SSNP140 - Tensile test on an elastoplastic level perforated by the method IMPLEX

Summary:

This case test is used to validate the implementation of the method of resolution IMPLEX. The case studied test is a tensile test of a perforated plane test-tube. The solution obtained with the method IMPLEX is very close to that obtained with the method of Newton-Raphson.

1 Problème of reference

1.1 Geometry

The geometry of the case studied test consists of a rectangular plate with a hole in its center subjected to a traction.
For reasons obvious of symmetry, only a quarter of the plate is studied.

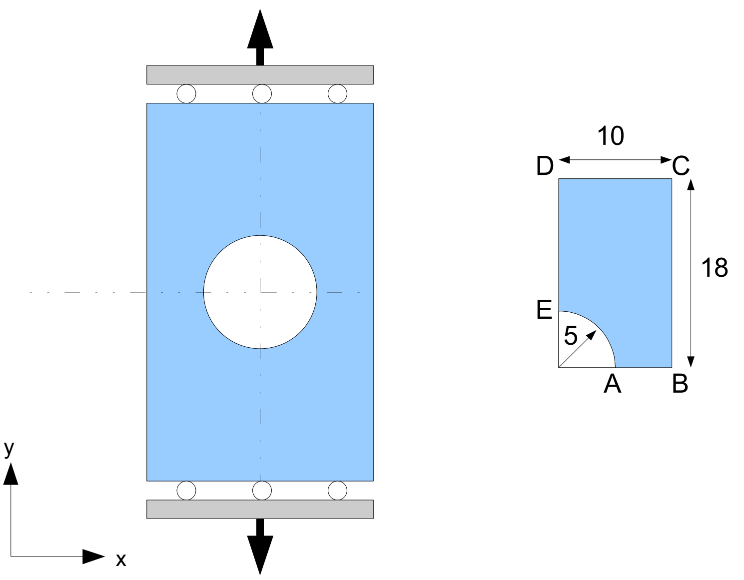

Figure 1.1-a: Studied problem

1.2 Properties of material

The objective being to test the various laws of behavior, various modelings use different laws of behavior.
In the case of modelings A , B and E , the material which constitutes the plate is modelled by an elastoplastic law of behavior. The criterion of plasticity is that of von Mises and a linear isotropic work hardening is considered (`VMIS_ISOT_LINE`). The values of the various parameters are summarized in the table which follows.

Parameters	Symbol	Values
Young modulus	E	$70\,MPa$
Coeff. of Fish	ν	$0{,}2$
Yield stress	σ_y	$0{,}24\,MPa$
Slope of work hardening	H	$2{,}24\,MPa$

Table 1.2-1: Parameters materials for modelings A, B and E

In the case of modeling C , the plate is élasto-endommagable fragile (`ENDO_FRAGILE`). The values of the various parameters are summarized in the table which follows.

Parameters	Symbol	Values
Young modulus	E	$20000\,MPa$
Coeff. of Fish	ν	0
Yield stress	σ_y	$2\,MPa$
Slope of work hardening	H	$-2000\,MPa$

Table 1.2-2: Parameters materials for modelings C

In the case of modeling D, the plate is out of fragile concrete (ENDO_ISOT_BETON). The values of the various parameters are summarized in the table which follows.

Parameters	Symbol	Values
Young modulus	E	$20000\,MPa$
Coeff. of Fish	ν	0
Yield stress	σ_y	$2\,MPa$
Slope of work hardening	H	$-2000\,MPa$

Table 1.2-3: Parameters materials for modelings D

1.3 Boundary conditions and loadings

They are identical for 5 modelings.
In order to recreate the conditions of symmetry, displacements are blocked:

- according to y on AB,
- according to x on DE.

The loading is defined by imposing a displacement of $0,3\,mm$ along the axis y at the border DC.

1.4 Initial conditions

At the moment 0, the system is with balance and does not undergo any prestressing.

2 Reference solutions

2.1 Method of calculating

The reference solution is calculated with Code_Aster by using the “classical” algorithm of Newton-Raphson.

2.2 Sizes and results of reference

The result of reference is the curve of force-displacement obtained with the iterative method of Newton-Raphson. One compares the values of the forces at various levels of loading.

2.3 Uncertainty on the solution

Comparison between two solutions obtained and Code_Aster. Method `IMPLEX` being by approached definition, there will be a variation with the solution Newton (but which must remain weak).

2.4 Bibliographical references

1. J. OLIVER, A.E. HUESPE and J.C. LAY “Year implicit/explicit design to increase computability of non-linear material and contact/friction problems”, Methods Computer in Applied Mechanics and Engineering, vol. 197.2008.

3 Modeling A

This modeling tests the triangular elements with VMIS_ISOT_LINE. The loading in the elastic zone is done in several steps of time in order to test the convergence of method IMPLEX in only one iteration.

