

## SSNP02 - Element of plate in plane deformations and biaxial traction (law of Norton)

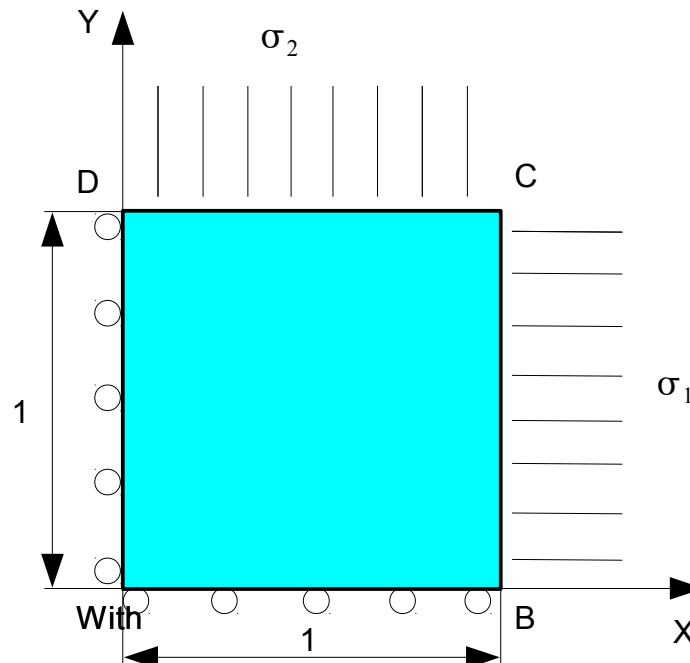
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### Summary:

This CAS-test makes it possible to test the law of NORTON by using the relation of behavior of LEMAITRE in the case of a plate in plane deformations in biaxial traction. One is interested in the plastic deformations.

## 1 Problem of reference

### 1.1 Geometry



Coordinates of the points ( $m$ ) :

- $A(0., 0.)$
- $B(1., 0.)$
- $C(1., 1.)$
- $D(0., 1.)$

### 1.2 Properties of material

Rubber band

- $E = 178\,000\text{ MPa}$  Young modulus
- $\nu = 0.3$  Poisson's ratio

LEMAITRE

- $n = 9.7$
- $K = 1920.$
- $\frac{1}{m} = 0.$

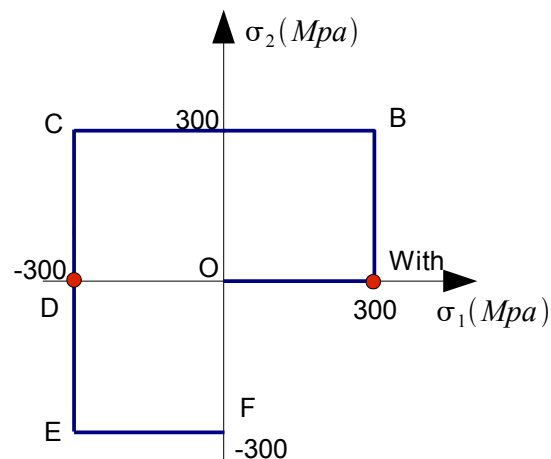
## 1.3 Boundary conditions and loadings

Imposed displacement ( $m$ ) :

- $AB$  :  $DY=0$
- $AD$  :  $DX=0$

Loading

- Uniform pressure on  $BC$  :  $\sigma_1$
- Uniform pressure on  $CD$  :  $\sigma_2$
- Ways  $OA$ ,  $AB$ ,  $CD$ ,  $DE$  and  $EF$  from duration 30 seconds
- Way  $BC$  from duration 60 seconds
- Time of maintenance in  $A$ ,  $B$  and  $D$  from 3600 seconds



## 2 Reference solution

### 2.1 Method of calculating used for the reference solution

The reference solution was obtained with various codes calculations finite elements using various explicit, semi-implicit or implicit algorithms [2]

### 2.2 Reference variables

$EPXX$  : plastic deformation according to  $X$

$EPYY$  : plastic deformation according to  $Y$

## 2.3 Size and result of reference

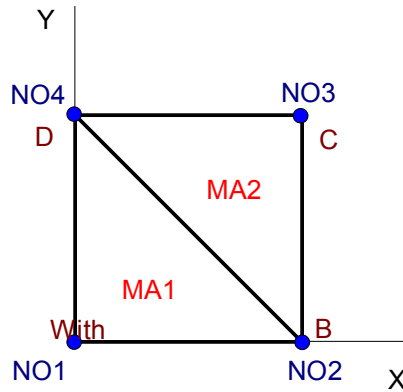
Moment ( $s$ )	Component	Reference
30.	<i>EPXX</i>	$6.125 \times 10^{-7}$
	<i>EPYY</i>	$-4.684 \times 10^{-7}$
3630.	<i>EPXX</i>	$7.056 \times 10^{-4}$
	<i>EPYY</i>	$-5.720 \times 10^{-4}$
3660.	<i>EPXX</i>	$7.061 \times 10^{-4}$
	<i>EPYY</i>	$-5.724 \times 10^{-4}$
7260.	<i>EPXX</i>	$7.061 \times 10^{-4}$
	<i>EPYY</i>	$-5.724 \times 10^{-4}$
7320.	<i>EPXX</i>	$-2.443 \times 10^{-5}$
	<i>EPYY</i>	$1.377 \times 10^{-4}$
7350.	<i>EPXX</i>	$-7.788 \times 10^{-4}$
	<i>EPYY</i>	$8.423 \times 10^{-4}$
11010.	<i>EPXX</i>	$-1.534 \times 10^{-3}$
	<i>EPYY</i>	$1.432 \times 10^{-3}$

