UNIVERSITAT POLITÈCNICA DE CATALUNYA

MASTER IN COMPUTATION MECHANICS AND NUMERICAL METHODS IN ENGINEERING

COMPUTATIONAL MECHANICS TOOLS

ABAQUS – NONLINEAR ANALYSIS

by

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1- Introduction

The goal of the assignment is to solve structural problems involving materials with plasticity behavior. The first problem [1] involves the evaluation of a plate with a hole under a prescribed displacement with four different materials. The second problem [1] involves contact interaction between a fixed pin and a plate which is under a prescribed displacement. Plastic behavior is applied to both the pin and the plate.

2 – Problem 1

To solve problem one, four different cases were analyzed. One considering only an elastic material and the other three considering an elasto-plastic material with different plastic behavior. Table 1 presents the description of the material applied in each case.

Table 1. Material properties of the four cases

Case	Elastic property - E [Mpa]	Plastic property – f_{y1} [MPa]	Plastic strain ε_1	Plastic property – f_{y2} [MPa]	Plastic strain ε_2
1	210000	-	-	-	-
2	210000	460	0	0	0
3	210000	460	0	520	0.005
4	210000	460	0	520	0.002

Figures 1-4 present the Von-Mises stress distribution for all cases.

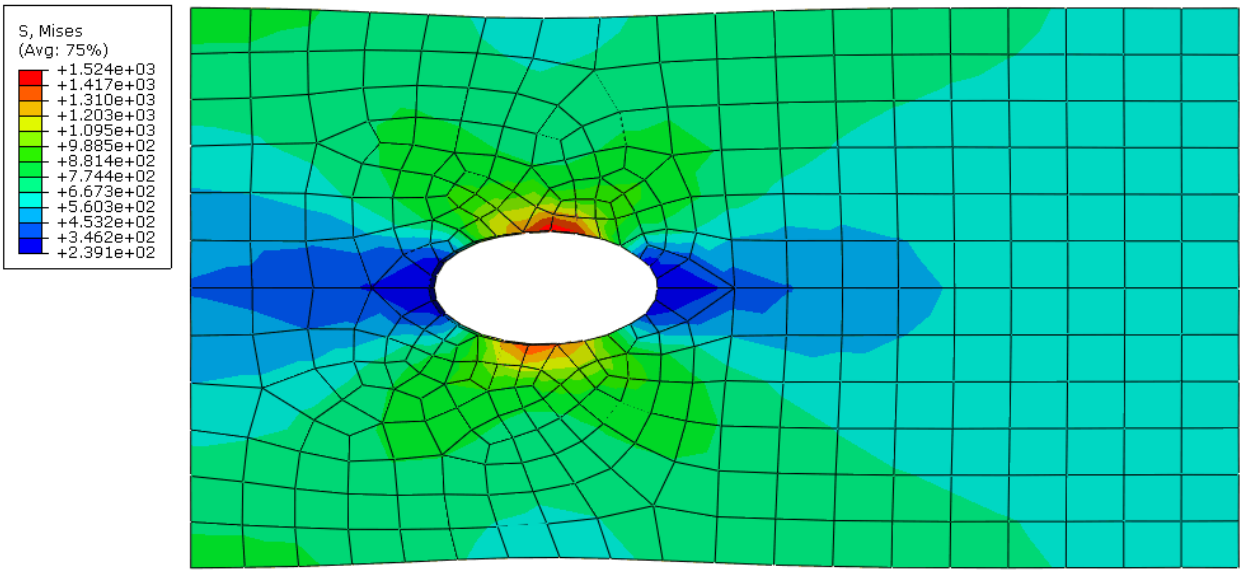

Figure 1. Von Mises stress field for case 1.

