Master in Numerical Method in Engineering

Computational Mechanics Tools

Assignment 3
Plasticity

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Excersice 1

Important Remark: The units system used in this assignment were N, mm, and MPa. 3D linear 8 nodes elements were used in order to generate each mesh in this assignment.

1. Following the given tutorial.

   In figure below can be seen the geometry used to generate the model and the generated mesh. It was necessary split the geometry in order to obtain a good structural mesh.

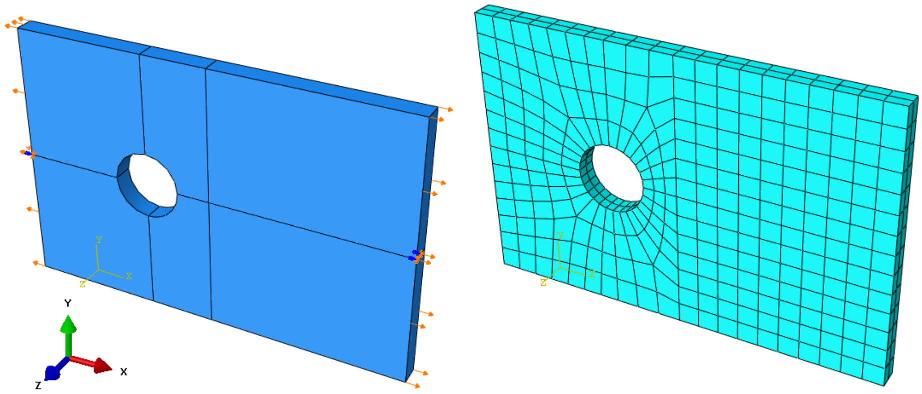

Figure 1: Model. Left: Geometry and BC. Right: Mesh.

The material used was steel, with the following mechanical properties.

$$E = 210000MPa, \mu = 0.25, \sigma_{yield} = 460MPa$$

(a) Plot the distribution of Von Mises stresses in the plate.

In the following figure can be seen the Von Mises stresses distribution over the plate, and also, can be noted the level of stresses have surpassed the material yield stress, noticing that the surrounding hole zone is being plasticized.

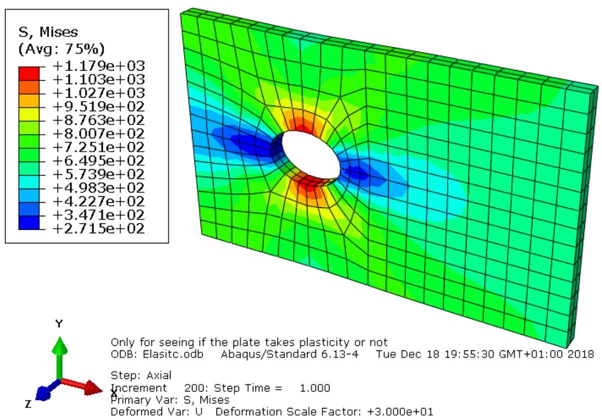

Figure 2: Elastic analysis of the model.

(b) Add the plastic properties and plot the Force-displacement curve at the point-set. Compare the results. Discuss the differences in the Force-displacement curve for the three different cases

Three different isotropic plastic models were analysed. For the first one, perfect plasticity was introduced, while the remain models bilinear isotropic plasticity was studied.

i. Isotropic, perfect plasticity $\sigma_{yield} = 460MPa$.

ii. Isotropic, bilinear plasticity $\epsilon = 0$, $\sigma_{yield} = 460MPa$; $\epsilon = 5e^{-3}$, $\sigma_{yield} = 520MPa$.

iii. Isotropic, bilinear plasticity $\epsilon = 0$, $\sigma_{yield} = 460MPa$; $\epsilon = 2e^{-3}$, $\sigma_{yield} = 520MPa$.