3.1 Characteristics of modeling

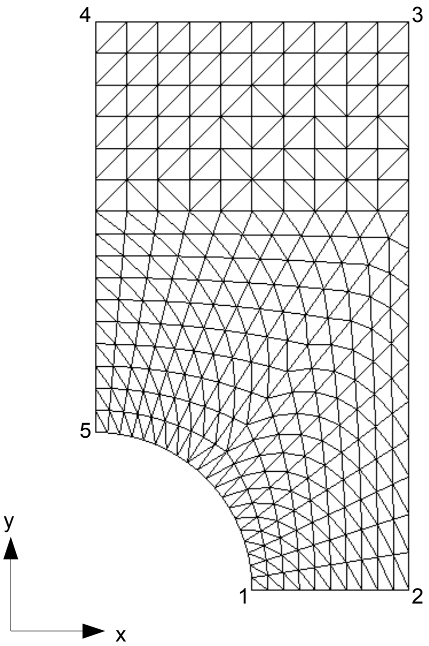

Figure 3.1-a: Grid of modeling A

Modeling: D_PLAN

Boundary conditions:

- $DX=0.0\,mm$ on 45 ,
- $DY=0.0\,mm$ on 12 ,
- $DY=0.3\,mm$ on 34 .

3.2 Characteristics of the grid

The number of nodes is of 297. The grid consists of linear triangular elements:

- SEG2 : 92
- TRIA3 : 520

3.3 Sizes tested and results

Figure 3.4-1 represents the curved force-displacement calculated with the two methods. The values tested are differences in effort between the two methods at various moments.

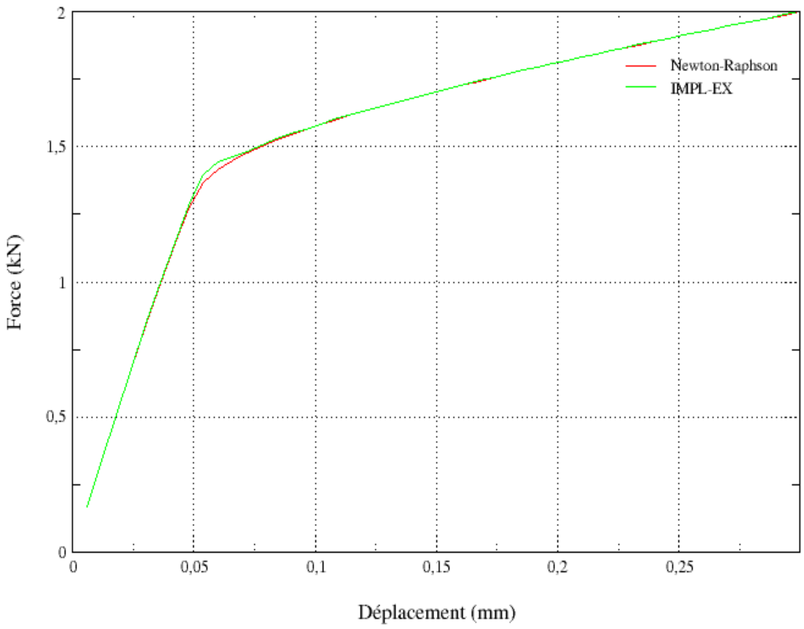

Figure 3.3-a: Curved force-displacement

Moment (S)	Variation enters the two curves (kN)
0,04	0
0,08	-5,65E-004
0,12	-5,00E-003
0,16	-8,95E-003
0,2	-2,94E-002
0,32	-1,26E-003
0,4	-5,63E-004
0,6	-1,60E-004
0,8	-9,43E-005
1	-8,69E-005

These values are tested in nonregression.

A criterion of least square between the two curves is also used. Its value is of: $0{,}0824$.

4 Modeling B

This modeling test quadratic elements with the law of behavior `VMIS_ISOT_LINE`.

4.1 Characteristics of modeling

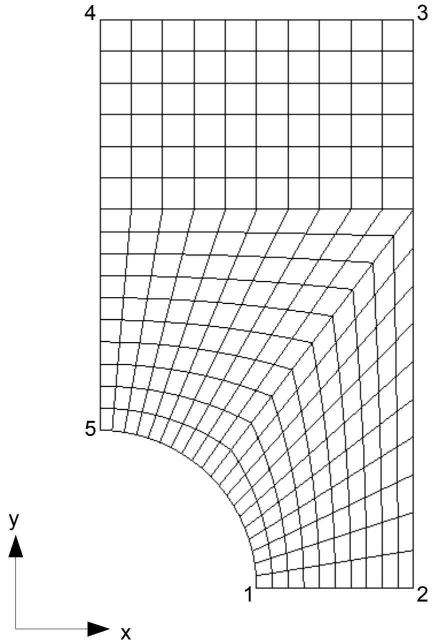

Figure 4.1-a: Grid of modeling B

Modeling: `D_PLAN`

Boundary conditions:

- $DX=0.0\,mm$ on 45 ,
- $DY=0.0\,mm$ on 12 ,
- $DY=0.3\,mm$ on 34 .