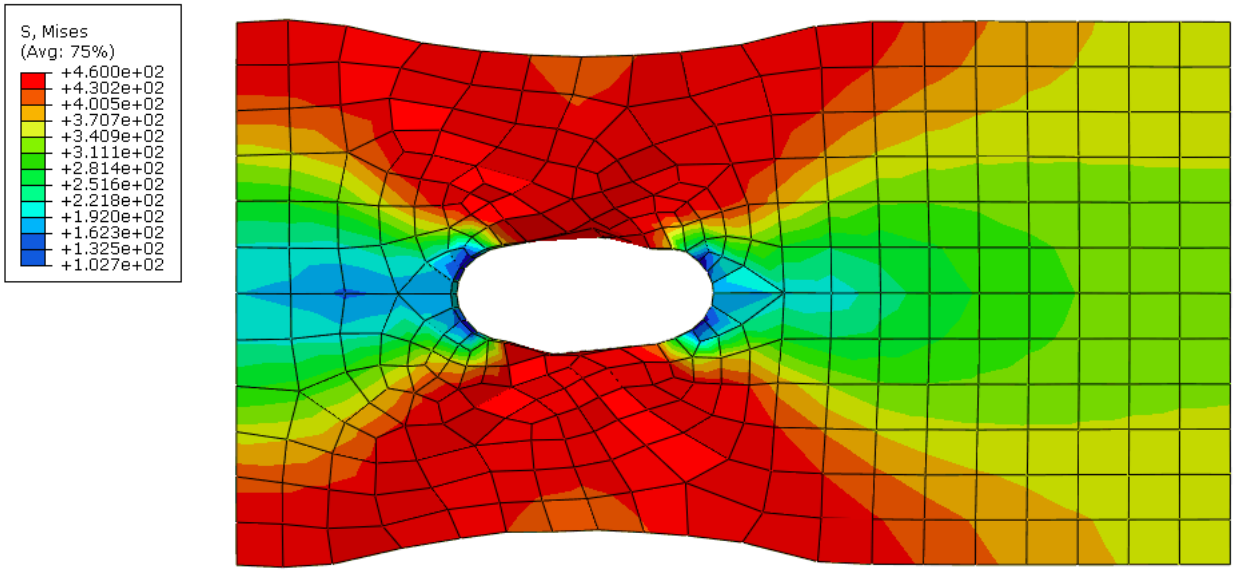

Figure 2. Von Mises stress field for case 2.

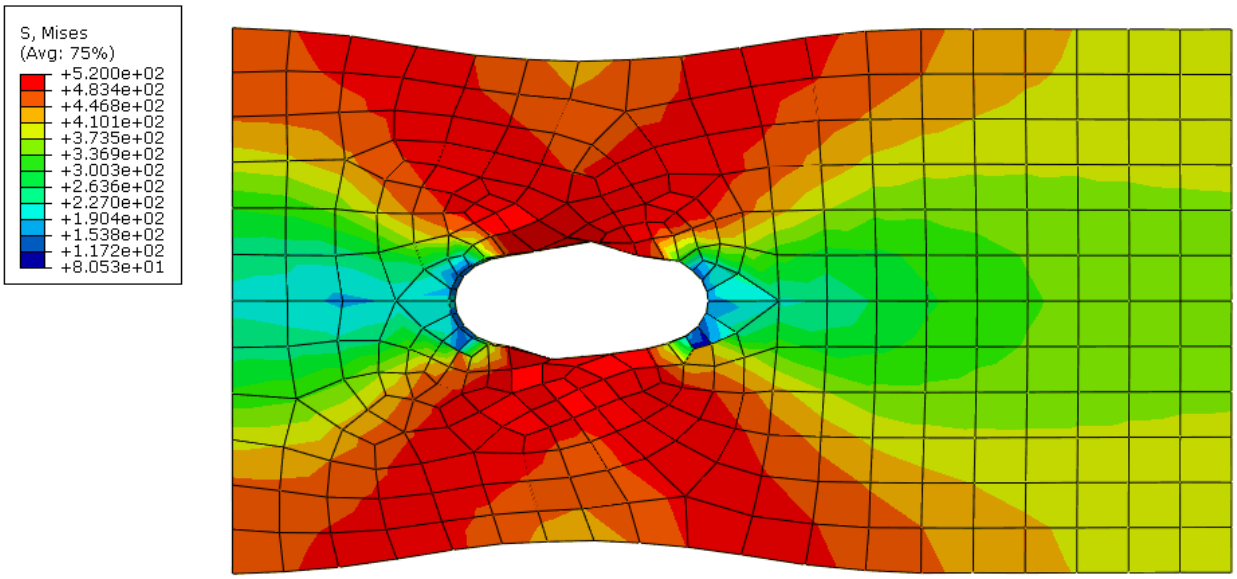

Figure 3. Von Mises stress field for case 3.

