SSNL133 – Elastic postbuckling of a structure in L

Summary:

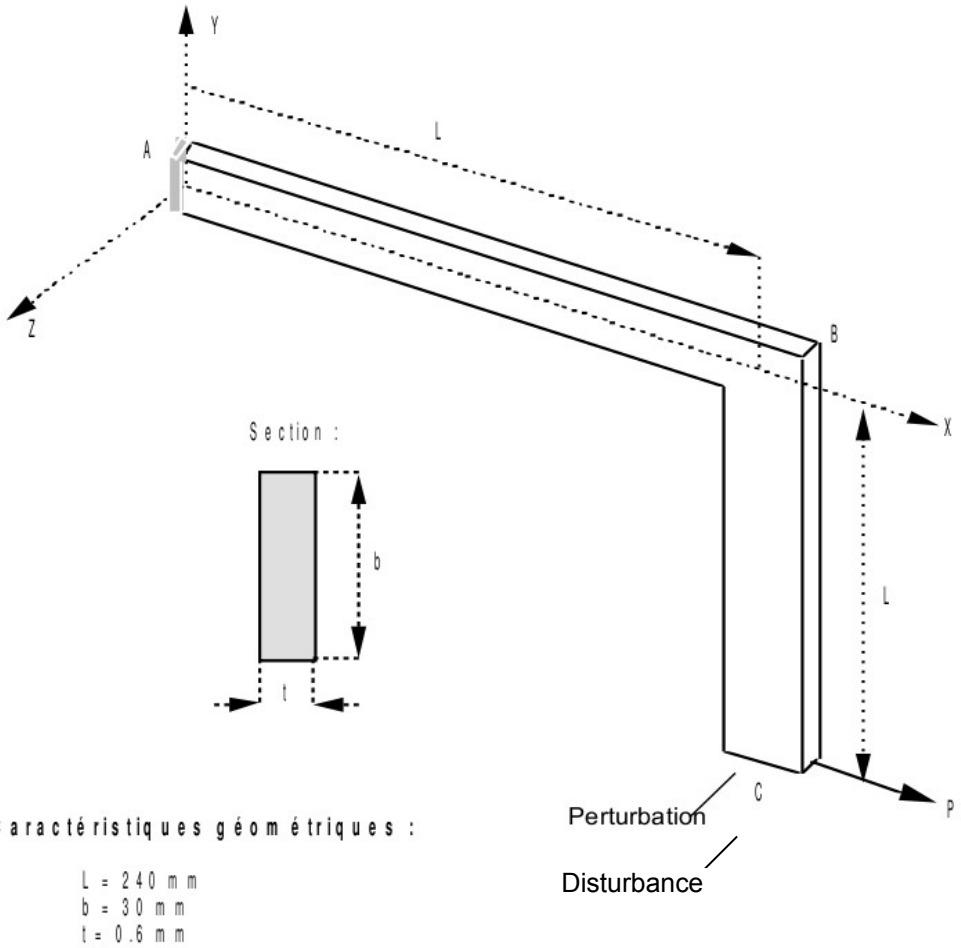
An L-shaped structure made up of two slim beams of mean rectangular section is embedded with one of its ends and is subjected to a force at its other end. One seeks the behavior postbuckling associated with the positive values with the force. The field of the test is:

- non-linear elastic mechanics (great displacements, great rotations),
- buckling of beams (instability),
- modelings tested are POU_D_TGM, POU_D_T_GD, POU_D_TG, POU_D_T, POU_D_E and POU_D_EM.

It makes it possible to test kinematics in great displacements and great rotations activated via the keyword GROT_GDEP.
Note: one will be able to refer to the case test SSLL105 for a determination of the critical loads of buckling for this structure.

1 Problem of reference

1.1 Geometry



1.2 Material properties

$E = 71240\,MPa$
$\nu = 0.3$

1.3 Boundary conditions and loadings

Boundary condition: embedding in A
Loading out of C according to pseudo-time $t \in [0;5]$:
$F_x = 1.0 \times t\,[N]$
$F_z = 0.001 \times t\,[N]$ (disturbance to initiate the behavior postbuckling of the blade)

2 Reference solution

2.1 Method of calculating used for the reference solution

One takes as reference solution, the answer postbuckling obtained with modeling POU_D_T_GD (modeling A), which will provide values of not-regression.

2.2 Results of reference

Tests of not-regression on some points of curved force-displacement representative of the behavior of the structure (Force applied to the point C according to the displacement of the point C according to X and Z).

2.3 Uncertainty on the solution

Another modeling Aster.

2.4 Bibliographical references

[1] G. DEVESA: Treatment of great displacements in the element of angle with 7 ddl established in *Code_Aster* validation by a classical case test (HM - 77/94/079).

[2] H. Shakourzadeh. Modeling of the three-dimensional structure-beams with thin walls and simulation of the geometrical and elastoplastic nonlinear behavior. Doctorate, University of Compiegne, Compiegne (1994).

3 Modeling A

3.1 Characteristics of modeling

20 elements POU_D_T_GD

3.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 20 SEG2 (10 in each branch)

3.3 Sizes tested and results

For this modeling, the tests are of not-regression. The values seem references in all other modelings.

