus by first considering the material as isotropic and then as kinematic. In the two kinematic cases, f_{y2} is considered as 520 MPa while plastic strain corresponding to f_{y2} is taken as 5×10^{-3} and 2×10^{-3}, respectively. Figures 1.3, 1.4 and 1.5 show the force-time plots for the three cases.

From the figures, it can be seen that in the case of perfect plasticity, the force (in turn stress) does not increase with increase in displacement (or strain), after the yield point has been reached. In the other two cases, due to hardening, the force increases with displacement after the yield point. However, the slope of this curve is not same as the line in the elastic limit. This is because, once the material yields, then its deformation is controlled by the tangent modulus and not Young's modulus. In the first case of kinematic plasticity, tangent modulus is smaller than the second case. This can be seen from the slopes of the plastic region of plots in Figures 1.4 and 1.5.

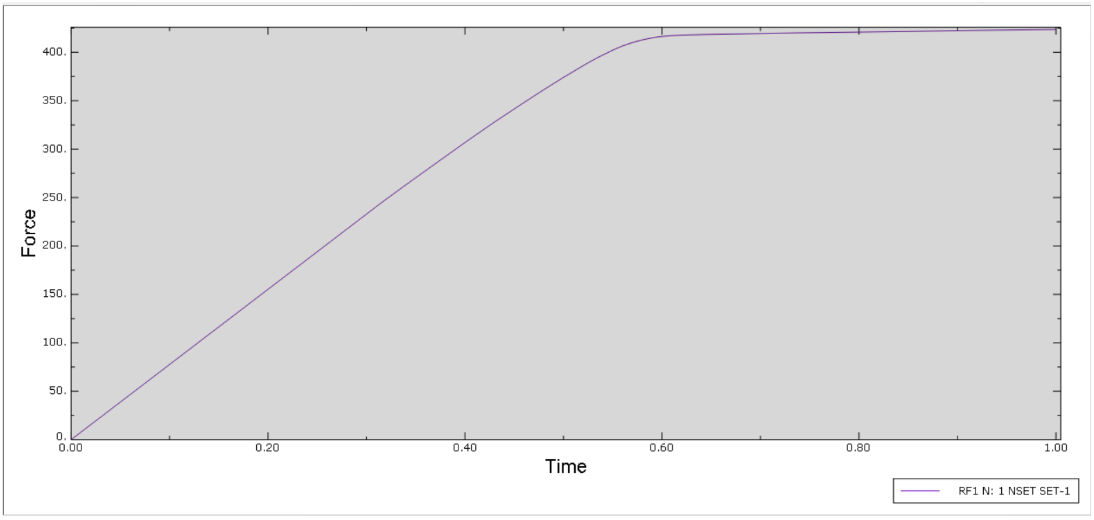


Figure 1.3: Plate with hole force-time for perfect plasticity case