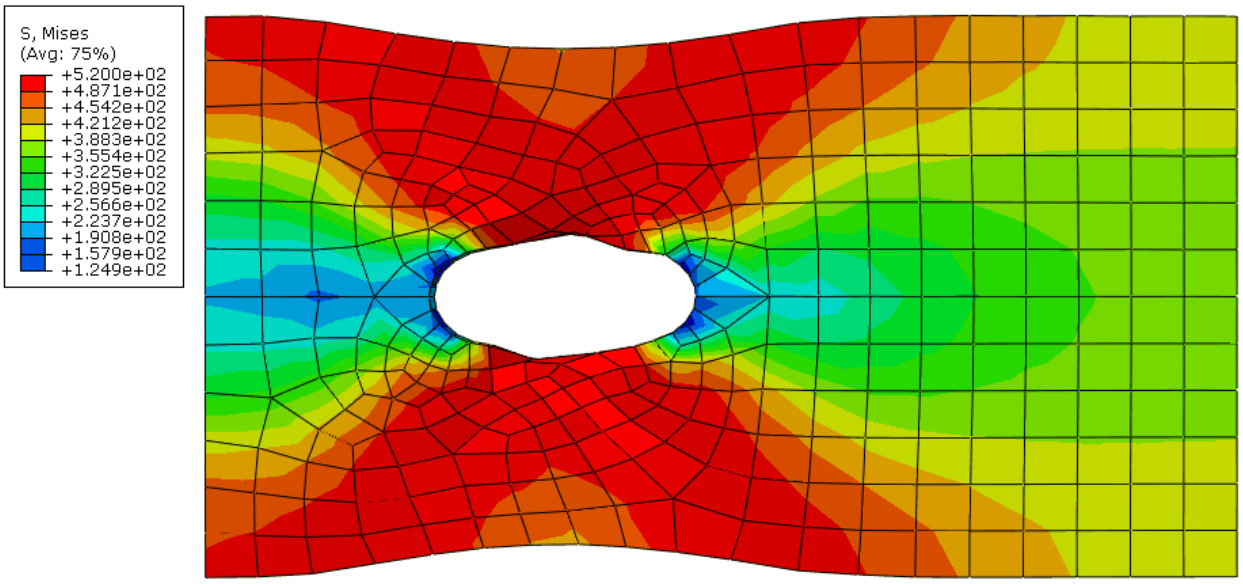

Figure 4. Von Mises stress field for case 4.

Considering a qualitative evaluation of Figures 1-4, the Von Mises stress field has similar behavior in all cases regarding location of stress concentration and distribution. Nevertheless, the values of the stress differ from one case to the other. Case 1 (Figure1)

presents the highest value of stresses due to the elastic behavior of the material (no plastic behavior). Cases 2-4 present lower stress values due to the yielding of the material (elasto-plastic behavior), which corresponds, in these cases, to the degeneration of the materials' stiffnesses. Figure 5 presents the force versus displacement curve for all cases considering the force and displacement of the node pre-determined for the current assignment [1].