4.2 Characteristics of the grid

The number of nodes is of 297. The grid consists of linear quadrangular elements:
- `SEG2` : 92
- `QUAD4` : 260

4.3 Sizes tested and results

Figure 4.4-1 represents the curved force-displacement calculated with the two methods. The values tested are differences in effort between the two methods at various moments.

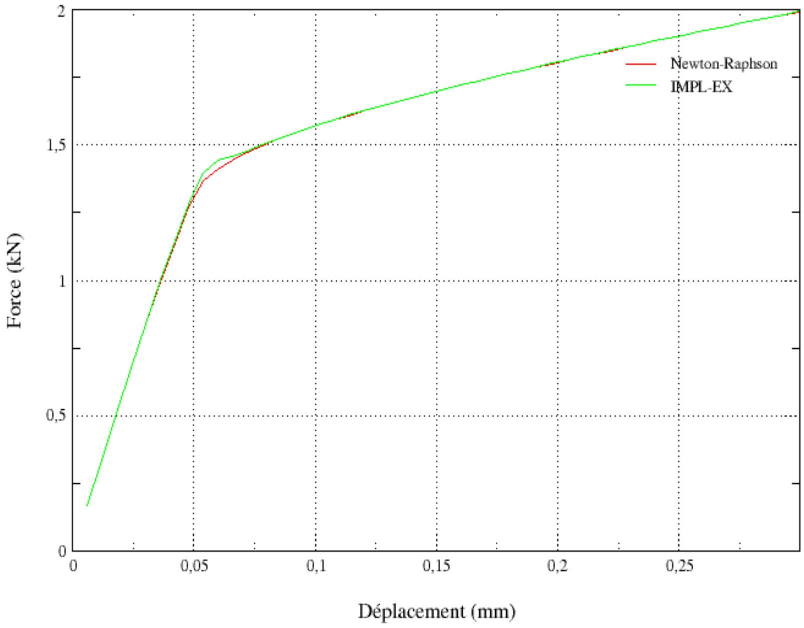

Figure 4.3-a: Curved force-displacement

Moment (S)	Variation enters the two curves (kN)
0,04	1,66E-016
0,08	-3,32E-005
0,12	-6,75E-003
0,16	-1,22E-002
0,2	-3,40E-003
0,32	-1,58E-003
0,4	-5,70E-004
0,6	-2,47E-004
0,8	-1,43E-004
1	-1,21E-004

These values are tested in nonregression.

A criterion of least square between the two curves is also used. Its value is of: 0,0949E-001 .

5 Modeling C

This modeling tests the triangular elements with ENDO_FRAGILE

5.1 Characteristics of modeling and grids

The characteristics of this modeling are identical to those used for modeling A .

5.2 Sizes tested and results

Moment (S)	Variation enters the two curves (kN)
0,04	0,00E+00
0,08	0,00E+00
0,12	0,00E+00
0,16	0,00E+00
0,2	0,00E+00
0,32	0,00E+00
0,4	0,00E+00
0,6	-2,20E-16
0,8	3,30E-16
1	4,20E-05

These values are tested in nonregression.

6 Modeling D

This modeling tests the triangular elements with ENDO_ISOT_BETON

6.1 Characteristics of modeling and grids

The characteristics of this modeling are identical to those used for modeling A .

6.2 Sizes tested and results

Moment (S)	Variation enters the two curves (kN)
0,04	3,60E-15
0,08	3,10E-15
0,12	7,10E-15
0,16	2,20E-15
0,2	1,11E-14
0,32	5,00E-01
0,4	3,50E+00
0,6	5,70E-01
0,8	6,30E-01
1	6,60E-01

These values are tested in nonregression.

7 Modeling E

This modeling tests the triangular elements with VMIS_ISOT_LINE and tests moreover the automatic method of management of the step of time.

7.1 Characteristics of modeling and grids

The characteristics of this modeling are identical to those used for modeling A .

7.2 Sizes tested and results

Moment (S)	Variation enters the two curves (kN)
0,12	2,50E-04
0,32	6,68E+00
0,6	1,77E+00
1	1,14E+00

These values are tested in nonregression.

8 Summary of the results

Results of simulations with the method IMPLEX are very close to those obtained with the method of Newton-Raphson, the 4 laws of behavior and the automatic method of management of the step of time. As indicated in [1], the only difference observed is the appearance of an excess stress during initiation of plasticity. This phenomenon disappears at the time of refinement of the temporal discretization.