3.3.1 Graphic results of modeling A

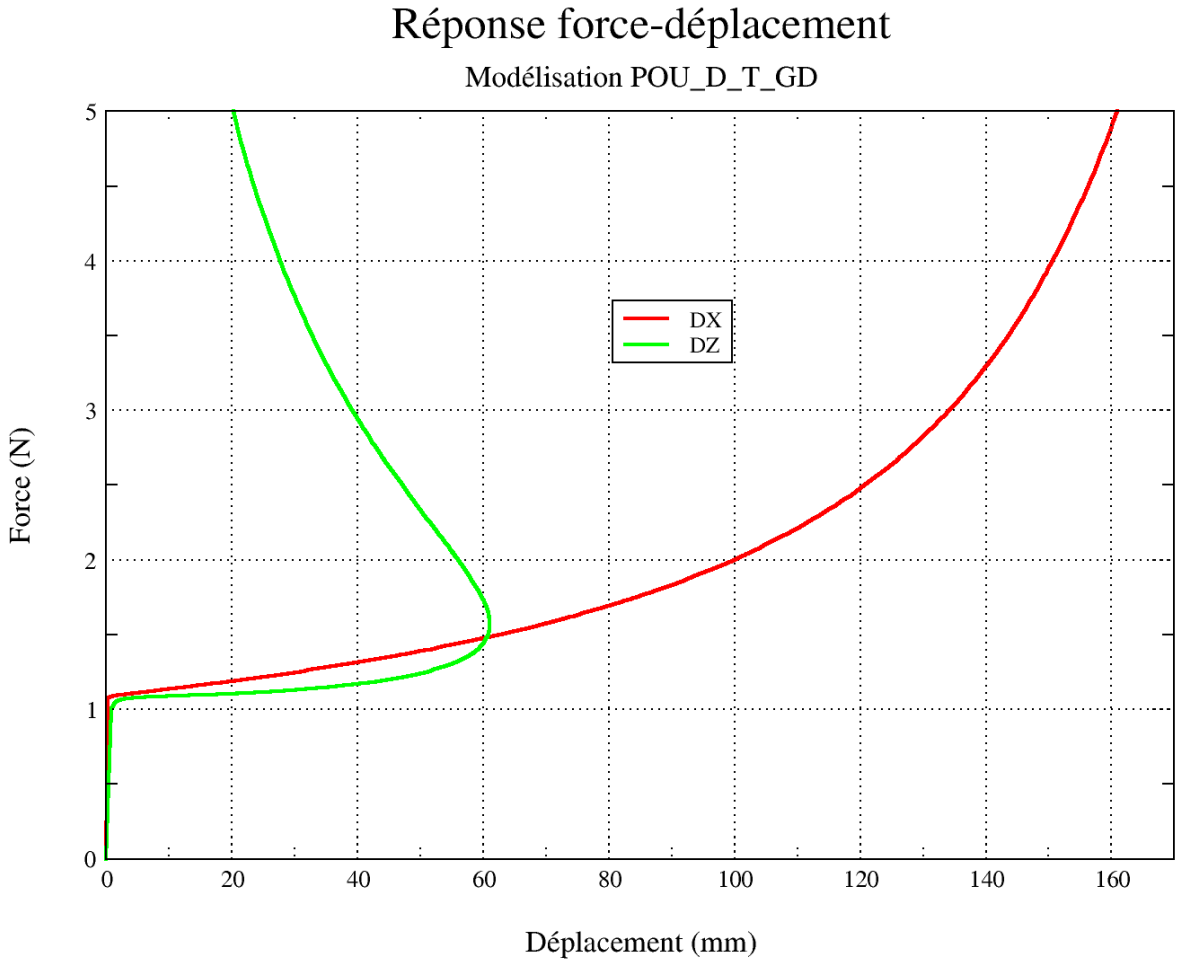


Figure 3.3.1-a : Answer Force-displacement, modeling POU_D_T_GD.

The values being used as reference for all other modelings are those of the table 3.3.1-a. The tolerances are adapted so that the test passes on the various platforms.

Effort (N)	DX (mm)	DZ (mm)	Tolerance/ DX	Tolerance/ DZ
1.0	1.9557493476051e-01	8.1849504447187e-01	1.0e-06	1.0e-06
1.2	2.2002897190547e+01	4.5085481299695e+01	1.6e-05	1.2e-05
1.4	5.1370576657920e+01	5.9127404636640e+01	3.7e-06	5.3e-06
1.6	7.2308205991507e+01	6.1009065262385e+01	5.9e-06	9.7e-06
2.0	9.9971410898183e+01	5.5985793815570e+01	2.6e-06	7.8e-06
3.0	1.3415732610325e+02	3.9186782348842e+01	1.0e-06	7.0e-06
4.0	1.5070726838590e+02	2.7660150436455e+01	1.0e-06	6.5e-06
5.0	1.6092764983263e+02	2.0199366888417e+01	1.0e-06	6.2e-06

Table 3.3.1-a : values of reference.

3.4 Remarks

The strategy adopted to obtain the answer in force-displacement of the structure is to control in effort.
It is in addition necessary to use the automatic subdivision of the step of time. Indeed, the element `POU_D_T_GD` do not converge uniformly in residue and it is thus difficult to conclude a calculation its with a uniform time division unless taking very small steps of time what is sub-optimal.

4 Modeling B

4.1 Characteristics of modeling

20 elements POU_D_TGM

4.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 20 SEG2 (10 in each branch)

4.3 Characteristics of the grid of the transverse section

Many fibres: 100 (10 in each side)
Many meshs and types: 100 QUAD4

4.4 Sizes tested and results

4.4.1 Values tested

The values tested result from the table 3.3.1-a.