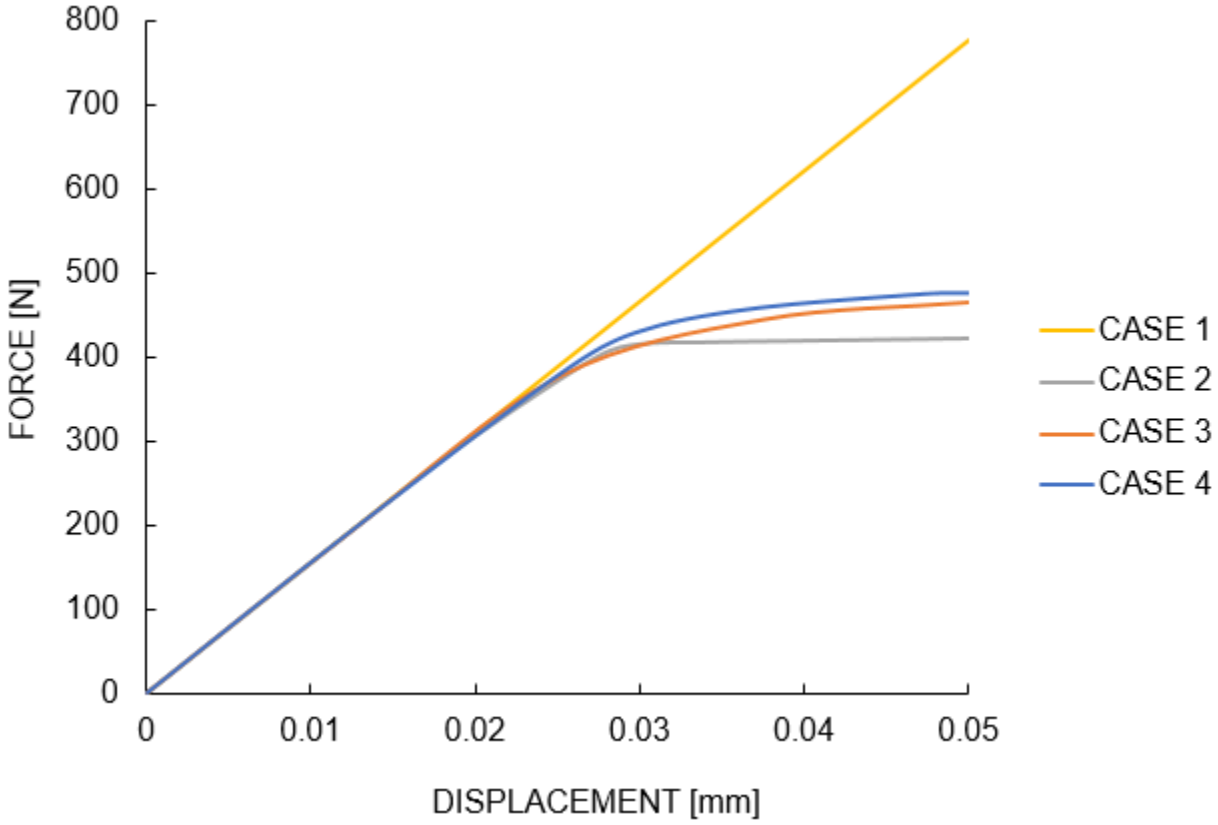

Figure 5. Force versus displacement curves for all cases

3 – Problem 2

To solve problem two, three different cases were analyzed. One considering only an elastic material for both the plate and the pin (Case 1) and the other two considering an elasto-plastic materials with different plastic behavior for both bodies as well. Table 1 presents the description of the materials applied in each case.

Table 1. Material properties of the four cases

Body	Case	Elastic property - E [Mpa]	Plastic property – f_{y1} [MPa]	Plastic strain ε_1	Plastic property – f_{y2} [MPa]	Plastic strain ε_2
Plate	1	210000	-	-	-	-
Pin	1	210000	-	-	-	-
Plate	2	210000	460	0	520	0.005
Pin	2	210000	900	0	1000	0.002
Plate	3	210000	460	0	520	0.005
Pin	3	210000	320	0	400	0.005

For Case 1 the Von Mises stress field is presented in Figure 6 (the stress field for the remaining cases are presented in Appendix A) considering a scaling factor of 10. The regions in dark red, corresponding to a stress above 460 MPa, are the regions which would reach the plastic regime if the initial yield stress were set to 460 MPa.

