Work n°3: Infinitesimal plasticity

Non-linear Mechanics of Materials

Carlos Felipe Guzmán
University of Santiago of Chile (USACH), Civil Engineering Department
linktr.ee/cf.guzman

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Unit	:	Infinitesimal theory of plasticity
Learning goal	:	Develop computational solutions for small strain elastoplastic problems, implementing robust numerical algorithms in a scientific software

Evaluation description

Consider a structural steel obeying a J_2 plasticity material model with Voce isotropic hardening, which is defined as:

$$\sigma_Y(\varepsilon^P) = \sigma_{Y0} + K\left(1 - \exp\left(-n\varepsilon^P\right)\right)$$

where K, n and σ_{Y0} are material parameters. The structural steel has the following material parameters: $E = 210\,\text{GPa}$, $\nu = 0.3$, $K = 259.59\,\text{MPa}$, $n = 9.42$ and $\sigma_{Y0} = 180.0\,\text{MPa}$.

1. Using ANSYS APDL:
   (a) Perform a numerical simulation of an homogeneous (quasi-static) tensile test in a single `SOLID185` finite element. Obtain the stress-strain curve from a single integration point.
   (b) Perform a tensile test in a specimen according to the ISO-6892, as shown in Figure 1, where $L_0 = 80\,\text{mm}$, $L_c = 100\,\text{mm}$, $L_t = 200\,\text{mm}$, $d_0 = 13\,\text{mm}$ and S_0 is the transversal area.
      i. The FE mesh with the applied boundary conditions
      ii. Obtain the force-displacement curve for the test until $\varepsilon = 0.3$
      iii. Obtain the stress-strain curve. Compare with the homogeneous case and analyze the results

      The geometry of the specimen is available in the `ISO6892_specimen_geometry.inp` file.
2. For the theoretical model:
   (a) Derive rigorously the initial value problem (IVP) of the elasto-plastic constitutive equations for this material.
   (b) Derive the incremental (discretized) IVP to solve the elasto-plastic equations.
   (c) Using a scientific software, implement a return-mapping algorithm and perform a numerical simulation of an uniaxial tensile test to obtain the stress-strain curve until $\varepsilon = 0.3$. Compare with the results from the previous section.