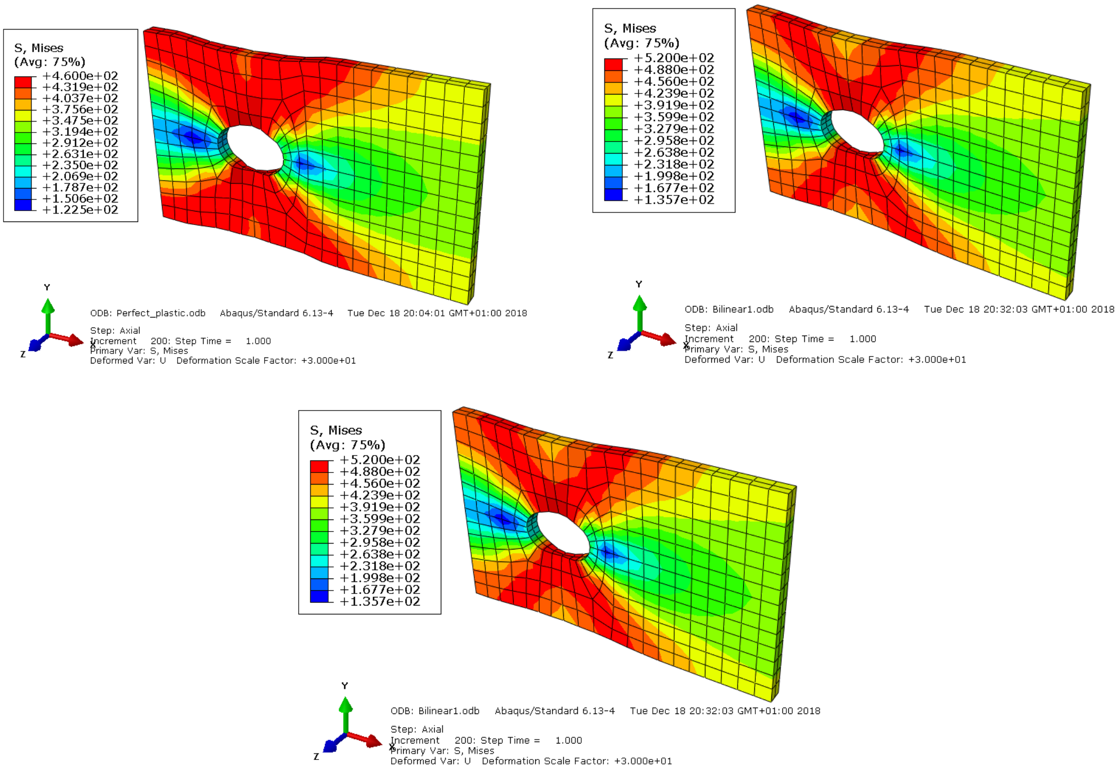

Figure 3: Plasticity models. Top-Left: Isotropic perfect plasticity. Top-right: Isotropic bilinear plasticity. Bottom: Isotropic bilinear plasticity.

In the first model (figure 3 top-left) can be seen the maximum Von Misses stresses value is bounded by $\sigma_{yield} = 460MPa$, remaining constant along strain values. This remark can also be noted in curve corresponds to perfect plasticity in figure 4, when the reaction force remains constant after displacement reaches a value of 0.025 mm. On the other hand, the last two models have been showing similar results. It can be seen the maximum Von Misses stresses value reached 520 MPa. While the reaction force for both bilinear models once the displacement surpass a value of 0.02mm start to increase, but less than the model analysed elastically.

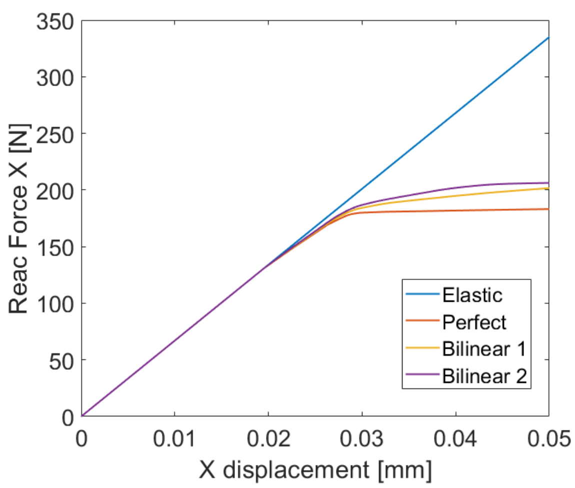

Figure 4: X component of Reaction force vs X displacement.

It can be observed, in figure 4, that the linear analysis was not be able to predict the relief of the reaction force where the system exceed the yield stress. On the other hand, it can be noted, in perfect plastic model, that the reaction force remains constant once the system surpass the yield stress. On the contrary, both bilinear models have shown that once the yield stress is overcame, the reaction force is relieved.

Excersice 2

1. Following the given tutorial.

   In figure below can be seen the geometry used to generate the model and the mesh. It was necessary split the geometry in order to obtain a good structural mesh.

   The material used for the plate and pin was steel, with the following mechanical properties.

$$E = 210000MPa, \mu = 0.25, \sigma_{yield} = 460MPa$$

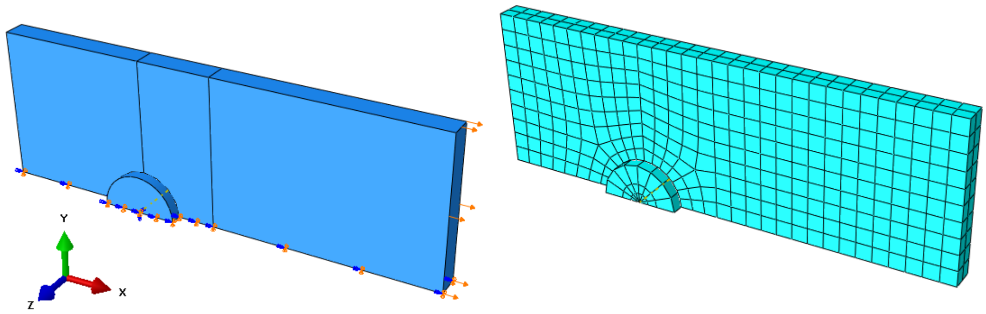

Figure 5: Model. Left: Geometry and BC. Right: Mesh.