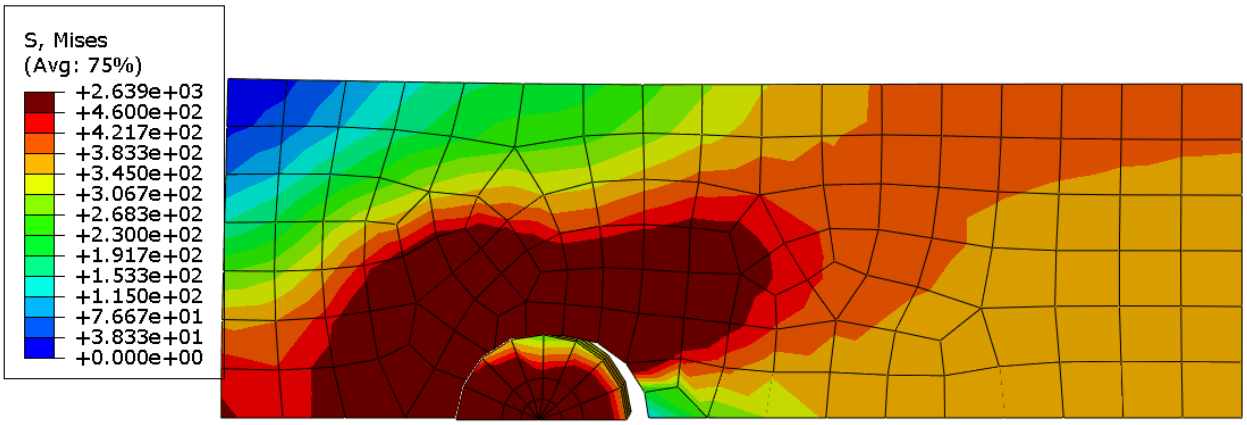

Figure 6. Von Mises stress field for case 1

To compare all cases, a force versus displacement plot at the node pre-determined for the current assignment [1] is depicted in Figure 7.

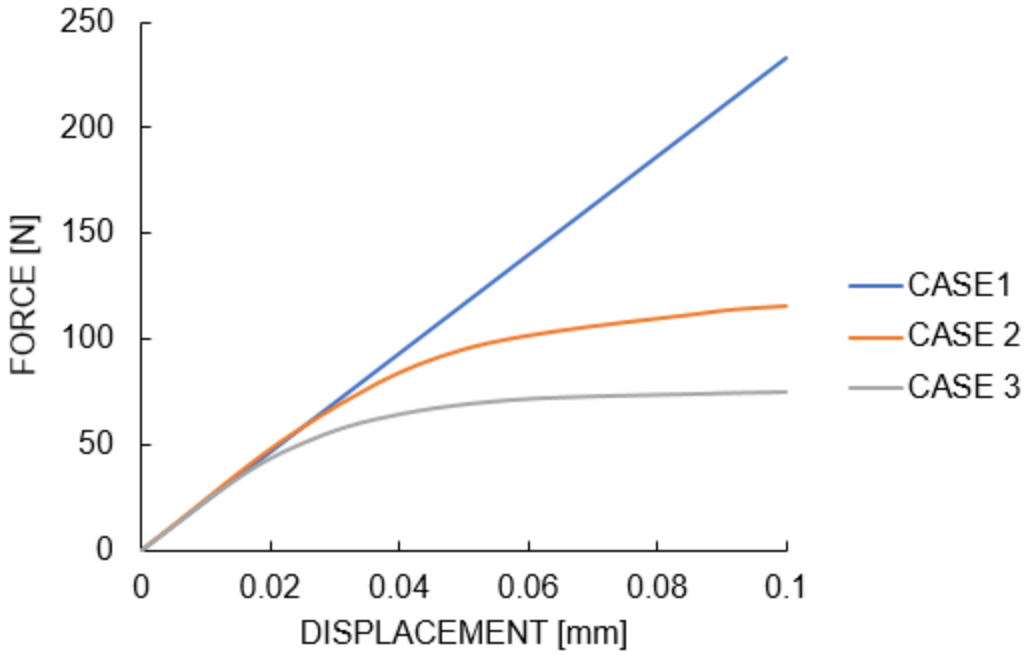

Figure 7. Force versus displacement curve comparing Cases 1-3 at node pre-determined for current assignment.

According to Figure 7, Case 1 presented a higher maximum reaction force. Such behavior is expected since the materials in such case only have an elastic regime and, therefore, no degradation of the materials stiffness. Case 3 presented the lowest maximum force among the three analyzed cases. Such response is also expected since in Case 3 the material for the pin starts yielding at a lower stress value. Hence, the pin's material loses its initial stiffness before and can not hold a greater force with increasing displacement.

