Nonlinear analysis – Assignment 6

**Problem 1:**

The modelization of the frame is done accordingly to assignment 5, with an introduced bi-linear behavior in the columns. The beam is modelized as an elastic element with two zero-length elements at its extremities with a tri-linear constitutive law.

**Column elements discretization**

In order to capture the inelastic behavior of the steel columns, composed of HEA450 cross section, the cross section is discretized into a set number of fibers.

As it is assumed that the column will be stressed not only in the axial direction, but also in bending and in shear, it appears that a minimum of 3 elements in each direction is required. In order to mitigate the computation time, it is decided to discretize the section into 9 fibers as a first approach. The discretization is the following (unit : [mm]) :

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Description générée automatiquement

The columns are implemented in OpenSees as displacement-based beam column elements with Steel01 material, and discretized cross section as defined.

The effect of gravity is neglected in the applied forces.

Une image contenant capture d’écran, diagramme, ligne

Description générée automatiquement

Figure 1: Elements defined in OpenSeesNavigator for the steel MRF

Displacement controlled incrementation is applied on the frame, at the node corresponding to the top left corner of the frame (defined as node 2).

A total displacement of 600 mm is applied, with 1mm increments.

**Computation results**

The final deformed shape is obtained:

Une image contenant capture d’écran, ligne

Description générée automatiquement

Figure 2: Deformed shape, for total displacement incrementation of 600mm at node 2.

The final deformed shape is obtained:

It is observed that the left column is subject to the biggest displacement of the two columns. It is expected, as we observed in the assignment 5 that the left zero length element plastify for forces corresponding to smaller displacements than 600 mm.

**Problem 2:**

**OLD:**

In order to study the in-elastic behavior of the beam, it is important to observe the plastification behavior of the zero-length element.

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Description générée automatiquement

Figure 3: Bending stresses in the top left zero-length element, as a function of the horizontal displacement at node 2

The hardening behaviour of the zero-length element begins at a displacement of 28mm. The degradation behaviour begins at 123 mm.