Effort (N)	DX (mm)	DZ (mm)	Tolerance/ DX	Tolerance/ DZ
1.0	1.9557493475982E-01	8.1849504440533E-01	2.0E-02	7.0E-02
1.2	2.2003159601578E+01	4.5085834614729E+01	6.0E-02	1.0E-02
1.4	5.1370721240215E+01	5.9127605459760E+01	2.2E-02	1.5E-02
1.6	7.2307885049332E+01	6.1008538728158E+01	2.0E-02	2.0E-02
2.0	9.9971229134146E+01	5.5985405418044E+01	1.0E-02	2.2E-02
3.0	1.3415730437940E+02	3.9186532467172E+01	1.0E-02	2.0E-02
4.0	1.5070726872507E+02	2.7659987903886E+01	1.0E-02	1.0e-02
5.0	1.6092765462757E+02	2.0199252710901E+01	1.0E-02	0.5E-02

One uses a technique length of arc to obtain the answer of the structure, the moments of calculation cannot thus be directly imposed. However one endeavours to choose the values of the state of piloting closest to the moments of reference.

4.4.2 Graphic results of modeling B

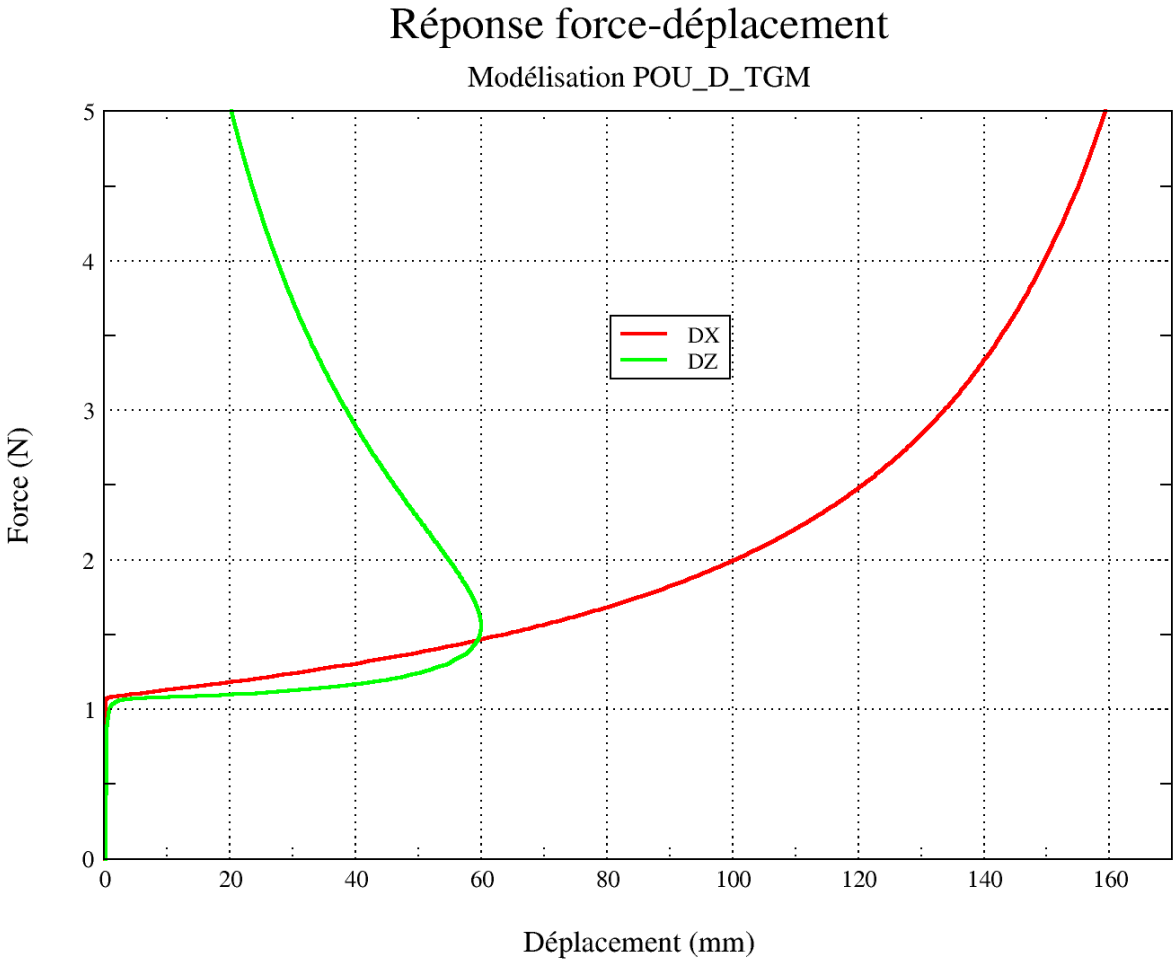


Figure 4.4.2-a : Answer Force-displacement, modeling POU_D_TGM.

4.4.3 Remarks

The relative variations with the results of modeling A taken as reference are in the rather weak whole in spite of a variation of 7.0% in DZ at the moment 1.0 and of 6.0% in DX at the moment 1.2. It is noticed that the differences decrease in the course of time and are finally weak at the moment 5.0. Kinematics 'GROT_GDEP' element POU_D_TGM is thus very satisfactory.