4 – Reference

[1] – Computational Mechanics Tools. Presentation AbaqusNonlinear.2019.

Appendix A – Von Mises stress fields for cases with plasticity (Problem 2)

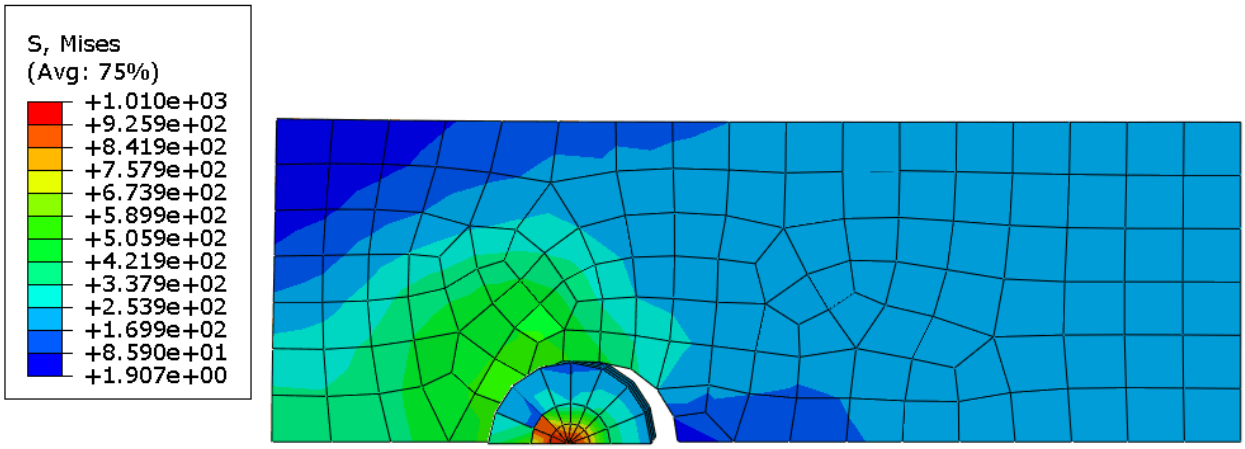

Figure A.1 - Von Mises stress field for Case 2

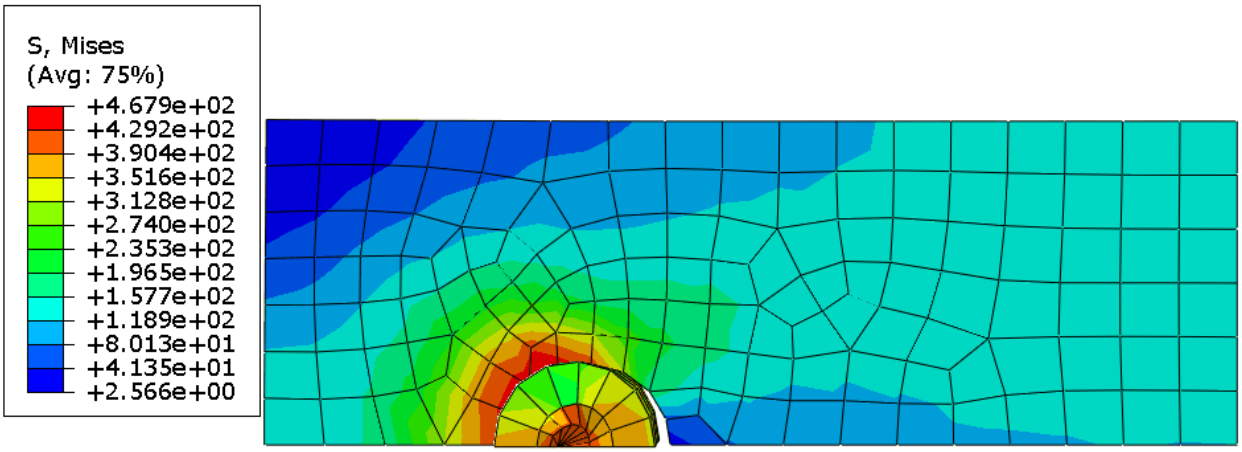

Figure A.2 - Von Mises stress field for Case 3