## 2.4 Bibliographical references

- [1] Guide of Validation of the Software packages of Calculations of the Structures: SFM, technical AFNOR, ISBN: 2-12-486611-7
- [2] Validation of computer codes in viscoplasticity: Report of a scientific interest group. (GIS), ONERA France, 1989

## 3 Modeling A

### 3.1 Characteristics of modeling A



Modeling D\_PLAN :

Many nodes 4  
Many meshes 4 That is to say:  
SEG2 2  
TRIA3 2

Group of meshes:

- *DROITE* : segment BC
- *HAUT* : segment CD

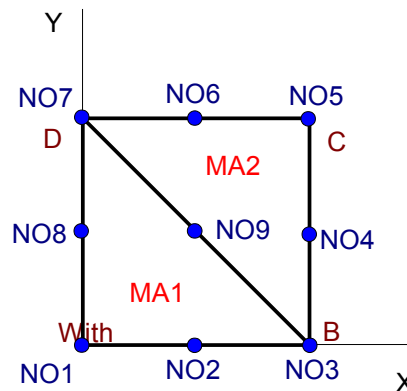
### 3.2 Sizes tested and results

Mesh	Not	Moment (s)	Component	Reference	Tolerance (%)
MA1	1	30.	EPXX	$6.125 \times 10^{-7}$	0.2
			EPYY	$-4.684 \times 10^{-7}$	0.2
MA1	1	3630.	EPXX	$7.056 \times 10^{-4}$	0.2
			EPYY	$-5.720 \times 10^{-4}$	0.2
MA1	1	3660.	EPXX	$7.061 \times 10^{-4}$	0.2
			EPYY	$-5.724 \times 10^{-4}$	0.2
MA1	1	7260.	EPXX	$7.061 \times 10^{-4}$	0.2
			EPYY	$-5.724 \times 10^{-4}$	0.2
MA1	1	7320.	EPXX	$-2.443 \times 10^{-5}$	0.2
			EPYY	$1.377 \times 10^{-4}$	0.2
MA1	1	7350.	EPXX	$-7.788 \times 10^{-4}$	0.2
			EPYY	$8.423 \times 10^{-4}$	0.2

<i>MAI</i>	1	11010.	<i>EPXX</i>	$-1.534 \times 10^{-3}$	0.2
			<i>EPYY</i>	$1.432 \times 10^{-3}$	0.2

## 4 Modeling B

### 4.1 Characteristics of modeling B



Modeling D\_PLAN:

Many nodes 9  
Many meshes 4 That is to say:

SEG3 2  
TRIA6 2

Group of meshes:

- *DROITE* : segment *BC*
- *HAUT* : segment *CD*

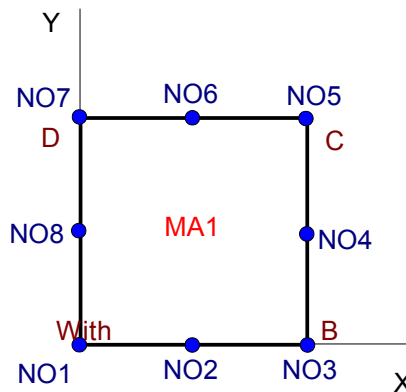
### 4.2 Sizes tested and results

Mesh	Not	Moment (s)	Component	Reference	Tolerance (%)
<i>MAI</i>	1	30.	<i>EPXX</i>	$6.125 \times 10^{-7}$	0.2
			<i>EPYY</i>	$-4.684 \times 10^{-7}$	0.2
<i>MAI</i>	1	3630.	<i>EPXX</i>	$7.056 \times 10^{-4}$	0.2
			<i>EPYY</i>	$-5.720 \times 10^{-4}$	0.2
<i>MAI</i>	1	3660.	<i>EPXX</i>	$7.061 \times 10^{-4}$	0.2
			<i>EPYY</i>	$-5.724 \times 10^{-4}$	0.2
<i>MAI</i>	1	7260.	<i>EPXX</i>	$7.061 \times 10^{-4}$	0.2
			<i>EPYY</i>	$-5.724 \times 10^{-4}$	0.2
<i>MAI</i>	1	7320.	<i>EPXX</i>	$-2.443 \times 10^{-5}$	0.2
			<i>EPYY</i>	$1.377 \times 10^{-4}$	0.2