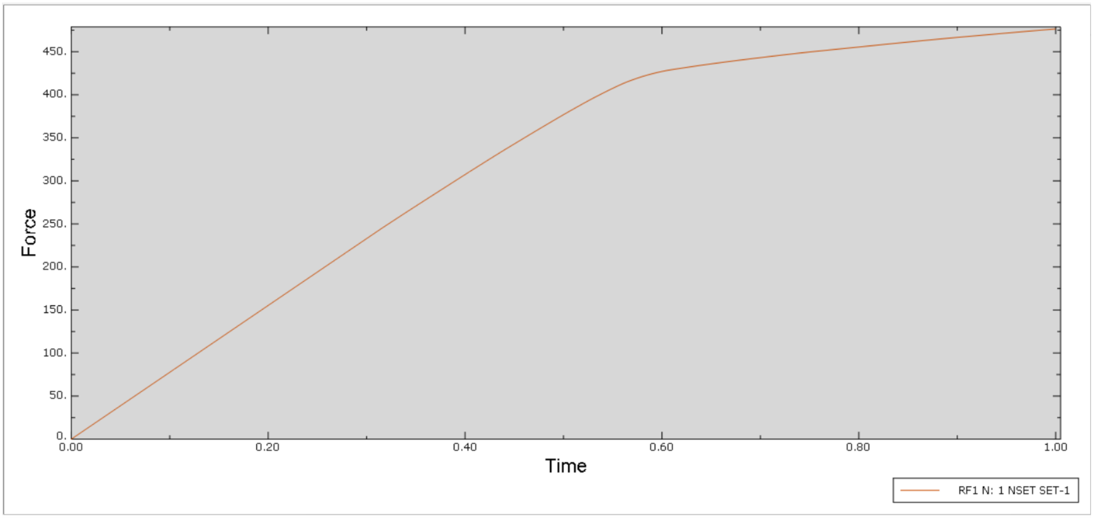


Figure 1.4: Plate with hole force-time for case 1 of kinematic plasticity

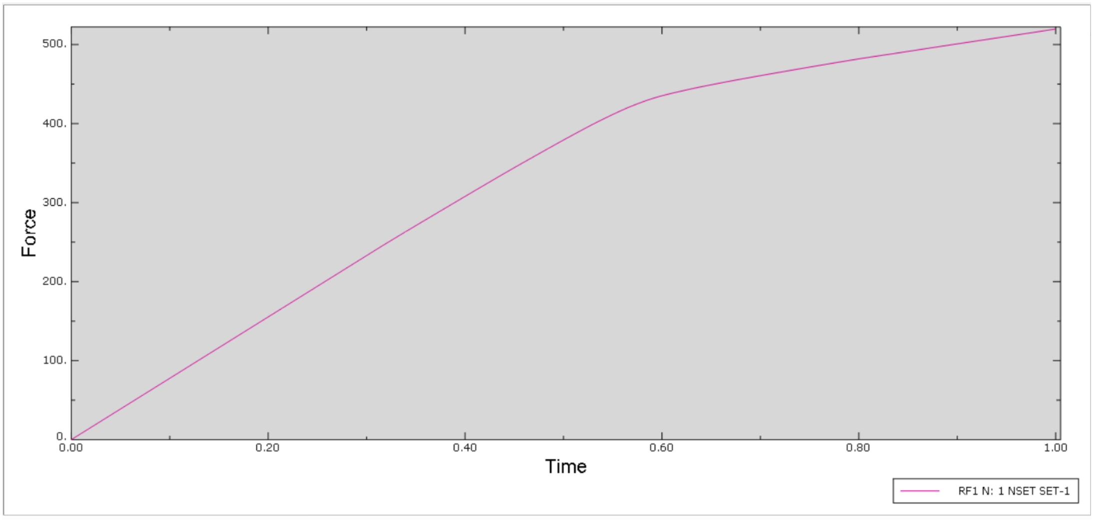


Figure 1.5: Plate with hole force-time for case 2 of kinematic plasticity

1.3 Question 2 : Problem statement

Another tutorial has been provided to model the contact between a fixed pin and a plate, which is pulled at one of its ends. Following this tutorial, the distribution of Von Mises stresses on the deformed shape with an amplification factor of 10 is to be plotted. Also scale of stresses has to be set between 0-460 MPa and the stresses over this limit are to be plotted in dark red. Then the Force-displacement curve for the horizontal reaction at the point-set is to be plotted. Following this, plastic properties to the two materials, one for the plate, and another one for the pin according are to be added and the results have to be compared with the elastic case.

1.4 Solution

The plot of the distribution of von Mises stresses in the plate is shown in Figure 1.6