5 Modeling C

5.1 Characteristics of modeling

20 elements POU_D_TG

5.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 20 SEG2 (10 in each branch)

5.3 Characteristics of the grid of the transverse section

Many fibres: 100 (10 in each side)
Many meshs and types: 100 QUAD4

5.4 Sizes tested and results

5.4.1 Values tested

The values tested are those of the table 3.3.1-a.

Effort (N)	DX (mm)	DZ (mm)	Tolerance/ DX	Tolerance/ DZ
1.0	1.9557493475982E-01	8.1849504440533E-01	6.0E-03	1.6E-03
1.2	2.2003159601578E+01	4.5085834614729E+01	2.5E-03	2.0E-02
1.4	5.1370721240215E+01	5.9127605459760E+01	1.7E-03	2.0E-02
1.6	7.2307885049332E+01	6.1008538728158E+01	2.5E-04	2.0E-02
2.0	9.9971229134146E+01	5.5985405418044E+01	4.0E-03	2.0E-02
3.0	1.3415730437940E+02	3.9186532467172E+01	1.0E-02	5.1E-03
4.0	1.5070726872507E+02	2.7659987903886E+01	1.5E-02	8.0E-03
5.0	1.6092765462757E+02	2.0199252710901E+01	1.5E-02	2.0E-02

One uses a technique length of arc to obtain the answer of the structure, the moments of calculation cannot thus be directly imposed. However one endeavours to choose the values of the state of piloting closest to the moments of reference.

5.4.2 Graphic results of modeling C

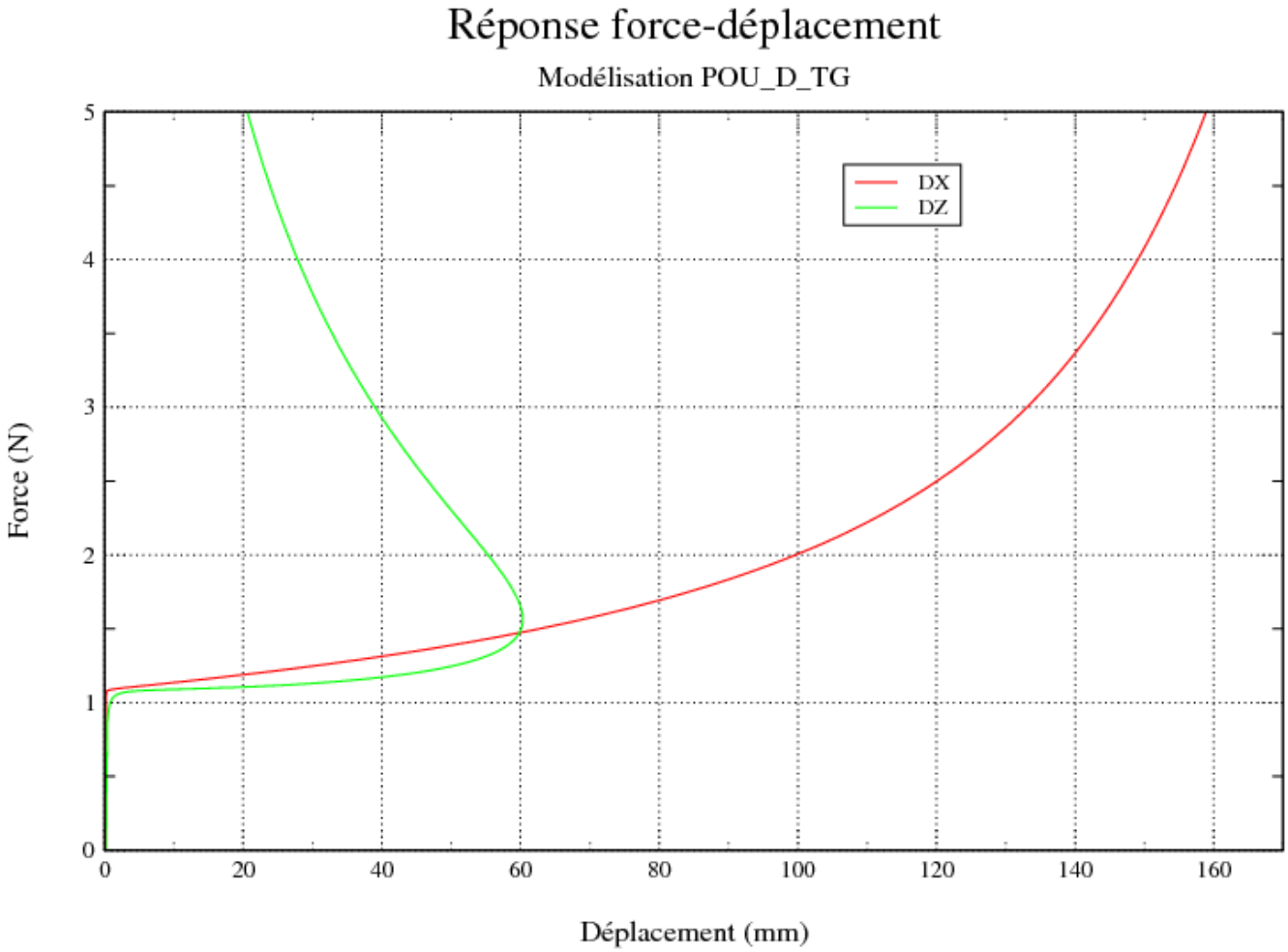


Figure 5.4.2-a : Answer Force-displacement, modeling POU_D_TG .

