SSNP311 - Biblio_131. Cracking in mode II of an elastoplastic test-tube

Abstract:

This test is resulting from the validation independent of version 3 in fracture mechanics.

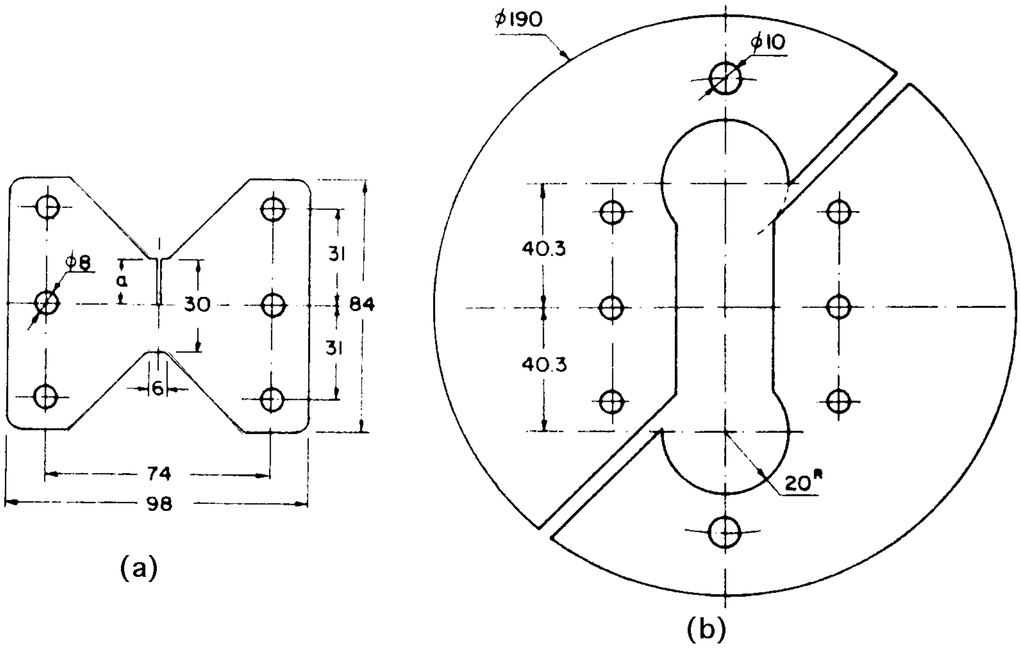
It is of a two-dimensional test in static which aims at the validation of the computation of G, and about its nondependence with respect to contour, in elastoplastic mode in an incremental computation, on a nontrivial geometry. The constitutive law used is an elastoplastic model of Von Mises with isotropic hardening.

This case test understands only one modelization $2D$ planes in which one studies the influence of an incremental load.

The results got with *Code_Aster* are compared with the computations carried out using code ADINA.

1 Problem of reference

1.1 Geometry



the test-tube in the shape of twin wheel, represented in (A), is fixed at the system of loading (b) by six pins equivalent to pinned ends.

Dimensions of the parts are expressed in mm.

Test-tube:

variable B thickness	$6{,}36$; $6{,}39$; $6{,}44\,mm$
overall width	$98\,mm$
outdistances between the axes of the pins	$74\,mm$
width of the overall height	$6\,mm$
central part	$84\,mm$
outdistances between centers of the pins	$31\,mm$
height in the center W	$30\,mm$
length of crack a	$15, 18$ or $21\,mm$
ligament $b=W-a$	$15, 12$ or $9\,mm$
bore of pins	$8\,mm$

Carry-test-tube:

thickness	$25\,mm$
external diameter	$190\,mm$
and the outdistances between the center of the part centers of the circular cavities	$40{,}3\,mm$
radius of the cavities	$20\,mm$
diameter of 2 holes where are applied the loads	$10\,mm$

1.2 Properties of the materials

Test-tube:

The material is elastoplastic, of type Von Mises, with isotropic hardening, defined by a uniaxial curve of tension.

