SSNP102 - Rate of refund of energy for a plate notched in elastoplasticity: approach GTP

Summary:

This test makes it possible to validate the calculation of the rate of refund of energy G for a plastic problem élasto - in plane deformations by the approach G_{TP} [R7.02.07].

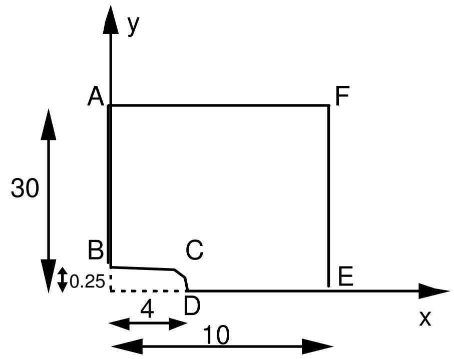
This test contains a modeling in plane deformations and the results are compared with digital values obtained by WATANABE by another method of calculating of G in élasto - plasticity. The variations are considered to be satisfactory.

Caution:

The defect is modelled by a notch and not by a crack like usually in breaking process (cf [R7.02.07]).

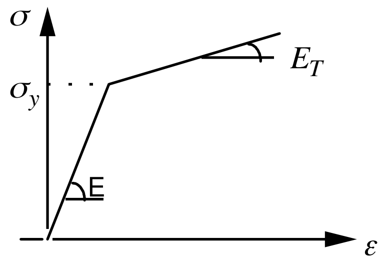
1 Problem of reference

1.1 Geometry



1.2 Material properties

The law of behavior of material constituting the notched plate is the law `'VMIS_ISOT_TRAC'`. The traction diagram is selected such as the law of behavior thus defined corresponds to a law of Von Mises with isotropic linear work hardening, whose characteristics are given to the figure below.



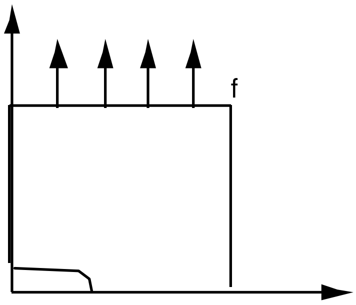
E = 205800 MPa
ν = 0.3
σ_y = 480.2 MPa
E_T = 20.58 MPa

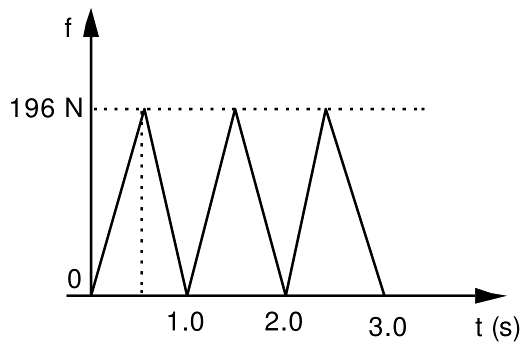
1.3 Boundary conditions and loadings

The plate is blocked:

- according to Ox along the side AB
- according to Oy along the side DE

It is subjected to a cyclic traction on the side AF .





2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is resulting from an article of WATANABE [bib1]. To calculate the rate of refund of energy in elastoplasticity WATANABE uses an integral ε_J who is detailed in [bib1] and [bib2].

The reference solution is digital:

$t(s)$	0.	0.5	1.0	1.5	2.0	2.5	3.0
G	0.	2,769	3,183	4,276	4,651	5,691	6,052

It should be noted that:

- the theoretical method used in the reference is different from the method established in *Code_Aster*,
- the geometry of the test and the reference are identical, but the grid of the test *Aster* is refined more than that of the reference.

2.2 Bibliographical references

1) K. WATANABE: Of application ε_J - integral to elasto-plastic Ace, Bulletion of JSME, vol. 28, n°242, August 1985

2) G. DEBRUYNE: Proposal for an energy parameter of ductile rupture in thermo - plasticity HI-74/95/027/0

3 Modeling A

The plate is modelled by 243 TRIA6 and 39 SEG3.

3.1 Characteristics of the grid

Many nodes: 527

Many meshs and types: 243 TRIA6

3.2 Values tested

Identification	Reference	*Aster*	% difference	Tolerance
$t=0.5\,s$				
$G(couronne\,A)$	2,769	2,863	3.39	3.5
$G(couronne\,B)$	2,769	2,860	3.29	3.5
$G(couronne\,C)$	2,769	2,859	3.27	3.5
$G(couronne\,D)$	2,769	2,858	3.25	3.5
$t=1.0\,s$				
$G(A)$	3,183	3,208	0.81	1.0
$G(B)$	3,183	3,212	0.93	1.0
$G(C)$	3,183	3,212	0.93	1.0
$G(D)$	3,183	3,212	0.93	1.0
$t=1.5\,s$				
$G(A)$	4.2760	4,204	1.66	2.0
$G(B)$	4.2760	4,201	1.75	2.0
$G(C)$	4.2760	4,199	1.78	2.0
$G(D)$	4.2760	4,199	1.80	2.0
$t=2.0\,s$				
$G(A)$	4.6510	4,640	0.22	1.0
$G(B)$	4.6510	4,645	0.13	1.0
$G(C)$	4.6510	4,645	0.13	1.0
$G(D)$	4.6510	4,645	0.13	1.0
$t=2.5\,s$				
$G(A)$	5,691	5,570	2.12	3.0
$G(B)$	5,691	5,565	2.20	3.0
$G(C)$	5,691	5,564	2.22	3.0
$G(D)$	5,691	5,563	2.25	3.0
$t=3.0\,s$				
$G(A)$	6,052	6,048	0.06	1.0
$G(B)$	6,052	6,052	0.01	1.0
$G(C)$	6,052	6,052	0.01	1.0
$G(D)$	6,052	6,052	0.01	1.0

One also tests the calculation of total energy for a behavior, modelled either by VMIS_ISOT_TRAC (which is used as value of reference), that is to say by VMSI_ECMI_TRAC with a worthless constant of Prager.

Identification	Reference	*Aster*	% difference	Tolerance
E_{tot} with $t=0{,}1\,s$	1,12	1,12	0	0,1
E_{tot} with $t=0{,}9\,s$	1,36	1,36	0,31	0,5

E_{tot} with $t=2{,}0\,s$	0,27	0,26	2,2	2,5
E_{tot} with $t=3{,}0\,s$	0,3	0,29	2,4	2,5

3.3 Remarks

	A	B	C	D
R_{inf}	0.55	1.0	1.5	2.0
R_{sup}	1.0	1.5	2.0	3.0

4 Modeling B

It is a modeling 3D of the problem.

4.1 Characteristics of the grid

The grid is obtained by extrusion of $0,25$ grid of modeling A.

Many nodes: 2402

Many meshs and types: 502 PENTA15

4.2 Values tested

One tests the same values exactly as those of modeling A, at the same moments
The reference solution 2D must be multiplied by the thickness of the plate, that is to say $0,25$.
Results on G_{glob} are identical.

5 Summary of the results

The comparison of the results resulting from the test Aster and those obtained numerically by another method by WATANABE are satisfactory (the maximum change is of 3.4%).

It should be noted that the digital results are sensitive to the grid in the vicinity of the notch and the shape of this notch. In particular if a crack is modelled the values obtained are false. On the other hand, starting from a sufficient smoothness of the grid and ray of the notch, the digital results are stable. For more information, it is advised to consult the bibliographical document [R7.02.07] and references.