5.4.3 Remarks

The relative variations with the results of modeling A taken as reference are weak. One does not notice contrary to modeling POU_D_TGM of reduction in the variation in the course of time. Kinematics 'GROT_GDEP' element POU_D_TG is very satisfactory.

6 Modeling D

6.1 Characteristics of modeling

20 elements POU_D_T

6.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 20 SEG2 (10 in each branch)

6.3 Characteristics of the grid of the transverse section

Many fibres: 100 (10 in each side)
Many meshs and types: 100 QUAD4

6.4 Sizes tested and results

6.4.1 Values tested

The values tested result from the table 3.3.1-a.

Effort (N)	DX (mm)	DZ (mm)	Tolerance/ DX	Tolerance/ DZ
1.0	1.9557493475982E-01	8.1849504440533E-01	1.0E-02	1.5E-02
1.2	2.2003159601578E+01	4.5085834614729E+01	3.0E-02	0.2E-02
1.4	5.1370721240215E+01	5.9127605459760E+01	2.0E-02	2.0E-02
1.6	7.2307885049332E+01	6.1008538728158E+01	2.0E-02	2.0E-02
2.0	9.9971229134146E+01	5.5985405418044E+01	0.5E-02	2.2E-02
3.0	1.3415730437940E+02	3.9186532467172E+01	0.5E-02	2.0E-02
4.0	1.5070726872507E+02	2.7659987903886E+01	1.0E-02	1.4E-02
5.0	1.6092765462757E+02	2.0199252710901E+01	1.0E-02	1.0E-02

One uses a technique length of arc to obtain the answer of the structure, the moments of calculation cannot thus be directly imposed. However one endeavours to choose the values of the state of piloting closest to the moments of reference.

6.4.2 Graphic results of modeling D

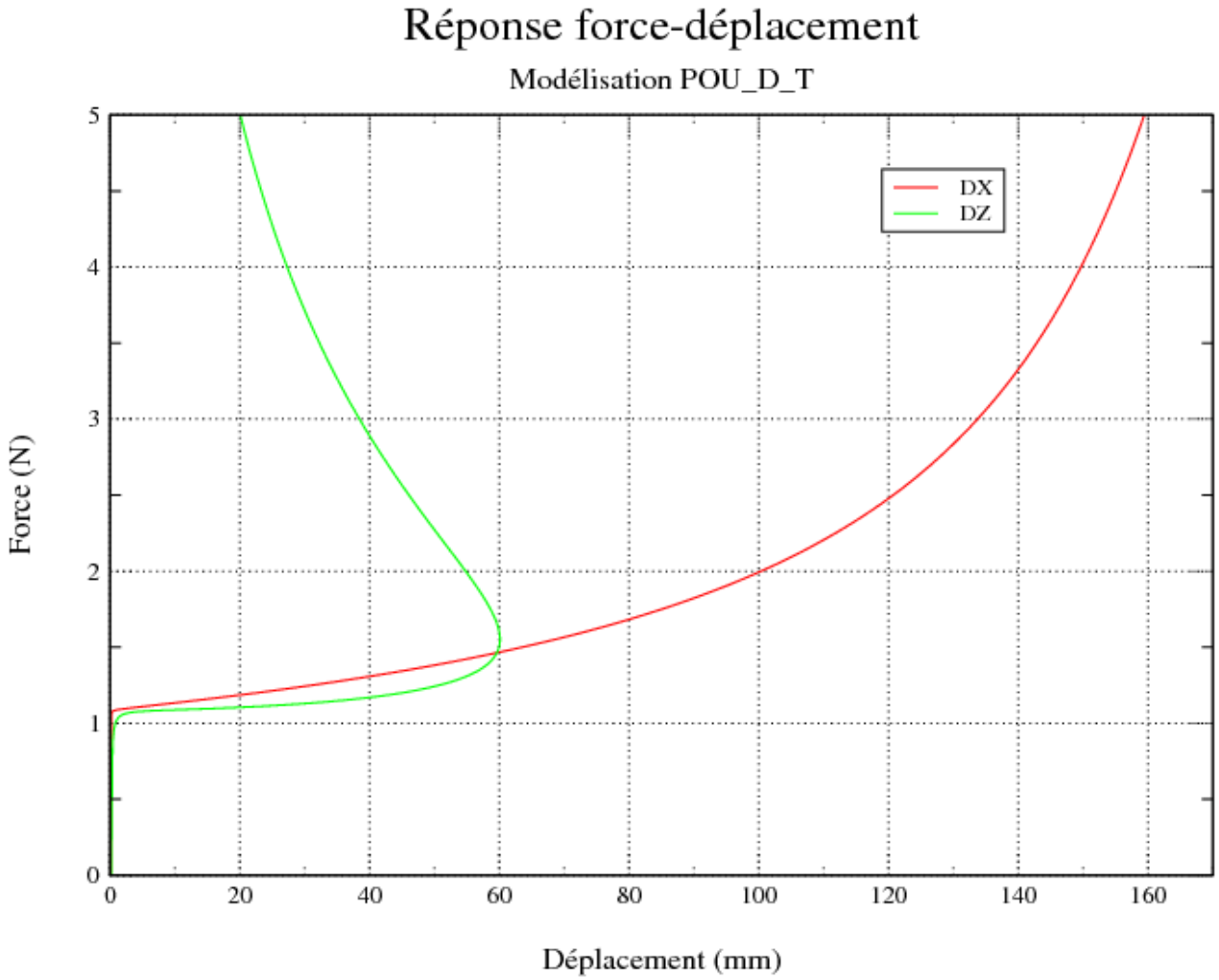


Figure 6.4.2-a : Answer Force-displacement, modeling POU_D_T.

