SSNP140 - Traction test on an elastoplastic level perforated by Summarized method

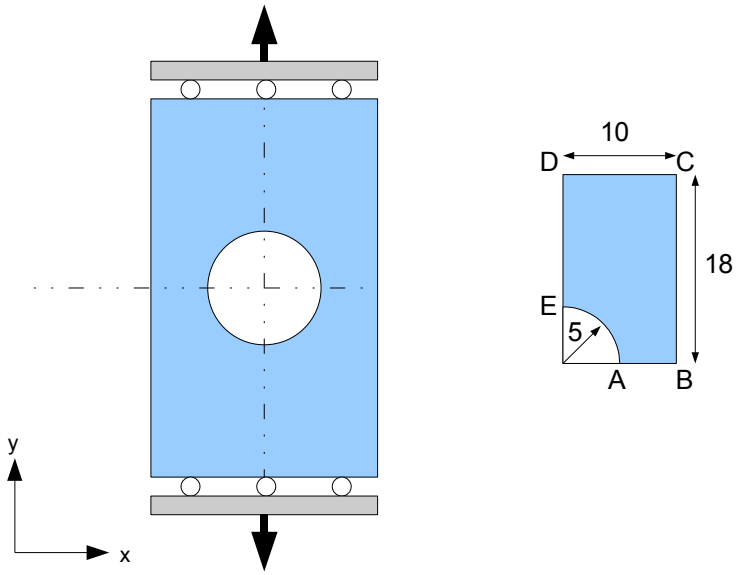
IMPLEX:

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

1 Problem of reference

1.1 Geometry

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



Appear 1.1-a: Problem studied

1.2 Properties of the material

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

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

Table 1.2-1: Materials parameters for the modelizations A, B and E

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

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

Table 1.2-2: Materials parameters for the modelizations C

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

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

Table 1.2-3: Materials parameters for the modelizations D

1.3 Boundary conditions and loadings

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

suivantsur y AB ,
suivantsur x DE .

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

1.4 Initial conditions

At time 0 , the system is with the equilibrium and does not undergo any prestressing.

2 Reference solutions

2.1 Method of calculating

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

2.2 Quantities and results of reference

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, one will have a variation with the solution Newton (but which must remain weak).

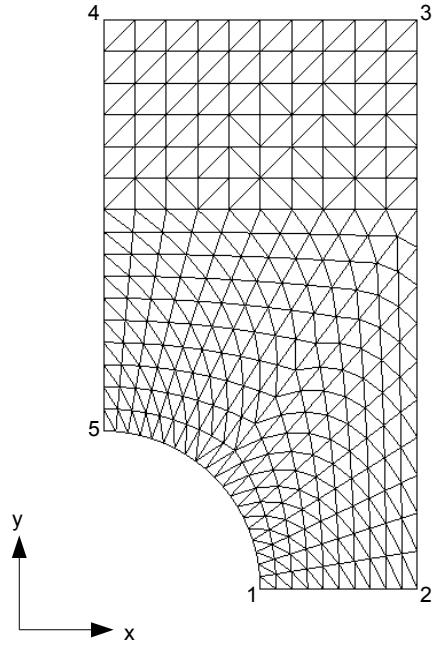
2.4 Bibliographical references

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 Modelization A

This modelization tests the triangular elements with VMIS_ISOT_LINE.

3.1 Characteristics of the modelization



Appears 3.1-a: Mesh of the modelization A

Modelization: D_PLAN

Boundary conditions:

$$DX = 0.0\,mm \quad \text{on} \quad 45 \;,$$
$$DY = 0.0\,mm \quad \text{on} \quad 12 \;,$$
$$DY = 0.3\,mm \quad \text{on} \quad 34 \;.$$

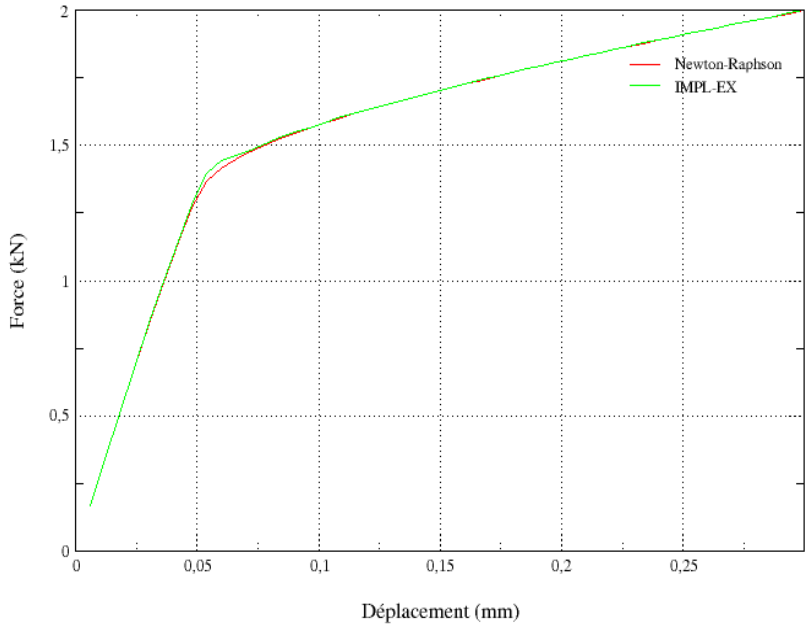
3.2 Characteristics of the mesh

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

SEG2 : 92
TRIA3 : 520

3.3 Quantities tested and results

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



Appear 3.3-a: Curved force-displacement

Time (S)	Difference between 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