Young modulus: $E=74{,}2\,GPa$

Poisson's ratio: $\nu=0{,}32$

E tangent (GPa)	σ uniaxial) (MPa)	ε_T uniaxial) ($\%$)
72,74	334,6	0,46
50,69	410,7	0,61
15,00	431,6	0,75
4,75	443,5	1,00
1,82	480,0	3,00
0,80	500,1	5,50
0,0017	505,2	300,0

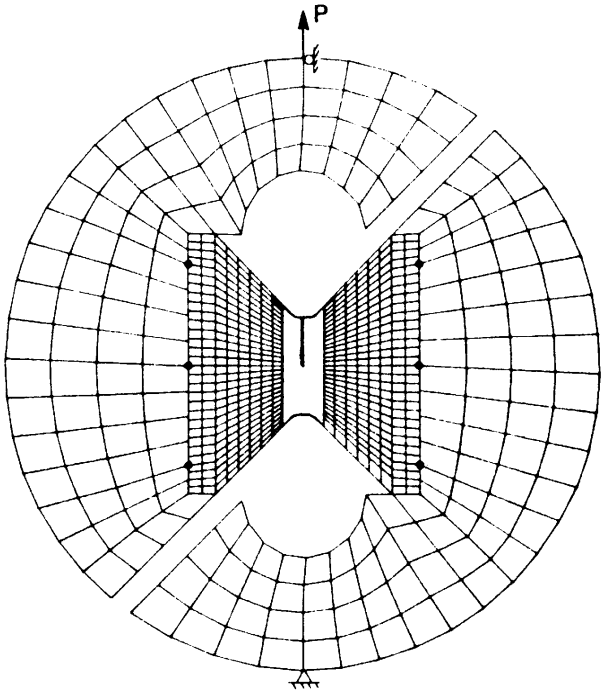
Carry-test-tube:

The material is elastic linear isotropic.

Young modulus: $E=206\,GPa$

Poisson's ratio: $\nu=0{,}3$

1.3 Boundary conditions and loading



the carry-test-tube has a fixed point $UX=UY=0$ with lower clamp hole and is subjected to a vertical specific loading applied to clamp hole higher $UX=0$, $FY=P$ variable.

For a length of crack $a/W=0{,}5$:

P vary:

$0\,N$ with $11772\,N$ in 12 steps of $981\,N$

$11772\,N$ with $19620\,N$ in 16 step of $490{,}5\,N$
$19620\,N$ with $23544\,N$ in 20 steps of $196{,}2\,N$
$23544\,N$ with $25114\,N$ in 16 step of $98{,}1\,N$

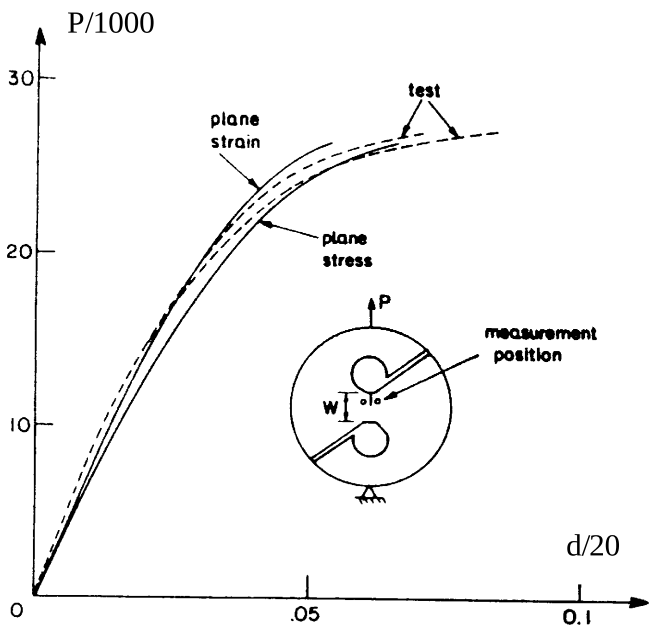
2 Reference solution

2.1 Method of calculating used for the reference solution

Computation in finite elements with ADINA. Update of the tangent stiffness matrix by method BFGS (BROYDEN, FLETCHER, GOLDFARB and SHAMNO). Computation from J integral of Rice in whom the density of strain energy is evaluated according to the theory of plasticity of Hencky (models elastic reversible nonlinear equivalent with the incremental theory of plasticity for a monotonous radial loading growing within the space of principal stresses)