6.4.3 Remarks

The relative variations with the results of modeling A taken as reference are weak. One does not notice contrary to modeling POU_D_TGM of reduction in the variation in the course of time. Kinematics 'GROT_GDEP' element POU_D_T is thus very satisfactory.

7 Modeling E

7.1 Characteristics of modeling

20 elements POU_D_E

7.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 20 SEG2 (10 in each branch)

7.3 Characteristics of the grid of the transverse section

Many fibres: 100 (10 in each side)
Many meshs and types: 100 QUAD4

7.4 Sizes tested and results

7.4.1 Values tested

The values tested result from the table 3.3.1-a.

Effort (N)	DX (mm)	DZ (mm)	Tolerance/ DX	Tolerance/ DZ
1.0	1.9557493475982E-01	8.1849504440533E-01	4.0E-03	1.2E-02
1.2	2.2003159601578E+01	4.5085834614729E+01	2.3E-02	1.0E-02
1.4	5.1370721240215E+01	5.9127605459760E+01	2.0E-02	1.5E-02
1.6	7.2307885049332E+01	6.1008538728158E+01	1.5E-02	1.5E-02
2.0	9.9971229134146E+01	5.5985405418044E+01	7.0E-03	2.0E-02
3.0	1.3415730437940E+02	3.9186532467172E+01	2.0E-03	1.7E-02
4.0	1.5070726872507E+02	2.7659987903886E+01	5.5E-03	1.0E-02
5.0	1.6092765462757E+02	2.0199252710901E+01	1.0E-02	1.0E-03

One uses a technique length of arc to obtain the answer of the structure, the moments of calculation cannot thus be directly imposed. However one endeavours to choose the values of the state of piloting closest to the moments of reference.

