SSNP102 - Rate of energy restitution for a plate notched in elastoplasticity: approaches Summarized

GTP:

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

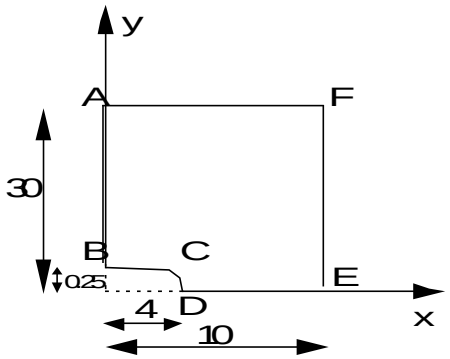
This test contains a modelization in plane strains and the results are compared with numerical values obtained by WATANABE by another method of calculating of G in élasto - plasticity. The variations are considered to be satisfactory.

Caution:

The default is modelled by a notch and not by a crack like usually in fracture mechanics (cf [R7.02.07]).

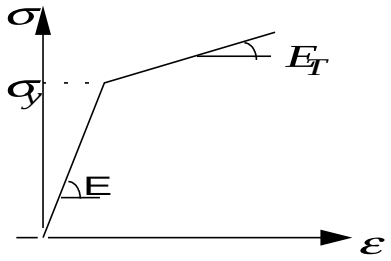
1 Problem of reference

1.1 Geometry



1.2 Material properties

the constitutive law of the material constituting the notched plate is a model of plasticity with criterion of von Mises and isotropic linear hardening. It is described in command DEFI_MATERIAU [U4.23.01].



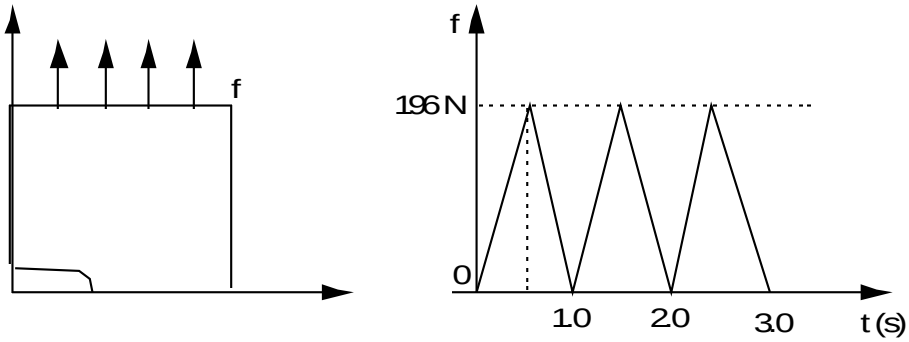
E=205800MPa
ν=0.3
σ_y=480.2MPa
E_T=2058MPa

1.3 Boundary conditions and loadings

the plate is blocked:

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

It is subjected to a cyclic tension 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 compute: rate of energy restitution in elastoplasticity WATANABE uses an integral ε_J which is detailed in [bib1] and [bib2].

The reference solution is numerical:

$t(s)$	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 of the reference are identical, but the mesh 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 ductility fracture in thermo - plasticity HI-74/95/027/0

3 Modelization With

the plate is modelled by 243 TRIA6 and 39 SEG3.

3.1 Characteristics of the mesh

Many nodes: 527

Number of meshes and types: 243 TRIA6

3.2 Functionalities tested

Commands

DEFI_MATERIAU	TENSION	SIGM	
STAT_NON_LINE	COMP_INCR	RELATION	VMIS_ISOT_TRAC
CALC_THETA	THETA_2D		
CALC_G	COMP_INCR	RELATION	VMIS_ISOT_TRAC
STAT_NON_LINE	COMP_INCR	RELATION	VMIS_ECMI_TRAC
POST_ELEM			

4 Results of the modelization A

4.1 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 computation of total energy for a behavior, modelled either by `VMIS_ISOT_TRAC` (which is used as value of reference), or by `VMSI_ECMI_TRAC` with a constant of Prager null.

Identification	Reference	*Aster*	% difference	Tolerance
E_{tot} to $t=0,1\,s$	1.12	1.12	0	0.1
E_{tot} to $t=0,9\,s$	1.36	1.36	0.31	0.5
E_{tot} to $t=2,0\,s$	0.27	0.26	2.2	2.5
E_{tot} to $t=3,0\,s$	0.3	0.29	2.4	2.5

4.2 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

5 Modelization B

It is a modelization 3D problem.

5.1 Characteristics of the mesh

The mesh is obtained by extrusion of $0,25$ mesh of modelization A.

Nombre of nodes: 2402

Number of meshes and types: 502 PENTA15

5.2 Functionalities tested

Commands

DEFI_MATERIAU	TENSION	SIGM	
STAT_NON_LINE	COMP_INCR	RELATION	VMIS_ISOT_TRAC
CALC_THETA	THETA_3D		
CALC_G	COMP_INCR	RELATION	VMIS_ISOT_TRAC
	OPTION	CALC_G_GLOB	

6 Results of the modelization B

6.1 Values tested

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

7 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 numerical results are sensitive to the mesh 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, from a sufficient smoothness of the mesh and radius of the notch, the numerical results are stable. For more information, it is advised to consult the document [R7.02.07] and the bibliographical references.