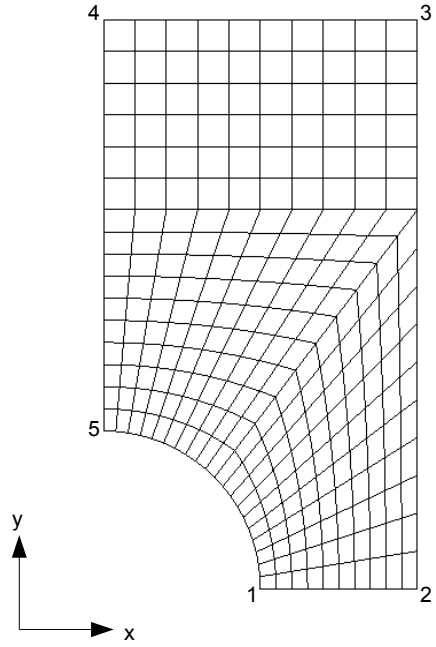
These values are tested into non regression.

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

4 Modelization B

This modelization test quadratic elements with constitutive law VMIS_ISOT_LINE.

4.1 Characteristics of the modelization



Appears 4.1-a: Mesh of the modelization B

Modelization: D_PLAN

Boundary conditions:

$$DX = 0.0\,mm \quad \text{on} \quad 45 \;,$$
$$DY = 0.0\,mm \quad \text{on} \quad 12 \;,$$
$$DY = 0.3\,mm \quad \text{on} \quad 34 \;.$$

4.2 Characteristics of the mesh

the number of nodes is of 297. The mesh consists of linear quadrangular elements:

SEG2 : 92
QUAD4 : 260

4.3 Quantities tested and results

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

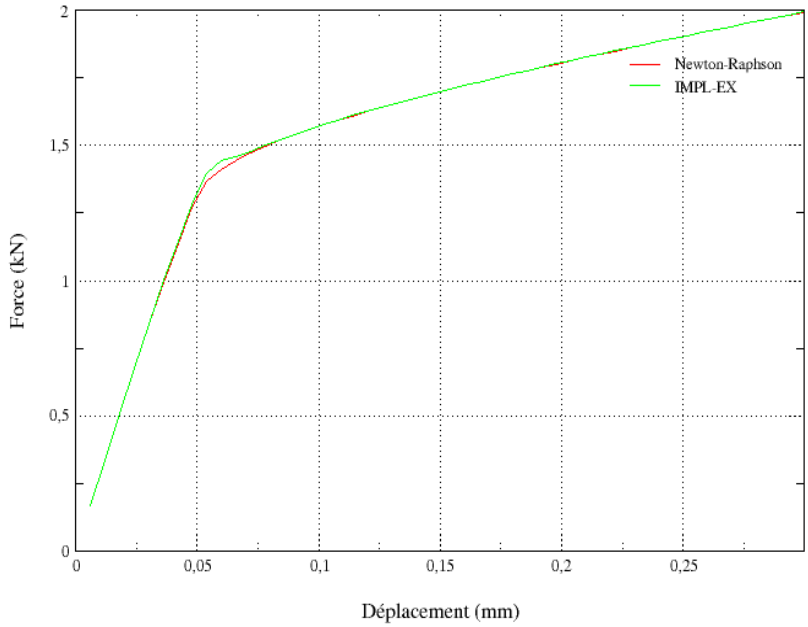


Figure 4.3-a : 4.3-a Curved force-displacement

Time (S)	Difference between 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 into non regression.

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

5 Modelization C

This modelization tests the triangular elements with ENDO_FRAGILE

5.1 Characteristics of the modelization and meshes

the characteristics of this modelization are identical to those used for the modelization A .

5.2 Quantities tested and results

Time (S)	Difference between 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 into non regression.

6 Modelization D

This modelization tests the triangular elements with ENDO_ISOT_BETON

6.1 Characteristics of the modelization and meshes

the characteristics of this modelization are identical to those used for the modelization A .

6.2 Quantities tested and results

Time (S)	Difference between 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 into non regression.

7 Modelization E

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

7.1 Characteristics of the modelization and meshes

the characteristics of this modelization are identical to those used for the modelization A .

7.2 Quantities tested and results

Time (S)	Difference between 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 into non regression.

8 Summary of the results

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