7.4.2 Graphic results of modeling E

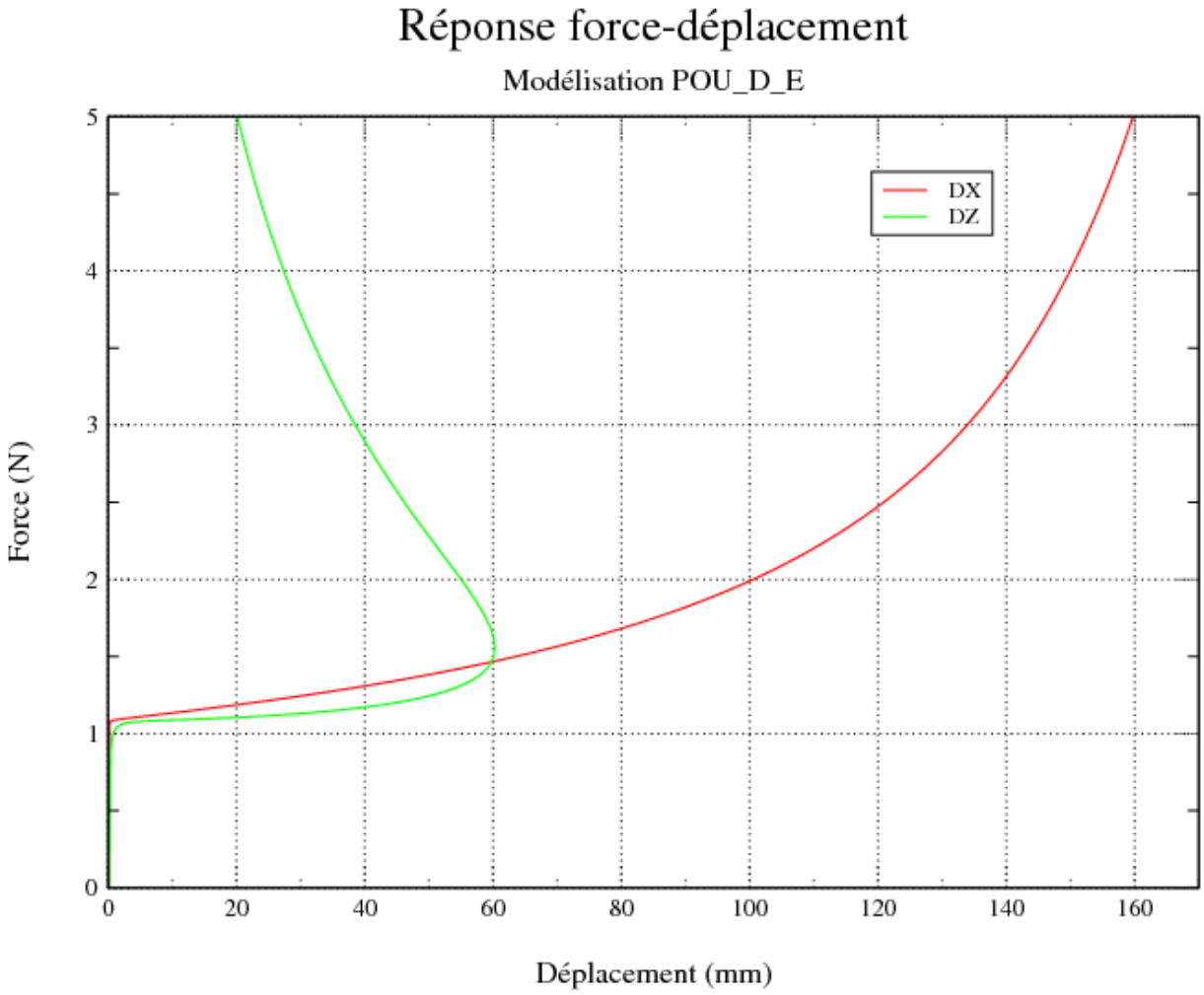


Figure 7.4.2-a : Answer Force-displacement, modeling POU_D_E.

7.4.3 Remarks

The relative variations with the results of modeling A taken as reference are weak. One does not notice contrary to modeling POU_D_TGM of reduction in the variation in the course of time. Kinematics 'GROT_GDEP' element POU_D_E is thus very satisfactory.

8 Modeling F

8.1 Characteristics of modeling

20 elements POU_D_EM

8.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 20 SEG2 (10 in each branch)

8.3 Characteristics of the grid of the transverse section

Many fibres: 100 (10 in each side)
Many meshs and types: 100 QUAD4

8.4 Sizes tested and results

8.4.1 Values tested

The values tested result from the table 3.3.1-a.

Effort (N)	DX (mm)	DZ (mm)	Tolerance/ DX	Tolerance/ DZ
1.0	1.9557493475982E-01	8.1849504440533E-01	2.0E-02	9.0E-02
1.2	2.2003159601578E+01	4.5085834614729E+01	6.0E-02	1.1E-02
1.4	5.1370721240215E+01	5.9127605459760E+01	2.0E-02	2.5E-02
1.6	7.2307885049332E+01	6.1008538728158E+01	6.5E-03	2.5E-03
2.0	9.9971229134146E+01	5.5985405418044E+01	5.5E-03	5.5E-03
3.0	1.3415730437940E+02	3.9186532467172E+01	1.6E-02	1.6E-02
4.0	1.5070726872507E+02	2.7659987903886E+01	2.0E-02	3.0e-02
5.0	1.6092765462757E+02	2.0199252710901E+01	2.0E-02	3.5E-02

One uses a technique length of arc to obtain the answer of the structure, the moments of calculation cannot thus be directly imposed. However one endeavours to choose the values of the state of piloting closest to the moments of reference.