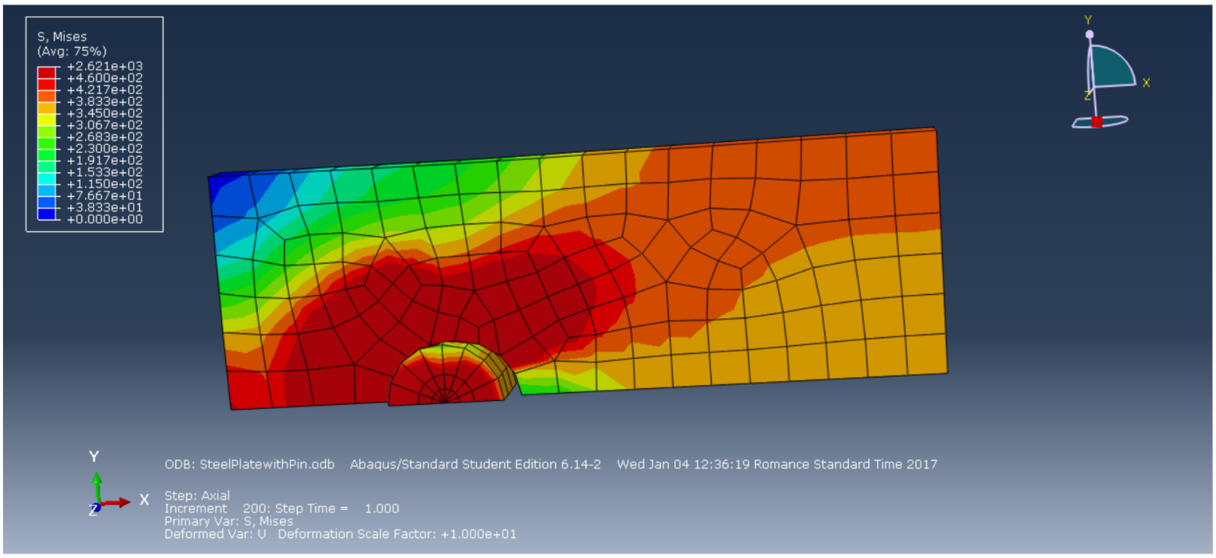


Figure 1.6: Plot of von Mises stresses in the plate with pin subjected to axial loading

From Figure 1.6 it can be seen that the stresses pass the yield limit of 460 MPa.

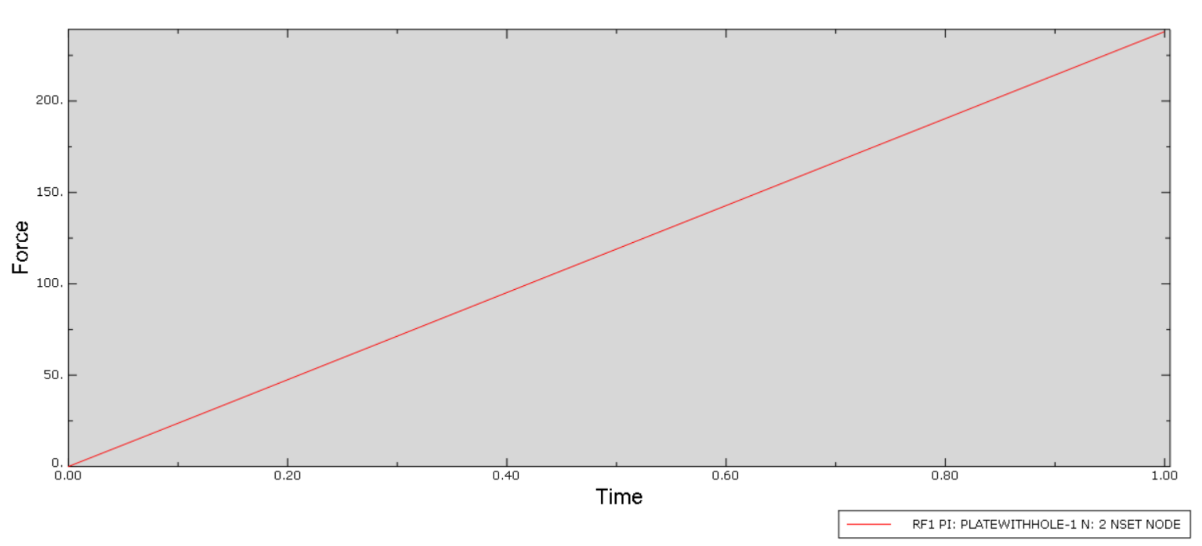


Figure 1.7: Force-time plot for the plate with hole subjected to axial loading

Figure 1.7 shows that the force-time relationship is a straight line, thus showing the elastic nature of the material.

Three different cases of plasticity with hardening are considered. This is achieved in Abaqus by considering the material as kinematic. In the two kinematic cases, f_{y1} is taken as 900 MPa and 320 MPa, respectively, f_{y2} is considered as 1000 MPa and 400 MPa, respectively, while plastic strain corresponding to f_{y2} is taken as 2×10^{-3} and 5×10^{-3}, respectively. Figures 1.8 and 1.9 show the force-time plots for these two cases.