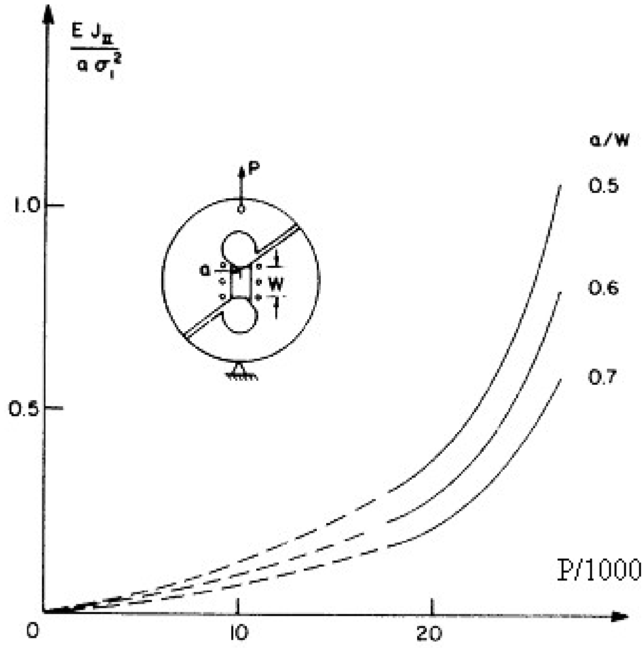
2.2 Results of Curve

response reference charges/Curve



displacement response giving the load $P/1000$ according to displacement $d/20$. Higher curve calculated in plane strains, curves lower calculated in plane stresses. The curves in stopped feature are experimental results. Stress of reference $\sigma_{ref}=334,6\,MPa$ (first point on curve of tension). Thickness of test-tube $B=6,36$ or $6,39\,mm$. Length of crack $a/W=0,5$.

Integral J according to the Integral



load standardized $E \times J_{II} / (a \times \sigma_{ref}^2)$ according to the stress $P/1000$, where $\sigma_{ref} = 334{,}6\,MPa$, for a test-tube of thickness $B = 6{,}44\,mm$

One also has some tabulated values, for a length of crack $a/W = 0{,}5$ and a computation in plane strains; the dispersion of J_{II} is related to the choice of the contour of integration around the crack tip.

No the loading	$P(KN)$	$E \times J_{II} / (a \times \sigma_{ref}^2)$
22	27,66	0,292 to 0,295
36	35,11	0,540 to 0,543
50	38,83	0,798 to 0,813
64	41,49	1,065 to 1,190

2.3 Uncertainty on the solution

the difference between experimental measurements and computation does not exceed 7%, with regard to the response curve charges/displacement.

The accuracy of the computation of J is unknown; the error seems to grow with the level of load, as the increasing dependence from ratio with J the contour shows it, which reaches a margin of variation of 12% with the step n° 64.

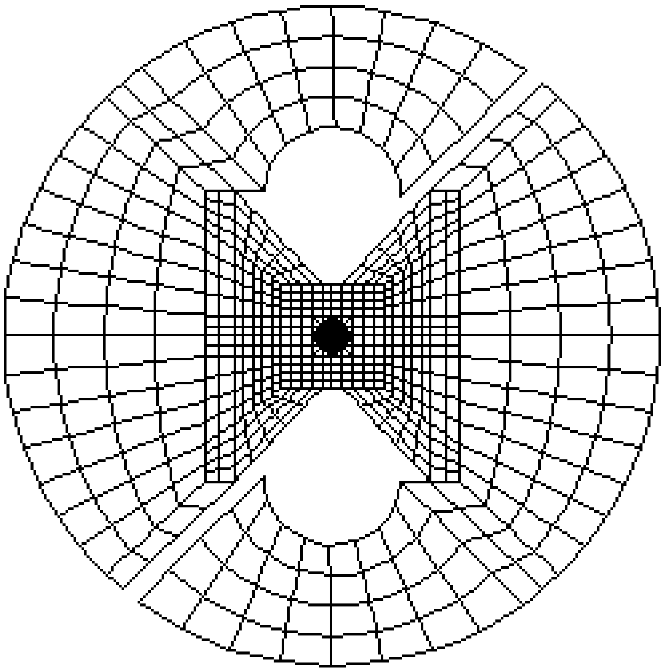
2.4 Bibliographical references

1) LESLIE BANKS-SILLS and DOV SHERMAN: Elasto-plastic analysis of has mode II fractures specimen. Int.J.Fracture, 46,105-122, **1993**. Modelization