   (a) Plot the distribution of Von Mises stresses in the plate.

   In the following figure can be seen the Von Mises stresses distribution over the plate and pin, and also, can be noted the level of stresses is higher than the material yield stress, therefore, the surrounding hole zone plate and pin is being plasticized.

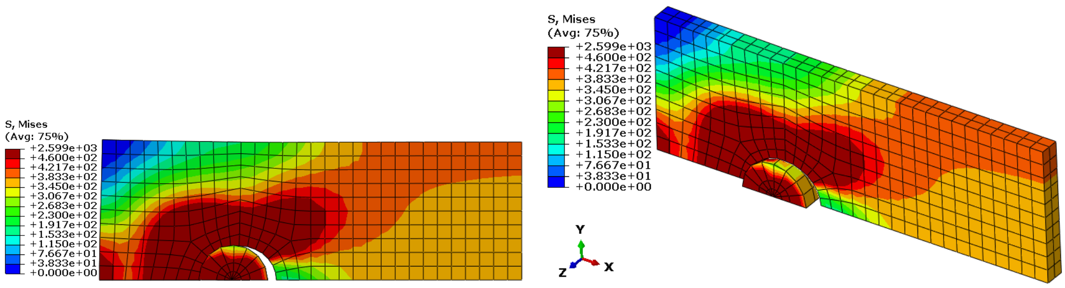

Figure 6: Elastic analysis of the model.

   (b) Add the plastic properties and plot the Force-displacement curve at the point-set. Compare the results. Discuss the differences in the Force-displacement curve for the two different cases.

   Figure below shows two models where plastic material properties was taken into account. It can be seen that the level of stresses have decreased, compared with the model shown previously. In addition, the model shown on the right has a level of stresses less than the left one. This is due to that this sort of steel, used in the pin, is hard than the one used in the plate. It's means that the yield stress of the steel, used in the pin, is higher than the one used in the plate. On the other hand, the model shown on the right presents a more uniform stress distribution over the plate and pin, it can be means that the steel used in the plate and pin has similar plastic properties, or similar yield stresses.

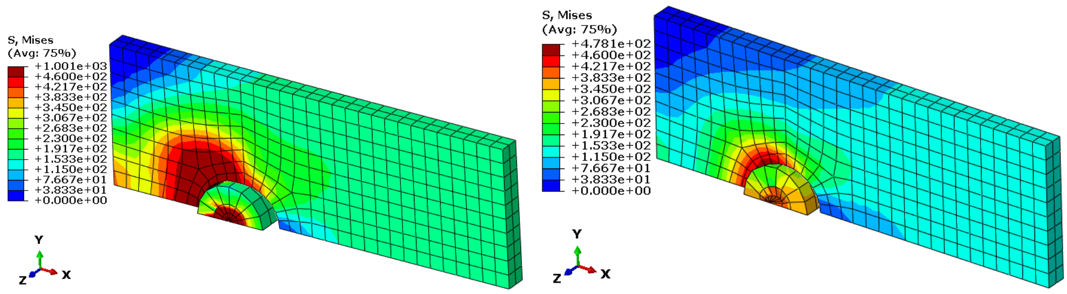

Figure 7: Two different models. Left: Pin with Hard material. Right: Pin with soft material.

Figure 8 shows three curve of the X component of reaction force vs the X component of displacement. The straight line is related with the elastic analysis, where it could not able to simulate plastic phenomena.

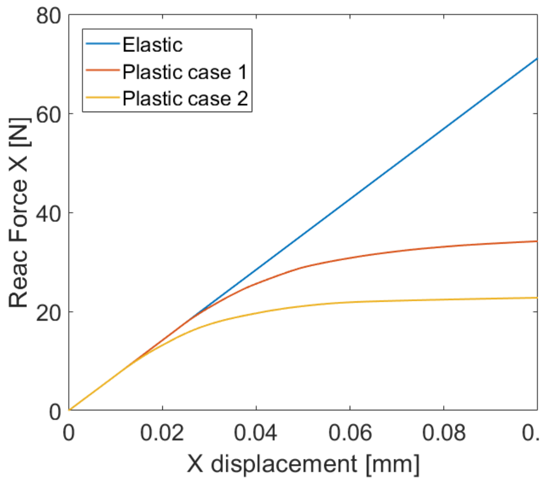

Figure 8: X component of Reaction force vs X displacement.

For plastic model 1 (Plastic case 1 in figure 8) the permanent deformation starts when the displacement reached a value equal to 0.03, while the plastic model 2 starts to plasticize when the displacement reached a value equal to 0.02.