8.4.2 Graphic results of modeling F

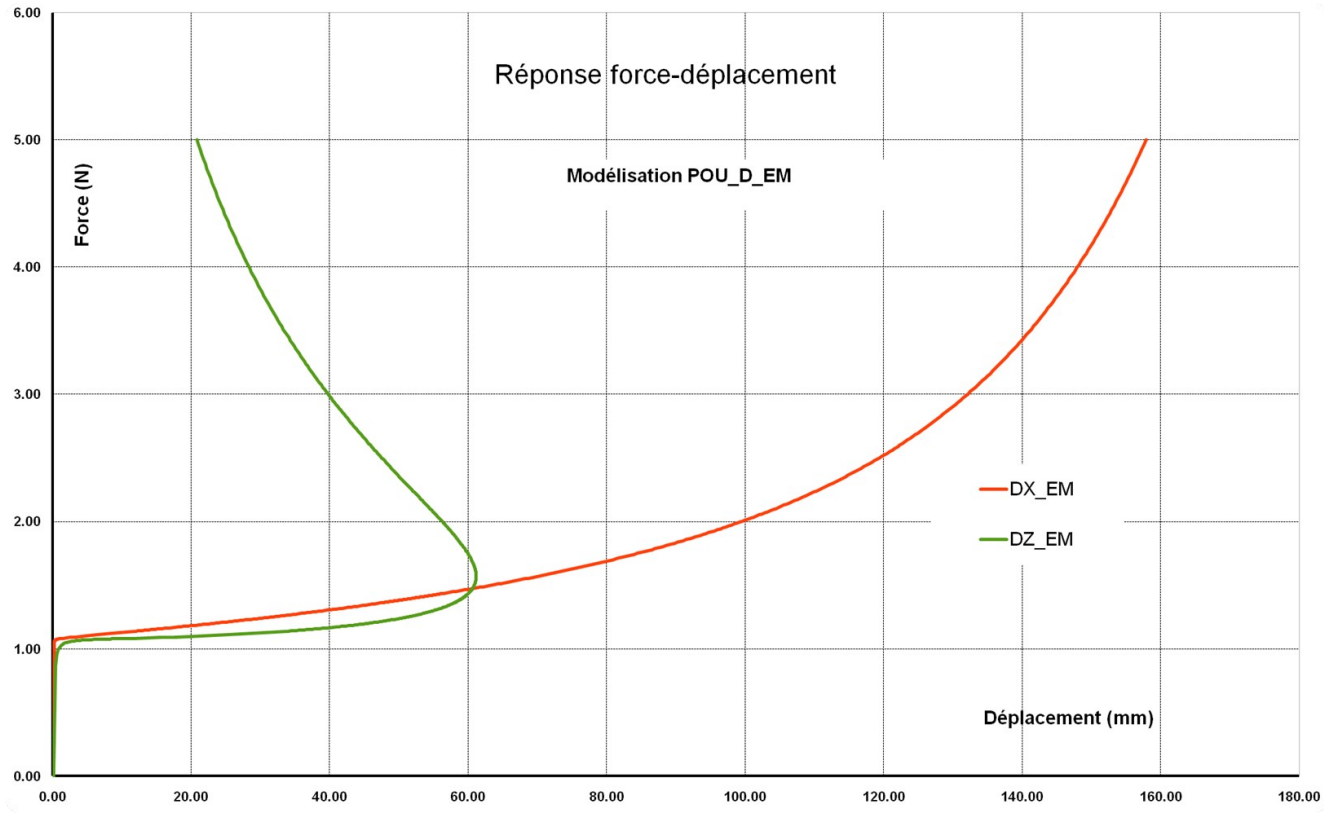


Figure 8.4.2-a : Answer Force-displacement, modeling POU_D_EM .

8.4.3 Remarks

The relative variations with the results of modeling A taken as reference are in the rather weak whole in spite of a variation of 9.0% in DZ at the moment 1.0 and of 6.0% in DX at the moment 1.2 . It is noticed then that the differences decrease up to values about 0.5% then goes up for the values of effort 3.0 , 4.0 and 5.0 until a maximum of 3.5% . Kinematics 'GROT_GDEP' element POU_D_EM is thus satisfactory.

9 Analysis of the results

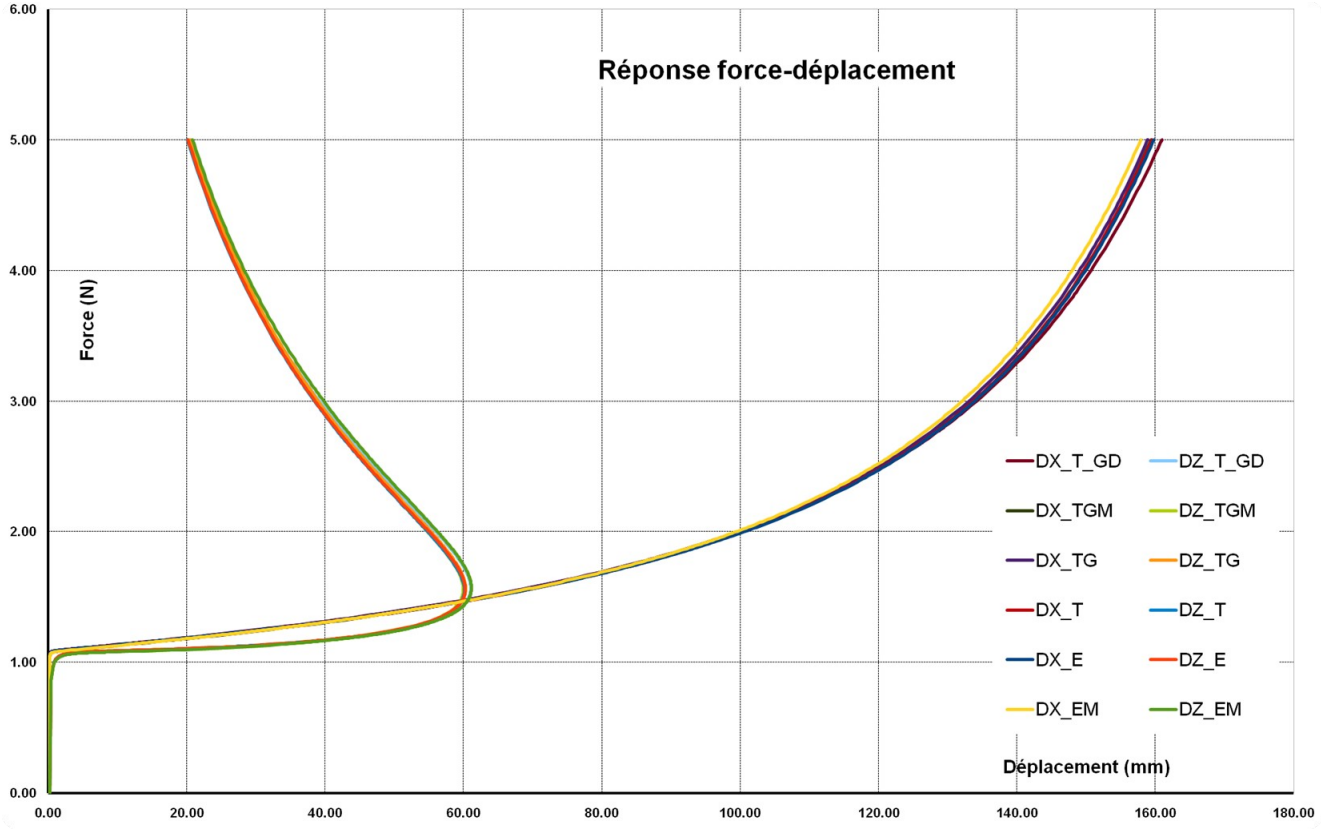


Figure 9-a : Answer Force-displacement, comparison of modelings.

The figure 9-a present the curved force-displacement obtained with various modelings.
One observes an excellent correlation of the results between various modelings.