MAI	1	7350.	EPXX	$-7.788 \times 10^{-4}$	0.2
			EPYY	$8.423 \times 10^{-4}$	0.2
MAI	1	11010.	EPXX	$-1.534 \times 10^{-3}$	0.2
			EPYY	$1.432 \times 10^{-3}$	0.2

## 5 Modeling C

### 5.1 Characteristics of modeling C



Modeling D\_PLAN :

Many nodes 8

Many meshes 3 That is to say:

SEG3 2  
QUAD8 1

Group of meshes:

- DROITE : segment BC
- HAUT : segment CD

### 5.2 Sizes tested and results

Mesh	Not	Moment (s)	Component	Reference	Tolerance (%)
MAI	1	30.	EPXX	$6.125 \times 10^{-7}$	0.2
			EPYY	$-4.684 \times 10^{-7}$	0.2
MAI	1	3630.	EPXX	$7.056 \times 10^{-4}$	0.2
			EPYY	$-5.720 \times 10^{-4}$	0.2
MAI	1	3660.	EPXX	$7.061 \times 10^{-4}$	0.2
			EPYY	$-5.724 \times 10^{-4}$	0.2
MAI	1	7260.	EPXX	$7.061 \times 10^{-4}$	0.2
			EPYY	$-5.724 \times 10^{-4}$	0.2

MAI	1	7320.	EPXX	$-2.443 \times 10^{-5}$	0.2
			EPYY	$1.377 \times 10^{-4}$	0.2
MAI	1	7350.	EPXX	$-7.788 \times 10^{-4}$	0.2
			EPYY	$8.423 \times 10^{-4}$	0.2
MAI	1	11010.	EPXX	$-1.534 \times 10^{-3}$	0.2
			EPYY	$1.432 \times 10^{-3}$	0.2

## 6 Modeling D

### 6.1 Characteristics of modeling D

Identical to modeling A. the behavior used is Norton, with implicit integration (NEWTON\_PERT)  
The reference solution is identical to modeling A.

### 6.2 Sizes tested and results

Mesh	Not	Moment ( $s$ )	Component	Reference	Tolerance (%)
MAI	1	30.	EPXX	$6.125 \times 10^{-7}$	0.6
			EPYY	$-4.684 \times 10^{-7}$	0.6
MAI	1	3630.	EPXX	$7.056 \times 10^{-4}$	0.2
			EPYY	$-5.720 \times 10^{-4}$	0.2
MAI	1	3660.	EPXX	$7.061 \times 10^{-4}$	0.2
			EPYY	$-5.724 \times 10^{-4}$	0.2
MAI	1	7260.	EPXX	$7.061 \times 10^{-4}$	0.2
			EPYY	$-5.724 \times 10^{-4}$	2
MAI	1	7320.	EPXX	$-2.443 \times 10^{-5}$	0.3
			EPYY	$1.377 \times 10^{-4}$	0.3
MAI	1	7350.	EPXX	$-7.788 \times 10^{-4}$	0.3
			EPYY	$8.423 \times 10^{-4}$	0.3
MAI	1	11010.	EPXX	$-1.534 \times 10^{-3}$	0.2
			EPYY	$1.432 \times 10^{-3}$	0.2

## 7 Modeling E

### 7.1 Characteristics of modeling E

Identical to modeling A. the behavior used is Norton, with integration ex plicite ( RUNGE\_KUTTA )  
The reference solution is identical to modeling A.

### 7.2 Sizes tested and results

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Mesh	Not	Moment ( <i>s</i> )	Component	Reference	Tolerance (%)
MAI	1	30.	EPXX	$6.125 \times 10^{-7}$	0.2
			EPYY	$-4.684 \times 10^{-7}$	0.2
MAI	1	3630.	EPXX	$7.056 \times 10^{-4}$	0.2
			EPYY	$-5.720 \times 10^{-4}$	0.2
MAI	1	3660.	EPXX	$7.061 \times 10^{-4}$	0.2
			EPYY	$-5.724 \times 10^{-4}$	0.2
MAI	1	7260.	EPXX	$7.061 \times 10^{-4}$	0.2
			EPYY	$-5.724 \times 10^{-4}$	0.2
MAI	1	7320.	EPXX	$-2.443 \times 10^{-5}$	0.2
			EPYY	$1.377 \times 10^{-4}$	0.2
MAI	1	7350.	EPXX	$-7.788 \times 10^{-4}$	0.2
			EPYY	$8.423 \times 10^{-4}$	0.2
MAI	1	11010.	EPXX	$-1.534 \times 10^{-3}$	0.2
			EPYY	$1.432 \times 10^{-3}$	0.2

## 8 Summary of the results

The got results are satisfactory.