From the figures, it can be seen that in the two cases, due to hardening, the force increases with displacement after the yield point. However, the slope of this curve is not same as the line in the elastic limit. This is because, once the material yields, then its deformation is controlled by the tangent modulus and not Young's modulus. In the first case of kinematic plasticity, tangent modulus is higher than the second case. This can be seen from the slopes of the plastic region of plots in Figures 1.8 and 1.9. Also in the figures it can be seen that, in case 2, the material yields for a lower value of displacement than in case 2. This is because the yield stress in case 2 is smaller than that of case 1.

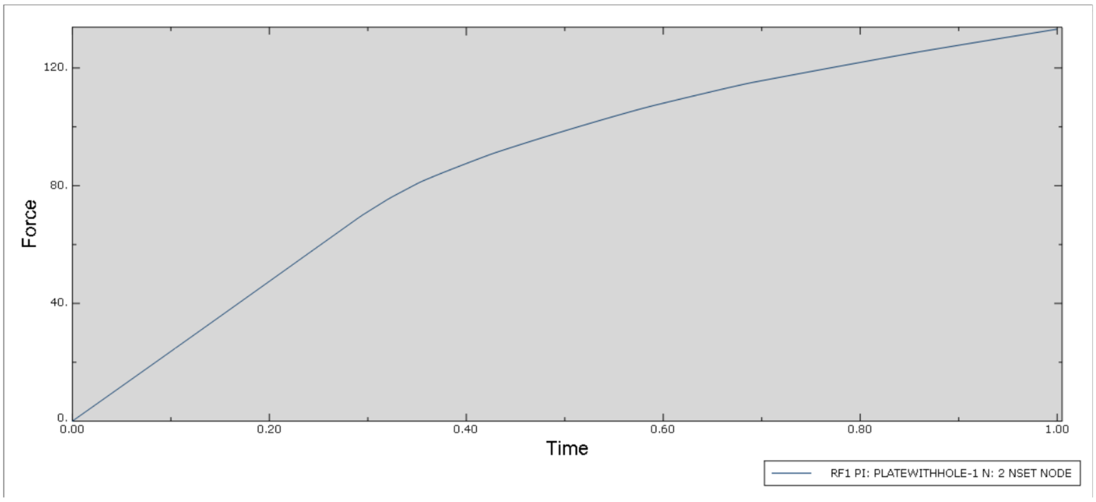


Figure 1.8: Plate with pin force-time for case 1 of kinematic plasticity

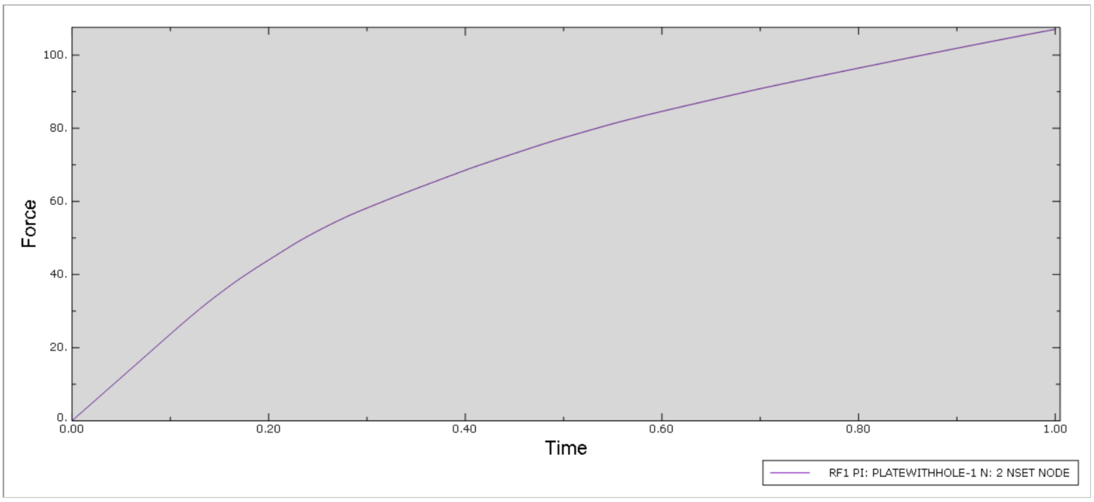


Figure 1.9: Plate with pin force-time for case 2 of kinematic plasticity