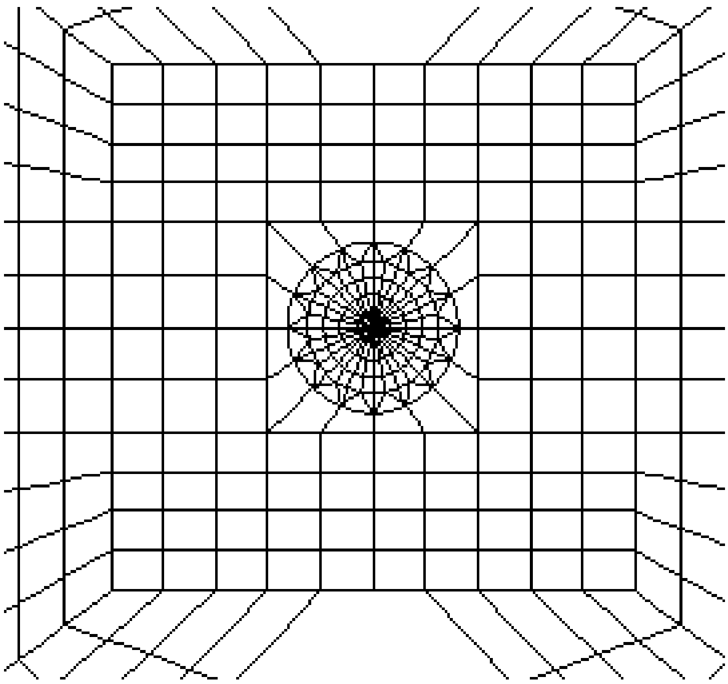
3 A Characteristic

3.1 of the modelization Mesh of

3.1.1 the test-tube and the door test-tube Mesh of



the test-tube and the door test-tube Zoom on the crack tip



Definition of

3.1.2 radius of contours We radius

define the values of higher and lower, to specify in command CALC_THETA: the 1st contour

	the 2nd contour	the 3rd contour	the 4th contour	1 2 3 4 2 3 4
$\mathrm{rinf}(mm)$	5	Characteristics		
$\mathrm{rsup}(mm)$				

3.2 of the mesh The mesh

consists of two objects: the door test-tube

- consists of 718 nodes and 200 elements QUA8. the test-tube
- consists of 1741 nodes and 576 elements including 496 QUA8 and 80 TRI6. Quantities tested

3.3 and results It is noted that in

this benchmark the constitutive law in CALC_G (ELAS_VMIS_TRAC) differs from the constitutive law of STAT_NON_LINE (VMIS_ISOT_TRAC). This is due to the fact that one wants to calculate by supposing G that the loading is monotonous proportional. The use of model VMIS_ISOT_TRAC in CALC_G would have resulted in calculating the parameter (see the U2.82.03 GTP document). Identification

Reference Aster	**difference**	***Increment***	**% in**
load n° 22, contour n°			
G 1 () 6,7451 7,005 KN/mm	3,868,	contour	n°
G 2 () 6,7451 6,99728 KN/mm	3,739	, contour	n°
G 3 () 6,7451 6,9964 KN/mm	3,726	G, contour	N
°4 () 6,7451 6,998 KN/mm	3,75 Increment		of
load n°36, contour n°			
G 1 () 12,473 13,069 KN/mm	4,786	, contour	n°
G 2 () 12,473 13,094 KN/mm	4,977	, contour	n°
G 3 () 12,473 13,083 KN/mm	4,887	, contour	n°
G 4 () 12,473 13,071 KN/mm	4,795	Increment	of
load n°50, contour n°			
G 1 () 18,433 19,49 KN/mm	5,744,	contour	n°
G 2 () 18,433 19,573 KN/mm	6,184	, contour	n°
G 3 () 18,433 19,577 KN/mm	6,204	, contour	n°
G 4 () 18,433 19,574 KN/mm	6,194	Increment	of
load n°64, contour n°			
G 1 () 24,601 26,84 KN/mm	9,105,	contour	n°
G 2 () 24,601 26,977 KN/mm	9,657	, contour	n°
G 3 () 24,601 26,981 KN/mm	9,672	, contour	n°
G 4 () 24,601 26,983 KN/mm	9,684	Summary	of

4 the results the results

concerning the rate of refund D" energy give 1 maximum change from ratio to $9,7\ \%$ the reference solution on last contour, for an accuracy announced of. The results 12% are excellent taking into account the nonlinear character of the test-tube.